Five-Year Review Report

for

Brookhaven National Laboratory Superfund Site (NY7890008975)

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

June 21, 2016

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

PREPARED BY:
Environmental Protection Division
Brookhaven National Laboratory
Upton, New York 11973

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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 $580 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 2016 *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 Explanations of Significant Differences* (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, several additional remedy optimizations were accomplished. These include the addition of extraction wells associated with the Middle Road, OU III South Boundary, and Industrial Park groundwater treatment systems. These extraction wells were added to allow for the capture and treatment of the deeper VOC contamination identified. A new groundwater treatment system was added near the Building 96 treatment system in 2012 to capture and treat a plume of Freon-11 associated with Building 452. This system successfully remediated the plume and was shut down in March 2016. In 2013, the Former Hazardous Waste Management Facility (HWMF) Perimeter Soils were designated as Sub-Area of Concern 1J. The final phase of radiological soil cleanup at this area was completed in 2014. From 2014 through 2016, the former Waste Concentration Facility Buildings 810 and 811 were demolished, waste transfer lines were removed, and excavation of radiologically contaminated soil was completed. This action is expected to further reduce Sr-90 contamination in the soil, thus helping to meet the groundwater cleanup objective.

Long-term protectiveness of the Peconic River remedy has been verified by continued monitoring of the sediment, surface water, and fish, and by completing the revegetation in areas that underwent supplemental

remediation during the winter of 2010/2011. One location, Area PR-WC-06 was identified as having significantly elevated mercury levels in the sediment based on 2014 and 2015 monitoring. Additional excavation is being proposed for this small area of approximately 0.06 acres. All other areas have met their long-term cleanup objectives identified in the ROD.

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 stack and reactor vessel removal.

The fourth comprehensive Five-Year Review in 2021 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 2016 Five-Year Review. The recommendations are subject to regulatory review, and implementation 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	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.	BNL	DOE, EPA, NYSDEC, SCDHS	July 2021	N	N
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*.	BNL	DOE, EPA, NYSDEC, SCDHS	July 2018	N	N
OU III Western South Boundary deep VOC contamination	Characterize nature and extent of deep VOCs identified in 2016/run model.	BNL	DOE, EPA, NYSDEC, SCDHS	September 2017	N	N
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.	BNL	DOE, EPA, NYSDEC, SCDHS	July 2021	N	N
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.	BNL	DOE, EPA, NYSDEC, SCDHS	July 2021	N	N
Peconic River Remedy Optimization	Complete supplemental excavation of elevated mercury at Area PR-WC-06.	BNL	DOE, EPA, NYSDEC, SCDHS	September 2018	N	N
HFBR	Remove stack by 2020 per the ROD.	BNL	DOE, EPA, NYSDEC, SCDHS	September 2020	N	N

Issue	Recommendations/ Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Y/N)	
					Current	Future
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 - Deeds not reflecting operating treatment systems	Record property access agreements with County Clerk	BNL	DOE, EPA, NYSDEC, SCDHS	June 2017	N	Y
Soil contamination north of former Buildings 810/811	Add radiological soil contamination area to Building 811 Waste Concentration Facility LUIC fact sheet	BNL	DOE, EPA, NYSDEC, SCDHS	January 2017	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: Frank Crescenzo	
Author title: DOE Site Manager	**Author affiliation:** U.S. DOE, Upton, NY
Review period:** 1/1/2011 to 3/30/2016	
Date(s) of site inspection: 4/30/15 through 11/3/15	
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) _____	
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)*: 8/9/2011	
Due date *(five years after triggering action date)*: 8/9/2016	

* ["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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5. Technology and Standards Review Memos (T. Sullivan to W. Dorsch, dated 10/1/15)
6. Operable Unit Cleanup Levels Matrix

List of Acronyms

ALARA	As Low As Reasonably Achievable
AOC	Area of Concern
AGS	Alternating Gradient Synchrotron
AS/SVE	Air Sparging/Soil Vapor Extraction
BER	Brookhaven Executive Round Table
BGD	below-ground duct
BGRR	Brookhaven Graphite Research Reactor
BHSO	Brookhaven Site Office
BLIP	Brookhaven Linac Isotope Producer
BNL	Brookhaven National Laboratory
BSA	Brookhaven Science Associates
CAC	Community Advisory Council
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
DQO	Data Quality Objective
EDB	ethylene dibromide
EPA	U.S. Environmental Protection Agency
ESD	*Explanation of Significant Differences*
FFA	Federal Facilities Agreement
gpm	gallons per minute
HFBR	High Flux Beam Reactor
HWMF	Hazardous Waste Management Facility
IAG	Interagency Agreement
IP	Industrial Park
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

mRem	milliRem
MTBE	methyl tertiary-butyl ether
NCP	*National Contingency Plan*
NEPA	*National Environmental Policy Act*
NPL	*National Priorities List*
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
OU	Operable Unit
pCi/L	picoCurie(s) per liter
pCi/g	picoCurie(s) per gram
PCBs	polychlorinated biphenyls
PCE	tetrachloroethylene
ppm	part(s) per million
RA	Removal Action
RAO	Remedial Action Objective
ROD	Record of Decision
SCDHS	Suffolk County Department of Health Services
SCWA	Suffolk County Water Authority
SPDES	State Pollutant Discharge Elimination System
Sr-90	strontium-90
STP	Sewage Treatment Plant
SVOC	semivolatile organic compound
TBC	Items “to be considered”
TCA	1,1,1-trichloroethane
TCE	trichloroethene
TSS	total suspended solids
TVOC	total volatile organic compound
UST	underground storage tank
VOC	volatile organic compound
WCF	Waste Concentration Facility
WSB	Western South Boundary
µg/L	microgram(s) per liter

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 32 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.

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 with the ability of the current remedial actions to meet the cleanup objectives, if any, 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 third 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 2016 sitewide statutory Five-Year Review is the completion of the second sitewide review in July 2011. 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 third 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 RODs.
- The second sitewide Five-Year Review was submitted to the regulators in March 2011, and the Addendum addressing regulator comments was issued as final in November 2011 (BNL 2011a). The triggering action for this review was the completion of the last review.

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. The chronology in **Table 2-1** first identifies general site information, and then breaks each OU down 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
Demolition of former Waste Concentration Facility and soil removal in progress	2016
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
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

Continued…

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

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, Bldg. 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 Bldg. 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 (BNL 2012a); 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
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
Operable Unit V	
RA for Imhoff Tanks	1995
ROD signed for Sewage Treatment Plant (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

Continued…

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

Operable Unit VI	
RA for public water hookups	1996–1997
ROD signed	2001
Completed constructing EDB groundwater treatment system off site	2004
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	2010
Engineered cap installed; Closeout Report issued	2011
Issued ESD (BNL 2012b); 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

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

RA = Removal Action
RI = Remedial Investigation
ROD = Record of Decision
STP = Sewage Treatment Plant
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
	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 Bldg. 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 in progress)
	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 ongoing
	AOC 12	USTs at Bldg. 830 – removal action complete
	AOC 13	Cesspools – removal action complete
	AOC 14	Bubble Chamber Spill Areas – groundwater monitoring ongoing
	Sub AOC 15A	Supply/Potable Wells 1, 2, 3, 4, 6, 7, 10, 11, 12
	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 ongoing
	AOC 19	TCE Spill Area, Building T-111 – groundwater monitoring ongoing
	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 ongoing
	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 & maintain per SPDES permit & NRMP
	Sub AOC 24C	Recharge Basin HN, Outfall 002 – monitor & maintain per SPDES permit & NRMP
	AOC 25	Building 479 PCB soil removal complete; groundwater monitoring underway

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 Bldg. 96 – treatment system operating; soil removal complete
	AOC 27	Building 464 mercury soil removal complete; groundwater monitoring ongoing
	AOC 29	Spent fuel pool in HFBR and associated groundwater plume of tritium – pump and recharge system in standby mode; groundwater monitoring ongoing
	AOC 32	Building 452 Freon-11 Source Area and Groundwater Plume - treatment system in standby mode
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 Bldg. 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; river monitoring ongoing
OU VI (ROD approved)	AOC 28	EDB groundwater contamination – treatment system operating
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, Bldgs. 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
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 – in progress
Other Removal Action	Not applicable	Former HWMF Perimeter Soils – Phases I, II, and III – complete
	Not applicable	Central Steam Facility Lead-Contaminated Soil – complete

Continued…

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

Category	AOC #	Description and Status
	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
HFBR = High Flux Beam Reactor
NRMP = *Natural Resource Management Plan*
ROD = Record of Decision
SPDES = State Pollutant Discharge Elimination System
STP = Sewage Treatment Plant
EDB = ethylene dibromide
TCE = trichloroethene
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. Approximately 150 people live in apartments on site, and many of the approximately 4,500 scientists and students who visit each year stay in the Lab's dormitories. 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 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 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. These three water-bearing units are designated as a "sole-source aquifer" by the EPA and serve 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 currently a federal facility that conducts cutting-edge research in physics, chemistry, biology, medicine, applied science, and advanced technologies.

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. Approximately 500 acres of land on the eastern portion of the site has been designated as the Upton Ecological 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) direct current solar photovoltaic power plant was constructed in 2011.

The current land-use designations for the BNL site as of March 2016 are shown on **Figure 3-1**. This includes industrial use in the central portion of the site, with open space borders. 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 2013a) which was initially issued in 2003. 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 that is available for regulatory use but is not open to the general public. The website is BNL's tool for internally managing Institutional Controls (ICs) and consists of an interactive Graphic Information Systems (GIS) base map that is linked to the AOC-specific fact sheets. Planning for any work at the site that may potentially disturb a formerly 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.

This Plan is a living document and is periodically updated by BNL and reviewed by the regulators in an effort to stay current with evolving management techniques. The Plan was updated four times since 2003 with the latest update in April 2013 (BNL 2003b, 2005d, 2007a, 2009d, and 2013a). 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 former AOCs is included in this report. The Plan 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 homeowner's well is no longer being used. This brings the number of homes not connected to public water to six (three 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.

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], ethylene dibromide [EDB], strontium-90 [Sr-90], and tritium), 2) soils contamination (primarily polychlorinated biphenyls [PCBs], tetrachloroethylene [PCE], metals, cesium-137 [Cs-137], and Sr-90) and landfills, 3) the Peconic River sediment contamination (primarily metals and PCBs), and 4) the BGRR/HFBR (primarily radioactivity). 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 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 and carbon tetrachloride; and PCE soil contamination at one location on BNL property.
- OU IV – Soil and groundwater contaminated with VOCs such as toluene and ethylbenzene, and semivolatile 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.
- BGRR – Activated components including the pile and bioshield, 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 underground storage tanks.
- 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 32 AOCs and six OUs at the BNL site.

As noted in **Table 2-1** in **Section 2.0**, 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.

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 threat. In addition, several 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) contained primarily Cs-137. Other contaminated soil areas included the Waste Concentration Facility (WCF, AOC 10) (which also contained leaking tanks), Building 650 Sump and Sump Outfall (AOC 6), and several areas throughout the site that were the result of contaminated soils that were unknowingly once 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 their being capped or excavated in the mid-1990s. Contaminants at the Former Landfill Area include 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 low levels of pesticides and metals below cleanup standards for human health but 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. Volatile organic compound 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, 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, 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 supply wells on and off of the BNL site are currently not impacted, 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 currently three homeowners continue to use their private wells 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 (e.g., TCE) 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 originates 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.

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 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 into the soil/groundwater. Most nonradiological hazardous materials associated with the BGRR were removed through previous interim stabilization measures. Isolated pockets of nonradiological 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 extends up to 1,500 feet south of this area.

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 significantly exceed the 20,000 pCi/L MCL. Although sodium-22 concentrations had occasionally exceeded the 400 pCi/L MCL, it was found to decay 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 formerly extended several thousand feet to the south at concentrations significantly above the 20,000 pCi/L MCL. Tritium has not been 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
2. OU III – Groundwater on and off of the BNL site
3. OU IV – Soil and groundwater on site
4. OU V – STP
5. OU V – Peconic River
6. OU VI – EDB in groundwater off of the BNL site
7. BGRR – Radiologically contaminated structures and soil on site
8. g-2/BLIP/USTs – Radiologically contaminated soil shielding and groundwater
9. HFBR – Radiologically contaminated structures and soil

The four ESDs are:

1. OU III – Magothy and Sr-90 groundwater cleanup, institutional controls
2. OU III – Building 96 soil and groundwater remedy optimization
3. BGRR – Biological shield removal changes
4. OU III – Building 452 Freon-11 groundwater remedy

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:
  - For radionuclides in soil, the cleanup goal is based on a total dose of 15 milliRem/yr (mRem) above background.
  - The NYSDEC guidance of 10mRem/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.
  - Leaching of contaminants (radiological and chemical) from soil into the groundwater.
  - Migration of contaminants present in surface soil via surface runoff and windblown dust.
  - Human exposure including direct external exposure, ingestion, inhalation, and dermal contact, and environmental exposure to contaminants in the surface and subsurface soils.
  - Uptake of contaminants present in the soil by ecological receptors.
- 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.
  - 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 Decisions

Remedial actions for the OU II AOCs are documented in the OU I ROD (BNL 1999a), 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., maximum contaminant levels [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 volatile organic compounds 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 volatile organic compounds by 2030).

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

- Objectives are to restore the groundwater quality at 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 the surface and subsurface soil and groundwater.
  - 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.

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
  - 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 (D&D) of the remaining HFBR structures (e.g., stack, large activated components including reactor vessel, systems, and confinement building), all soil, groundwater, and D&D 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. 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 (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 24,000 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, 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. Starting in 2014 and continuing into 2016, the former Waste Concentration Facility Buildings 810 and 811 were demolished, waste transfer lines were removed, and excavation of radiologically-contaminated soil was initiated (approximately 1,800 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/year 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 (formerly the Contracts and Procurement Division) 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 South Boundary Treatment System, installed under a Removal Action, began operation in 1997 and was approved for shutdown in 2013.

Operable Unit III: Fourteen of BNL's 17 groundwater treatment systems are included under OU III. Following the signing of the OU III ROD in June 2000, the groundwater treatment systems were designed and 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 2015, the OU III treatment systems have removed approximately 95 percent of the 7,387 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 and was 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 Well RTW-1 was modified from a recirculation well to surface discharge of the effluent due to a rebound of VOC concentrations in source area monitoring wells. Subsequent investigations identified a localized source of VOC contamination within the vadose zone. In accordance with the OU III ESD approved in 2009, 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. Well RTW-1 also included treatment for the hexavalent chromium from 2008 through 2010. 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, 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 2015, 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, and the Industrial Park 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, 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 approved for shutdown by the regulators in March 2016.

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

- Carbon Tetrachloride: Approved for shutdown in 2004. Approved for closure in 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.
- HFBR Tritium Pump and Recharge: Approved for shutdown in 2013.
- Industrial Park: Approved for shutdown in 2013, however it was restarted in 2014 due to rebound of VOCs. Two additional extraction wells became operational in 2015 to address the deep VOCs.
- North Street East: Approved for shutdown in 2014.
- Building 452 Freon-11: Approved for shutdown March 2016.

Operable Unit IV: In accordance with the March 1996 OU IV ROD, 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 dismantlement 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 Groundwater Monitoring* (BNL 2012d), natural attenuation monitoring of the low-level VOC groundwater plume that originated from the STP area was completed in 2013.

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 (approximately 1,700 sediment, surface water, and fish samples) collected between 2006 and 2010, DOE and the regulatory agencies determined that supplemental sediment removal in the River was necessary. In late 2010/early 2011, an additional 800 cubic yards of contaminated sediment were excavated. The final completion report was issued in 2012. 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. In February 2016, DOE submitted a plan to the regulators for supplemental sediment removal at on-site Area WC-06. Regulatory comments on the plan are being addressed.

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. This was the last of the planned systems to be installed beyond the BNL site property. Per the OU III and VI RODs, DOE continues to offer homeowners not connected to public water free annual testing of their private wells.

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 upper portion of air tight membrane, removal and disposal of Invar rods, and removal and disposal of Graphite Pile.

Installation of the final engineered cap adjacent to Building 701was completed in 2011. In 2012 the biological shield was removed in accordance with the ESD.

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 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 was subsequently discontinued in association with the leading plume edge. 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: Fan houses, confinement building stabilization, underground utilities, soil (2011), and stack silencer baffles (2012).

The WLA was part of the former HWMF, AOC 1. It is an area (of about two acres) 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 and HFBR 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. 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.

The stack demolition and reactor vessel are scheduled for removal by 2020 and 2072, respectively.

Groundwater Monitoring: An essential component of the groundwater remediation program is continued monitoring of the groundwater to ensure the cleanup is progressing as planned. An average of 1,500 samples were collected and analyzed annually from the groundwater monitoring wells between 2011 and 2015. 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 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 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: Eight access agreements are currently in place with the county, town, local utility, college, and private landowners. Seven of these agreements enable BNL to perform groundwater remediation activities for contamination that has migrated beyond the property boundary of BNL. The eighth agreement is with Suffolk County and allowed for the supplemental remediation of the Peconic River sediment in 2011. The terms of these agreements must be adhered to by BNL, such as maintaining adequate liability insurance, and in some cases, making annual monetary payments.

4.3 System Operations/Operation and Maintenance

All 17 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 early 2012. The location of each of the treatment systems and their operational status is shown on **Figure 4-2**. (Note that Brookhaven Airport and LIPA are one treatment system.) The operational status of each of the extraction wells is provided on **Figure 4-3**. The Industrial Park East, OU IV and Carbon Tetrachloride systems met their cleanup goals and were dismantled, and the OU I South Boundary, North Street East, HFBR and Building 452 systems are in standby mode awaiting closure. New extraction wells were installed in 2014 to address VOC contamination that was detected in the deep portion of the Upper Glacial aquifer in the Industrial Park. The remaining 10 systems are in active operation. 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 (BNL 2002-2012). 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 70 wells. Currently, 29 of these wells are in standby mode, 9 are in pulsed pumping mode, and 2 were decommissioned in 2014 (i.e., abandoned by sanding and grouting the well in place). Three extraction wells for the Carbon Tetrachloride system were previously decommissioned in 2010. Average individual extraction well flow rates range from approximately 5 gallons per minute (gpm) for the Sr-90 systems to up to 450 gpm for some of the VOC systems. System treatment for VOCs consists primarily of air stripping or carbon adsorption. Ion exchange is used for the Sr-90 groundwater contamination. 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.

The annual O&M costs for the treatment systems during 2011-2015 were as follow:

Table 4-1: Groundwater Treatment System O&M Costs for FY 2011 to 2015

System	($ in K) FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Comments
OU I South Boundary	136	130	105	58	59	Air stripping. Standby since 2013.
OU III South Boundary/ Middle Road	450	532	495	552	200	Air stripping. Only 5 of 15 wells running in 2015.
OU III Industrial Park	285	278	232	573	626	In-well air stripping with vapor phase carbon treatment, with recirculation wells. System in standby 2013, restarted in 2014. New extraction wells added 2014/2015.
OU III Building 96	326	96	73	107	90	Air stripping treatment. Source area excavation in early 2011.
Bldg. 452 Freon-11	NA	55	60	55	52	Air stripping treatment. Began pulsed pumping in February 2015.
OU III Western South Boundary	147	87	89	83	88	Air stripping treatment. Additional characterization in 2011.
OU III Industrial Park East	28	23	3	62	7	Carbon treatment. Wells abandoned in early 2014.
OU III North Street	296	247	182	187	199	Carbon treatment. Standby in late 2013, restarted in mid 2014. Includes property access costs.
OU III North Street East	151	79	72	34	33	Carbon treatment. Additional characterization in 2011. Standby in 2014.
OU III Airport/LIPA	285	341	260	237	312	Carbon treatment.
OU III HFBR Tritium	297	139	35	54	40	Pump and recharge. 2011 includes temporary wells. Standby since 2013.
OU III Sr-90 Chemical Holes	97	92	95	78	83	Ion-exchange treatment
OU III Sr-90 BGRR/WCF	1088	569	242	231	243	Ion-exchange treatment. Four wells installed in late 2010, became operational in 2011. Started pulse pumping wells in late 2011.
OU VI EDB	225	235	283	197	191	Carbon treatment. Monitoring wells installed in 2013. Includes property access costs.

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 third 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 2011a) 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:

- The third and final phase of cleanup of the former HWMF Perimeter Soils (Sub-AOC 1J) was completed in 2014.
- Starting in 2014 and continuing into 2016, the former Waste Concentration Facility Buildings 810 and 811 were demolished, waste transfer lines were removed, and excavation of radiologically contaminated soil was initiated. This action is expected to further reduce Sr-90 contamination in the soil, thus helping to meet the groundwater cleanup objective.

Groundwater Remediation:

- Hydraulic control of the VOC plumes was accomplished by the OU I South Boundary treatment system. The off-site segment of the plume was 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 Shutdown* of the treatment system in 2013 (BNL 2013b). Elevated VOCs previously seen in an area located approximately 500 feet to the north of the extraction wells, have declined to less than the system capture goal of 50 µg/L total VOCs since 2013. As a result, the ROD cleanup goals are expected to be achieved.
- Characterization was initiated in 2015 and is continuing to determine the current extent of Sr-90 groundwater contamination migrating from the Former HWMF, and to determine if there is a significant continuing source remaining. Targeted soil sampling, continued groundwater monitoring, and fate and transport analysis will be used to evaluate the need for any further actions. See **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 two years. VOCs continue to be detected at fluctuating levels above MCLs immediately east of the Current Landfill. Characterization of the groundwater in this area is in progress to confirm the extent of the contamination.

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 2011 are as follow:
  - The Industrial Park East system met MCLs and was approved for closure in 2013.
  - The North Street system was originally approved for shutdown in 2013; however it was restarted in 2014 due to rebound of VOCs.
  - The HFBR Tritium Pump and Recharge system was approved for shutdown in 2013.

- The Industrial Park system was approved for shutdown in 2013; however it was restarted in 2014 due to rebound of VOCs. Two additional extraction wells were added in 2014 to address deeper VOC contamination.
- The North Street East system was approved for shutdown in 2014.
- The Western South Boundary system expected operational period was extended to 2019 to ensure capture of upgradient VOCs.
- The Building 96 system expected operational period was extended to 2018 to address residual high VOC concentrations in the former source area.
- The South Boundary system – an additional deep extraction well was added in 2012 and the expected operational period was extended to 2019 to ensure capture of upgradient VOCs.
- The Middle Road system – an additional deep extraction well was added in 2013 to capture deeper VOCs on the west side of the plume.
- The LIPA and Airport system expected operational period was extended to 2019 and 2021, respectively to ensure capture of upgradient VOCs.
- The Chemical Holes Sr-90 system expected operational period was extended to 2019 to ensure capture of upgradient Sr-90.

- **Figure 4-3** 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.
- Following the 2011 detection of Freon-11 in groundwater downgradient of Building 452, an extraction well and Freon-11 treatment system was installed in 2012. Existing Building 96 extraction well RTW-1 was also used to capture the downgradient lower level Freon-11 concentrations. This system met its cleanup goals by reducing Freon-11 concentrations in groundwater to less than 50 µg/L, and was placed in standby mode in March 2016.
- The BGRR/WCF Sr-90 treatment system captures and treats Sr-90-contaminated groundwater originating from several source areas utilizing a network of nine extraction wells. Source area characterization indicates that elevated concentrations of Sr-90 are still present in the BGRR and WCF source areas. The system was designed based on the source no longer being present due to capping of the area via both the BGRR building structure and an engineered cap. It is likely that Sr-90 contamination below the facility structures in the vadose zone is being periodically mobilized to the aquifer by water-table elevation increases. This water-table flushing process has been observed at several other BNL source areas including the HFBR and g-2. Characterization of the groundwater conducted immediately downgradient of the WCF identified elevated Sr-90 concentrations. It is expected that these concentrations will attenuate since Buildings 810 and 811 were removed in 2015, along with contaminated soil. Monitoring of the source areas will continue.
- The Chemical Holes system has been effectively addressing the Sr-90 groundwater plume. However, due to elevated Sr-90 concentrations remaining upgradient of extraction well EW-1, the submittal of the *Petition for Shutdown* of the system was postponed in 2015. Soil and groundwater characterization of this former source area was performed in 2015 and early 2016. No significant Sr-90 contamination was detected. Monitoring of the former source area will continue.
- As shown on **Figure 5-2**, the HFBR tritium plume has significantly attenuated over the previous five years. Tritium concentrations immediately downgradient of the facility have continued to decline to slightly above to below the MCL of 20,000 pCi/L since 2011. Tritium did not exceed the MCL in 2015. The downgradient segment of the HFBR plume is no longer monitored because tritium concentrations have declined to below the 20,000 pCi/L MCL.

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 at the Building 650 Sump Outfall and is slowly migrating and attenuating within the central portion of the site (see **Figure 4-2**).

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 have been excavated in 2004/2005 and in 2011 to meet the appropriate cleanup levels. The Completion Report for the 2011 supplemental remediation was approved by the regulators in March 2012. Re-vegetation of the remediated areas has been completed and the State wetland equivalency permit requirements were met, as well as the federal requirements.

- Peconic River sediment monitoring from the three remaining areas during 2011 through 2015 indicated that additional sediment removal is needed at one on-site location to meet the cleanup goals for mercury. In February 2016, a remedy optimization plan for remediation of Area WC-06 was submitted to the regulators for review.
- Based on the recommendation in the 2012 *Petition to Discontinue Operable Unit V Groundwater Monitoring* (BNL 2012d), two additional years of VOC data were collected at one monitoring well. Since the 2013 results were less than MCLs, the groundwater sampling requirements were met and no additional sampling is required.

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 4-2**). The plume is moving slower than originally simulated by the groundwater model during the system design. Therefore, the expected system operational period was extended to 2019 to ensure capture of the upgradient EDB.

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 and monitoring of groundwater are underway in accordance with the Operable Unit III ROD, and are 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, such as the window replacements in the former offices on the second and third floor, sealing of precipitation infiltration areas, roof repairs performed in 2014 and 2015, and minor repairs to the cap.

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 in the downgradient portion of the plume is complete, however monitoring of the source area continues.

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. Activities completed for the HFBR since 2011 include:

- Dismantling of Buildings 704 and 802 (Fan Houses) and above- and below-ground structures (2011).
- Stabilization of the confinement building 2011).
- Removal of underground utilities and associated soil (2011).
- Removal of stack silencer baffles and survey of outside areas (2012).

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, water intrusion monitoring, preventive maintenance of Building 750 and the infiltration management system, and groundwater monitoring. Repairs have been performed on the facility including the replacement of light bulbs, roof repairs over the former machine shop area located outside of the confinement dome, re-caulking of a vent on the outside of the dome outside the generator room, and paving of the access road to the stack.

The WLA continues to be used for 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 monitoring of groundwater 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 2011 Five-Year Review.

Table 5-1: Follow-Up Actions to the 2011 Five-Year Review Recommendations

Issue	Recommendations/ Follow-Up Actions	Milestone Date	Action Taken/Current Status
Capture of remaining VOCs in OU I Plume	Implement Pulse Pumping of extraction wells. Continue pumping until 2015 to meet VOC capture goal.	July 2011	Began pulse pumping July 2011. Treatment system shut down in July 2013, in standby mode. Monitoring continues.
Sr-90 in OU I Groundwater	Enhance monitoring well network to track Sr-90.	June 2011	In March 2011, two sentinel monitoring wells were installed. In 2015/2016, Geoprobes® were installed at former HWMF to further characterize Sr-90. Sr-90 up to 302 pCi/L was detected. Further characterization and modeling in progress.
OU III Building 96 Source Removal Effectiveness	Continue treatment system operations. Monitor plume and determine if continuing source remains.	September 2012	RTW-1 continues to operate. RTW-4 was shut down in 2012; RTW-2 and RTW-3 shut down January 2016. VOCs concentrations downgradient of source area continue to decline. May achieve capture goals for system shut down by 2018. Performed soil vapor survey and soil borings for elevated VOCs in western plume segment. No VOCs detected. RTW-1 also captures downgradient portion of Freon-11 plume.
Monitoring of downgradient OU III Industrial Park East Plume	Install additional downgradient monitoring well.	August 2011	A new downgradient Magothy monitoring well was installed in September 2011. According to the *Petition for Closure,* downgradient VOCs are expected to attenuate to below MCLs before 2065. Monitoring continues. Bldg. OS-2 now being used to treat deep Industrial Park VOCs.

Issue	Recommendations/ Follow-Up Actions	Milestone Date	Action Taken/Current Status
OU III Industrial Park Treatment System Shutdown	Install additional temporary well between UVB-3 and UVB-4 in support of anticipated system shutdown.	August 2011	Two temporary wells were installed in March 2011 and May 2012, and two permanent wells were installed in 2012 to support the *Petition for Shutdown* (BNL 2013g). Following approval of the *Petition for Shutdown*, the system was shut down May 2013. Due to elevated VOCs, wells UVB-3 through UVB-6 were restarted in March 2014. Deep VOCs are being remediated via two extraction wells installed in late 2014.
OU III North Street Treatment System Shutdown	Increase system operation through 2013 due to continued high VOCs	October 2012	Following approval of the *Petition for Shutdown* (BNL 2013c), the system was shut down August 2013. Due to elevated VOCs slightly above the capture goal, the system was restarted in June 2014 and again in July 2015.
OU III North Street East Treatment System Shutdown	Characterize contamination upgradient of NSE-1 and monitor for achievement of capture goal. Extend system operation through 2013 to achieve capture goal.	September 2011	From 2010 through 2013, five temporary wells and a permanent monitoring well were installed to help monitor the upgradient portion of the plume. Following approval of the *Petition for Shutdown* (BNL 2013d), the system was shut down in June 2014.
OU III Middle Road Treatment System	Assess contamination to west of RW-1 and need for an additional extraction well.	September 2012	Two temporary wells were installed in April 2013 to evaluate deeper VOCs on the west portion of the plume. A new extraction well (RW-7) was installed and started operation in November 2013. Temporary wells were installed near Weaver Drive to define the northern extent of the plume.
OU III South Boundary deep VOC contamination	Install additional extraction well(s) to capture and treat deeper contamination. Extend system operation until 2017.	September 2012	New extraction well EW-17 became operational in July 2012 to capture the deep VOCs.
OU III Western South Boundary TCA/Freon contamination	Extend operation of extraction well WSB-1 to 2019 to capture high TCA concentrations. Characterize extent of Freon contamination and develop path forward.	November 2012	Continuous operation of one extraction well, WSB-1, and pulsed operation of WSB-2. A monitoring well was installed in June 2012 to monitor the downgradient extent of Freon-12. Low Freon-12 was detected. Continue monitoring of the deeper VOCs identified in 2016, then update the model.
OU III HFBR contingency pumping termination	Determine shutdown of pump and recharge system based on characterization of high–concentration slug.	March 2012	Following approval of the *Petition for Shutdown* (BNL 2013e), the system was shut down May 2013.
OU IV Sump Outfall Sr-90	Install additional monitoring wells as per 2009 *Groundwater Status Report* recommendations.	October 2011	Three new monitoring wells were installed in March 2011. Additional temporary wells have been added periodically (latest in 2015). Plume projected to attenuate to less than the Drinking Water Standard by 2034.
OU V Groundwater	Petition regulatory agency to conclude groundwater monitoring program pending 2011 perchlorate results.	December 2011	*Petition to Discontinue Operable Unit V Groundwater Monitoring* (BNL 2012e) was submitted to the regulators in March 2012. As of 2014, all wells were below standards and monitoring was discontinued.
Potential continuing Sr-90 source at BGRR	Monitor to determine existence and assess feasibility of in-situ source stabilization. Monitor the effectiveness of new extraction wells.	July 2012	As discussed in the 2012 *Groundwater Status Report*, periodic flushing of Sr-90 from the deep vadose zone into groundwater results in spikes of Sr-90 downgradient of the BGRR. The extraction wells are successfully capturing the plume. Source area options, such as a permeable reactive barrier, are not feasible. Continue to operate the treatment system and monitor and evaluate the data.

Issue	Recommendations/ Follow-Up Actions	Milestone Date	Action Taken/Current Status
Potential continuing Sr-90 source at Chemical Holes	Monitor to determine existence and assess feasibility of in-situ source stabilization and/or removal.	July 2012	Nine temporary wells installed in June 2012 upgradient of EW-1 identified Sr-90 up to 134 pCi/L. Three permanent monitoring wells, numerous soil borings, and temporary groundwater wells were installed in 2015. No source area was identified. Treatment system operations are projected to continue until 2019.
Peconic River Monitoring Program	Modify monitoring program following remedy optimization.	September 2011	Changed to biannual fish monitoring in 2011, reduced annual sediment sampling locations from 30 to 3, reduced surface-water monitoring from 30 to 15 locations, 2x/year, and eliminated water quality monitoring in 2012. Supplemental monitoring performed in late 2014 through October 2015 at Area WC-06 to determine extent of elevated mercury in sediment. Perform supplemental cleanup at this area.
OU VI EDB	Add new monitoring well to bound the east side of the plume.	September 2011	Two additional monitoring wells were installed in March 2011 and September 2012 to monitor the eastern extent of the plume. EDB concentrations in the eastern perimeter well are below the standard.
BGRR Decommissioning	Complete remaining remedial actions and submit closeout report(s) to the regulators.	October 2012	The Closeout Report for the Bioshield removal was submitted to the regulators in September 2012. The BGRR building was put in long-term safe storage in July 2012.
HFBR	Complete remaining remedial actions and submit closeout report(s) to the regulators.	October 2011	The Closeout Reports for the Fan Houses and Stack Silencer Baffles were submitted to the regulators in November 2011 and May 2012. Stack to be removed by 2020.
HFBR	Explore the feasibility of reducing the 65-year safe storage (decay) period and completing the removal of large activated components earlier.	Recurring	A 2015 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.
OU III and VI – Deeds not reflecting operating treatment systems	Complete survey/mapping of treatment systems off of BNL property and record updated deeds with the County.	June 2005 (survey mapping completed)	The easement figures were completed in 2014. BSA Legal issued the State TP-584 Form and letters to the property owners 8/12/14. Two of the five property owners signed the forms and were subsequently signed by the DOE Brookhaven Site Office. BSA has the action to record the deeds with the County Clerk.
Former HWMF Perimeter Soils	Phase III - Assess soil contamination. Additional cleanup if necessary.	September 2012 September 2014	The Phase III soil remediation was completed in September 2014. The Closeout Report was submitted to the regulators in February 2015. Project is complete.

There is one issue that was identified in **Table 5-1** above from the 2011 Five-Year Review that affected future protectiveness.

The issue was to complete surveying/mapping of the groundwater treatment systems off of BNL property and to record the license or access agreements with the Suffolk County Clerk's Office. The survey and mapping of the treatment systems was completed in June 2005 and forwarded to the property owners. 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 is for the original Industrial Park system. Two of the remaining five property owners signed the New York State Transfer Tax Form TP-584, which were subsequently signed by DOE in 2014. BNL is responsible for completing the endorsement forms for these two properties for filing with the County Clerk. BNL will record the remaining agreements with the County Clerk.

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, J. Burke, D. Paquette, R. Howe, J. Remien, T. Green, T. Sullivan, S. Johnson (recently retired), and N. Sundin
- DOE staff – T. Kneitel, G. Granzen, and J. Carter
- Regulatory staff – J. Mollin (EPA), B. Jankauskas (NYSDEC), and A. Rapiejko (SCDHS)

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

6.2 Community Notification and Involvement

A Communications Plan for the Five-Year Review was prepared, and on October 1, 2015 was distributed to the project team including the regulatory agencies. 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* newspaper on September 30, 2015. 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 October 8, 2015. The BER was informed via email. In addition, an announcement on October 2, 2015 in the BNL weekly email newsletter *Brookhaven This Week* and a BNL website update were made 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 given during the October 8, 2015 meeting 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?*
   All feedback was very positive. Most felt that there has been a good continuing effort to keep the status of the cleanup in the forefront via presentations and reports. Some new members feel better-informed about the cleanup and appreciate BNL's willingness to provide follow-up information as requested.
2. *Are there any specific aspects of the cleanup that you feel should be of particular focus during the review? (e.g. RODs, cleanup goals, community input, etc.)*
   One member wanted to see the decommissioning of the former Medical Research Reactor and the HFBR vessel move forward, as well as acceleration of the 70-year remediation timeframe for the BGRR/WCF Sr-90 groundwater plume. Some members wanted focus on progress in meeting the ROD cleanup goals and timelines, while another wanted to see a section describing any new techniques, procedures, equipment or methods that evolved over the last five years that are now standard procedures. One requested more focus on radionuclide cleanup.

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.
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 the ROD goals. Others requested that updates on the cleanup should also be communicated to the surrounding community/civic associations. One member also suggested a published history of the cleanup, written in layman's terms, would be helpful and should be made available in local libraries.

   The CAC survey is included as **Attachment 1**. It should be noted that over the last couple of years, many new members have joined the CAC and are relatively new to BNL's environmental cleanup. As a result, an environmental cleanup background presentation was provided to the CAC in February 2016 that discussed the history of the cleanup program and what work remains to meet the ROD requirements.

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, and two in 2012 [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/Completion reports for soil (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)
- *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 2016b)
- O&M manuals for the groundwater treatment systems (BNL 2002-2012)
- *BNL Land Use Controls Management Plan* (BNL 2013a)
- *EPA 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 2011b)
- *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 2011c)
- *Final Closeout Report for the High Flux Beam Reactor Stabilization, Area of Concern 31* (BNL 2011d)
- *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 2011e)
- *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)

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. 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 17 groundwater remediation systems is provided in the *2015 BNL Groundwater Status Report* (BNL 2016a—see **Attachment 2** for the CD 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 7,370 pounds of VOCs have been removed, and over 25 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 31 milliCuries (mCi) of Sr-90 while returning nearly 168 million gallons of treated water to the aquifer.

Figure 4-2 shows the location of the 17 groundwater treatment systems. **Table 6-1** provides a summary of the treatment system status through March 2016.

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	Standby	P&T with AS	2013 (Complete)	VOCs remain low.
Current Landfill	VOCs tritium	Long-Term Monitoring & Maintenance	Landfill capping	NA	Characterization underway for elevated VOCs downgradient of one well.
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 Response Action	Monitoring	NA	2015/2016 characterization completed for elevated Sr-90 in former source area. Maximum Sr-90 detected at 302 pCi/L in a temporary well. Attenuation modeling is in progress and will be used to help evaluate future actions.
OU III					
Chemical/Animal Holes	Sr-90	Operational (EW-2 and EW-3 pulsed pumping)	P&T with IE	2019	Persistent elevated Sr-90 in former source area postponed Shutdown Petition submittal. Performed extensive soil and groundwater characterization in former source area. No elevated Sr-90 detected. Continue system operations.
Carbon Tetrachloride source control	VOCs (carbon tetra-chloride)	Decommis-sioned	P&T with carbon	2004 (Complete)	Petition for closure approved in 2009. 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.	2018	High VOCs in former source area dropping significantly following source area soil remediation in 2010. RTW-1 also capturing downgradient portion of Freon-11 plume.
South Boundary	VOCs	Operational (EW-3, EW-5, EW-6, EW-7, EW-8 and EW-12 on standby)	P&T with AS	2019	Continued decline in monitoring well VOC concentrations at the site boundary. Beginning to see decline in deeper VOCs being addressed by EW-17 which was installed in 2012.
Middle Road	VOCs	Operational (RW-1,RW-4, RW-5, and RW-6 on standby)	P&T with AS	2025	RW-7 was installed in 2013 to capture elevated deep VOCs.

Continued...

Project	Target	Mode	Treatment Type	Expected System Shutdown	Highlights
Western South Boundary	VOCs	Operational (WSB-2 pulsed pumping)	P&T with AS	2019	Elevated VOCs detected in 2016 temporary wells in upgradient portion of plume, but no Freon-12 was detected. Characterization is continuing in this area.
Industrial Park	VOCs	Operational (UVB-1, UVB-2, and UVB-7 on standby)	In-well stripping P&T with carbon for deep wells	2020	Wells UVB-3, UVB-4, UVB-5, and UVB-6 restarted 2015. Two EWs (IP-EW-8 and IP-EW-9) installed in late 2014 to address deep VOCs.
Industrial Park East	VOCs	Decommis-sioned	P&T with carbon	2009 (Complete)	Decommissioned in 2014. Building infrastructure repurposed for the treatment of the deep Industrial Park VOCs..
North Street	VOCs	Operational (NS-2 on standby)	P&T with carbon	2016	EWs restarted 2014 due to elevated VOCs.
North Street East	VOCs	Standby	P&T with carbon	2014 (Complete)	VOC concentrations remain low since 2014 shutdown. EDB detected above standard in one well in 2015.
LIPA Right-of-Way/ Airport	VOCs	Operational (LIPA wells EW-1L, 2L, 3L on Standby/ Airport wells RTW-2A, 3A, 5A Pulsed pumping)	P&T and recirculation wells with carbon	2019 (LIPA) 2021 (Airport)	Three Airport wells are operational (RTW-1A, 4A, 6A) and three continued pulsed pumping. LIPA well EW-4 remains operational.
Building 452 Freon-11	VOCs	Standby	Air stripping	2016 (Complete)	Approximately 100 pounds of Freon-11 removed since 2012. Cleanup goals for treatment system have been reached. *Petition for Shutdown* approved in 2016.
HFBR Tritium	Tritium	Standby	Pump and recharge	2013 (Complete)	Tritium remains low. Downgradient monitoring discontinued. Expected system decommissioning in 2018.
BGRR/WCF	Sr-90	Operational (Wells SR-4, 5, 6 Pulsed pumping)	P&T with IE	2026	Sr-90 detected in 2015 up to 100 pCi/L in WCF yard.
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 Response Action	MNA	NA	132 pCi/L of Sr-90 detected in 2014. Additional plume characterization in 2015 were less than DWS. Maximum Sr-90 in 2015 was 37 pCi/L. Continue monitoring.

Continued...

Project	Target	Mode	Treatment Type	Expected System Shutdown	Highlights
OU V					
STP	VOCs, tritium	Long-Term Response Action (Complete)	MNA	NA	VOC plume has attenuated to below MCLs. No further monitoring.
OU VI					
EDB	EDB	Operational	P&T with carbon	2019	The EDB plume is migrating slower than predicted so system operations were extended to 2019.

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 Limits
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: The third and final phase of cleanup was completed in 2014 for the former HWMF Perimeter Soils. The residual soil concentrations met the radiological cleanup level for residential land use. A Closeout Report was issued in 2015. The average and maximum residual Cs-137 concentrations following cleanup for the Phase III perimeter soils were 1.33 pCi/g and 7.4 pCi/g, respectively.

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. The Closeout Report stated that these two areas would be remediated when the operating facilities are decommissioned. A final status survey and dose assessment is being prepared to ensure that the residential land-use cleanup goals have been met. A Closeout Report will be issued. During the 2015/2016 excavation of the former WCF, an area of radiologically contaminated soil was identified along the north fenceline to the adjacent storage yard. This yard contains activated steel, lead and equipment that are being stored for potential reuse by the Collider-Accelerator Facility complex. Based on preliminary surveys, the contaminated soil is believed to be surficial. This area will be placed under institutional controls, added to the LUIC contaminated soil map and will be remediated as funds become available in the future. 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 Rem/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 monitoring wells immediately to the southeast. This indicates that decomposition is still occurring. At the request of the NYSDEC, in 2016 soil-gas samples were obtained southeast of the Current Landfill to ensure that contaminant concentrations are not migrating beyond the existing well network. Soil-gas samples were collected at two depths for each of three locations using the Geoprobe®. There were no detections of soil gas in any of the samples. (See 2015 Report https://www.bnl.gov/gpg/landfills.php). However, another round will be collected during a dry period to confirm the readings. The four outpost monitoring wells, located immediately north of the Current Landfill along the south side of Brookhaven Avenue, showed no methane during 2015. These wells ensure there is no impact to the closest facility, the National Weather Service building. Soil-gas monitoring at the Former Landfill Area indicates that there are only minimal detections of hydrogen sulfide, with no detectable levels of methane present. The soil-gas monitoring well networks are sufficient to monitor both landfill areas.

As part of the compliance monitoring for the Current Landfill, beginning in 2009 the frequency for the collection of inorganic surface-water and sediment samples from the adjacent wooded wetland was reduced from annually to once every two years. Although elevated lead and mercury average concentrations were identified in sediment at the North Pond in two of the last three sampling rounds (2010 and 2014), the data are consistent with previous years' average metals concentrations. Average inorganic surface-water data from the last three sampling rounds (2010, 2012, 2014) have remained low (except for iron). Since metals in water are the primary source of absorption by tiger salamanders, no significant change in dissolved metals indicates that the wooded wetland is not experiencing an increase in metals concentrations. At the request of the NYSDEC during their review of the *2014 Environmental Monitoring Report, Current and Former Landfill Areas* (BNL 2015e), eight sediment samples were collected around two of the routine sample locations at the North Pond in December 2015. The data indicate that mercury was identified slightly above the benchmark maximum concentration in five of the eight samples, but below the BNL background concentration. Lead was only identified in two of the eight sediment samples above the benchmark maximum concentration and background. The 2014 concentration of lead in the water column at this elevated sediment sample location was well below the critical benchmark water concentration. This may indicate that the lead is mainly insoluble and not available for uptake into the Tiger Salamanders (https://www.bnl.gov/gpg/landfills.php).

Groundwater: The landfill areas were capped between 1995 and 1997. Monitoring data presented in the *2015 Environmental Monitoring Report, Current and Former Landfill Areas* (BNL 2016c) indicate that, in general, contaminant concentrations have decreased following the capping of the landfills and landfill controls continue to be effective. VOCs and metals continue to be detected downgradient of the Current Landfill. The most prevalent VOCs detected above standards are chloroethane and benzene, at maximum concentrations in 2015 of 124 µg/L and 2 µg/L, respectively. **Figure 6-1** 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. Concentrations of these metals were similar to those detected in 2014. Maximum concentrations of iron, manganese, and arsenic in downgradient wells in 2015 were 75,900 µg/L, 5,220 µg/L, and 29 µg/L, respectively. Between

January and March 2016, 12 temporary wells were installed downgradient of monitoring well 088-109 (located on the east side of the landfill), where elevated chloroethane continues to be detected in the groundwater at the Current Landfill. The maximum chloroethane concentration of 158 µg/L was detected as part of this characterization in the northern-most temporary well adjacent to well 088-109. The four temporary wells located approximately 300 feet downgradient detected significantly lower concentrations. Additional temporary wells are currently being sampled. Following this characterization, the groundwater model will be updated to project the attenuation of VOCs from this area. These data are discussed in detail in the *2015 Groundwater Status Report* (BNL 2016a).

VOCs were not detected above standards in Former Landfill Area monitoring wells in 2015. Water chemistry parameters and metals concentrations were equivalent to historical background levels.

The OU I pump and treat system continued to maintain hydraulic control and treat contaminants originating from the Current Landfill and former HWMF, and prevent further contaminant migration across a portion of the site's southern boundary. In 2011, an additional monitoring well was installed to monitor VOC concentrations immediately upgradient of the extraction wells. Due to the reduction of VOCs in the plume, in July 2013 the regulators approved the *Petition for Shutdown* of the groundwater treatment system. VOC concentrations in one core monitoring well (107-40) hovered around the treatment system capture goal of 50 µg/L total volatile organic compounds (TVOCs) through January 2013. Since then, the TVOC concentrations have remained below 50 µg/L (**Figure 6-2**).

Groundwater monitoring continues for an area of Sr-90 contamination that originated at the former HWMF and is now located approximately 2,200 feet to the south (approximately 1,000 feet north of the site boundary and OU I extraction wells). The maximum Sr-90 concentration detected in these downgradient wells since 2011 was 20 pCi/L. However, based on the occasional increases and subsequent decline in Sr-90 concentrations for wells 088-26 and 098-30 (located immediately downgradient of the former HWMF source area) there appears to be some remnant contamination in the source area that is periodically released to the water table and subsequently migrates south. From April 2015 through March 2016, several transects consisting of 58 temporary wells were installed to determine the magnitude and extent of Sr-90 continuing to migrate from the former source area. The maximum Sr-90 concentration observed in groundwater from the temporary wells was 302 pCi/L at 14 feet below grade from a location near the center of the former HWMF. Additional groundwater samples obtained in April 2016 from three locations where the highest concentrations were observed, identified Sr-90 up to 234 pCi/L. A soil sample at the highest location did not detect Sr-90. Detailed discussion of the characterization is presented in Section 3.1 of the *2015 Groundwater Status Report* https://www.bnl.gov/gpg/gw-reports.php. An update to the groundwater model was performed in March/April 2016 to project the attenuation of Sr-90 from this area. A discussion of the modeling results is presented in **Section 7.1** below. The rate of migration of Sr-90 in this area of this site is approximately 45 feet per year.

6.4.2 Operable Unit II

The remedial actions for the OU II 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 **6.4.8**).

6.4.3 Operable Unit III

Soil: Due to elevated VOCs in groundwater located west of the main Building 96 plume, in July 2015 a soil-vapor survey was performed upgradient of well 095-307 to determine any residual source areas. Of the 39 locations, three points identified stable elevated soil-gas readings. In August, follow-up soil samples were obtained via Geoprobe® at three locations, sampled at depths of every two feet from ground surface to the top of the water table, and analyzed for VOCs. A soil sample was also obtained at the top of the water

table at each Geoprobe® location. No VOCs above the reporting limit were detected in the soil samples and there were no detections of VOCs in the three groundwater samples.

Groundwater: Over the past five years, the OU III groundwater remediation systems continued to maintain hydraulic control of contaminants originating from the central portion of the BNL site. Nine of these systems are currently in active operation. The Carbon Tetrachloride and Industrial Park East systems met their cleanup goals and were dismantled, and the HFBR, North Street East, and Building 452 Freon-11 systems are in standby mode and could be restarted if necessary. The extent of the high-concentration segments of the OU III VOC plumes have decreased as the result of active groundwater remediation and the effects of natural attenuation. Hydraulic control of the plume segments near the Middle Road, South Boundary, Industrial Park, Industrial Park East, and LIPA/Airport treatment systems 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 4-3**).

A review and evaluation of the performance data for the treatment systems is conducted monthly for most of the systems and quarterly for all of the systems, as well as annually for all 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 2015.

Carbon Tetrachloride Treatment System

The Carbon Tetrachloride treatment system was successful in remediating the source area and was decommissioned in 2010. Although one well, 105-23, continues to detect carbon tetrachloride just above the MCL of 5 µg/L, the source area where the groundwater cleanup took place has met MCLs. Well 105-23 is over 2,000 feet downgradient of the former source area and this contamination is expected to attenuate before it reaches the Middle Road Treatment System. Monitoring of the source area was discontinued in 2013.

Building 96 Treatment System

In October 2012 and in January 2016, respectively, Building 96 recirculation wells RTW-4 and RTW-2/RTW-3 were shut down and placed in standby mode due to low VOC concentrations in adjacent monitoring wells. Starting in 2012, treatment well RTW-1 was also being used to treat the downgradient portion of the Building 452 Freon-11 plume. Since 2011, VOCs in the Building 96 plume core monitoring wells have significantly declined (See trends on **Figure 6-3**). The system is expected to continue operating until 2018. Due to the significant reduction of hexavalent chromium in the monitoring wells over the last five years, it was agreed in 2015 that no further sampling will be performed.

Building 452 Freon-11 Treatment System

A groundwater treatment system was installed in 2012 to remediate a Freon-11 plume that originated from the Building 452 area. From 2012 through 2015, the system removed approximately 100 pounds of Freon-11 from the aquifer. In 2015, all Freon-11 concentrations in groundwater monitoring wells and the extraction wells were below the cleanup goal of 50 µg/L. As a result, a *Petition for Shutdown* was submitted to the regulatory agencies in January 2016. Following regulatory agency approval, the treatment system was shut down and placed in standby mode in March 2016. Freon-11 trend graphs are shown on **Figure 6-4**. As noted above, Building 96 treatment well RTW-1 is still being used to remediate the remaining downgradient portion of the Building 452 Freon-11 plume.

Middle Road Treatment System

The three eastern-most of the six extraction wells (RW-4, RW-5 and RW-6) remain in standby as TVOC concentrations have decreased below the system capture goal of 50 µg/L over the past several years. Groundwater characterization was performed in 2013 for an area immediately to the west of the extraction wells to determine whether an area of elevated VOC concentrations migrating from the north will be captured by the Middle Road wells. Based on the characterization and subsequent modeling, it was determined that the deep VOCs identified were not being captured by the existing extraction wells. As a result, a new extraction well (RW-7) was installed in 2013 to capture the elevated deep VOCs. In 2013 and 2014, a series of temporary and permanent monitoring wells were installed along Weaver Drive and to the north to identify the northern extent of the deeper VOCs observed at the Middle Road and South Boundary. Since the VOC results were relatively low at Weaver Drive, it is believed that the concentrations observed along Princeton Avenue represent the "tail end" of higher concentrations that should begin to drop within the next several years. See **Figure 6-5** for the monitoring well trends. In November 2015, shallow western extraction well RW-1 was placed in standby mode due to low concentrations of VOCs.

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 decreased below the system capture goal of 50 µg/L over the past several years. Well EW-4 continues to operate although VOC concentrations in this extraction well and surrounding monitoring wells have shown marked declines (**Figure 6-5**). As a result of elevated VOCs identified along the south boundary in temporary and permanent monitoring wells below the capture zone of the existing extraction wells, a new deeper extraction well (EW-17) was installed near EW-4 in 2012. This well remains operational.

Western South Boundary Treatment System

Plume and extraction well data show that elevated VOC concentrations continue to be observed in the western portion of the OU III 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. Due to TVOC concentrations that continue to be detected upgradient of the extraction well just above the capture goal of 20 µg/L, WSB-1 remains in full-time operation.

Two temporary wells were installed in 2011 south of East Princeton Avenue to better define the extent of the Freon-12 contamination. The maximum TVOC value detected was 28 µg/L at 150 feet below grade. The maximum value of Freon-12 detected was 2.1 µg/L. Although Freon-12 was detected up to 35 µg/L in an upgradient monitoring well between East Princeton Avenue and Middle Road in 2015, the maximum concentration immediately upgradient of WSB-1 was 9 µg/L. Additional temporary well samples were obtained in February 2016 to determine the extent of this Freon contamination. Freon-12 was not identified above the standard; however significant concentrations of other VOCs were detected at 180 feet below grade. These data are presented in the *2015 Groundwater Status Report*. Further characterization will be performed.

Industrial Park Treatment System

Three of the seven extraction wells remain in standby mode (UVB-1, UVB-2, and UVB-7) as shown on **Figure 4-3.** Two temporary and permanent wells were installed in March 2011 and May 2012 to support the *Petition for Shutdown*. Following approval of the *Petition for Shutdown*, the system was shut down in 2013. Due to elevated VOCs, extraction wells UVB-3 through UVB-6 were restarted in March 2014. In 2014, several temporary wells were installed to evaluate the extent of migration of the deep VOC plume beneath the Industrial Park area. The maximum TVOC concentration detected was 268 µg/L approximately 225 feet below land surface. Since the contamination is beneath the capture zone of the existing Industrial Park extraction wells, two additional extraction wells (IP-EW-8 and IP-EW-9) and several monitoring wells were

installed in late 2014. See **Figure 6-5** and **Figure 6-7** for the monitoring well trends in this area. Data from deep monitoring wells 000-538 and 127-09 depict the elevated VOCs in the Magothy aquifer.

Industrial Park East Treatment System

There have been no rebound of VOCs in the monitoring or extraction wells since the Industrial Park East treatment system was shut down in 2009. See **Figure 6-8** for the monitoring well trends. As a result, the regulators approved the *Petition for Closure* of the system in 2013. In late 2013, the extraction and several of the monitoring wells were decommissioned in accordance with State protocols. Starting in late 2014, the building and related infrastructure are being used for the remediation of the deep VOC contamination in the Industrial Park.

North Street Treatment System

In June 2013 a *Petition for Shutdown OU III North Street Groundwater Treatment System* (BNL 2013c) was submitted to the regulators for review and approval. The system was shut down in August 2013 after receiving approval from the regulators. The system was restarted two times since June 2014 due to a rebound in VOC concentrations in upgradient monitoring wells above the 50 µg/L TVOC concentration capture goal. See **Figure 6-9** for the trends. Only one monitoring well remained above the capture goal in 2015. Well 000-465, located upgradient of extraction well NS-1 detected TVOC concentrations up to 78 µg/L in August 2015. Extraction well NS-1 is currently operating and NS-2 has been in standby mode since June 2015.

North Street East Treatment System

The off-site segment of the OU I VOC plume is captured and treated by the North Street East System. Two additional temporary wells and a monitoring well were installed in 2012 and 2013 to evaluate VOC concentrations upgradient of extraction well NSE-1. Due to the low VOC concentrations identified in the temporary and permanent monitoring wells, following approval from the regulators, the system was shut down in June 2014. No rebound in VOCs have been observed since. However, on two occasions in 2015, EDB was detected in one monitoring well above the standard of 0.05 µg/L. In accordance with the BNL Groundwater Contingency Plan, BNL collected additional samples from his well and confirmed these detections. Monitoring for EDB will continue. These data are presented in the *2015 BNL Groundwater Status Repor*t (BNL 2016). See monitoring well trends on **Figure 6-2**.

LIPA/Airport Treatment System

The LIPA extraction well EW-4L is capturing and treating VOCs in the upper Magothy aquifer. Although influent TVOC concentrations in this extraction well remained less than 20 µg/L since 2011, two upgradient Magothy monitoring wells have had periodic detections above the 50 µg/L capture goal. The closest monitoring well to EW-4L is 000-460, which contained TVOC concentrations of 166 µg/L in 2012 and 65 µg/L in late 2013. See **Figure 6-10** for Magothy monitoring well trends. The nearest upgradient plume core monitoring well is 000-130. This well displayed peak TVOC concentrations of 5,000 µg/L in 1999 and has declined to less than 50 µg/L since 2013. In 2013 there was a detection of toluene at 530 µg/L in well 000-130. Previous elevated detections of toluene in this well were believed to be due to sample contamination from surface run-off. As a follow-up to the 530 µg/L detection, the protective cover of this flush-mount well was replaced to reduce the potential for contamination by street run-off entering the well. Following the repair, well 000-130 was sampled again (after purging four well volumes), and there were no detectable levels of toluene. Since then, the well continues to be sampled (after pumping one well volume) and toluene has not been detected. The remaining three LIPA extraction wells, EW-1L, EW-2L, and EW-3L, remain in standby mode.

Although TVOC concentrations in the six Airport extraction wells have been slightly increasing since 2011, only RW-6A has exceeded the capture goal of 10 µg/L during this time. In 2015, the maximum TVOC concentration in RW-6A was 15 µg/L. VOC reductions in upgradient monitoring wells at the

western portion of the plume indicate that the trailing edge of the high-concentration area is along Crestwood Drive approximately 1,500 feet north of RW-6A. Monitoring well 800-92, located in the eastern portion of the plume approximately 2,000 feet north of the Airport, has been showing TVOC concentrations steadily declining since 2012. Magothy monitoring well 800-90, located adjacent to but deeper than 800-92, has experienced spikes in TVOC concentrations in 2013 and 2015. The 2015 range of TVOC concentrations was 23 µg/L to 123 µg/L (See trends on **Figure 6-10 and Figure 6-11**). This contamination will be captured by Airport extraction well RTW-4A. Extraction wells RTW-1A, RTW-4A, and RW-6A continue to operate full time, while wells RTW-2A, RTW-3A, and RTW-5A are in pulsed pumping mode (pumping one week per month).

HFBR Pump and Recharge System/Plume

Since 2011, considerable progress has been observed in the attenuation of the HFBR tritium plume both at the source area and at the downgradient portion of the plume. See **Figure 6-12** for tritium trends in the monitoring wells near the HFBR. The most recent exceedance of the standard in a monitoring well near the HFBR was in 2014 with a concentration of 28,700 pCi/L. Since 2011, the highest concentration observed in the downgradient portion of the plume was 7,850 pCi/L in 2013. The last exceedance of the standard was in 2009 in both a monitoring well and a temporary well. A well located adjacent to extraction well EW-16 detected 27,800 pCi/L in 2009 and a temporary well located in this same area detected 56,600 pCi/L also in 2009. The permanent well network was supplemented in 2013 with 11 temporary wells located between Weaver Drive and EW-16 as per a recommendation in the *Petition for Shutdown, High Flux Beam Reactor, Tritium Plume Pump and Recharge System* (BNL 2013e). The peak tritium concentration in these temporary wells was 9,050 pCi/L.

Groundwater modeling results predicted that the pump and recharge system would have to operate until approximately 2013. In March 2013, a *Petition for Shutdown, High Flux Beam Reactor, Tritium Plume Pump and Recharge System* (BNL 2013e) was submitted to the regulators for review and approval. The system was shut down in May 2013 after receiving approval from the regulators. No rebound in tritium concentrations in the downgradient portion of the plume has been observed.

BGRR/WCF Treatment System

This treatment system began operations in January 2005. There are two extraction wells (SR-1 and SR-2) located south of the WCF, and three extraction wells (SR-3, SR-4, and SR-5) located south of the BGRR. SR-4 and SR-5 have been in a pulsed pumping mode since 2011. They are pulsed on a monthly basis of one month on and one month off. Four extraction wells (SR-6, SR-7, SR-8, and SR-9) were installed in 2010 to address higher Sr-90 concentrations located in the downgradient portion of the WCF plume (in the vicinity of the HFBR) and they began operation in 2011. SR-6 was placed in a pulsed pumping mode in 2013 due to low Sr-90 concentrations. See trends on **Figure 6-13**.

A number of temporary wells were sampled in 2013 and 2014 to assess the eastward shift of the plume in the area south of Rutherford Drive. Characterization of this segment of the plume is hindered by the presence of the HFBR. The highest Sr-90 concentration detected in the vicinity of the extraction wells was 117 pCi/L in 2013. This temporary well location is approximately 80 feet east of SR-9. See Section 3.2.16 of the *2014 Groundwater Status Report* for details of the characterization. There are currently no permanent monitoring well locations in this area. In 2015, the highest concentration of Sr-90 in this area was 54 pCi/L (BNL 2016). This is to the east of the most easterly extraction well and shows the eastward shift of the plume in this area. Geoprobe® groundwater sampling was also performed in the vicinity of the WCF in April 2015 near extraction wells SR-1 and SR-2. The highest concentration identified in the Geoprobe® samples was 103 pCi/L, which will be captured by extraction wells SR-1 and SR-2. During 2015, Buildings 810 and 811 were removed and contaminated soils in this area were excavated and disposed of. The removal of this contaminated soil, which was believed to be a continuing source, is expected to enhance the groundwater cleanup in this area.

The other source area for Sr-90 contamination in this part of the site is the BGRR. This source is effectively captured and treated by extraction wells SR-3, SR-4, and SR-5. Sr-90 influent concentrations in SR-3 have shown a steady decline over the past several years. Over the past several years the highest concentration of Sr-90 in SR-3 has been 43 pCi/L in April 2014. This lower concentration shows some correlation with and demonstrates the effectiveness of the engineered cap around Building 701 and is immediately upgradient of well SR-3.

Chemical Holes Treatment System

Sr-90 migrating south from the former source area is captured and treated by extraction well EW-1. Two additional extraction wells (EW-2 and EW-3) were installed south of EW-1 in 2007 to capture and treat an area of higher Sr-90 concentrations that had migrated south of EW-1 prior to startup. See trends on **Figure 6-14**. Concentrations in wells EW-2 and EW-3 have steadily declined. Due to low Sr-90 concentrations, extraction wells EW-2 and EW-3 are now in pulsed pumping mode on a schedule of two months off and one month on. EW-1 continues full-time operation. The shutdown of the treatment system was planned for 2015; however, due to the slower than expected drop in concentrations in the source area, it is estimated from groundwater modeling that the treatment system will need to operate until 2019. A source area investigation was conducted in 2015 and extensive groundwater and soil sampling was performed. The results of this investigation indicated that there were only low levels of Sr-90 in several soil samples, and only one of the groundwater samples collected was above the drinking water standard of 8 pCi/L, at a concentration of 9.7 pCi/L). These data are presented in the *2015 BNL Groundwater Status Repor*t (BNL 2016).

6.4.4 Operable Unit IV

Soil: Remediated radiologically contaminated soil at the Building 650 Sump Outfall is included under OU I.

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

Groundwater monitoring continues to evaluate the natural attenuation of an area of Sr-90 contamination which originated at the Sump Outfall and is slowly migrating to the south. Sr-90 concentrations for key wells are shown on **Figure 6-15**. Three new monitoring wells were installed in March 2011 and additional temporary wells were added periodically (latest in 2015) to enhance the monitoring well network. The most recent observed data are consistent with the attenuation model in terms of the extent and magnitude of Sr-90 contamination in groundwater. The plume is projected to attenuate to less than the Drinking Water Standard (DWS) by 2034. This is a conservative estimate and the maximum southward extent of the leading edge of this area (defined by 8 pCi/L) will be approximately 200 feet south of Brookhaven Avenue.

6.4.5 Operable Unit V

Peconic River: Annual data for the 2011 Peconic River sediment, surface-water, and fish monitoring program are detailed in the *Final 2011 Peconic River Monitoring Report* (BNL 2012g) (https://www.bnl.gov/gpg/peconic-reports.php). Beginning in 2012, preparation of a separate annual Peconic River Monitoring Report was discontinued and the annual monitoring results are now summarized in the annual BNL *Site Environmental Report* which can be found at https://www.bnl.gov/esh/env/ser/. The annual data are routinely reviewed with the regulators. Following agreement reached during the 2011 Five-Year Review, Peconic River post-cleanup monitoring was reduced:

- From 30 sediment locations per year to 3 locations per year (WC-06, SS-15, Sediment Trap)
- 15 surface-water locations two times per year
- Fish collection every other year
- Wetland monitoring to ensure vegetation success

The 2011 to 2015 mercury concentration data for sediment, surface water and fish each indicate substantial improvements relative to pre-cleanup conditions and the sediment cleanup goals or other criteria (surface water and fish concentrations). Sediment is the only matrix in the ROD where a specific goal is provided. The ROD identifies a goal that all mercury concentrations in the remediated areas are less than 2.0 milligram per kilogram (mg/kg) following the cleanup. [Note: There is no specific action level for mercury in sediment in the ROD. The originally proposed excavation areas were based on the removal of sediment in depositional areas and other areas that promote methyl mercury production.] The ROD also identifies that the average mercury concentrations in the remediated areas will be less than 1.0 mg/kg and 0.75 mg/kg on and off of BNL property, respectively. EPA's mercury criterion[1] for fresh waters is 0.3 mg/kg mercury in fish tissue residue. Although this is not a ROD-required goal, Peconic River fish tissue mercury concentrations were measured and compared to this criterion as both a reference and as a benchmark for water quality improvement.

Peconic River Sediment: The *Peconic River Supplemental Sediment Removal Completion Report*, March 2012 (BNL 2012h), documented that the 2011 supplemental sediment cleanup at the three areas (SS-15, the Sediment Trap, and WC-06) was effective. See **Figure 6-16** for the location of these areas. In accordance with the *Soil and Peconic River Surveillance and Maintenance Plan* dated March 2013 (BNL 2013f), post-cleanup sediment samples were obtained annually from 2011 through 2015 at the location of the maximum historical pre-cleanup mercury detection for each of these areas. The following summarizes the monitoring during this period:

- Area PR-SS-15-U1-L65-O: This area is located off of BNL property approximately 0.1 miles downstream of the former Sediment Trap. The mercury results were:

2011	0.049 mg/kg
2012	0.25 mg/kg
2013	0.064 mg/kg
2014	0.23 mg/kg
2015	0.20 mg/kg

- Former Sediment Trap (ST1-80-U20): This area is located on BNL property approximately 0.3 miles downstream of Area PR-WC-06. The mercury results were:

2011	0.41 mg/kg
2012	0.38 mg/kg
2013	0.50 mg/kg
2014	0.33 mg/kg
2015	0.017 mg/kg

- Area PR-WC-06-D1-L50: This area is located on BNL property approximately one mile downstream of the former Sewage Treatment Plant outfall. The mercury results were:

2011	1.90 mg/kg
2012	3.60 mg/kg

[1] *Final Water Quality Criterion for the Protection of Human Health: Methylmercury*, Office of Science and Technology, Office of Water, U.S. Environmental Protection Agency, Washington, DC, 20460, EPA-823-R-01-001, January 2001. All mercury within a fish is assumed to be methyl mercury.

2013	1.50 mg/kg
2014	7.40 mg/kg
2015	0.77 mg/kg

Following review of the elevated 2014 data, a decision was made to collect additional sediment samples at the PR-WC-06-D1-L50 location to determine the extent of contamination.

In November 2014, the regulators agreed with a plan to collect four samples (five feet upstream, five feet downstream, five feet to the left, and five feet to the right of the original sample) to delineate the area. The samples were obtained in December 2014 and the maximum mercury detection was 5.6 mg/kg, with an average of the four samples being 2.6 mg/kg. The regulators were briefed on the results as well as proposed additional sample locations. Due to elevated mercury detected, this process continued through 2015 with nine additional sampling events culminating with the October 21, 2015 collection. A total of 140 sediment samples were collected during this time to delineate the area of elevated mercury. The maximum mercury concentration was 23 mg/kg at location PR-WC-06-D1-L50-101, with an average concentration of 2.7 mg/kg. The regulators were briefed on the results of each collection event during the monthly IAG teleconferences.

For additional detail on the sediment characterization effort and BNL/DOE proposed excavation of this area, see the *Draft Plan for Optimization of the Peconic River Remedy PR-WC-06 Area,* (BNL, 2016d). The Plan was submitted to the regulators for their review in February 2016. Based on feedback received from the regulators and the Community Advisory Council in March 2016, the area proposed for excavation will include all WC-06 locations exceeding 2.0 mg/kg and extend the area approximately five feet beyond the most downstream sample point PR-WC-06-D1-L50-145. The Plan is currently being revised based on regulator comments.

Peconic River Water Column: Mercury concentrations in the 80 Peconic River water samples collected between 2011 and 2015 were less than 70 nanograms per liter (ng/L; equivalent to parts of mercury per trillion parts of water) with the exception of one sample. Sample point PR-WC-06 detected 140 ng/L of mercury in the July 2014 sample. This sample contained significant vegetation throughout the water column and is not considered representative of the water column.

Mercury data for the water-column samples from 2011 through 2015 are plotted on **Figure 6-17**. The plan was to sample each of the 15 stations twice per year (when the water depth is greater than one foot to help assure a representative sample). In 2011, 29 samples were collected; however due to the low water levels, the number of samples collected since then have significantly dropped off. In 2015, only six samples were obtained. The STP effluent samples were collected through 2014 from about 30 feet before the effluent enters the Peconic River. Starting in the fall of 2014, the STP effluent no longer discharges to the River, but is discharged to groundwater via recharge basins. As shown on **Figure 6-17**, the mercury concentrations downstream of the STP (i.e., to the right of the STP-EFF-UVG sampling station) are clearly elevated relative to the station upstream of the STP (PR-WC-12-D7). A downward trend in mercury concentration between STP-EFF-UVG and PR-WC-02 is evident. The STP effluent mercury concentrations have significantly declined over the years with a maximum detection of 58 ng/L in 2013. The maximum mercury concentration for the last year of sampling at this location was 32 ng/L in 2014. The data is presented in the 2013 and 2014 Site Environmental Reports (BNL 2014b and 2015c) located at https://www.bnl.gov/esh/env/ser/. The average mercury concentration for all 80 samples from 2011 through 2015 is 24 ngL and is presented on **Figure 6-18**. This is a significant reduction from the average mercury concentration from 2006 through 2010 of 45 ng/L. As a follow-up to a comment from SCDHS during the previous Five-Year Review, water samples from station PR-WCS-04 (east of Manor Road) continued to be collected in 2011 and 2012. Since the average mercury value for the four samples was below 7.0 ng/L, monitoring of this location was discontinued in 2013.

Methyl mercury data for the 80 water-column samples collected between 2011 and 2015 are plotted on **Figure 6-19.** The maximum methyl mercury concentration detected during this period was 5.9 ng/L at the station located upstream of the former STP outfall. **Figure 6-20** presents the annual mean concentration of methyl mercury from 2011 through 2015. The average methyl mercury concentration for all 80 samples from 2011 through 2015 is 1.1 ngL. This is a significant decrease from the average methyl mercury concentration from 2006 through 2010 of 3.5 ng/L.

Peconic River Fish: A total of 219 fish samples were analyzed in 2011, 2013, and 2015 as part of the post-cleanup monitoring program. Due to the decreasing river water levels over the last few years, the number of fish collected has declined between 50% and 70% since 2011. As shown on **Figure 6-21**, fish tissue mercury concentrations have varied significantly since 2011. The annual average fish tissue mercury concentrations for the three sampling events were; 0.31 mg/kg in 2011, 0.69 mg/kg in 2013, and 0.40 mg/kg in 2015. These are higher than the 2006 through 2010 average of 0.28 mg/kg, but the 2011 and 2015 values are still lower than the 1997 and 2001 pre-cleanup concentration (0.58 mg/kg)[2]. For reference purposes, the EPA mercury criterion for fish is 0.3 mg/kg. Factors that may have contributed to the increased mercury levels in fish over the last five years include reduced sample size, fish age, fish size, food consumed, and limited open water areas. Consequently, fish were isolated to the BNL site in areas with high methylation of mercury and no dilution by river flow.

Groundwater: Active treatment of the low-level VOC plume that originated from the BNL Sewage Treatment Plant (STP) was not required by the ROD. However, the groundwater continued to be monitored to verify the expected natural attenuation of the low-level VOCs. As a follow-up to the recommendation in the 2011 Five-Year Review, perchlorate was detected in two of five monitoring wells in 2011, but at concentrations below the reporting limit of 4 µg/L. The NYSDOH Action Level for perchlorate in drinking water supply wells is 18 µg/L, and in 2012 EPA initiated the process of proposing a national primary drinking water regulation for perchlorate. Subsequently, EPA established an Interim Lifetime Drinking Water Health Advisory of 15 µg/L. A *Petition to Discontinue Operable Unit V Groundwater Monitoring* (BNL 2012e) was therefore submitted to the regulators in March 2012. Based on the recommendations and the regulatory comments, the groundwater monitoring program was reduced to one monitoring well (000-122) in 2012. The last round of data from this well in 2013 indicated that all VOC concentrations were below MCLs. Based on the recommendation in the *2013 Groundwater Status Report* (BNL 2013h), sampling of well 000-122 was discontinued. This completed the groundwater sampling requirements for OU V. Groundwater quality in the immediate vicinity of the STP is currently monitored under the Facility Monitoring Program.

6.4.6 Operable Unit VI

Groundwater: As shown on trend **Figure 6-22**, monitoring over the past five years continues to show a steady decline in ethylene dibromide (EDB) concentrations as the plume migrates south and is captured and treated by the EDB treatment system. Overall, peak EDB concentrations declined from 7.6 µg/L in 2001 to 1.2 µg/L in 2015. The drinking water standard for EDB is 0.05 µg/L. A monitoring well was installed in 2011 to ensure that the eastern extent of the plume is defined. In addition, a new bypass monitoring well was installed in 2013 south of extraction well EW-2E to verify capture of the deeper contamination. EDB was not detected in the three bypass wells in 2013 and 2014. The plume is moving slower than originally simulated by the groundwater model during the system design. Therefore, the expected system operational period was extended to 2019 to ensure capture of the upgradient EDB.

[2] The 2006-2011 fish data sets are described in each of the respective annual Peconic River Monitoring Reports. The 2012 through 2015 fish data are presented in the annual Site Environmental Reports (e.g., BNL 2015c).

6.4.7 BGRR

Structures and Soil: Following cleanup, the maximum residual Cs-137 and Sr-90 concentrations were 89,000 pCi/g and 11,200 pCi/g, respectively. These samples were located adjacent to the secondary bustle on the northeast side of the below ground duct where it exits from Building 701. Excavation of these soil contamination pockets was not possible without compromising the building structure. Radiological surveys were completed to measure the extent of, and document, residual contamination. Soil samples were obtained to document the as-left conditions. The excavated areas have been backfilled, compacted and covered with an engineered asphalt cap to minimize water infiltration.

The installation of the final engineered cap was completed in May 2011. Removal of the bioshield was completed in May 2012. The completion and closeout reports document the final status of the various cleanup activities at the BGRR. For a complete list of these reports, see the reference list at the end of this report.

Repairs performed since 2013 as a result of surveillance and maintenance inspections include, window replacements in the former offices on the second and third floor, sealing of precipitation infiltration areas, roof repairs, and minor repairs to the cap.

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

6.4.8 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 continue to routinely exceed the 20,000 pCi/L MCL in the g-2 source area monitoring wells. During 2015, the maximum tritium concentration at the g-2 source area was 55,000 pCi/L. The continued detection of tritium at concentrations above the MCL appears to be 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 is decreasing with time. See trend **Figure 6-23**. Contingency actions were developed in the ROD for the g-2 tritium plume. If tritium levels in the g-2 plume were to exceed 1,000,000 pCi/L anywhere in the plume or if the tritium plume did not attenuate to less than 20,000 pCi/L before reaching Brookhaven Avenue, an assessment would be made to determine whether additional remedial actions would be necessary.

From 1999 through 2015, a g-2 tritium plume segment (as defined by concentrations >20,000 pCi/L) was tracked from the source area to the vicinity of the National Synchrotron Light Source II facility, a distance of approximately 4,000 feet. In December 2011, tritium was detected above the 20,000 pCi/L contingency trigger level in several temporary wells installed south of Brookhaven Avenue, with a maximum concentration of 58,000 pCi/L. In response, BNL informed the regulatory agencies about the monitoring results, and recommended continued monitoring of the plume segment. Monitoring conducted from 2011 through 2015 verified that tritium levels in the plume segment attenuated to concentrations below the 20,000 pCi/L 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. During 2015, the Linac Y cap, which adjoins the BLIP cap to the north, was extended in several areas to provide protection of soil shielding that are expected to become activated following planned changes in beam line operations. For the former UST areas, no additional remedial actions were required.

6.4.9 HFBR

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

Structures and Soil: The report, *BNL High Flux Beam Reactor Characterization Summary Report, Rev 1* (BNL 2007e) summarizes the historical characterizations of the facility, including the reactor itself, systems and components, ancillary support structures, and the surrounding soil. These characterizations have involved direct radiation surveys, samples for radioactivity, and calculations of activated materials over a period of several years. The data summarized in this report have helped provide the basis for many of the actions taken to prepare the HFBR for decommissioning including; dismantling ancillary buildings in the HFBR complex in 2006; the removal and disposal of the HFBR control rod blades and beam plugs in 2008 and 2009; confinement building stabilization; removal of fan house, above and below ground structures, and associated soil removal; and underground utilities and associated soil removal. The removal of the Stack Silencer Baffles and Final Status Survey for remaining HFBR Outside areas was completed in November 2011. Completion and closeout reports document the final status of the various decommissioning activities at the HFBR (including BNL 2009c and 2010e). For a complete list of these reports, see the reference list at the end of this report.

Cleanup of the Waste Loading Area, and removal of Buildings 801-811 waste transfer lines (A/B waste lines with co-located piping) and associated soil were completed and documented in completion/closeout reports (BNL 2009c and 2010d). Sampling and analysis were conducted in accordance with the dose-based cleanup goal (15 mRem/year above background with 50 years of institutional control) and methodology specified in the OU I ROD to verify that the remaining soils meet the cleanup goal. The results were presented in the completion/closeout reports. Following cleanup, the average and maximum residual Cs-137 concentrations for the Waste Loading Area were 7.4 pCi/g and 61.3 pCi/g, respectively. Following cleanup, the average and maximum residual Cs-137 concentrations for the A/B waste line soils were 0.15 pCi/g and 1.0 pCi/g, respectively.

Repairs performed since 2013 as a result of surveillance and maintenance inspections include, building security system upgrades, roof repairs over the former machine shop area located outside of the confinement dome, re-caulking of a vent on the outside of the dome outside the generator room, and paving of the access road to the stack and minor repairs to the cap.

6.4.10 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 2011 through 2015, 70 permanent wells were installed to enhance the monitoring networks for the various plumes. **Table 6-4** identifies the 25 monitoring wells that were decommissioned between 2011 and 2015 in accordance with State policy.

6.5 Inspections

Representative site inspections took place between April 30 and November 3, 2015 for the landfills, soils, Peconic River, and groundwater. Representatives from BNL and DOE attended. 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. Since 2011, several changes have been made to the LUIC inspection process. These include recommending to no longer perform inspections of the former Building 355 landscape soils (since they were previously excavated and moved to the former

HWMF, as previously documented to the regulators) and the Old Firehouse (since the ROD calls for no further monitoring/maintenance of this area). Following remediation of the former A/B waste transfer lines and the former HWMF Perimeter Soils, these areas were added to the inspection process. 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, Tier 1 assessments that evaluate primarily safety and operational concerns are performed on all of the systems annually. Representatives of EPA also performed an inspection of the BNL site on June 9, 2016.

For the HFBR confinement dome, the frequency of the routine surveillances were changed from monthly to quarterly in 2011 as part of the long-term surveillance and maintenance program for this facility. There have been no significant issues during the inspections; however, routine repairs and maintenance have been performed over the last five years including roof repairs, collection of paint chips on the ground, collection and disposal of precipitation water generated from the stack, and paving of the stack access road. Structural inspections of the HFBR and the stack are performed annually. Overall the interior and exterior of the building and stack remain in good condition. Work planning is underway for safety improvements to the stack ladder and platforms in 2016.

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 includes roof repair, office windows replacement, 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 September and October 2015 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 feel well informed about BNL's cleanup activities and progress?
- 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. Jessica Mollin - EPA Region 2
- Ms. Mindy Pensak, EPA Region 2
- Mr. Brian Jankauskas - NYSDEC
- Mr. Steve Karpinski - NYSDOH
- Mr. David O'Hehir - NYSDOH
- Mr. Andy Rapiejko- SCDHS
- Ms. Terri Kneitel - DOE

Most of the regulators interviewed were impressed with the progress of the cleanup and thought BNL and DOE have been very responsive to questions and issues identified by the regulators. They believe that BNL and DOE are actively managing the cleanup in accordance with the RODs, and do not believe there are any significant obstacles with achieving the ROD goals. Most of the regulators felt that the elevated mercury concentrations in one area of the Peconic River should be a particular focus during this review. In addition to concerns on the Peconic River path forward, the EPA Project Manager, a NYSDOH representative, and the SCDHS representative feel that BNL and DOE are properly maintaining appropriate institutional controls. NYSDOH also wants to see focus on the plans for moving forward with the removal of the HFBR stack by 2020, and believes the biggest risk in achieving the cleanup goals are unknown source areas for groundwater contamination. The NYSDEC Project Manager has positive impressions of the BNL cleanup, would like to see the sensitive environment of the Peconic River assessed when determining the path forward, and is also concerned with potential future unknown groundwater contamination that could impact meeting the ROD goals. SCDHS was very positive about the progress of the cleanup, and BNL and DOE are diligently monitoring the groundwater to help avoid any unknowns. The County also feels it is important for the Laboratory to have the funding and staff to continue the cleanup and long-term monitoring effort. The DOE representative believes that the cleanup is progressing as expected and that the Laboratory is doing a good job. She feels that focus should continue to be placed on the Peconic River sediment and believes that the biggest risk would be the identification of a continuing source of Sr-90. The interview summaries are included under **Attachment 4**.

7.0 Technical Assessment

The following subsections assess both the soil and groundwater remedies by Operable Unit and address the three EPA-designated questions. Information on the majority of the soil cleanup work was completed prior to the last two Five-Year Reviews and can be found in those 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 2015 Report (*2015 BNL Groundwater Status Report* [BNL 2016a]) and reports from prior years are available for review.

The only significant institutional control issues noted over the previous five years are as follow:

- 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 the properties has conformed to these controls. However, 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. 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 is for the original Industrial Park system. Two of the remaining five property owners signed the New York State Transfer Tax Form TP-584 and were subsequently signed by DOE in 2014. BSA is responsible for completing the endorsement forms for these two properties for filing with the County Clerk. Efforts by BSA will continue to be made to record the remaining agreements with the County Clerk.
- During a 2013 LUIC inspection, topsoil was observed being temporarily staged along the road between the former Chemical Holes and the Long Island Solar Farm. The work was being performed by a subcontractor to the solar farm maintenance DOE contractor. The soil piles were infringing on a portion of the former Chemical Holes area. Although there was evidence that the ground surface was slightly scraped, no signs of digging were evident. Following discussions between the inspection team and the subcontractor, worked ceased and DOE was informed of the incident. It was determined that this was not a breach of institutional controls; however, BSA and DOE conducted a follow-up investigation as to why the subcontractor did not communicate to DOE/BSA the work that was performed outside of the solar farm easement areas as stipulated in the Easement Management Agreement. A formal *Lessons Learned* was published which identified recommended actions to ensure better communication and coordination of any work activity associated with the solar farm. An additional LUIC information sign was installed at the former Chemical Holes area.

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 the planting of aquatic vegetation plants within the pond, planting of native grasses adjacent to the pond, and the addition of 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, 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 third and final phase of cleanup for the radiological soil contamination within the former HWMF Perimeter Area (AOC 1J) was completed in 2014. 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 work is nearing completion. A final status survey will be performed following the completion of soil remediation and an independent verification will be conducted by ORISE. An additional area of shallow radiological soil has been identified along the northern fence line separating this area from the Collider Accelerator Department storage yard. This area will be placed under institutional controls until remediation is completed.

- 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 is being performed in 2016. The monitoring network will be supplemented with several new wells to allow for more precise monitoring of these VOCs. Previous downgradient monitoring of VOCs from this location indicates that concentrations attenuate to below the DWS before they arrive at the southern site boundary. The groundwater model will be updated following the completion of the latest characterization effort and the attenuation of VOCs from this area will be simulated. Furthermore, although low levels of tritium and Sr-90 continue to be detected in the Current Landfill monitoring wells, all concentrations have been below MCLs since 1998. At the Former Landfill, there has been an overall 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. Iron concentrations continue to exceed MCLs in one downgradient well. 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 has been in operation since 1997, and is effectively remediating groundwater contamination originating from the former HWMF and the Current Landfill. The OU I groundwater treatment system was placed in standby mode in July 2013 following regulatory approval of the *Petition for Shutdown* (BNL 2013b). TVOC concentrations have remained below the capture goal of 50 µg/L in both the monitoring and extraction wells associated with this plume. There has been no evidence of VOC concentration rebound since the system was shut down.

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 at the Current Landfill, the burrows do not penetrate beyond the outer soil layer, and therefore do not affect the protectiveness of the cap. As they are found, the burrows are filled in and repaired. Grass areas are periodically mowed, and small pine seedlings are removed before their roots can damage the caps. Monthly inspections will continue to ensure that the caps are properly maintained and repaired.
- The OU I treatment system operated without any significant down time or maintenance issues since 1997 and the system effluent has consistently met the discharge requirements. The system has

remained in an operationally ready mode since it was shut down and placed in standby in 2013. The O&M manual identifies required preventative maintenance tasks, and there do not appear to be any issues that would impact future operations or the effectiveness of the remedy.

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 is approximately $59K. 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, Upland Recharge/Meadow Marsh pond, 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 cleanup of Phase II allowed for industrial reuse as the 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 2016b). The monitoring data are reported in the annual *BNL Groundwater Status Report* (BNL 2016a) and the *BNL Environmental Monitoring Report – Current and Former Landfill Areas* (BNL 2016c).
- The Sr-90 source area in the former HWMF was characterized in 2015 and 2016 utilizing temporary wells in response to a *2014 Groundwater Status Report* (BNL 2015d) recommendation. An area of elevated Sr-90 concentrations ranging up to 302 pCi/L was observed from the central portion of the former facility extending approximately 2,200 feet to the south.

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**). The groundwater model was updated in March/April 2016 with the recent characterization data and the attenuation of Sr-90 from the former HWMF was simulated. The model predicts that a small area of Sr-90 at or just above the DWS of 8 pCi/L will 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* https://www.bnl.gov/gpg/gw-reports.php. 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.
- 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

- The recent characterization of an area of Sr-90 contamination in groundwater migrating from the center of the former HWMF yard requires additional and continued monitoring. The monitoring can be achieved with new monitoring wells, the periodic installation of temporary wells using the Geoprobe®, or a combination of the two. The next Five-Year Review Report will evaluate the model-predicted Sr-90 attenuation by comparing monitoring data with the model projections.

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. Except for the lowering of the arsenic standard in 2001, radiological soil cleanup levels and the MCLs for drinking water are unchanged since the signing of the ROD in 1999. EPA's third Six-Year Review of the drinking water standards is expected to be completed in 2016. The last review was completed in 2010. **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 2006, 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 of 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. The previous Five-Year Review presented the soil vapor intrusion screening for the plume.
- In the event that further construction is planned at BNL within the area of the OU I VOC groundwater plume, landfills, or former HWMF, BSA will reevaluate any potential issues and, if necessary, undertake appropriate measures to address them. Any construction projects to be undertaken at the Lab are reviewed for environmental, security, and safety and health concerns in the conceptual design or early planning phase. BSA 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 factsheet will be revised to reflect the potential for soil vapor intrusion should new buildings be proposed.

- As discussed in **Section 6.4.1** above, additional soil-gas samples were obtained in 2016 southeast of the Current Landfill. There were no detections of soil gas in any of the samples. However, another round will be collected during a dry period to confirm the readings.

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). As long as no significant rebound in VOCs are observed, the system will remain in standby mode for two more years, then a *Petition for Closure* of the system will be submitted to the regulators for review and approval. This period of monitored natural attenuation will reduce any remaining low-level VOCs in the plume to below MCLs.
- Based on the groundwater model update, the Sr-90 from the former HWMF is projected to be at or near the DWS when it reaches the site boundary by approximately 2058. 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 further 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** 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 *BNL Environmental Monitoring Plan* (BNL 2016b), and the monitoring results are summarized in the annual *Groundwater Status Report*.

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 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 kicked 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. Fourteen of BNL's 17 groundwater treatment systems are included under OU III. Nine of these systems are currently in active operation. Two systems met the cleanup goals and were dismantled (Carbon Tetrachloride and Industrial Park East) and three systems (North Street East, HFBR Tritium Pump and Recharge, and Building 452 Freon-

11) are in standby mode and will be restarted if needed.

- The operational timeframe of several treatment systems have recently been extended to ensure capture of upgradient contamination, and two of the systems approved for shutdown were restarted due to rebound of contaminants. However, these systems are still 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 *2015 BNL Groundwater Status Report* (BNL 2016a) (see **Attachment 2** for the CD or https://www.bnl.gov/gpg/gw-reports.php).
- DOE continues to offer free annual water testing to three homeowners known to be using a private well for drinking water purposes in the OU III public water hookup area. The last time the homeowners accepted the annual test was in 2015. The test results indicate that the water quality complies with NYS drinking water standards, except for iron, which can cause taste, stain, and odor problems. In addition to iron, one residential well detected manganese and nitrates above drinking water standards. For that well, Suffolk County recommended that the homeowner not use their well water supply for consumptive purposes, and to either connect to a public water supply or use NYSDOH-certified bottled water.
- The additional extraction wells installed between 2012 and late 2014 at the Middle Road, South Boundary, and Industrial Park systems are addressing the VOC contamination that is deeper than the extraction recirculation wells originally installed in these areas. These wells are addressing contamination in 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, during preparation of the quarterly operation reports, and annually in 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 (BNL 2002-2012). The systems are routinely inspected and can also be 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 2011f) to ensure protection of potential eastern tiger salamander habitats.

The VOC treatment systems experienced mostly 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. However, there have been three instances where a treatment system was not sampled due to a scheduling error. A sample tracking tool is used to help ensure that samples are collected monthly while the systems are operating. There was one instance of an exceedance of total xylenes in the BGRR system effluent just above the discharge limit. Xylene has never been detected in the system influent, and it is believed that this detection was due to sample contamination or from maintenance work performed on the treatment system that may have inadvertently introduced the contaminant. These excursions are documented in NYSDEC Noncompliance Reports. A summary of issues, successes, and lessons learned from the operation of the various treatment systems follows.

- The Middle Road and 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. Due to repairs needed on BNL's potable water supply wells or Water Treatment Plant, there were two instances over the last five years where the eastern supply wells were used to provide the majority of the Laboratory's water supply for several months. This resulted in a noticeable change in groundwater flow directions in several areas, including a slight eastward shift in the movement of the g-2 tritium plume near the source area.

- Resin usage for the Sr-90 treatment systems remain lower than originally estimated, resulting in lower operational costs. To increase their reliability, minor modifications were made to the systems' design; at the Chemical Holes treatment system the post-treatment bag filters were removed, and at the BGRR system the post-treatment bag filters were relocated to the pretreatment process stream. These helped to reduce maintenance costs.
- 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.
- The recirculation wells in the Industrial Park require more maintenance to keep them operational than conventional extraction wells and injection wells. This is due to the increased amount of equipment associated with them and the difficulties in cleaning the double screen design. The injection screens on the seven recirculation wells are cleaned on an annual basis to remove iron deposition that causes clogging.
- In 2013 there was a water leak at the pitless adaptor at one of the Chemical Holes Sr-90 system extraction wells, resulting in the discharge of untreated water to the nearby ground surface. DOE and the regulators were immediately notified. Monitoring data indicated that all Sr-90 concentrations in the untreated water from that well had been below the 8 pCi/L MCL during the year prior to the leak. The well piping/connection was quickly repaired. As a preventative measure, a portion of the steel piping that was connected to the second extraction well was also replaced. This was not an issue with the original extraction well at the Chemical Holes system since it was installed in a vault.
- In 2015, a hole was found in the submersible pump drop pipe on one of the extraction wells at the Middle Road system which caused water to shoot up out of the top of the pitless adaptor of the well. The regulators were informed of the untreated water discharge, and the drop pipe and well screen were subsequently repaired. A NYSDEC Noncompliance Report was issued. The remaining extraction wells at this system were also evaluated to ensure the same issue did not occur.
- Lightning strikes in the vicinity of the treatment systems have caused numerous 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.
- Flow meter failures have been a common problem. Both mechanical and digital meters have been used and there have been durability issues with each type. Changing some of the meters to a different manufacturer has increased durability.
- Due to prolonged repairs to BNL's meteorological tower, which houses the antennae used to communicate with the off-site groundwater treatment systems, the LIPA Magothy extraction well had several weeks of downtime over the last year. Fortunately, VOC concentrations were significantly below the system capture goal during 2015. The tower repairs were completed in March 2016.

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 and disposal or reuse of spent carbon and resins. 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 status of the individual extraction wells is provided on **Figure 4-3**.
- 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 will be 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, 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:

- Groundwater quality is monitored 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 threatening a water supply source. The details of this monitoring program are described in the *BNL Environmental Monitoring Plan* (BNL 2016b).
- Extensive groundwater monitoring program to track contaminant plumes and reporting of the data.
- Monitoring of BNL potable supply system and SCDHS monitoring of Suffolk County Water Authority (SCWA) well fields closest to BNL.
- Remediation progress is continually assessed by project managers and reported annually in the *Groundwater Status Report*.
- In accordance with CERCLA, five-year reviews are performed until cleanup goals are met and to help determine the effectiveness of the groundwater remediation program.
- Controls are placed on the installation of new supply wells and recharge basins on BNL property.
- Public water service has been offered in plume areas south of BNL.
- BNL maintains 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.
- The treatment systems installed off of the BNL site are fenced, and have locked and alarmed buildings. No significant security violations have been identified.

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 *2015 BNL Groundwater Status Report* (BNL 2016a). Typically, these modifications include the installation of additional permanent and temporary monitoring wells, changes in sampling frequency for wells, changes in analytical procedures, or the decommissioning of monitoring wells no longer needed. 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 wells installed and those decommissioned by well identification number 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 by 2016. The most likely cause for increased remedial pumping duration is the presence of residual amounts of PCE beneath the excavation being mobilized to groundwater. Another potential issue is whether there are any additional sources of PCE that have not been identified. Additional sources appear unlikely due to results of extensive soil-gas surveys and soil sampling conducted in the area in 2008 and 2015. Groundwater monitoring results near the former source area indicate that PCE concentrations have been significantly decreasing over the last three years. The system is currently projected to continue operating until 2018.
- Several of the Sr-90 plumes on the site have similar issues that are being addressed:
    - Since 2011, when high concentrations of Sr-90 were observed in BGRR extraction well SR-3 (located immediately downgradient of the below ground ducts), the levels have significantly dropped off. However, Sr-90 concentrations in the two source area monitoring wells upgradient of this extraction well have shown significant increases and decreases from 2011 through 2015. There appears to be 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 as a result of long- and short-term groundwater recharge variations. The persistence of this residual Sr-90 source, which was not accounted for in the groundwater modeling projections, will require the treatment system to operate longer than originally planned.
    - 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, in 2015 and 2016 WCF Buildings 810 and 811 were removed along with contaminated soil, thereby reducing any residual Sr-90 source(s) that may have been present.
    - Elevated concentrations of Sr-90 continue to be detected in the former Chemical Holes source area and monitoring wells upgradient of extraction well EW-1. Characterization efforts since 2012, which included a comprehensive soil investigation in 2015, failed to identify a continuing source area. The rise and fall of the water table appears to be flushing the residual Sr-90 from the deep vadose zone. Groundwater modeling performed in 2015 identified the need to extend the operational period of the groundwater treatment system in order to meet the drinking water standard before 2040.
- 2016 characterization of groundwater in the upgradient portion of the Western South Boundary plume identified elevated VOCs deeper than expected. Freon-12 was not identified above the standard, however significant concentrations of other VOCs were. Further monitoring and

groundwater modeling will be needed to evaluate the nature and extent of this deeper contamination.

- Additional elevated detections of EDB in the North Street East plume over the next couple of years could result in the restart of extraction well NSE-1. This could delay the planned closure/decommissioning of this system, however, it is not expected to impact meeting the overall cleanup objective.
- Although the operational period of several of the treatment systems has been extended compared to the original designs, 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 was recommended as part of the *2013 BNL Groundwater Status Report*. Several other optimization recommendations are planned for the 2015 Report. The status of each of the groundwater treatment systems is shown on **Figure 4-2** and the operational status of the extraction wells is provided on **Figure 4-3**. These changes are based on an evaluation of treatment system and monitoring well contaminant concentration trends. A summary of optimization activities and opportunities include:

- Additional groundwater extraction wells were installed from 2012 through 2014 to address the deep VOC contamination identified at the Middle Road, South Boundary, and Industrial Park areas. 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 during this time to evaluate if any rebound in contamination is identified. 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 existing BGRR/WCF and Chemical Holes treatment systems are successfully capturing the Sr-90 plumes; however, the cleanup period is longer than originally anticipated. This is primarily due to the continued release of Sr-90 from the vadose zone to the aquifer, which was not accounted for in the original design modeling. Efforts to locate a continuing source in the vadose zone and/or reduce infiltration through capping, if successful, would reduce the time required for active pumping to remove the Sr-90. A 2015 review of other DOE sites (**Attachment 5)** identified a trend over the last five years towards installing permeable reactive barriers that would allow for decay of the Sr-90 *in-situ*. However, use of a permeable reactive barrier at BNL is probably not feasible due to the absence of a competent geologic layer to key into and the high initial cost of barrier installation. Options will continue to be reviewed if the duration of the strontium plume cleanup remains a concern.
    - To reduce the time for active pump and treat of the Sr-90 plumes requires either: a) removal of the vadose zone source term or b) capping at the surface to reduce or eliminate surface recharge (from precipitation and/or runoff) and thereby the flux of water and Sr-90 through the unsaturated zone and into the aquifer. However, finding the exact location of the source would be extremely difficult (particularly beneath the BGRR). Even with a cap, a rising water table will continue to add strontium from the vadose zone until the soil in the zone of water-table fluctuation is depleted of Sr-90. To help optimize the groundwater cleanup, in 2015 and 2016 WCF Buildings 810 and 811 were removed along with residual contaminated soil. As noted above, an extensive soil characterization effort was conducted in 2015 in the former source area upgradient of the Chemical Holes extraction wells, but failed to identify a continuing source in the vadose zone.

- 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 25 wells in 2016.

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. There have been no substantial changes to the regulations since 2010. Groundwater MCL values were last updated in 2008 (NYS) and 2009 (EPA). 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. **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. The PCB soil cleanup levels and MCLs for groundwater have remained the same since 1999.

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.
- The number of homes that continue to use their private well as their sole source of drinking water remains at three within the OU III area. DOE continues to offer free annual water testing to these homeowners.
- In 2011, a new source of groundwater contamination was identified within OU III which required the construction of the Building 452 Freon-11 treatment system. This plume did not impact the operation of any potable supply wells. From 2012 through 2016, the treatment system removed approximately 100 pounds of Freon-11 from the aquifer and successfully reduced the Freon-11 concentrations to below the 50 μg/L cleanup goal. The system was placed in standby mode in March 2016.
- The drop in hexavalent chromium concentrations in the Building 96 plume over the last few years indicates that it has converted back to the trivalent form, which is less toxic. As a result, further sampling was eliminated in 2015.
- A preliminary initial soil vapor screening of the OU III VOC groundwater plumes and the potential impact to existing and 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.
- 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. Planning studies will begin in 2016, with a goal for the start of the first phase of construction in 2018. A soil vapor screening for this area will be performed as plans are further developed.

- 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 gas intrusion, be identified, documented, and mitigated, if necessary. In addition, the *BNL Land Use Controls Management Plan* and the LUIC groundwater plume factsheets 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 nine groundwater remediation systems in operation under OU III. All 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 *2015 BNL Groundwater Status Report* (BNL 2016a) evaluates each system's performance based on decision rules identified from the BNL groundwater Data Quality Objective (DQO) process (see *BNL Environmental Monitoring Plan* [BNL 2016b] 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. As noted previously, the original planned operational period of several systems has been extended; however, they are still on track to meet their overall groundwater cleanup goals. Of the 14 treatment systems in OU III, two have met their goals and were decommissioned, and three were shut down and placed in standby mode.
- Within the last four years, the Building 452 Freon-11 groundwater treatment system has successfully decreased the high Freon-11 concentrations levels to below the capture goal. This is consistent with the original projections identified in the 2012 ESD.
- With the addition of the four new extraction wells to capture the deep OU III VOC plume from Middle Road to the Industrial Park, BNL will be on track to meet the objectives of reducing VOCs in the Upper Glacial and Magothy aquifers to below MCLs by 2030 and 2065, respectively.
- 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.

- 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 2016b). Sr-90 continues to attenuate as predicted as it migrates slowly to the south. Characterization work in 2015 identified the leading edge of an area of Sr-90 above DWS located just to the north of Brookhaven Avenue. The results are reported in the 2015 *BNL Groundwater Status Report* (BNL 2016a).
- 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 drinking water have remained the same since 1999. **Attachment 6** provides the cleanup levels for the OU IV primary contaminants of concern.
- The remedial action objectives have been met and have not changed.
- The groundwater within OU IV is not contaminated with VOCs above MCLs; therefore, subsurface vapor intrusion is not an issue.

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 January 2011, supplemental remediation of PR-WC-06 and PR-SS-15, as well as removal of the Sediment Trap was completed. The Completion Report (BNL 2012h) was issued in 2012 and the regulators provided their approval.
- The Peconic River remedy performed as intended:
  - The 2004/2005 Peconic River cleanup of mercury in the sediment has led to substantially reduced mercury concentrations in fish. Although there was a rise in concentrations from 2011 through 2015, the average mercury levels in fish for 2011 and 2015 remain lower than the pre-2004/2005 cleanup values. Reduced mercury concentrations mitigate potential health impacts for human and wildlife consumers of fish.
  - Routine sediment monitoring has functioned as intended by identifying one small on-site area with elevated mercury concentrations in the sediment that merits removal. The plan for cleanup of this area is being reviewed with the regulators.

- 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. Mercury concentrations in the STP effluent have been substantially lower since completion of the removal and shipment of the sand filter waste. The average of the two 2014 STP effluent Peconic River water-column monitoring program samples (31 ng/L) was substantially lower than the average mercury concentration for the six 2006 – 2009 samples (106 ng/L).
- 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. This change, together with the completed sludge digester/sand filter bed remediation and the completed Peconic River sediment removal, are anticipated to even further reduce mercury concentrations in 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). As noted in **Section 6.4.5** above, based on the previous five years of data, the monitoring program was reduced starting in 2011. The 2011 through 2015 monitoring requirements are identified in the *Soil and Peconic River Surveillance and Maintenance Plan* (BNL 2013f).

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 will be performed until cleanup goals are met and to determine the effectiveness of the groundwater monitoring program and sediment remediation.
- Controls have been placed on the installation of new supply wells and recharge basins on BNL property.
- NYSDEC regulations regulate 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

- From 2011 to 2015, Peconic River post-cleanup monitoring included collection of: sediment samples at three locations per year; surface-water samples at 15 locations two times per year; fish

samples every other year; and wetland monitoring to ensure vegetation success. This work is performed in accordance with the *Soil and Peconic River Surveillance and Maintenance Plan* (BNL 2013f). Beginning in 2012, the annual monitoring results are summarized in the annual *BNL Site Environmental Report* which can be found at https://www.bnl.gov/esh/env/ser/.

- Detailed sediment sampling in 2014 and 2015 identified the need to perform supplemental remediation of one remaining area in the Peconic River, PR-WC-06.
- Due to the reduced water levels in the river, the number of surface-water samples has drastically dropped since 2011. The mercury concentrations in the STP discharge through 2014, as well as values in the river, have been significantly reduced since the 2006 to 2010 timeframe.
- Mercury concentrations in fish during the 2011, 2013, and 2015 collections have varied and were somewhat higher than the 2006 to 2010 average values. However, the 2011 and 2015 average values are still less than the 2004/2005 pre-cleanup average mercury levels.
- In 2013, NYSDEC concurred that the wetland monitoring and maintenance performed by BNL from 2011 through 2012 satisfied the conditions in the equivalency permit, and no further monitoring was needed. In 2014, BNL also satisfied the federal duration requirements for monitoring and control of invasive species in the three supplemental remediated areas. The details of the monitoring efforts are presented in the *2012 Wetland Monitoring Status Report* (Roux 2013a) and the *2013* and *2014 Invasive Species Monitoring and Control Letter Reports* (Roux 2013b and 2014).
- All groundwater monitoring requirements were met in 2013, and no further sampling is needed. See the *2013 Groundwater Status Report* (BNL 2014a) for more information.

OU V Early Indicators of Potential Issues

- Disposal of the excavated sediment from the supplemental cleanup of Area PR-WC-06 is planned at a Subtitle D facility. The previous sediment cleanups in 2004/2005 and 2011 disposed of the waste in this manner. However, a justification for release of the waste to this facility needs to be prepared and approved by DOE, with concurrence from NYSDEC and NYSDOH. If the concentrations of radionuclides (such as Cs-137) in the sediment do not meet the release limit criteria, then the waste would need to be disposed of as low-level radioactive waste. This will not have an impact on the protectiveness of the remedy, but will significantly impact the cost for disposal.
- The planned excavation of Area PR-WC-06 is expected to be performed during a dry period, typically in the summer/early fall. Should the river and groundwater levels significantly increase during this time, implementation of the excavation would be complicated and require the use of river diversion/bypass and significant groundwater dewatering. Although the cleanup is still technically feasible, it will require a more significant effort and subsequent cost implications.

OU V Opportunities for Monitoring Optimization

- As discussed in **Section 6.4.5** above, VOC concentrations have remained below MCLs and perchlorate was below the NYSDOH Action Level and EPA Interim Lifetime Drinking Water Health Advisory level. As a result, the groundwater sampling requirements for OU V have been met and no further monitoring is required.
- Concurrent with the preparation of the 2016 Five-Year Review Report, DOE proposed, and the regulators agreed, to optimize the Peconic River remedy and perform a supplemental sediment removal in one remaining area (PR-WC-06). The supplemental sediment removal is expected to begin in summer/fall of 2018. Residual mercury concentrations in the Peconic River sediment and the proposed sediment cleanup area are shown in **Figure 7-2**.
- The Peconic River ROD states that after the first five years of monitoring are completed (2006 - 2010) and the data are reviewed by EPA, NYSDEC and SCDHS, appropriate modifications will be

made as necessary for subsequent sampling.[3] These modifications were identified in the 2011 Five-Year Review Report (BNL 2011a) and summarized in **Section 6.4.5** above.

- As a result of the continued long-term monitoring performed from 2006 through 2015, additional modifications to the Peconic River monitoring program are recommended. These modifications are supported by the following analytical data:
  - Approximately 2,380 confirmation sediment samples collected during the 2004 to 2005 20-acre excavation to ensure that the cleanup goals from the ROD were met;
  - Approximately 1,700 post-cleanup sediment, surface-water, and fish monitoring samples collected between 2006 and 2010;
  - 37 confirmation sediment samples collected in December 2010 and January 2011 at the supplemental excavation of PR-WC-06, Sediment Trap, and PR-SS-15 areas to ensure that the sediment cleanup goals from the ROD were met;
  - Annual samples collected from 2011 through 2015 at the supplemental cleanup areas PR-WC-06, former Sediment Trap, and PR-SS-15;
  - 140 sediment samples collected in 2014 and 2015 to characterize area PR-WC-06;
  - 80 surface-water samples collected between 2011 and 2015;
  - 219 fish samples collected in 2011, 2013, and 2015;
  - Approximately 43,000 native transplants were planted in the remediated areas of the river during the 2004/2005 cleanup, and additional revegetation performed during the 2010/2011 supplemental cleanup;
  - Removal of invasive species following the 2004/2005 and 2011 cleanups; and
  - Monitoring and maintenance of wetland vegetation following the 2004/2005 and 2011 sediment cleanups in accordance with the equivalency permits.

- All long-term monitoring data collected during the last 10 years have been reviewed by and with the DOE, EPA, NYSDEC, NYSDOH, and the SCDHS. Modifications to sediment, water column and fish monitoring are discussed below.

Table 7-1: Recommendations for Peconic River Optimization

	2011 - 2015 Requirements	2016	Comments
Surface Water	15 samples 2x/yr - Hg, MeHg, TSS	Discontinue	
Sediment	1 sample annually (SS-15 and former Sediment Trap)	Discontinue	All values were below 2.0 mg/kg of mercury
	1 sample annually (PR-WC-06)	Perform supplemental sediment cleanup	Obtain confirmatory sediment samples every 100 square feet following the excavation.
Fish	4 locations every other year (2011, 2013, 2015)	Discontinue	
	Age determination on all fish	Discontinue	
Vegetation	NYSDEC - Monitor for 2 full growing seasons for plant survival and invasive species control (4/2011 - 9/2012) EPA - 3 to 5 years for invasive species control	TBD based on discussion w/regulators	Allow river to naturally recover following the planned excavation at Area PR-WC-06 in 2018.

[3] *Final Operable Unit V Record of Decision for Area of Concern 30 (Peconic River)*, page 38, paragraph 2.

Sediment Monitoring Modifications

- The 2011 through 2015 long-term sediment monitoring results presented in **Section 6.4.5** for Areas PR-SS-15 and the former Sediment Trap indicate that all samples are below the ROD cleanup goal that all mercury samples in the remediated areas would be less than 2.0 mg/kg[4]. **BNL recommends that sediment monitoring at these two stations be discontinued in 2016. Data indicate that monitoring is no longer necessary and can be discontinued without jeopardizing the protectiveness of the Peconic River remedy**.
- In accordance with the *Draft Plan for Optimization of the Peconic River Remedy PR-WC-06 Area,* (BNL 2016d), **BNL recommends that excavation and offsite disposal of sediment containing elevated mercury greater than 2.0 mg/kg be performed at Area PR-WC-06**. The excavation will extend approximately five feet beyond downstream sample point PR-WC-06-D1-L50-145. Following the excavation, confirmatory sediment samples will be collected at a density of 100 square feet to ensure that the sediment cleanup goals from the ROD are met (average mercury concentration of less than 1.0 mg/kg and all individual samples are less than 2.0 mg/kg). **BNL recommends that following the supplemental remediation at Area PR-WC-06 and successful confirmatory sampling, long-term sampling of this area be discontinued. Data indicate that sampling is no longer necessary and can be discontinued without jeopardizing the protectiveness of the Peconic River remedy.** The data from the post-cleanup confirmation samples will be reported in a completion report.

Surface-Water Monitoring Optimization

- As shown on **Figure 6-17**, the 2011-2015 Peconic River water column mercury concentrations are higher between station STP-EFF-UVG and PR-WC-02 than at the stations located upstream and downstream of this section of the river. However, the mercury concentrations in the STP discharge through 2014, as well as the values in the river, have been significantly reduced since the 2006 to 2010 timeframe. As noted previously, as of September 2014, the STP no longer discharges into the Peconic River.
- As discussed in **Section 6.4.5** above, methyl mercury concentrations from 2011 through 2015 are higher at stations PR-WC-12-D7 (located upstream of the former STP) and PR-WC-06. However, the methyl mercury concentrations are significantly lower than the data from 2006 to 2010.
- Sufficient water quality data have been collected over the past 10 years to support **BNL's recommendation that routine water-column monitoring for total mercury, methyl mercury and Total Suspended Solids (TSS) at the 15 stations between PR-WC-15 (upstream of STP-EFF-UVG) and PR-WC-02 be discontinued in 2016. Data indicate that is monitoring is no longer necessary and can be discontinued without jeopardizing the protectiveness of the Peconic River remedy.**

Fish Monitoring Optimization

Fish tissue mercury concentrations have varied during the 2011, 2013, and 2015 collections. The annual average fish tissue mercury concentrations for the three sampling events were; 0.31 mg/kg in 2011, 0.69 mg/kg in 2013, and 0.40 mg/kg in 2015. These are higher than the 2006 through 2010 average of 0.28 mg/kg, but the 2011 and 2015 values are still lower than the 1997 and 2001 pre-cleanup concentration (0.58 mg/kg). Since there is no action or cleanup level for mercury in fish identified in the ROD, the EPA mercury criterion for fish of 0.3 mg/kg has been used for reference purposes. Factors that may have contributed to the increased mercury levels in fish over the last five years include reduced sample size, fish age, fish size, food consumed, and limited open water areas.

- Based on the data collected over the past 10 years following the 2004/2005 cleanup, there does not appear to be any significant increasing or declining trends in mercury concentrations in fish.

[4] *Final Operable Unit V Record of Decision for Area of Concern 30 (Peconic River),* page 28, paragraph 4.

Flow in the on-site portion of the river has become increasingly intermittent over the last couple of years since there is no continuing discharge to the river. These seasonal variations are also not favorable for the survival of fish populations. **BNL recommends that fish monitoring, including age determination, be discontinued in 2016. Data indicate that monitoring is no longer necessary and can be discontinued without jeopardizing the protectiveness of the Peconic River remedy.**

- As a best management practice, BNL will continue to periodically monitor fish under the environmental surveillance monitoring program every other year (even years) provided sufficient river water levels are present to support fish populations. These monitoring requirements are identified in the *Environmental Monitoring Plan* (BNL 2016b) and are subject to change annually.

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 Lifetime Drinking Water Health Advisory for perchlorate of 15 μg/L was established by EPA in 2012. This is lower than the NYSDOH Action Level for perchlorate of 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.

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 and surface-water sampling on site. This change also eliminated continued discharges of low levels of metals (such as mercury) to the river.
- 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 2013. To date, all test results indicate that the water quality complies with NYS drinking water standards.
- No new contaminants or sources of contamination have been identified within OU V, and no unanticipated toxic byproducts have been detected.

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 will be completed. It is recommended that further monitoring of the Peconic River be discontinued.
- Groundwater monitoring in OU V has demonstrated that MCLs have been met in 2013 and no further monitoring was needed.

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 OU VI EDB groundwater plume has been defined and continues to be monitored via a network of monitoring wells on and off of BNL property. The plume is currently positioned entirely south of the BNL site.
- 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 *2015 BNL GroundwaterStatus* Report (BNL 2016a). The system is currently on schedule to meet the cleanup goal of reaching the MCL by 2030.
- 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 showed 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.
- 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 Report.* 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 11 years and the average annual O&M cost is approximately $225K. 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. These costs are in addition to the payments required for the OU III systems discussed above.

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.
- Changes to the OU VI plume monitoring network are recommended in the annual *BNL Groundwater Status Report*. These modifications, such as additional monitoring wells and temporary wells, would increase BNL's confidence in the plume's distribution and remediation progress.

OU VI Opportunities for Optimization

The existing treatment system is successfully capturing the EDB plume, however at a slower rate than originally anticipated. Two treatment options, enhanced *in-situ* biodegradation or adding new treatment wells, could reduce the time required to meet the drinking water standard of 0.05 µg/L EDB in the aquifer. However, considering the cost of implementing these options, it appears that continued operation of the existing two extraction wells is the most cost-effective solution to meet the cleanup goal at this time.

OU VI Early Indicators of Potential Issues

There do not appear to be any problems or issues at this time that could place protectiveness of the remedy at risk. Although the system was planned to be shut down in 2015, the data and updated groundwater modeling indicate the system will need to operate until 2019. This increased duration will not impact the ROD cleanup goal of reaching MCL by 2030.

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.

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.
- 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 below the 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 2016b] for the DQO process). As described in the *2015 BNL Groundwater Status Report* (BNL 2016a), EDB concentrations are expected to be below the 0.05 µg/L MCL by 2030, as required by the OU VI ROD.
- 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 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: Fanhouse 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 the window replacements in the former offices on the second and third floor and roof repairs performed in 2014 and 2015.

BGRR Costs of System Operations/O&M

The estimated cost of long-term surveillance and maintenance activities is approximately $200K annually (in FY15 dollars) for routine surveillance and groundwater monitoring. Additionally, surveillance and maintenance costs for the BGRR include upkeep every 10 years for the infiltration barrier and $760K 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

- There are no opportunities for optimization of the remedial or surveillance and maintenance activities at this time.

BGRR Early Indicators of Potential Issues

- A potential continuing source of Sr-90 contamination 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.

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

- A significant effort has already been completed with the removal and disposal of contaminated components, structures, water, and soil at the BGRR complex. 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 BGRR has been either removed or stabilized as a result of the cleanup actions.
  - The implementation of long-term monitoring, maintenance, and institutional controls continues for the BGRR.
  - The overall remedy removed over 99 percent of the radioactive material inventory at the BGRR complex.
  - The Building 701 structure and engineered cap protect the contaminated soil and components that will remain under the building footprint. It will form a significant barrier to future excavation and direct exposure, and serve as an effective barrier to prevent the migration of the remaining contaminants to groundwater.
  - Water infiltration management and institutional controls are effective in protecting human health and the environment.
- As noted in **Section 7.3** above, BNL will carefully evaluate the performance and efficiency of the Sr-90 ion exchange treatment system implemented for remediation of the BGRR/WCF plumes to ensure that they 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. BNL will also remain alert to any new Sr-90 remediation techniques and technologies as well as any operational efficiencies that might accomplish cleanup sooner with less remediation waste. Continued evaluation of the potential continuing source of Sr-90 contamination from the BGRR below-ground ducts 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.

7.8 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 have been below the 20,000 pCi/L MCL since early 2006. During 2015, the maximum tritium concentration in the BLIP monitoring wells was 2,690 pCi/L. 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. During 2015, the maximum tritium concentration in the source area wells was 55,000 pCi/L. 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 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 is 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 Land Use and Institutional Controls and Other Measures
- The *BNL Land Use Controls Management Plan* (BNL 2013a) 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
- During 2015, the Linac Y cap, which adjoins the BLIP cap to the north, was extended in several areas to provide protection of soil shielding that are expected to become activated following planned changes in beam line operations. 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.

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 appears 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 the g-2 source area wells since 2003 suggest 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 Brookhaven Avenue will be 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.

7.9 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
- Removal of ancillary buildings and associated soils
- Removal of fan houses
- Removal of contaminated underground pipes and utilities
- Soil excavation and disposal of the former HWMF WLA
- Removal of Bldgs. 801-811 underground waste transfer lines and associated soil

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.
- Water intrusion monitoring.
- Preventive maintenance of Building 750 and the infiltration management system.
- Management and disposal of water generated from precipitation through the stack.
- Groundwater monitoring required as part of the OU III ROD.

HFBR Costs of System Operations/O&M

The estimated cost of surveillance and maintenance activities required to ensure that Building 750 (HFBR) remains in a safe and stable condition during the safe storage phase is approximately $180K

annually (in FY15 dollars). The surveillance and maintenance activities include radiation and environmental monitoring, management and disposal of stack drain water, 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.
- 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. 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. The details of the surveillance and maintenance processes are contained in a supporting document – the *Long-Term Surveillance and Maintenance Manual*. 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 on the facility including the replacement of light bulbs, roof repairs over the former machine shop area located outside of the confinement dome, and re-caulking of a vent on the outside of the dome outside the generator room. Radiation measurements of the V-14 port (located at the top of the reactor vessel) were conducted in 2010 and 2015 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 the selected decay period (until 2073) is justified. See **Attachment 5** for additional information. The water (from precipitation) generated from the stack is routinely pumped-out and disposed of.

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.

An evaluation was performed of covering the stack to minimize the volume of water generated from precipitation events. The capital cost to install a cover compared to the existing annual water management and disposal cost through 2020 was deemed not economical.

HFBR Early Indicators of Potential Issues

Continued protection of workers during the remaining activities (demolition of the stack) is an important consideration. Controls developed and implemented for the completed remedial actions (demolition of Buildings 704 and 802, and removal of underground utilities) will be used to help mitigate potential risk.

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.

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. Also, the exposure assumptions have not changed since the ROD was finalized in 2009.
- 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 will 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.
    - 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.
    - 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

- A significant effort has already been completed with the removal and disposal of contaminated components, structures, water, and soil at the HFBR complex. 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 removal actions.
    - The implementation of long-term monitoring, maintenance, and institutional controls has been initiated for the HFBR.
- The remaining remedial actions to be implemented for stack demolition and removal of the reactor vessel are 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.

7.10 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 stack and 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, tanks, and the installation and operation of all planned groundwater treatment systems. All closeout reports were submitted to the regulators and approved.

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.

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	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.	BNL	DOE, EPA, NYSDEC, SCDHS	September 2021	N	N
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*.	BNL	DOE, EPA, NYSDEC, SCDHS	July 2018	N	N
OU III Western South Boundary deep VOC contamination	Characterize nature and extent of deep VOCs identified in 2016/run model.	BNL	DOE, EPA, NYSDEC, SCDHS	September 2017	N	N
Continuing Sr-90 source at BGRR	Monitor plume and continued degradation of source area. Perform intermittent pulsed pumping of extraction well SR-3. Evaluate during next Five-Year Review.	BNL	DOE, EPA, NYSDEC, SCDHS	July 2021	N	N
Continuing Sr-90 source at Chemical Holes	Continue attenuation monitoring of former source area. Perform intermittent pulsed pumping of extraction well EW-1. Evaluate during next Five-Year Review.	BNL	DOE, EPA, NYSDEC, SCDHS	July 2021	N	N
Peconic River Remedy Optimization	Complete supplemental excavation of elevated mercury at Area PR-WC-06.	BNL	DOE, EPA, NYSDEC, SCDHS	September 2018	N	N
HFBR	Remove stack by 2020 per the ROD.	BNL	DOE, EPA, NYSDEC, SCDHS	September 2020	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 - Deeds not reflecting operating treatment systems	Record property access agreements with County Clerk	BNL	DOE, EPA, NYSDEC, SCDHS	June 2017	N	Y

Issue	Recommendations/ Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Y/N)	
					Current	Future
Soil contamination north of former Buildings 810/811	Add radiological soil contamination area to Building 811 Waste Concentration Facility LUIC fact sheet	BNL	DOE, EPA, NYSDEC, SCDHS	January 2017	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 shut down and placed in standby mode in 2013 since the capture goal for VOCs was met. 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: 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. 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 MCLs by 2034.

Operable Unit V: The remedy is protective of human health and the environment, and in the interim, exposure pathways that could result in unacceptable risks are being controlled. Revegetation of remediated areas has been completed. The 10 years of 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 and the 2011 supplemental sediment cleanup of the Peconic River met the remediation goals of the ROD.
- Long-term monitoring has demonstrated the effectiveness of the Peconic River cleanup and it is recommended that further monitoring of the Peconic River be discontinued.
- Supplemental remediation in one small area will be completed.

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 health and safety monitoring, 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 facility 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 near-term actions (demolition of the stack), and 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 health and safety monitoring, periodic structural inspections of the reactor confinement building and stack, water intrusion monitoring, preventive maintenance of the infiltration management system, and groundwater monitoring required as part of the OU III ROD.

Comprehensive Protectiveness Statement

- A comprehensive sitewide protectiveness determination covering all the OUs and BGRR must be reserved at this time because HFBR remedy implementation is not yet complete, including stack demolition and reactor vessel removal.

11.0 Next Review

The fourth 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.

Frank Crescenzo, Site Manager
Brookhaven Site Office
U.S. Department of Energy

6/24/2016
Date

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Tables

(Tables 6-3 and 6-4)

Table 6-3
Permanent Monitoring Wells Installed Since January 2011

Permanent Well Identification	Temporary Well Identification	Installation Date
113-30	OU3-MR-MW01-2010	1/26/2011
105-67	OU3-MR-MW02-2010	2/4/2011
126-17	WSB-MW01-2010	2/16/2011
107-42	OU1-MW02-2010	3/3/2011
000-520	EDB-MW-01-2011	3/14/2011
076-417	650-MW03-2010	3/22/2011
076-416	650-MW02-2010	3/24/2011
076-415	650-MW01-2010	3/25/2011
075-701	BGRR-MW-05-2011	3/30/2011
075-700	BGRR-MW-03-2011	3/31/2011
065-402	BGRR-MW-04-2011	4/4/2011
075-699	BGRR-MW-02-2011	4/6/2011
065-401	BGRR-MW-01-2011	4/7/2011
065-404	BGRR-MWA-2011	7/27/2011
108-55	OU1-MW01-2011	8/16/2011
108-56	OU1-MW02-2011	8/17/2011
121-49	SB-MW01-2011	9/9/2011
095-314	B452-MW-11	9/14/2011
095-315	B452-MW-12	9/15/2011
085-388	B452-MW-10	9/16/2011
095-313	B452-MW-08	9/19/2011
085-387	B452-MW-09	9/20/2011
085-386	B452-MW-07	9/21/2011
085-382	B452-MW-03	9/22/2011
085-385	B452-MW-06	9/22/2011
085-384	B452-MW-05	9/23/2011
085-383	B452-MW-04	9/26/2011
085-381	B452-MW-02	9/27/2011
085-380	B452-MW-01	9/28/2011
085-389	EW-18	9/28/2011
000-526	MW-MAG	10/20/2011
065-405	065-366 Replacement	3/6/2012

Table 6-3
Permanent Monitoring Wells Installed Since January 2011

Permanent Well Identification	Temporary Well Identification	Installation Date
121-47	SB-MW01-2012	4/26/2012
121-48	SB-MW02-2012	5/2/2012
113-31	OU3-MR-MW01-2012	5/8/2012
121-46	EW-17	5/18/2012
000-530	IP-MW01-2012	5/25/2012
000-525	NSE-MW01-2012	6/1/2012
119-10	WSB-MW-01-2012	6/14/2012
085-398	BGRR-MW01-2012	8/8/2012
085-399	BGRR-MW02-2012	9/12/2012
085-402	BGRR-MW03-2012	9/13/2012
000-524	EDB-MW01-2012	9/21/2012
000-531	IP-MW02-2012	10/12/2012
105-68	MRMW-01-2013	5/23/2013
000-528	IP-MW02-2013	6/12/2013
000-529	IP-MW01-2013	6/15/2013
121-53	MRMW-03-2013	8/21/2013
113-33	RW-7	8/22/2013
000-527	EDB-MW01-2013	9/10/2013
800-138	AP-MW01-2013	9/19/2013
000-541	IP-MW-05-2014	6/17/2014
127-08	IP-MW-03-2014	6/25/2014
127-09	IP-MW-04-2014	6/26/2014
000-537	IP-MW-01-2014	7/2/2014
000-538	IP-MW-02-2014	7/9/2014
095-322	MR-MW02-2014	7/22/2014
095-323	MR-MW01-2014	7/24/2014
121-54	SB-MW02-2014	8/20/2014
000-542	IP-MW-06-2014	9/26/2014
000-533	IP-EW-9	10/1/2014
000-543	IP-MW-07-2014	10/2/2014
000-532	IP-EW-8	10/20/2014
000-544	IP-MW-08-2014	10/22/2014

Table 6-3
Permanent Monitoring Wells Installed Since January 2011

Permanent Well Identification	Temporary Well Identification	Installation Date
TBD	CAH-MW01-2015	5/6/2015
TBD	BGRR-MW01-2015	5/7/2015
TBD	CAH-MW02-2015	5/7/2015
TBD	CAH-MW03-2015	5/7/2015
TBD	CAH-MW04-2015	6/3/2015
TBD	IP-MW01-2015	6/15/2015

TBD = To be determined following receipt of survey coordinates

Table 6-4
Monitoring Wells Decommissioned Since January 2011

Permanent Well Identification	Decommissioned Date
041-01	9/5/2013
600-20	9/5/2013
600-23	9/5/2013
600-26	9/5/2013
000-513	9/6/2013
000-514	9/6/2013
095-300	9/20/2013
049-05	9/23/2013
066-190	9/23/2013
095-53	9/23/2013
095-42	9/24/2013
095-90	9/24/2013
085-162	9/26/2013
085-163	9/26/2013
095-277	9/26/2013
095-279	9/26/2013
076-314	9/27/2013
095-280	9/27/2013
000-489	10/3/2013
000-493	10/4/2013
000-433	10/18/2013
038-03	6/30/2014
000-436	9/18/2014
000-215	9/17/2015
084-02	9/27/2015