12.1 INTRODUCTION AND MONITORING SCHEDULE

DQO START DATE January 1, 2012

IMPLEMENTATION DATE January 1, 2025

POINT OF CONTACT Brian Barth (631) 344-2242

GROUNDWATER RESOURCE MANAGEMENT

Groundwater monitoring is driven by regulatory requirements, U.S. Department of Energy (DOE) Orders, best management practices, and Brookhaven National Laboratory's (BNL) commitment to environmental stewardship. The Laboratory monitors its groundwater resources for the following reasons:

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

GROUNDWATER FACILITY MONITORING

- To verify that operational and engineered controls effectively prevent groundwater contamination.
- To trigger early action and communication, should the unexpected happen (e.g., control failure).
- To determine the efficacy of the operational and engineered control measures designed to protect the groundwater.
- To demonstrate compliance with applicable requirements for protecting and remediating groundwater.

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

- To track a dynamic groundwater cleanup problem when designing, constructing, and operating treatment systems.

12.1 INTRODUCTION AND MONITORING SCHEDULE

DQO START DATE January 1, 2012

IMPLEMENTATION DATE January 1, 2025

POINT OF CONTACT Brian Barth (631) 344-2242

GROUNDWATER RESOURCE MANAGEMENT

Groundwater monitoring is driven by regulatory requirements, U.S. Department of Energy (DOE) Orders, best management practices, and Brookhaven National Laboratory's (BNL) commitment to environmental stewardship. The Laboratory monitors its groundwater resources for the following reasons:

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

GROUNDWATER FACILITY MONITORING

- To verify that operational and engineered controls effectively prevent groundwater contamination.
- To trigger early action and communication, should the unexpected happen (e.g., control failure).
- To determine the efficacy of the operational and engineered control measures designed to protect the groundwater.
- To demonstrate compliance with applicable requirements for protecting and remediating groundwater.

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

- To track a dynamic groundwater cleanup problem when designing, constructing, and operating treatment systems.

- To measure the performance of the groundwater remediation efforts in achieving cleanup goals.
- To protect public health and the environment during the cleanup period.
- To define the extent and degree of groundwater contamination.
- To provide early warning of the arrival of a leading edge of a plume which could trigger contingency remedies to protect public health and the environment.

BNL's CERCLA groundwater monitoring has been streamlined into five general phases**:**

Start-up Monitoring

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

Operations and Maintenance (O&M) Monitoring

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

Shutdown Monitoring

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

Standby Monitoring

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

Post-Closure Monitoring

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

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

- <u>Background</u> – Water quality results will be used to determine upgradient water quality.
- <u>Plume Core</u> – Utilized to monitor the high concentration or core area of the plume.
- <u>Perimeter</u> – Used to define the outer edge of the plume both horizontally and vertically.
- <u>Bypass</u> – Used to determine whether plume capture performance is being met.

- Sentinel – An early warning well to detect the leading edge of a plume.

See Table 12.1.1. below for the well sampling frequency of the CERCLA Groundwater Monitoring Program.

Table 12.1.1. CERCLA Groundwater Monitoring Program – Well Sampling Frequency

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

Notes:

*- Duration varies by project.

** - Chemical Holes Sr-90: 2040; Magothy: 2065; BGRR Sr-90: 2070

*** - Verification monitoring for achieving maximum contaminant levels (MCLs).

****- Strontium-90 (Sr-90) monitoring projects use approximately half the defined sampling frequency for a given phase.

Intentionally Left Blank

12.2 OU I South Boundary (RA V Removal Action)

DQO Start Date January 1, 2003

Implementation Date January 1, 2025

Point of Contact Brian Barth (631) 344-2242
Vincent Racaniello (631) 344-5436
James Milligan (631) 344-4458

Summary of Changes

The proposed changes for the OU I South Boundary (RA V Remedial Action) Treatment System groundwater monitoring program for calendar year 2025 are as follows:

- Maintain the VOC post-closure groundwater monitoring program of annual sample collection from post-closure wells: 107-40, 107-41, 115-13, 115-16, and 115-51. Maintain quarterly sampling of Current Landfill sentinel well 098-99.

- Install temporary wells as needed to fill monitoring data gaps and characterize extent of the Sr-90 plume. Install a temporary well to the west of OU I -Sr-90-GP-74 to verify the western extent of this higher concentration plume segment.

The OU I South Boundary project monitors the downgradient extent of commingled contaminant plumes from several sources, including the Current Landfill and the Hazardous Waste Management Facility (HWMF). The groundwater contaminant plume, consisting of VOCs, at one time extended approximately 3,000 feet south of the Brookhaven National Laboratory (BNL) property boundary. In December 1996, a remediation system comprised of two extraction wells screened within the deep Upper Glacial aquifer began operation at the southern property boundary to prevent groundwater with total VOCs exceeding 50 micrograms per liter (µg/L) from migrating off site.

The system was shut down in 2013, as it had met the cleanup goals for treating VOCs. The extracted groundwater was treated via air stripping and recharged northwest of the source areas. In addition, radiological parameters, including tritium and Sr-90, have been detected in several wells near the source areas. A Sr-90 plume originating in the former HWMF is monitored with 38 of the OU I South Boundary wells and supplemented with temporary vertical profile wells as necessary.

The monitoring well network for the OU I South Boundary project consists of 30 wells. Well locations are shown in Figure 12.2.1. The wells are sampled annually to quarterly for analysis of VOCs and Sr-90.

The contaminants of concern in this area are VOCs and Sr-90. The leading edge of the Sr-90 contamination is approximately 400 feet north of the site boundary.

DRIVERS FOR MONITORING BEING CONDUCTED UNDER THIS CHANGE

___ Compliance
____Support
____Surveillance
__X_Restoration

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

A plume of groundwater contaminated by VOCs has been identified within the Upper Glacial aquifer in the southern portion of the BNL site and off site. In response, groundwater remediation was implemented at the southern site boundary in December 1996. A plume of contaminated groundwater off site to the south is addressed by the North Street East remediation system which began operation in June 2004.

Data are needed to demonstrate that:

- The existing groundwater remediation system is intercepting the on-site groundwater plume.
- Influent concentrations to the existing treatment system will not exceed the design criteria.
- Groundwater quality is improving according to plan.

Problem Statement: A VOC plume that could represent a potential risk to human health has been defined on the BNL site. Remediation of the on-site plume has been conducted since December 1996. Data are needed to verify that the remediation is occurring according to plan.

Step 2: Identify the Decision

The decisions for the project include:

- Is there a continuing source of contamination? If present, has the source area been remediated or controlled?
- Were unexpected levels or types of contamination detected?
- Has the downgradient migration of the plume been controlled?
- Can individual extraction wells or the entire treatment system be shut down or placed in pulse pumping operation?
- Has the groundwater cleanup goal of meeting maximum contaminant levels (MCLs) by 2030 been achieved?

Step 3: Identify Inputs to the Decision

The project was divided into four decision subunits to reflect the categories of wells for which decisions will be made with respect to the VOC contamination. The identified subunits and the decisions supported by each are listed below:

- Background (upgradient) wells (Decisions 1 and 2)
- Plume Core wells (Decisions 1, 2, 3, 4, and 5)
- Plume Perimeter wells, used to define the extent of the plume (Decisions 1, 2, and 5)
- Bypass Detection wells (Decisions 2 and 3)

The wells included in each subunit are shown in Table 12.2.1. The inputs necessary for the decisions include the following:

- Direction and velocity of groundwater flow
- Analytical results for VOCs and radionuclides in groundwater

- Locations of existing wells relative to flow patterns (Figure 12.2.1)
- Evaluation of capture zone for extraction wells
- Action levels
- Analytical methods and detection limits as described in the BNL Environmental Monitoring Plan
- Variability of data

Step 4: Define the Study Boundaries

As currently defined, the spatial boundaries of the study area are defined by:

- North side of the current landfill to the north
- Wells 115-41 and 115-42 to the south
- West side of the current landfill and well 087-21 to the west
- Wells 098-61, 107-10, and 108-08 to the east
- Saturated thickness of the Upper Glacial aquifer

Separate decisions will be made in the subunits described in Step 3. However, some of the decisions, such as system performance, are based on the entire study system. The temporal boundaries of the study area vary, based on the decision. Some decisions are based on the most recent sampling event, while others are based on historic trends (two to three years). Section 12.1 details the general sampling frequency based on the phase the monitoring program is in.

Step 5: Develop the Decision Rules

Decision 1

Future sample results will be evaluated in context with historic data for each sampling event. As part of that evaluation, circumstances that would require implementation of the BNL Groundwater Contingency Plan would be ascertained for each sampled well. Examples of such circumstances are unusually high contaminant concentrations, detection of previously undetected contaminants, and detection of contaminants in previously “clean” wells. **If** conditions indicate that the BNL Groundwater Contingency Plan needs to be implemented, **then** the Contingency Plan will be implemented.

Decision 2

Were unexpected levels or types of contamination detected?

Analytical results from wells in all subunits will be utilized for this decision. Future sample results will be evaluated in context with historic data for each sampling event. As part of that evaluation, circumstances that would require implementation of the BNL Groundwater Contingency Plan (Environmental Monitoring Standard Operating Procedure [EM-SOP]-309) would be ascertained for each sampled well. Examples of such circumstances are unusually high contaminant concentrations, detection of previously undetected contaminants, and detection of contaminants in previously “clean” wells.

If conditions dictate, **then** the BNL Groundwater Contingency Plan will be implemented.

Decision 3

Has the downgradient migration of the plume been controlled?

This decision applies to the plume perimeter and bypass detection wells. **If** the cleanup goals have not been met, **then** it must be verified that the plume is not growing. Plume growth is defined as an increase in total VOC concentration in plume fringe or bypass detection wells to above 50 µg/L (if currently less than 50 µg/L) or a significant increase in total VOC concentration (if currently above 50 µg/L).

If the trend in each plume perimeter and bypass detection well has a negative or zero slope, based on the four most recent consecutive samples, this trend is consistent with professional judgment, and the total VOC concentration is less than 50 µg/L, **then** continue to operate the system. **If not**, **then** consider an engineering evaluation or operational adjustments to optimize system operation.

Decision 4

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

If evaluation of analytical results for any contaminant of concern in any upgradient or plume core well sample, in conjunction with historic analytical results and trends, indicates that one or more treatment system recovery wells have met the shutdown criteria of achieving the cleanup goal within 30 years, **then** the well will be shut down or placed in pulse pumping mode.

If evaluation of analytical results for any contaminant of concern in any upgradient or plume core well sample, in conjunction with historic analytical results and trends, indicates that the treatment system has met the shutdown criteria of achieving the cleanup goals, **then** a petition for shutdown will be issued to the regulatory agencies.

4a. Are TVOC/Sr-90 concentrations in plume core wells above or below 50 µg/L or 8 pCi/L, respectively?

If the total VOC concentration in each plume core well has been reduced to less than 50 µg/L **then** proceed with pulsed operation of the system. **If not**, and treatment has occurred for less than seven to ten years, **then** continue treatment. **If not**, and treatment has occurred for at least seven to ten years, **then** perform an engineering evaluation to predict the fate of the remaining contamination and determine whether MCLs will be met by 2030.

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

This decision is to determine whether there is significant concentration rebound after system pulsing. **If yes**, and system has operated for less than seven to ten years, **then** continue operation. **If yes**, and system has operated for more than seven to ten years, **then** an engineering evaluation should be performed to evaluate whether continued operation of the system is warranted (see Decision subunit 4d to help with this decision). **If** no significant rebound is observed within one year, **then** petition for system shutdown and continue with monitored natural attenuation (MNA).

Decision 5

Has the groundwater cleanup goal of meeting MCLs by 2030 been achieved?

If the concentration of total VOCs in groundwater from all plume core wells over the previous two years is less than 50 µg/L and pulsing of the remediation system has not resulted in significant rebound of contaminant concentrations, **then** petition for system shutdown and continue with MNA until MCLs are met. **If not**, **then** consider the need for continued remediation. Note: This assumes that system operation is already considered "optimal."

Step 6: Specify Acceptable Error Tolerances

Table 12.2.1 summarizes the decision and possible decision errors for this project.

Table 12.2.1. Decisions, Potential Decision Errors, and Potential Consequences

Decision	Inputs	Potential Errors Based on Data	Potential Consequences
Is the Contingency Plan activated?	See Step 3 for inputs.	(1) Trigger Contingency Plan unnecessarily.	(1) Unnecessary administrative process, project delays.
		(2) Fail to trigger Contingency Plan when it should have been triggered.	(2) Lost time in addressing problem, loss of stakeholder confidence.
Is plume growth controlled?	See Step 3 for inputs.	(1) Determine plume is controlled when it is not.	(1) Premature petition for system shutoff, project delays.
		(2) Determine plume is not controlled when it is.	(2) Continue remediation longer than necessary, wasted resources.
Can the groundwater treatment system be shut down?	See Step 3 for inputs.	(1) Determine system can be shut down when operation should continue.	(1) Plume growth continues, ultimate project delays.
		(2) Determine to continue operating system when shut down is warranted.	(2) Wasted resources, project delays.
Is the system operating as planned?	See Step 3 for inputs.	(1) Determine system operating as planned when it is not.	(1) Premature petition for system shutoff, potential to have to restart system.
		(2) Determine system isn't operating as planned when it is.	(2) Continue remediation that is no longer effective

Step 7: Optimize the Design

Number and Locations of Wells

The well network consists of 30 wells located both on and off site.

Parameters and Frequency

The wells are sampled quarterly to annually for the analysis of VOCs and Sr-90. A summary of the proposed 2025 sampling program for this project is shown in Table 12.2.2.

Table 12.2.2. Proposed 2025 Sampling Frequency for the OU I South Boundary Monitoring Wells

Well ID	Sampling Frequency	Parameters
088-26	Annual-Semi-annual (Sr-90)	EPA 905 Sr-90
098-21	Annual-Semi-annual (Sr-90)	EPA 905 Sr-90
098-30	Annual-Semi-annual (Sr-90)	EPA 905 Sr-90
099-04	Annual-Semi-annual (Sr-90)	EPA 905 Sr-90
108-08	Annual	EPA 905 Sr-90
108-12	Annual	EPA 905 Sr-90
108-13	Annual	EPA 905 Sr-90
108-14	Annual	EPA 905 Sr-90
108-17	Annual	EPA 905 Sr-90
108-18	Annual	EPA 905 Sr-90

115-13	Annual	8260 Low Level
115-16	Annual	8260 Low Level
107-35	Semi-annual	EPA 905 Sr-90
108-43	Semi-annually	EPA 905 Sr-90
108-44	Semi-annually	EPA 905 Sr-90
107-34	Semi-annually	EPA 905 Sr-90
107-40	Annual	8260 Low Level
107-41	Annual	8260 Low Level
115-51	Annual	EPA 905 Sr-90 8260 Low Level
107-42	Semi-annually	EPA 905 Sr-90
108-45	Semi-annually	EPA 905 Sr-90
108-55	Semi-annually	EPA 905 Sr-90
108-56	Semi-annually	EPA 905 Sr-90
098-99	Quarterly	8260 Low Level
098-100	Semi-annually	EPA 905 Sr-90
098-103	Semi-annually	EPA 905 Sr-90
098-104	Semi-annually	EPA 905 Sr-90
108-57	Semi-annually	EPA 905 Sr-90
108-58	Semi-annually	EPA 905 Sr-90
108-59	Semi-annually	EPA 905 Sr-90

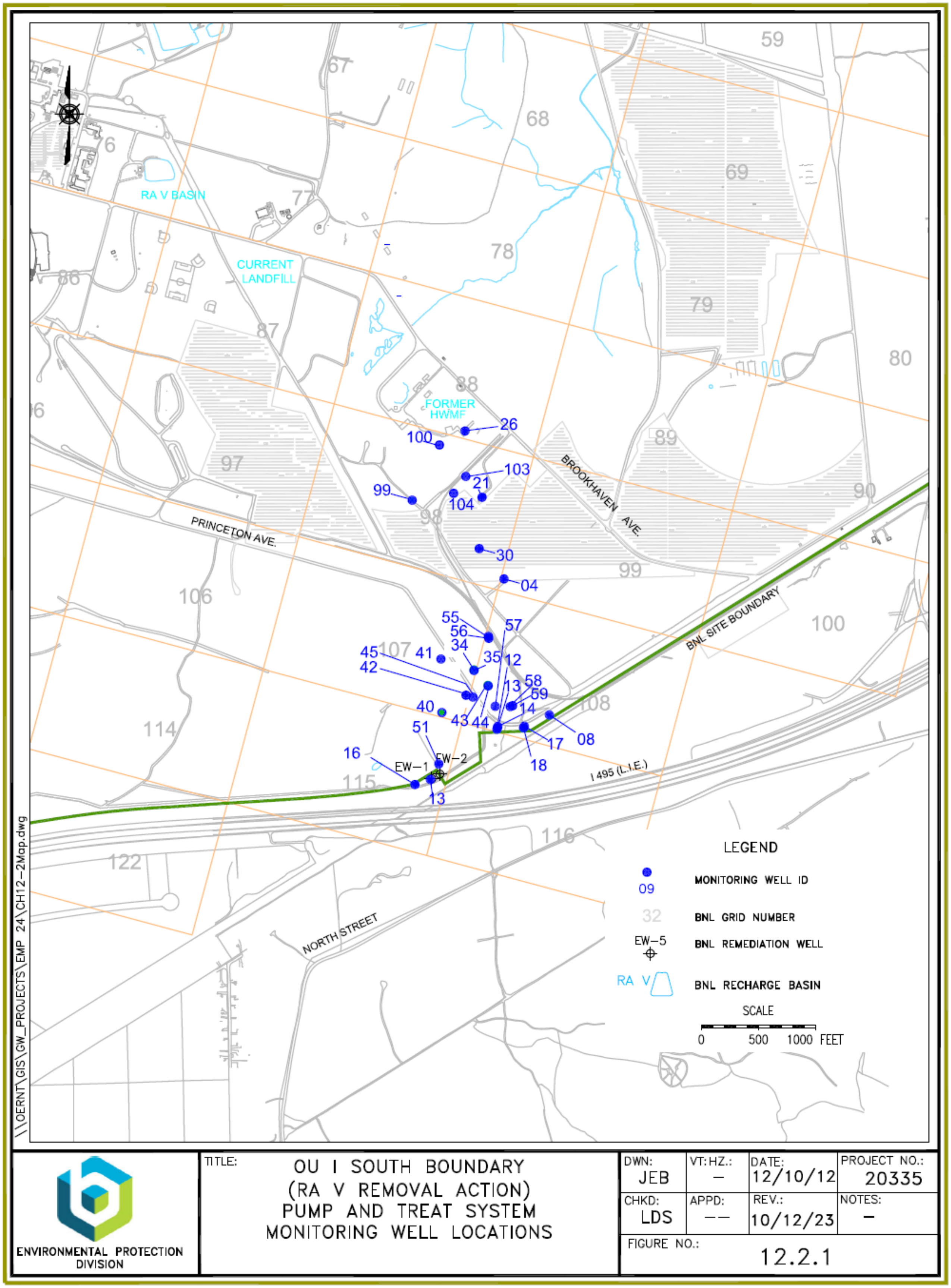

Figure 12-2.1 OU I South Boundary (RA V Removal Action) Pump and Treat System Monitoring Well Locations

See Appendix B for the monitoring program for this Data Quality Objective.

12.3 OU III Building 96 Area

DQO Start Date January 1, 2003

Implementation Date January 1, 2025

Point of Contact Brian Barth (631) 344-2242

Summary of Changes

There are no proposed changes to the OU III Building 96 Area Groundwater Remediation System monitoring program for calendar year (CY) 2025.

Description and Technical Basis

Solvents were historically used at a former vehicle maintenance and drum storage area located immediately west of the Supply and Material area. While no spills were documented in this area, soil and groundwater samples collected during the Operable Unit (OU) III Remedial Investigation contained high concentrations of tetrachloroethylene (PCE) and 1,1,1-trichloroethane (TCA), especially in shallow groundwater. These results indicated that spillage had historically occurred in this area and a narrow plume (approximately 200 feet wide) was defined migrating south from the area of Building 96.

The identified groundwater contamination was addressed by construction of a treatment system consisting of four recirculation wells (RTW-1, -2, -3, and -4). The highest concentrations of VOCs were detected just north of extraction well RTW-1. The remaining three wells (RTW-2, -3, and -4) are further south (downgradient) in an east–west line to intercept the plume migrating south of RTW-1. Well locations are shown on Figure 12.3.1.

Impacted groundwater is extracted through the well's lower screen, treated via air stripping, and recharged through the well's upper screen. Operation of the system began during CY 2001. On July 13, 2004, wells RTW-2, -3, and -4 were placed in standby mode due to reduced VOC concentrations in the plume. The system continued to operate utilizing well RTW-1 only. Influent samples from wells RTW-2, -3, and -4 continued to be collected quarterly. Due to the high concentrations remaining upgradient of extraction well RTW-1, an engineering evaluation of additional treatment technologies was performed as part of the recommendation to place the three downgradient wells in standby. The proposed remedy resulting from the screening process was chemical oxidation by *in situ* permanganate injection.

As of June 2005, all recovery wells were placed in standby mode. However, due to increasing VOC concentrations in a well immediately upgradient, recovery well RTW-1 was turned back on in October 2005. As noted above, RTW-1 was placed in standby mode in June 2006. Due to increasing VOC concentrations, well RTW-2 was restarted in October 2007.

As noted in the 2006 Groundwater Status Report, the continued operation of RTW-1 as a recirculation well may have been causing adverse impacts on the plume. On December 12, 2007, RTW-1 effluent resample results from two different labs indicated hexavalent chromium, or Cr(VI), at 124 µg/L and 131 µg/L. Subsequent data suggest that the most likely cause of the elevated Cr(VI) levels was the treatment of soils with $KMnO_4$. One of the byproducts of the reaction is manganese oxide, which oxidizes trivalent chromium to Cr(VI). It is expected that over time, the Cr(VI) will revert to trivalent chromium (the less toxic form). In May 2008, Well RTW-1 was modified from a recirculation well to a pumping well with hexavalent chromium ion-exchange treatment and discharge to the nearby surface drainage culvert which ultimately discharges to the recharge basin HS south of the Building 96 area. The ion-exchange treatment was approved by the regulators for decommissioning in January 2018 following the decline of hexavalent chromium to levels below the New York State Ambient Water Quality Standard.

The remediation wells were located to intercept the area of greatest contaminant concentrations. Groundwater flow maps indicate that existing contamination currently downgradient of the Building 96 remediation system will be intercepted by OU III Middle Road treatment system extraction wells, which are approximately 1,500 feet downgradient of the Building 96 area. As a result, the Building 96 contamination is not expected to migrate off site.

The monitoring well network for the OU III Building 96 program consists of 35 wells, all of which are screened in the shallow Upper Glacial aquifer. One of the wells (085-378) is upgradient of the former Building 96 source area. The remaining wells are within the plume core and serve to define the lateral extent of the contamination downgradient of the former source area. Well locations are shown in Figure 12.3.1. The monitoring wells are currently sampled quarterly, semi-annually, and annually for analysis of VOCs to monitor the plume configuration and the effectiveness of the remediation system. A monitoring schedule is provided in Table 12.1.1.

DRIVERS FOR MONITORING BEING CONDUCTED UNDER THIS CHANGE

____ Compliance
____ Support Compliance
____ Surveillance
_X_ Restoration

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

The remediation system for the Building 96 VOC plume consists of four recovery wells. Data are needed to verify that this system is reducing the identified contamination according to plan. In 2007, it was determined that the three applications of the oxidizer potassium permanganate performed in 2005 and 2006 were ineffective in addressing the continuing source of VOCs. In 2008, the source of the VOCs was determined to be a localized area of soil contamination above the water table. PCE-contaminated soils were removed from the source area in 2010.

Step 2: Identify the Decisions

The decisions for the project are:

- Is there a continuing source of contamination? If present, has the source area been remediated or controlled?
- Were unexpected levels or types of contamination detected?
- Has the downgradient migration of the plume been controlled?
- Can individual extraction wells or the entire treatment system be shut down or placed in pulse pumping operation?
- Has the groundwater cleanup goal of meeting maximum contaminant levels (MCLs) been achieved?

Step 3: Identify Inputs to the Decision

The project was divided into three decision subunits to reflect the categories of wells for which decisions will be made with respect to the VOC contamination. The identified subunits and the decisions supported by each are:

- Plume core wells (Decisions 1, 2, 4, and 5)
- Plume perimeter wells (Decisions 1, 2, and 5)
- Bypass detection wells (Decisions 2 and 5)

The decision units for each of the wells in the current monitoring network are shown in Table 12.3.1. The inputs necessary for the decision include:

- Direction and velocity of groundwater flow
- Analytical results for VOCs in groundwater
- Locations of existing wells relative to flow patterns (Figure 12.3.1)
- Evaluation of capture zone for extraction wells
- Action levels
- Variability of data

Step 4: Define the Study Boundaries

Section 12.1 details the general sampling frequency based on the phase the monitoring program is in. The decision unit limits for this project are the area being remediated near Building 96, as defined by a perimeter extending approximately 100 feet beyond the groundwater remediation wells. The Building 96 plume becomes commingled with other plumes immediately downgradient of the system.

The potential risk to downgradient receptors from the Building 96 VOC plume was determined to be low based on the following factors:

- Public water hookups have been provided off site.
- This contamination is not within the capture zone of Brookhaven National Laboratory (BNL) supply wells.
- Travel time is approximately 20 years to the BNL site boundary.
- Once the source is addressed, contamination that is not captured by the Building 96 treatment system will be intercepted by the Middle Road treatment systems before reaching the BNL site boundary.

The rate of source removal from the aquifer was expected to be relatively quick, as the treatment system was originally projected to operate for less than three years. The rate of groundwater migration is less than one foot per day. However, there is a continuing source of VOC contamination.

Step 5: Develop the Decision Rules

Decision 1

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

Analytical results from plume core wells will be utilized for this decision. Future sample results will be evaluated in context with historic data for each sampling event. **If** plume core wells located in the source area continue to show elevated levels of contaminants with no decreasing trend, **then** an evaluation of the source area will be conducted to determine if the source should be remediated or controlled.

Decision 2

Were unexpected levels or types of contamination detected?

Analytical results from wells in all three subunits will be utilized for this decision. Future sample results will be evaluated in context with historic data for each sampling event. As part of that evaluation, circumstances that would require implementation of the BNL Groundwater Contingency Plan (Environmental Monitoring Standard Operating Procedure [EM-SOP]-309) would be ascertained for each sampled well. Examples of such circumstances are unusually high contaminant concentrations, detection of previously undetected contaminants, and detection of contaminants in previously “clean” wells.

If conditions dictate, **then** the BNL Groundwater Contingency Plan will be implemented.

Decision 3

Has the downgradient migration of the plume been controlled?

This decision applies to the plume perimeter and sentinel wells. **If** the system is performing as planned, **then** actual VOC concentrations in plume perimeter and sentinel wells will compare well to predicted values, based on model runs. A significant difference between actual and predicted concentrations indicates the need for an evaluation for the reason for the difference.

Decision 4

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

If evaluation of analytical results for any contaminant of concern in any upgradient or plume core well sample, in conjunction with historic analytical results and trends, indicates that one or more treatment system recovery wells have met the shutdown criteria of achieving the cleanup goal by 2030, **then** the well will be shut down or placed in pulse pumping mode.

If evaluation of analytical results for any contaminant of concern in any upgradient or plume core well sample, in conjunction with historic analytical results and trends, indicates that the treatment system has met the shutdown criteria of achieving the cleanup goal by 2030, **then** a petition for shutdown will be issued to the regulatory agencies.

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

If the total VOC concentration in each plume core well has been reduced to less than 50 µg/L, **then** proceed with pulsed operation of the system. **If not, then** continue treatment.

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

This decision is to determine whether there is significant concentration rebound after system pulsing. **If yes**, **then** continue operation. **If yes**, and system has operated for more than ten years, **then** an engineering evaluation should be performed to evaluate whether continued operation of the system is warranted. **If** no significant rebound is observed within a one-year time period, **then** petition for system shutdown and continue with monitored natural attenuation.

Decision 5

Has the groundwater cleanup goal of meeting Maximum Contaminant Level (MCL) been achieved?

If the concentration of VOCs in groundwater is less than MCLs, **then** petition for the end of monitoring. **If not**, **then** continue monitoring.

Step 6: Specify Acceptable Error Tolerances

Table 12.3.1 summarizes the decision and possible decision errors for this project.

Table 12.3.1. Decisions, Potential Decision Errors, and Potential Consequences

Decision	Inputs	Potential Errors Based on Data	Potential Consequences
Was the Contingency Plan triggered?	See Step 3 for inputs.	(1) Trigger Contingency Plan unnecessarily (2) Fail to trigger Contingency Plan when it should have been triggered	(1) Unnecessary administrative process, project delays (2) Lost time in addressing problem, loss of stakeholder confidence
Have the source control objectives been met?	See Step 3 for inputs.	(1) Determine cleanup goals have been met then they are not (2) Fail to determine cleanup goals are met when they are	(1) Delay in making operational adjustments, avoidable growth of plume (2) Wasted resources considering/ implementing operational adjustments

There are no potential receptors immediately downgradient of the Building 96 area and ground-water travel time to the site boundary is approximately 20 years. In addition, groundwater remediation was implemented in this area during 2001, and other remediation systems (OU III Middle Road) are in place downgradient of the Building 96 area.

Due to these factors, it is very unlikely that a decision error will result in adverse consequences to human health. The consequences of decision error relate primarily to possible enforcement actions for environmental degradation, erosion of stakeholder trust and BNL credibility, and potentially wasted resources.

Step 7: Optimize the Design

Number and Locations of Wells

The current sampling program consisting of 34 monitoring wells is sufficient to monitor the OU III Building 96 area.

PARAMETERS AND FREQUENCY

The monitoring wells are sampled monthly, semi-annually, and quarterly for VOCs. Influent and effluent sampling is conducted monthly when the system is in operation. A summary of the 2025 sampling program for this project is provided in Table 12.3.2.

Table 12.3.2. Proposed 2025 Sampling Frequency for the Building 96 Treatment System Monitoring Wells

Well	Sampling Frequency	Parameters
085-293	Annually	8260 Low Level
095-84	Quarterly	8260 Low Level
095-85	Annually	8260 Low Level
095-159	Quarterly	8260 Low Level
095-162	Quarterly	8260 Low Level
095-163	Quarterly	8260 Low Level
095-165	Annually	8260 Low Level
095-166	Annually	8260 Low Level
095-168	Annually	8260 Low Level
095-169	Annually	8260 Low Level
095-170	Annually	8260 Low Level
095-172	Quarterly	8260 Low Level
095-294	Semi-annually	8260 Low Level
095-305	Quarterly	8260 Low Level
095-306	Quarterly	8260 Low Level
095-307	Semi-annually	8260 Low Level
095-308	Semi-annually	8260 Low Level
085-347	Semi-annually	8260 Low Level
085-348	Quarterly	8260 Low Level
085-349	Semi-annually	8260 Low Level
085-350	Semi-annually	8260 Low Level
085-351	Semi-annually	8260 Low Level
085-352	Semi-annually	8260 Low Level
085-354	Semi-annually	8260 Low Level
095-312	Quarterly	8260 Low Level
095-313	Semi-annually	8260 Low Level
095-318	Annually	8260 Low Level
085-378	Quarterly	8260 Low Level
085-379	Quarterly	8260 Low Level
95-325	Quarterly	8260 Low Level
85-386	Semi-annually	8260 Low Level
85-335	Semi-annually	8260 Low Level
85-383	Semi-annually	8260 Low Level
85-382	Semi-annually	8260 Low Level

085-416	Quarterly	8260 Low Level

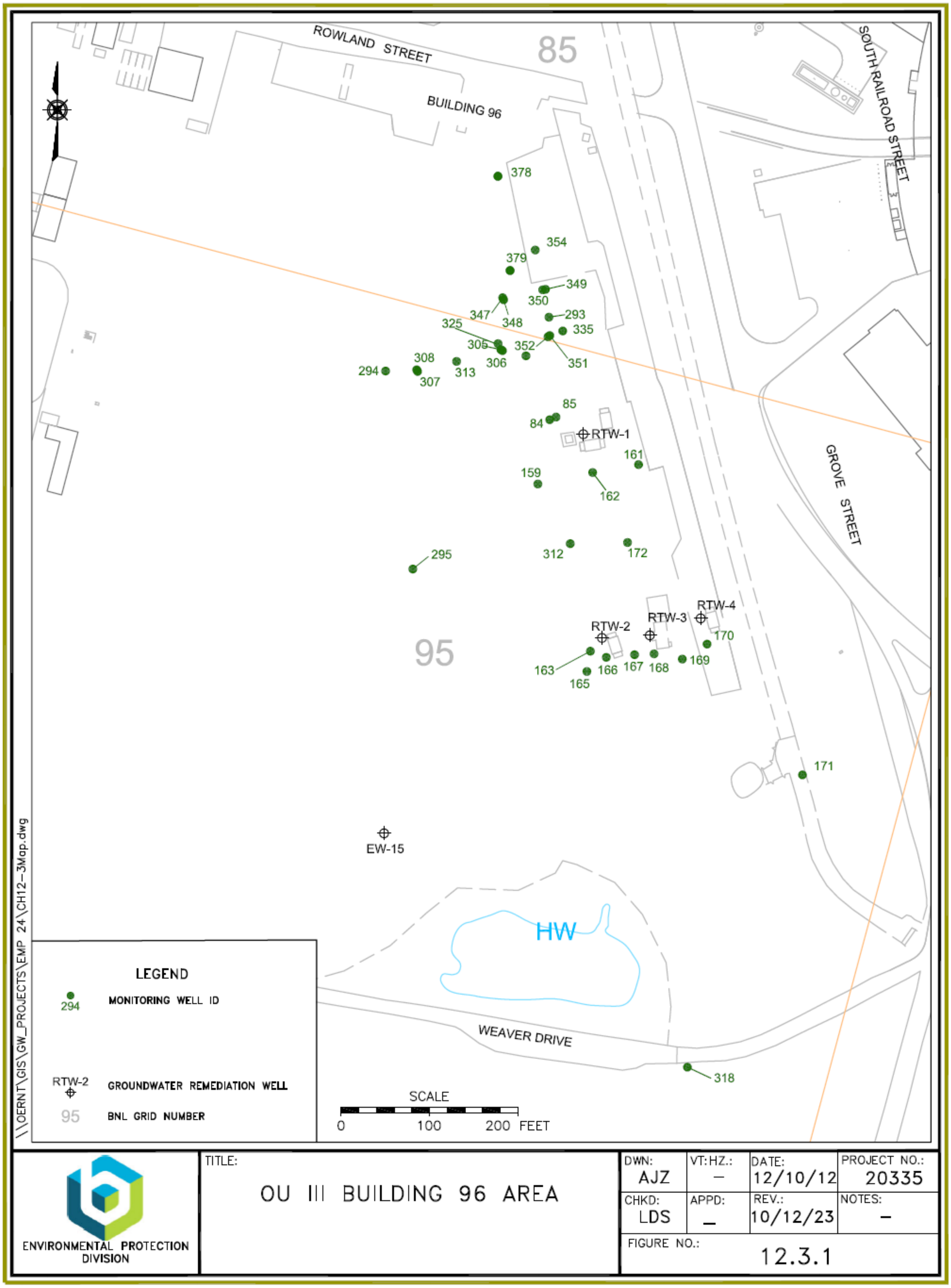

Figure 12-3.1 OU III Building 96 Area

See Appendix B for the monitoring program for this Data Quality Objective.

12.4 OU III MIDDLE ROAD PUMP AND TREAT SYSTEM

DQO START DATE January 1, 2003

IMPLEMENTATION DATE January 1, 2025

POINT OF CONTACT James Milligan (631) 344-4458

SUMMARY OF CHANGES

The proposed change to the OU III Middle Road Pump and Treat System groundwater monitoring program for calendar year 2025:

Remove monitoring well 106-56 from OU III Middle Road monitoring program. This well has not had VOC concentrations above maximum contamination levels (MCL)s in over ten years.
Two additional monitoring wells for VOCs were added during 2024, wells 105-80 and 105-81.

DESCRIPTION AND TECHNICAL BASIS

The OU III Middle Road Pump and Treat system was designed to capture contamination consisting of VOCs in the Upper Glacial aquifer upgradient of the Brookhaven National Laboratory (BNL) south property boundary. It includes seven extraction wells. The newest extraction well (RW-7) was installed and began operations in November 2013 to capture deeper contamination migrating along the western side of the plume. Extracted groundwater is treated via air stripping and recharged upgradient of the plume. The system has been in operation since the fall of 2001. Shallow groundwater flow in this area is toward the south.

As described in the Operation and Maintenance Manual for the Operable Unit (OU) III Middle Road project, the monitoring network includes 34 wells. Well locations are shown in Figure 12.4.1 at the end of this chapter.

A routine operation and maintenance monitoring frequency was implemented in August 2003. Plume core and perimeter wells will be monitored on a semi-annual frequency. Bypass wells will continue to be sampled at a quarterly frequency. Samples will be analyzed for VOCs.

DRIVERS FOR MONITORING BEING CONDUCTED UNDER THIS CHANGE

____ Compliance
____ Support Compliance
____ Surveillance
__X Restoration

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

A VOC plume that could represent a potential risk to human health has been defined on the BNL site. In response, capture and remediation of the plume was implemented in the fall of 2001. Data are needed to verify that the remediation is occurring according to plan.

Step 2: Identify the Decision

The decisions for the project are:

- Is there a continuing source of contamination? If present, has the source area been remediated or controlled?
- Has the downgradient migration of the plume been controlled?
- Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?
- Has the groundwater cleanup goal of meeting maximum contaminant levels (MCLs) been achieved?

Step 3: Identify Inputs to the Decision

The project was divided into three decision subunits to reflect the categories of wells for which decisions will be made with respect to the VOC contamination. The identified subunits and the decisions supported by each are:

- Plume core wells (Decisions 1, 2, and 3)
- Perimeter wells, used to define the extent of the plume (Decisions 2 and 4)
- Bypass detection wells (Decisions 2 and 4)

The inputs necessary for the decisions include:

- Direction and velocity of groundwater flow
- Analytical results for VOCs in groundwater
- Locations of existing wells relative to flow patterns
- Evaluation of capture zone for extraction wells
- Action levels
- Analytical methods and detection limits as described in the BNL Environmental Monitoring Plan (EMP)
- Variability of data

Step 4: Define the Study Boundaries

As currently defined, the spatial boundaries of the study area are:

- Princeton Avenue to the north
- Approximately 500 feet south of Middle Road (wells 113-16, -17, -18, -19, and -20)
- Well 122-33 to the east
- Well 113-08 to the west
- Upper Glacial and upper Magothy aquifers

Separate decisions will be made in the three subunits described in Step 3. However, some of the decisions, such as system performance, are based on the entire study system. As described below, the temporal boundaries of the study area are currently the same for each decision subunit. However, as more data are collected, the timeframe for decisions in a subunit may be modified. Therefore, the subunits have been described separately.

- *Plume Core:* Plume core wells will be used to provide data for measuring the performance of the system. Because the system is in its third year of operation and is in the Operations and Maintenance (O&M) phase, data are needed on a less frequent basis. Therefore, the timeframe for decisions for this subunit is 180 days.

- *Perimeter:* The wells included in this subunit define the plume horizontally and vertically, which is used to determine whether the plume is being captured. Because the system is in its third year of operation and in the O&M phase, data are needed on a less frequent basis. Therefore, the timeframe for decisions for this subunit is 180 days.

- *Bypass Detection Area:* Because the wells in this area indicate whether the plume capture performance objective is being met, the decision timeframe for this area is 90 days.

Step 5: Develop the Decision Rules

Decision 1

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

Analytical results from plume core wells will be utilized for this decision. Future sample results will be evaluated in context with historic data for each sampling event. **If** plume core wells located in the source area continue to show elevated levels of contaminants with no decreasing trend, **then** an evaluation of the source area will be conducted to determine if the source should be remediated or controlled.

Analytical results from wells in all three subunits will be utilized for this decision. Future sample results will be evaluated in context with historic data for each sampling event. As part of that evaluation, circumstances that would require implementation of the BNL Groundwater Contingency Plan (Environmental Monitoring Standard Operating Procedures [EM-SOP]-309) would be ascertained for each sampled well. Examples of such circumstances are unusually high contaminant concentrations, detection of previously undetected contaminants, and detection of contaminants in previously “clean” wells.

If conditions dictate, **then** the BNL Groundwater Contingency Plan will be implemented.

Decision 2

Has the downgradient migration of the plume been controlled?

This decision applies to the perimeter and bypass detection wells. **If** the cleanup goals have not been met, **then** it must be verified that the plume is not growing. Plume growth is defined as an increase in total VOC concentration in perimeter or bypass detection wells to above 50 µg/L (if currently less than 50 µg/L) or a significant increase in total VOC concentration (if currently above 50 µg/L).

Decision 3

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

If evaluation of analytical results for any contaminant of concern in any upgradient or plume core well sample, in conjunction with historic analytical results and trends, indicates that one or more treatment system recovery wells have met the shutdown criteria of achieving the cleanup goal by 2030, **then** the well will be shut down or placed in pulse pumping mode.

If evaluation of analytical results for any contaminant of concern in any upgradient or plume core well sample, in conjunction with historic analytical results and trends, indicates that the treatment system has met the shutdown criteria of achieving the cleanup goal within 30 years, **then** a petition for shutdown will be issued to the regulatory agencies.

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

This decision also applies to the plume core wells. If this occurs, then it is reasonable to expect (based on model projections) that monitored natural attenuation (MNA) of the remaining contamination in the plume core will be reduced further to meet the cleanup goals of restoring the Upper Glacial aquifer to MCLs within 30 years. **If** the TVOC concentration remains above 50 µg/L, **then** consider operational adjustments and/or engineering evaluation.

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

This decision is to determine whether there is significant concentration rebound after system pulsing. **If yes**, **then** continue operation. **If yes,** and system has operated for more than ten years, **then** an engineering evaluation should be performed to evaluate whether continued operation of the system is warranted (see Decision subunit 4d to help with this decision). **If** no significant rebound is observed within one year, **then** petition for system shutdown and continue with MNA.

Decision 4

Has the groundwater cleanup goal of meeting MCLs been achieved?

Analytical results from plume core wells will be utilized for this decision. To meet cleanup goals in the required timeframe (by 2030), groundwater extraction should be continued until plume core wells show total VOC concentrations below 50 µg/L. At that time, the project could be reclassified as MNA.

If the mean concentration of each contaminant of concern in groundwater in each plume core well, computed from measurements over the previous two years, is less than the established cleanup goal for that parameter and the computed mean is consistent with professional judgment, **then** the cleanup goals for this remedial action have been achieved. **If not**, **then** consider the need for continued remediation.

Step 6: Specify Acceptable Error Tolerances

Table 12.4.1 summarizes the decision and possible decision errors for this project.

Table 12.4.1. Decisions, Potential Decision Errors, and Potential Consequences

Decision	Inputs	Potential Errors Based on Data	Potential Consequences
Is the Contingency Plan triggered?	See Step 3 for inputs.	(1) Trigger Contingency Plan unnecessarily. (2) Fail to trigger Contingency Plan when it should have been triggered.	(1) Unnecessary administrative process; project delays (2) Lost time in addressing problem, loss of stakeholder confidence.
Have cleanup goals been met?	See Step 3 for inputs.	(1) Determine cleanup goals have been met then they are not. (2) Fail to determine cleanup goals are met when they are.	(1) Delay in making operational adjustments; avoidable growth of plume. (2) Wasted resources considering/ implementing operational adjustments.
Is plume growth controlled?	See Step 3 for inputs.	(1) Determine plume is controlled when it is not. (2) Determine plume is not controlled when it is.	(1) Premature petition for system shutoff; project delays. (2) Continue remediation longer than necessary; wasted resources.
Is the system performing as planned?	See Step 3 for inputs.	(1) Determine system is performing as planned when it is not. (2) Determine system is not performing as planned when it is.	(1) Delay in making operational adjustments; avoidable growth of plume. (2) Wasted resources considering/ implementing operational adjustments.
Have asymptotic conditions been demonstrated?	See Step 3 for inputs.	(1) Determine asymptotic conditions reached when they are not. (2) Determine asymptotic conditions not reached when they are.	(1) Premature petition for system shutoff; project delays. (2) Continue remediation that is no longer effective.

Step 7: Optimize the Design

Number and Locations of Wells

The current sampling program consists of 34 monitoring wells located near the Middle Road.

Parameters and Frequency

A routine operation and maintenance monitoring frequency was implemented in August 2003. Plume core and perimeter wells are monitored on a semiannual frequency. Bypass wells will continue to be sampled at a quarterly frequency.

A summary of the 2025 sampling program is shown in Table 12.4.2.

Table 12.4.2. Proposed 2025 Sampling Frequency for the Middle Road Project Monitoring Wells

Well ID	Sampling Frequency	Parameters
095-92	Semi-annually	8260 Low Level
104-11	Semi-annually	8260 Low Level
104-36	Semi-annually	8260 Low Level
104-37	Quarterly	8260 Low Level
104-38	Semi-annually	8260 Low Level
105-53	Semi-annually	8260 Low Level
105-66	Quarterly	8260 Low Level
113-17	Quarterly	8260 Low Level
113-18	Annually	8260 Low Level
113-19	Quarterly	8260 Low Level
113-22	Semi-annually	8260 Low Level
114-12	Quarterly	8260 Low Level
105-23	Quarterly	8260 Low Level
105-25	Semi-annually	8260 Low Level
105-42	Semi-annually	8260 Low Level
105-44	Semi-annually	8260 Low Level
113-07	Annually	8260 Low Level
113-08	Semi-annually	8260 Low Level
113-09	Semi-annually	8260 Low Level
113-11	Semi-annually	8260 Low Level
106-58	Semi-annually	8260 Low Level
106-62	Semi-annually	8260 Low Level
121-45	Semi-annually	8260 Low Level
113-29	Quarterly	8260 Low Level
113-30	Quarterly	8260 Low Level
105-67	Quarterly	8260 Low Level
113-31	Quarterly	8260 Low Level
105-68	Quarterly	8260 Low Level
121-54	Quarterly	8260 Low Level
095-322	Quarterly	8260 Low Level
095-323	Quarterly	8260 Low Level
121-53	Quarterly	8260 Low Level
105-80	Quarterly	8260 Low Level
105-81	Quarterly	8260 Low Level

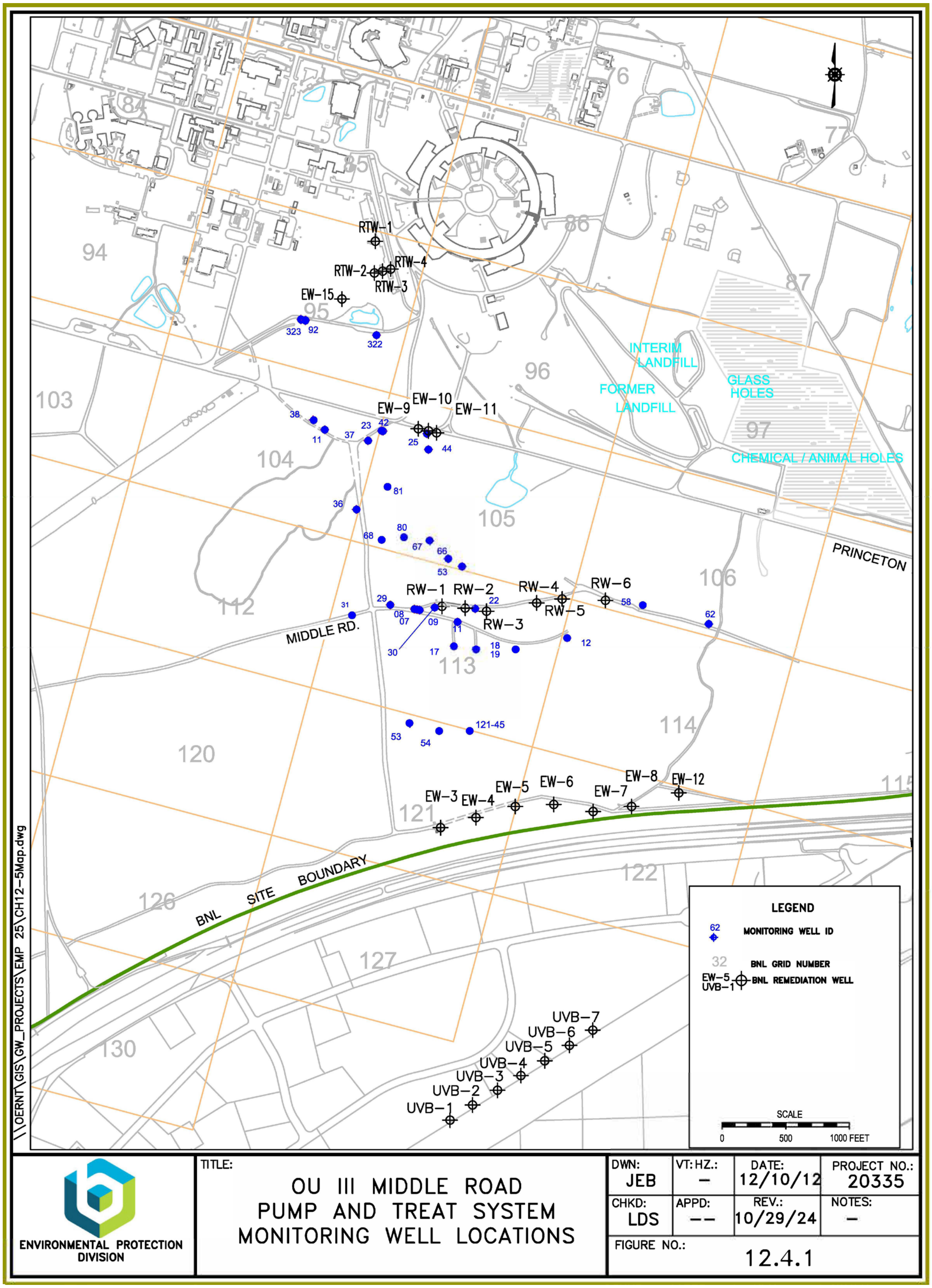

Figure 12.4.1 OU III Middle Road Pump and Treat System Monitoring Well Locations

See Appendix B for the monitoring program for this Data Quality Objective.

12.5 OU III South Boundary Pump and Treat System

DQO Start Date January 1, 2003

Implementation Date January 1, 2025

Point of Contact Brian Barth (631) 344-2242
Vincent Racaniello (631) 344-5436

Summary of Changes

The proposed change for the Operable Unit (OU) III South Boundary Treatment System groundwater monitoring program for calendar year 2025 is to:

Discontinue sampling monitoring wells 114-06, 121-18, 121-21, 122-09, 122-10 and 122-31 from OU III South Boundary monitoring program. These wells have not had VOC concentrations above MCLs in over ten years.
Monitoring well 121-57 for VOCs was added during 2024.

Description and Technical Basis

The OU III South Boundary Pump and Treat System was designed to capture contamination consisting of VOCs in the Upper Glacial aquifer. These systems, working together, are designed to remediate the OU III VOC plume. Some VOC contamination present in the upper portion of the Magothy aquifer has been addressed by the Long Island Power Authority (LIPA) and Industrial Park East off-site systems.

The OU III South Boundary groundwater extraction and treatment system includes eight extraction wells. Extraction well EW-17 was installed during 2013. Extracted groundwater is treated via air stripping and recharged upgradient of the plume. The system has been in operation since 1997. The monitoring network for the OU III South Boundary system includes 28 wells. Well locations are shown in Figure 12.5.1. Currently, the wells are sampled quarterly, semi-annual, and annual for analysis of VOCs, as shown in Table 12.5.2

Drivers for Monitoring Being Conducted Under This Change

____ Compliance
____ Support Compliance
____ Surveillance
_X_ Restoration

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

A VOC plume that could represent a potential risk to human health has been defined on the Brookhaven National Laboratory (BNL) site. In response, capture and remediation of the plume was implemented in the fall of 1997. Data are needed to verify that the remediation is occurring according to plan.

Step 2: Identify the Decisions

The decisions for the project are:

- Were unexpected levels or types of contamination detected?
- Has the downgradient migration of the plume been controlled?
- Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?
- Are total VOC concentrations in plume core wells above or below 50 µg/L?
- Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?
- Has the groundwater cleanup goal of meeting MCLs been achieved?

Step 3: Identify Inputs to the Decision

The project was divided into three decision subunits to reflect the categories of wells for which decisions will be made with respect to the VOC contamination. The identified subunits and the decisions supported by each are:

- Plume core wells (Decisions 1, 2, 3, 4, 5, and 6)
- Perimeter wells, used to define the extent of the plume (Decisions 1, 2, and 6)
- Bypass detection wells (Decisions 2 and 6)

The inputs necessary for the decisions include:

- Direction and velocity of groundwater flow
- Analytical results for VOCs in groundwater
- Locations of existing wells relative to flow patterns
- Evaluation of capture zone for extraction wells
- Action levels
- Variability of data

Step 4: Define the Study Boundaries

As currently defined, the spatial boundaries of the study area are defined by:

- Middle Road to the north
- Long Island Expressway to the south
- Well 122-33 to the east
- Wells 121-06, 121-07, and 121-08 to the west

- Upper Glacial and Magothy aquifers

Separate decisions will be made in the three subunits described in Step 3. However, Section 12.1 details the general sampling frequency based on the phase of the monitoring program.

Step 5: Develop the Decision Rules

Decision 1

Were unexpected levels or types of contamination detected?

Analytical results from wells in all three subunits will be utilized for this decision. Future sample results will be evaluated in context with historic data for each sampling event. As part of that evaluation, circumstances that would require implementation of the BNL Groundwater Contingency Plan (Environmental Monitoring Standard Operating Procedure [EM-SOP]-309) would be ascertained for each sampled well. Examples of such circumstances are unusually high contaminant concentrations, detection of previously undetected contaminants, and detection of contaminants in previously "clean" wells.

If conditions dictate, **then** the BNL Groundwater Contingency Plan will be implemented.

Decision 2

Has the downgradient migration of the plume been controlled?

This decision applies to the perimeter and bypass detection wells. **If** the cleanup goals have not been met, **then** it must be verified that the plume is not growing. Plume growth is defined as an increase in TVOC concentration in plume fringe or bypass detection wells to above 50 μg/L (if currently less than 50 μg/L) or a significant increase in TVOC concentration (if currently above 50 μg/L).

Decision 3

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

If evaluation of analytical results for any contaminant of concern in any upgradient or plume core well sample, in conjunction with historic analytical results and trends, indicates that one or more treatment system recovery wells have met the shutdown criteria of achieving the cleanup goal by 2030, **then** the well will be shut down or placed in pulse pumping mode.

If evaluation of analytical results for any contaminant of concern in any upgradient or plume core well sample, in conjunction with historic analytical results and trends, indicates that the treatment system has met the shutdown criteria of achieving the cleanup goals, **then** a petition for shutdown will be issued to the regulatory agencies.

Decision 4

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

If the total VOC concentration in each plume core well has been reduced to less than 50 µg/L, **then** proceed with pulsed operation of the system. **If not, then** continue treatment.

Decision 5

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

This decision applies to the plume core wells:

If, for each plume core well, the slope of mean concentrations for all contaminants of concern are not different from the previous three years and if subject matter experts on BNL hydrogeology and hydrochemistry concur with the results of the statistical analysis, **then** petition for system closure.

Decision 6

Has the groundwater cleanup goal of meeting MCLs been achieved?

Analytical results from plume core wells will be utilized for this decision. It has been determined that in order to meet cleanup goals in the required timeframe (30 years), groundwater extraction should be continued until plume core wells show TVOC concentrations below 50 µg/L. At that time, the project could be reclassified as Monitored Natural Attenuation.

If the mean concentration of each contaminant of concern in groundwater in each plume core well, computed from measurements over the previous two years, is less than the established cleanup goal for that parameter and the computed mean is consistent with professional judgment, **then** the cleanup goals for this remedial action have been achieved. **If not**, **then** consider the need for continued remediation.

Step 6: Specify Acceptable Error Tolerances

Table 12.5.1 summarizes the decision and possible decision errors for this project.

Table 12.5.1. Decisions, Potential Decision Errors, and Potential Consequences

Decision	Inputs	Potential Errors Based on Data	Potential Consequences
Is the Contingency Plan triggered?	See Step 3 for inputs.	(1) Trigger Contingency Plan unnecessarily. (2) Fail to trigger Contingency Plan when it should have been triggered.	(1) Unnecessary administrative process; project delays. (2) Lost time in addressing problem; loss of stakeholder confidence.
Have cleanup goals been met?	See Step 3 for inputs.	(1) Determine cleanup goals have been met then they are not. (2) Fail to determine cleanup goals are met when they are.	(1) Delay in making operational adjustments; avoidable growth of plume. (2) Wasted resources considering/ implementing operational adjustments.

Decision	Inputs	Potential Errors Based on Data	Potential Consequences
Is plume growth controlled?	See Step 3 for inputs.	(1) Determine plume is controlled when it is not. (2) Determine plume is not controlled when it is.	(1) Premature petition for system shutoff; project delays. (2) Continue remediation longer than necessary; wasted resources.
Is the system performing as planned?	See Step 3 for inputs.	(1) Determine system is performing as planned when it is not. (2) Determine system is not performing as planned when it is.	(1) Delay in making operational adjustments; avoidable growth of plume. (2) Wasted resources considering/ implementing operational adjust-ments.
Have asymptotic conditions been demonstrated?	See Step 3 for inputs.	(1) Determine asymptotic conditions reached when they are not. (2) Determine asymptotic conditions not reached when they are.	(1) Premature petition for system shutoff; project delays. (2) Continue remediation that is no longer effective.

Step 7: Optimize the Design

Number and Locations of Wells

The current sampling program consists of 28 monitoring wells located along the south boundary of the site.

Parameters and Frequency

Plume wells will be monitored on a quarterly, semi-annual, and annual frequency for VOCs. Select wells are analyzed either annually or quarterly for VOCs. These frequencies are based on historic data and proximity to the recovery wells. Monitoring schedule details for 2025 are provided in Table 12.5.2.

Table 12.5.2. Proposed 2025 Sampling Frequency for the South Boundary Monitoring Wells

Well	Sampling Frequency	Parameters
114-07	Annual	8260 Low Level
121-06	Annual	8260 Low Level
121-08	2nd, 3rd, 4th Quarter	8260 Low Level
121-10	Semiannual	8260 Low Level
121-11	Semiannual	8260 Low Level
121-12	Annual	8260 Low Level
121-14	Semiannual	8260 Low Level
121-20	Annual	8260 Low Level
121-23	Annual	8260 Low Level
121-43	Semiannual	8260 Low Level
121-45	Quarterly	8260 Low Level
122-04	Annual	8260 Low Level
122-05	Semiannual	8260 Low Level
122-17	Semiannual	8260 Low Level
122-19	Annual	8260 Low Level
122-20	Annual	8260 Low Level
122-21	Annual	8260 Low Level
122-22	Annual	8260 Low Level
122-32	Annual	8260 Low Level
122-33	Annual	8260 Low Level
122-34	Annual	8260 Low Level
122-35	Annual	8260 Low Level
121-47	Semiannual	8260 Low Level
121-48	Semiannual	8260 Low Level
121-49	Quarterly	8260 Low Level
121-53	Quarterly	8260 Low Level
121-54	Quarterly	8260 Low Level
121-57	Quarterly	8260 Low Level

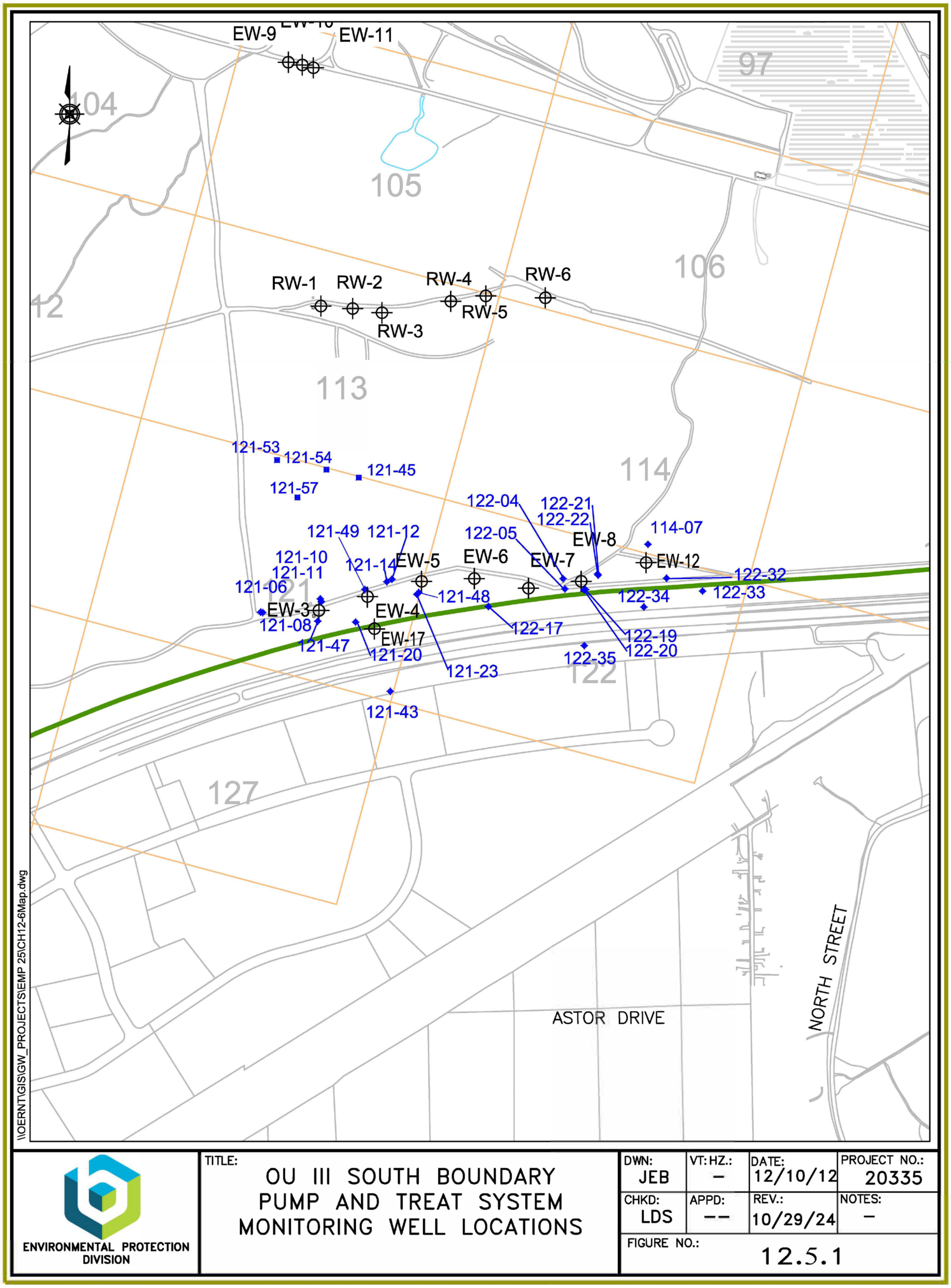

Figure 12.5.1 OU III South Boundary Pump and Treat System Monitoring Well Locations

See Appendix B for the monitoring program for this Data Quality Objective.

12.6 OU III WESTERN SOUTH BOUNDARY PUMP AND TREAT SYSTEM

DQO START DATE January 1, 2003

IMPLEMENTATION DATE January 1, 2025

POINT OF CONTACT Brian Barth (631) 344-2242
Vincent Racaniello (631) 344-5436
James Milligan (631) 344-4458

SUMMARY OF CHANGES

There are no proposed changes to the monitoring program for the Operational Unit (OU) III Western South Boundary Treatment System groundwater monitoring program for calendar year 2025.

DESCRIPTION AND TECHNICAL BASIS

The OU III Western South Boundary Pump and Treat System was designed to capture the higher concentrations of volatile organic compounds (VOCs) in the Upper Glacial aquifer along the western portion of the Brookhaven National Laboratory (BNL) south property boundary. This system captures and remediates a portion of the OU III VOC plume to reduce future off-site migration of the contamination and potential discharge of the VOC plume to the Carmans River.

The OU III Western South Boundary groundwater extraction and treatment system has been operational since May 2002. The system includes two extraction wells along the BNL south property boundary. Extracted groundwater is treated via air stripping and is piped and treated with the MR/SB systems effluent and discharged to the OUIII basins. Groundwater flow in this area is toward the south.

Four new extraction wells were installed in 2019. The four new wells, along with the existing two extraction wells, were connected to the Middle Road/South Boundary treatment system. The existing Western South boundary air stripper was no longer needed and scheduled for decommissioning.

The monitoring network for the OU III Western South Boundary program includes 35 wells. Well locations are shown on Figure 12.6.1. Groundwater samples are collected and analyzed for VOCs on a semi-annual or quarterly basis, as shown in Table 12.1.1.

DRIVERS FOR MONITORING BEING CONDUCTED UNDER THIS CHANGE

____ Compliance
____ Support Compliance
____ Surveillance
_X_ Restoration

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

A VOC plume that could represent a potential risk to human health or the environment (e.g., an off-site sensitive receptor such as the Carmans River) has been defined on the BNL site. In response, capture and remediation of the higher concentrations of VOCs are being implemented along the western site boundary. Data are needed to verify that the remediation is occurring according to plan.

Step 2: Identify the Decision

The decisions for the project include:

- Were unexpected levels or types of contamination detected?
- Has the downgradient migration of the plume been controlled?
- Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?
- Has the groundwater cleanup goal of meeting maximum contaminant levels (MCLs) been achieved?

Step 3: Identify Inputs to the Decision

The project was divided into four decision subunits to reflect the categories of wells for which decisions will be made with respect to the VOC contamination. The identified subunits and the decisions supported by each are:

- Plume core wells (Decisions 1, 2, 3, and 4)
- Perimeter wells, used to define the extent of the plume (Decision 1 and 2)
- Bypass detection wells (Decisions 1 and 2)
- Perimeter (recharge basin) wells (Decisions 1 and 2)

The wells included in each subunit are shown in Table 12.1.2. The inputs necessary for the decisions include:

- Direction and velocity of groundwater flow
- Analytical results for VOCs in groundwater
- Locations of existing wells relative to flow patterns
- Evaluation of capture zone for extraction wells
- Action levels
- Analytical methods and detection limits as described in the BNL Environmental Monitoring Plan (EMP)
- Variability of data

Step 4: Define the Study Boundaries

As currently defined, the spatial boundaries of the study area are defined by:

- Princeton Avenue to the north
- Carleton Drive in North Shirley and wells 000-558, 000-559, and 000-560 to the south
- Unpaved north-south access road and wells 121-042, 127-04, 127-06, and 127-07 to the east

- Western south boundary recharge basin and wells 119-03, 125-01, and 125-02 to the west
- Upper Glacial and upper Magothy aquifers

Section 12.1 details the general sampling frequency based on the phase the monitoring program is in.

Step 5: Develop the Decision Rules

Decision 1

Were unexpected levels or types of contamination detected?

Analytical results from wells in all four subunits will be utilized for this decision. Future sample results will be evaluated in context with historic data for each sampling event. As part of that evaluation, circumstances that would require implementation of the BNL Groundwater Contingency Plan (Environmental Monitoring Standard Operating Procedure [EM-SOP]-309) would be ascertained for each sampled well. Examples of such circumstances are unusually high contaminant concentrations, detection of previously undetected contaminants, and detection of contaminants in previously "clean" wells.

If conditions dictate, **then** the BNL Groundwater Contingency Plan will be implemented.

Decision 2

Has the downgradient migration of the plume been controlled?

This decision applies to the perimeter and bypass detection wells. **If** the cleanup goals have not been met, **then** it must be verified that the plume is not growing. Plume growth is defined as an increase in total VOC concentration in plume fringe or bypass detection wells to above 20 µg/L (if currently less than 20 µg/L) or a significant increase in total VOC concentration (if currently above 20 µg/L).

If the trend in each plume fringe and bypass detection well has a negative slope based on the four most recent consecutive samples, this trend is consistent with professional judgment, and the total VOC concentration is less than 20 µg/L, **then** continue to operate the system. If not, then consider an engineering evaluation or operational adjustments to optimize system operation.

Decision 3

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

If evaluation of analytical results for any contaminant of concern in any upgradient or plume core well sample, in conjunction with historic analytical results and trends, indicates that one or more treatment system recovery wells have met the shutdown criteria of achieving the cleanup goal by 2030, **then** the well will be shut down or placed in pulse pumping mode.

If evaluation of analytical results for any contaminant of concern in any upgradient or plume core well sample, in conjunction with historic analytical results and trends, indicates that the treatment system has met the shutdown criteria of achieving the cleanup goal within 30 years, **then** a petition for shutdown will be issued to the regulatory agencies.

3a. Are TVOC concentrations in plume core wells above or below 20 ug/L?
This decision also applies to the plume core wells. It is anticipated that approximately seven to ten years of active groundwater treatment will reduce the mean total volatile organic compound (TVOC) concentrations in the plume core to less than 20 µg/L.

If this occurs, **then** it is reasonable to expect (based on model projections) that monitored natural attenuation (MNA) of the remaining contamination in the plume core will be reduced further to meet the cleanup goals of restoring the Upper Glacial aquifer to MCLs within 30 years. **If** the TVOC concentration remains above 20 µg/L, **then** consider operational adjustments and/or engineering evaluation.

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

This decision is to determine whether there is significant concentration rebound after system pulsing. **If yes**, **then** continue operation. **If yes**, and system has operated for more than ten years, **then** an engineering evaluation should be performed to evaluate whether continued operation of the system is warranted. **If** no significant rebound is observed within a one-year time period, **then** petition for system shutdown and continue with MNA.

Decision 4

Has the groundwater cleanup goal of meeting MCLs been achieved?

If the mean concentration of TVOCs in groundwater, calculated from analytical results from all plume core wells for the most recent sampling event, is less than 50 µg/L, and if the mean TVOC concentration of each contaminant of concern in groundwater in each plume core well, computed from measurements over the previous two years, is less than 20 µg/L, and pulsing of the remediation system has not resulted in significant rebound of contaminant concentrations, **then** petition for system shutdown and continue with MNA until MCLs are met. **If not**, **then** consider the need for continued remediation. Note: This assumes that system operation is already considered “optimal.”

Step 6: Specify Acceptable Error Tolerances

Table 12.6.1 summarizes the decision and possible decision errors for this project.

Table 12.6.1. Decisions, Potential Decision Errors, and Potential Consequences

Decision	Inputs	Potential Errors Based on Data	Potential Consequences
Is the Contingency Plan triggered?	See Step 3 for inputs.	(1) Trigger Contingency Plan unnecessarily. (2) Fail to trigger Contingency Plan when it should have been triggered.	(1) Unnecessary administrative process, project delays (2) Lost time in addressing problem, loss of stakeholder confidence.
Is the system performing as planned?	See Step 3 for inputs.	(1) Determine system is performing as planned when it is not. (2) Determine system is not performing as planned when it is.	(1) Delay in making operational adjustments, avoidable growth of plume. (2) Wasted resources considering/ implementing operational adjustments.
Have asymptotic conditions been demonstrated?	See Step 3 for inputs.	(1) Determine asymptotic conditions reached when they are not. (2) Determine asymptotic conditions not reached when they are.	(1) Premature petition for system shutoff, project delays. (2) Continue remediation that is no longer effective.

Step 7: Optimize the Design

Number and Locations of Wells

The groundwater monitoring program for the Western South Boundary Pump and Treat System contains 35 monitoring wells.

Parameters and Frequency

A summary of the proposed 2025 sampling program for this project is shown in Table 12.6.2.

Table 12.6.2. Proposed 2025 Sampling Frequency for the Western South Boundary Monitoring Wells

Well ID	Sampling Frequency	Parameters
119-06	Quarterly	8260 Low Level
103-15	Quarterly	8260 Low Level
121-42	Semi-annual	8260 Low Level
126-01	Annual	8260 Low Level
130-02	Semi-annual	8260 Low Level
130-03	Semi-annual	8260 Low Level
130-04	Annual	8260 Low Level
126-11	Semi-annual	8260 Low Level
126-15	Semi-annual	8260 Low Level
127-04	Semi-annual	8260 Low Level
126-13	Semi-annual	8260 Low Level
126-14	Quarterly	8260 Low Level
127-06	Semi-annual	8260 Low Level
127-07	Quarterly	8260 Low Level
126-16	Quarterly	8260 Low Level
130-08	Quarterly	8260 Low Level
126-17	Quarterly	8260 Low Level
119-10	Quarterly	8260 Low Level
119-11	Quarterly	8260 Low Level
111-15	Quarterly	8260 Low Level
126-18	Quarterly	8260 Low Level
126-19	Quarterly	8260 Low Level
103-18	Quarterly	8260 Low Level
103-19	Quarterly	8260 Low Level
126-20	Quarterly	8260 Low Level
000-558	Quarterly	8260 Low Level
000-559	Quarterly	8260 Low Level
000-560	Quarterly	8260 Low Level
111-16	Quarterly	8260 Low Level
119-12	Quarterly	8260 Low Level
126-21	Quarterly	8260 Low Level
130-14	Quarterly	8260 Low Level
130-09	Quarterly	8260 Low Level
130-10	Quarterly	8260 Low Level
130-11	Quarterly	8260 Low Level

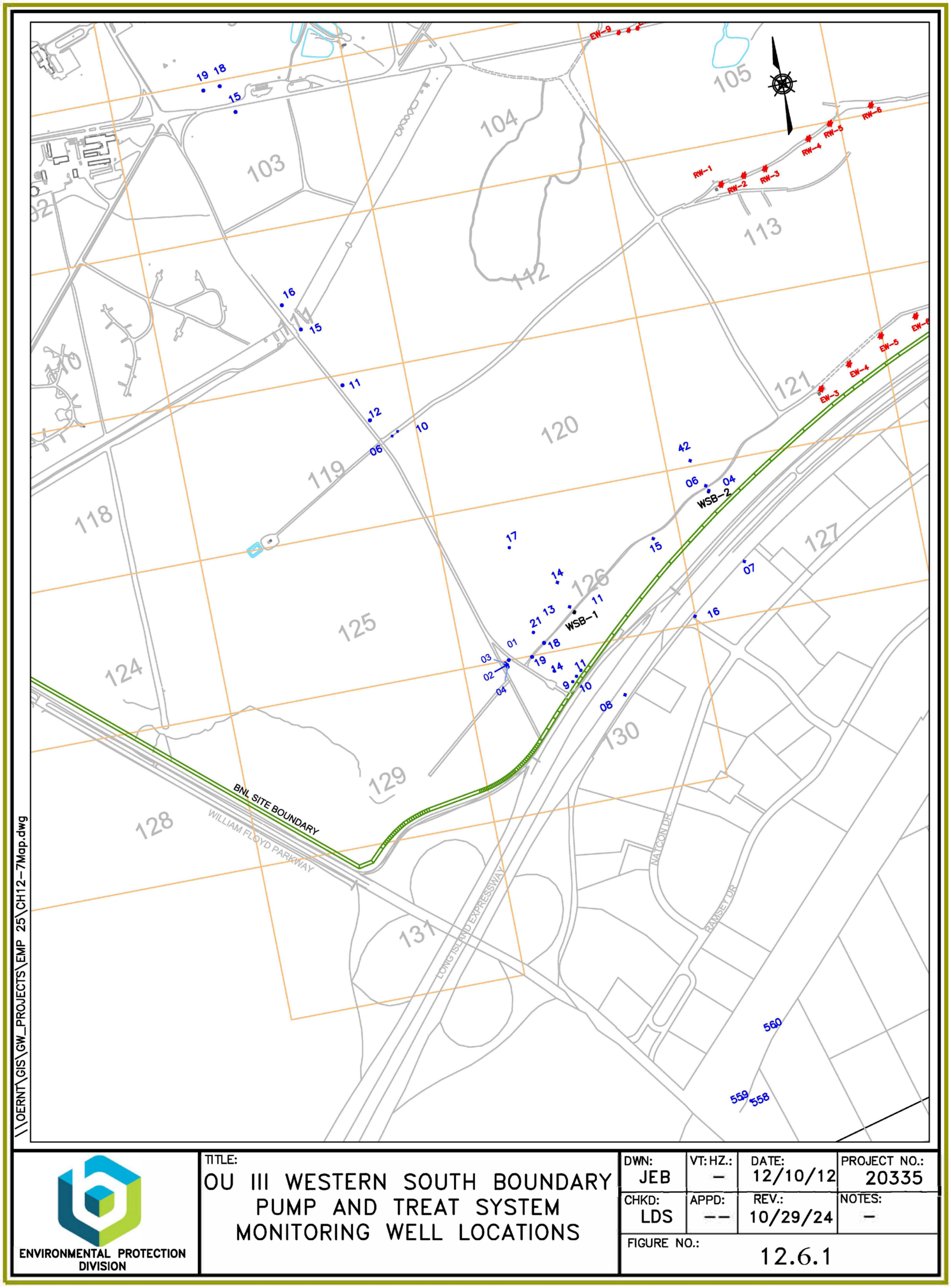

Figure 12.6.1 OU III Western South Boundary Pump and Treat Monitoring Well Locations

See Appendix B for the monitoring program for this Data Quality Objective.

12.7 OU III INDUSTRIAL PARK

DQO START DATE January 1, 2003

IMPLEMENTATION DATE January 1, 2025

POINT OF CONTACT Brian Barth (631) 344-2242
Vincent Racaniello (631) 344-5436

SUMMARY OF PROPOSED CHANGES

There are no changes for calendar year 2025 for the Industrial Park In-Well Air Stripping System groundwater monitoring program. Based upon the concentration trends in both the monitoring and extraction wells it is anticipated that this system will have achieved its cleanup goals by the end of 2024 and a Petition for Shutdown will be submitted in 2025.

DESCRIPTION AND TECHNICAL BASIS

The sources for the volatile organic compounds (VOC) plumes addressed by the Operational Unit (OU) III Industrial Park program are located within the developed central areas of the Brookhaven National Laboratory (BNL) site. Due to the proximity of the plume source areas and variability in groundwater flow direction near the source areas, the plumes are commingled south of the BNL site boundary.

A portion of the commingled VOC plume migrated beyond the BNL site boundary prior to construction and operation of the OU III South Boundary groundwater extraction and treatment system. In response, the seven in-well air stripping treatment wells that comprise the OU III Industrial Park System were constructed within the Industrial Park, located south of the west-central portion of the BNL southern site boundary. This system was constructed to provide hydraulic control to prevent further downgradient migration of the VOC plume and to remediate the portion of the plume with a concentration of total VOCs (TVOC) above 50 µg/L in the deep Upper Glacial aquifer. The system has been operating since December 1999. During 2014, two new groundwater extraction wells were installed in the Industrial Park. These wells became operational in January 2015. The wells are screened deeper than the adjacent wells to capture deeper VOC contamination identified just upgradient of this area. Currently, all extraction wells are in stand-by mode based on TVOC concentrations remaining below the capture goals in the area.

The monitoring well network for the OU III Industrial Park project consists of 40 wells. These wells monitor the VOC plume near the Industrial Park, as well as the effectiveness of the seven in-well groundwater treatment systems. The contaminants of concern associated with the OU III Industrial Park are VOCs.

Well locations are shown in Figure 12.7.1.

DRIVERS FOR MONITORING BEING CONDUCTED UNDER THIS CHANGE

____ Compliance
____ Support Compliance

____ Surveillance
_X_ Restoration

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

A VOC plume that could represent a potential risk to human health or the environment has been defined south of the BNL site. In response, remediation of the plume has been ongoing since September 1999. Data are needed to verify the effectiveness of the remediation.

Step 2: Identify the Decision

The decisions for the project are:

- Were unexpected levels or types of contamination detected?
- Has the downgradient migration of the plume been controlled?
- Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?
- Are TVOC concentrations in plume core wells above or below 50 ug/L?
- Is there a significant concentration rebound in core wells and/or extraction wells following shutdown?
- Has the groundwater cleanup goal of meeting maximum contaminant levels (MCLs) been achieved?

Step 3: Identify Inputs to the Decision

The project is divided into four decision subunits to reflect the categories of wells for which decisions will be made with respect to the VOC contamination. The identified subunits and the decisions supported by each are:

- Plume core wells (Decisions 1, 2, 3, 4, 5, and 6)
- Plume perimeter wells, used to define the extent of the plume (Decisions 1, 2, and 6)
- Bypass detection wells (Decisions 1, 2, and 6)
- Magothy (Decision 1, 2, and 6)

The inputs necessary for the decisions include:

- Direction and velocity of groundwater flow
- Analytical results for VOCs in groundwater
- Location of existing wells relative to flow patterns (Figure 12.7.1)
- Evaluation of capture zone for extraction wells
- Action levels
- Analytical methods and detection limits as described in the BNL Environmental Monitoring Plan (EMP)
- Variability of data

Step 4: Define the Study Boundaries

As currently defined, the spatial boundaries of the study area are defined by the following:

- Long Island Expressway to the north
- Carleton Drive to the south
- Boxwood Drive (well 000-272) to the east
- Lockwood Drive (well 000-245) to the west
- Upper Glacial aquifer
- Upper section of the Magothy aquifer

Section 12.1 details the general sampling frequency based on the phase the monitoring program is in.

Step 5: Develop the Decision Rules

Decision 1

Were unexpected levels or types of contamination detected?

Analytical results from wells in all subunits are utilized for this decision. Sample results are evaluated in context with historic data for each sampling event. As part of that evaluation, circumstances that would require implementation of the BNL Groundwater Contingency Plan (Environmental Monitoring Standard Operating Procedure [EM-SOP]-309) would be ascertained for each sampled well. Examples of such circumstances are unusually high contaminant concentrations, detection of previously undetected contaminants, and detection of contaminants in previously “clean” wells.

If conditions dictate, **then** the BNL Groundwater Contingency Plan will be implemented.

Decision 2

Has the downgradient migration of the plume been controlled?

This decision applies to the plume fringe and bypass detection wells. **If** the cleanup goals have not been met, **then** it must be verified that the plume is not growing. Plume growth is defined as an increase in TVOC concentration in plume fringe or bypass detection wells to above 50 μg/L (if currently less than 50 μg/L) or a significant increase in TVOC concentration (if currently above 50 μg/L).

If the trend in each plume perimeter and bypass detection well has a negative or zero slope, based on the four most recent consecutive samples, this trend is consistent with professional judgment, and the total VOC concentration is less than 50 μg/L, **then** continue to operate the system. If not, then consider an engineering evaluation or operational adjustments to optimize system operation.

Decision 3

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

If the TVOC concentration in each plume core well has been reduced to less than 50 μg/L, **then** proceed with pulsed operation of the system. **If not**, **then** continue treatment. **If not** and treatment has occurred for at least seven to ten years, **then** perform an engineering evaluation to predict the fate of the remaining contamination and determine whether Maximum Contaminant Levels (MCL) will be met by 2030.

Decision 4

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

In order to shut down the treatment system, the shutdown criteria of reaching less than 50 µg/L TVOC for at least four consecutive sampling rounds must be met in the core monitoring and extraction wells.

Decision 5

Is there a significant concentration rebound in core wells and/or extraction wells following shut-down?

If there is significant concentration rebound after system has been shut down completely or entered pulse pumping mode, **then** continue operation. **If yes**, and system has operated for more than seven to ten years, **then** an engineering evaluation should be performed to evaluate whether continued operation of the system is warranted (see Decision subunit 4d. to help with this decision). **If no**, significant rebound is observed within a one-year time period, **then** petition for system shutdown and continue with Monitored Natural Attenuation (MNA).

Decision 6

Has the groundwater cleanup goal of meeting MCLs been achieved?

If the concentration of VOCs in groundwater is less than MCLs, **then** petition for sampling to be discontinued. **If not**, **then** continue monitoring.

Step 6: Specify Acceptable Error Tolerances

Table 12.7.1 summarizes the decision and possible decision errors for this project.

Table 12.7.1. Decisions, Potential Decision Errors, and Potential Consequences

Decision	Inputs	Potential Errors Based on Data	Potential Consequences
Is the Contingency Plan triggered?	See Step 3 for inputs.	(1) Trigger Contingency Plan unnecessarily. (2) Fail to trigger Contingency Plan when it should have been triggered.	(1) Unnecessary administrative process; project delays. (2) Lost time in addressing problem, loss of stakeholder confidence.
Have cleanup goals been met?	See Step 3 for inputs.	(1) Determine cleanup goals have been met then they are not. (2) Fail to determine cleanup goals are met when they are.	(1) Delay in making operational adjustments; avoidable growth of plume. (2) Wasted resources considering/ implementing operational adjustments.
Is plume growth controlled?	See Step 3 for inputs.	(1) Determine plume is controlled when it is not. (2) Determine plume is not controlled when it is.	(1) Premature petition for system shutoff; project delays. (2) Continue remediation longer than necessary, wasted resources.
Is the system performing as planned?	See Step 3 for inputs.	(1) Determine system is performing as planned when it is not. (2) Determine system is not performing as planned when it is.	(1) Delay in making operational adjustments; avoidable growth of plume. (2) Wasted resources considering/ implementing operational adjustments.
Have asymptotic conditions been demonstrated?	See Step 3 for inputs.	(1) Determine asymptotic conditions reached when they are not. (2) Determine asymptotic conditions not reached when they are.	(1) Premature petition for system shutoff; project delays. (2) Continue remediation that is no longer effective.

Step 7: Optimize the Design

Number and Locations of Wells

The groundwater monitoring program for the III Industrial Park In-Well Air Stripping System contains 40 monitoring wells. Well locations are provided in Figure 12.7-1.

Parameters and Frequency

A summary of the proposed 2025 sampling program for this project is provided in Table 12.7.2.

Table 12.7.2. Proposed 2025 Sampling Frequency for the Industrial Park Project Monitoring Wells

Well	Sampling Frequency	Parameters
000-112	Semi-annually	8260 Low Level
000-114	Annually	8260 Low Level
000-245	Annually	8260 Low Level
000-248	Annually	8260 Low Level
000-249	Semi-annually	8260 Low Level
000-250	Annually	8260 Low Level
000-252	Annually	8260 Low Level
000-253	Semi-annually	8260 Low Level
000-255	Annually	8260 Low Level
000-256	Semi-annually	8260 Low Level
000-259	Semi-annually	8260 Low Level
000-261	Annually	8260 Low Level
000-262	Semi-annually	8260 Low Level
000-265	Semi-annually	8260 Low Level
000-267	Annually	8260 Low Level

000-268	Semi-annually	8260 Low Level
000-271	Semi-annually	8260 Low Level
000-272	Annually	8260 Low Level
000-273	Semi-annually	8260 Low Level
000-274	Semi-annually	8260 Low Level
000-275	Semi-annually	8260 Low Level
000-276	Semi-annually	8260 Low Level
000-277	Semi-annually	8260 Low Level
000-278	Semi-annually	8260 Low Level
000-279	Semi-annually	8260 Low Level
000-431	Semi-annually	8260 Low Level
000-432	Semi-annually	8260 Low Level
000-530	Quarterly	8260 Low Level
000-531	Quarterly	8260 Low Level
000-529	Quarterly	8260 Low Level
000-528	Semi-annually	8260 Low Level
000-537	Quarterly	8260 Low Level
000-538	Quarterly	8260 Low Level
127-08	Quarterly	8260 Low Level
127-09	Semi-annually	8260 Low Level
000-541	Quarterly	8260 Low Level
000-542	Semi-annually	8260 Low Level
000-543	Semi-annually	8260 Low Level
000-544	Semi-annually	8260 Low Level
000-548	Quarterly	8260 Low Level

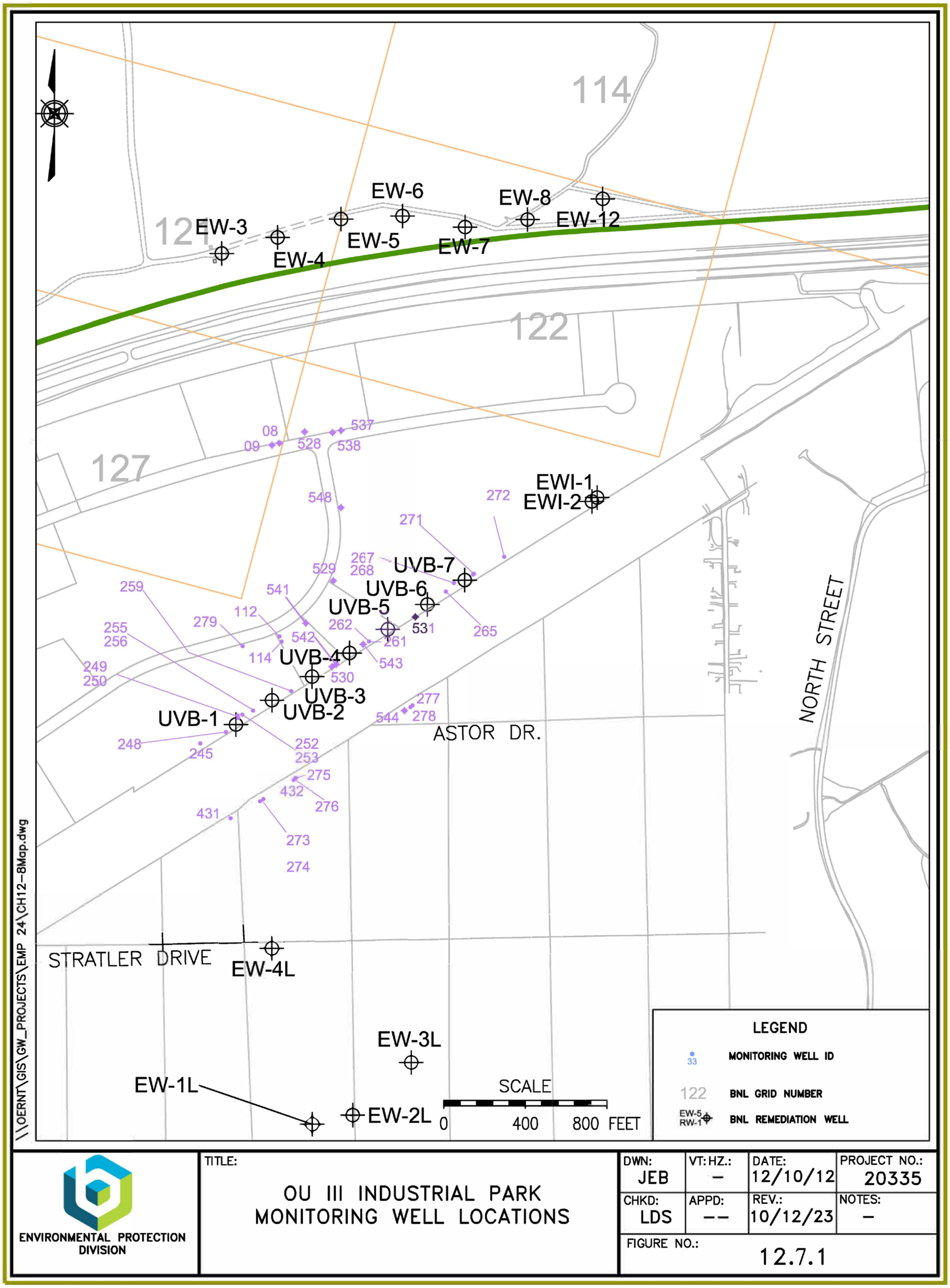

Figure 12.7.1 OU III Industrial Park Monitoring Well Locations

See Appendix B for the monitoring program for this Data Quality Objective.

12.8 OU III NORTH STREET

DQO START DATE January 1, 2003

IMPLEMENTATION DATE January 1, 2025

POINT OF CONTACT Brian Barth (631) 344-2242
Vincent Racaniello (631) 344-5436

SUMMARY OF CHANGES

There are no new changes proposed for the Operational Unit (OU) III North Street Post-Closure groundwater monitoring program for calendar year (CY) 2025.

Due to the system having met its cleanup goals, a Petition for Closure for the North Street Pump and Treat System and groundwater monitoring program was submitted and approved in CY 2019. Seven of the core monitoring wells will be sampled annually for volatile organic compounds (VOCs) until results for individual VOCs are consistently below Maximum Contaminant Levels (MCL). Sampling of the other monitoring wells will be discontinued but the wells will be retained until the completion of the per- and polyfluoroalkyl substances (PFAS) and 1,4-dioxane characterization as per regulatory guidance.

DESCRIPTION AND TECHNICAL BASIS

The OU III North Street project monitors the downgradient extent of commingled contaminant plumes from several sources, including the Former Landfill, Chemical/Animal Holes, and the OU IV fuel oil/solvent spill. A groundwater remediation system began full operation in 2004. Groundwater treatment consists of two extraction wells operating at a combined pumping rate of 450 gallons per minute. This pumping captured the higher concentration portion of the VOC plume (i.e., total VOC concentrations greater than 50 micrograms/liter [µg/L]) in the Upper Glacial aquifer and minimized the potential for VOC migration into the Magothy aquifer.

The monitoring well network for the North Street project presently consists of seven wells. Well locations are shown on Figure 12.8.1. The wells are sampled annually for analysis of VOCs. A monitoring schedule is provided in Table 12.1.1.

The primary VOCs associated with this plume are carbon tetrachloride, tetrachloroethylene, and trichloroethane. Total VOC (TVOC) concentrations greater than 1,000 µg/L were observed in 1997 and 1998 but have steadily declined since then.

DRIVERS FOR MONITORING BEING CONDUCTED UNDER THIS CHANGE

____ Compliance
____ Support Compliance
____ Surveillance
_X_ Restoration

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

Groundwater in the south-central portion of the Brookhaven National Laboratory (BNL) site and off site has been impacted by VOCs at concentrations exceeding New York State groundwater standards. Monitoring data are needed to verify the effectiveness of the treatment system and attenuation of the VOC contaminants.

Step 2: Identify the Decision

The decisions for the project are:

- Are unexpected levels or types of contamination detected?
- Has the downgradient migration of the plume been controlled?
- Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?
- Have the groundwater cleanup goals been achieved?

Step 3: Identify Inputs to the Decision

The inputs necessary for the decision include:

- Direction and velocity of groundwater flow
- VOC and radionuclide analytical results in groundwater
- Locations of existing wells relative to flow patterns
- Action levels (New York State groundwater standards and/or baseline groundwater concentrations)
- Analytical methods and detection limits

Step 4: Define the Study Boundaries

The project decision unit limits are:

- Background water quality is defined by the three monitored wells upgradient of the plume core wells (086-05, 086-43, and 086-70).

- The VOC plume core is defined as the area impacted by TVOCs above 50 μg/L, including wells 000-108, 000-153, 000-154, 000-212, 000-463, 000-464, 000-465, 000-467, 000-470, 000-472, and 115-32.

- The VOC plume fringe is the area surrounding the plume core (horizontally and vertically) where TVOC concentrations are less than 50 μg/L.

Section 12.1 details the general sampling frequency based on the phase of the monitoring pro- gram. Because the VOC contaminant plume has already passed the southern BNL site boundary and therefore has the potential to impact off-site receptors, tracking the plume configuration over time is of critical importance. Since the analytical results from the plume core and plume fringe wells are used to monitor the VOC plume configuration, the timeframe for decisions using these results is 90 days.

Step 5: Develop the Decision Rules

Decision 1

Were unexpected levels or types of contamination detected?

For each future sampling event, sample results will be evaluated in context with historic data. As part of that evaluation, circumstances that would require implementation of the BNL Groundwater Contingency Plan (Environmental Monitoring Standard Operating Procedure [EM-SOP]-309) would be ascertained for each sampled well. Examples of such circumstances are unusually high contaminant concentrations, detection of previously undetected contaminants, and detection of contaminants in previously "clean" wells. **If** conditions dictate, **then** the BNL Groundwater Contingency Plan will be implemented.

Decision 2

Has the downgradient migration of the plume been controlled?

If the cleanup goals have not been met, **then** it must be verified that the plume is not growing. Plume growth is defined as an increase in TVOC concentration in plume perimeter or bypass detection wells to above 50 µg/L (if currently less than 50 µg/l) or a significant increase in TVOC concentration (if currently above 50 µg/L).

If the TVOC concentration trend in each plume perimeter and bypass detection well has a negative or zero slope, based on the four most recent consecutive samples, this is consistent with professional judgment, and the TVOC concentration is less than 50 µg/L, **then** continue to operate the system. **If not**, **then** consider an engineering evaluation or operational adjustments to optimize system operation.

Decision 3

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

In order to shut down the treatment system, the shutdown criteria of reaching less than 50 µg/L TVOCs for at least four consecutive sampling rounds must be met in the core monitoring and extraction wells.

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

If the TVOC concentration in each plume core well has been reduced to less than 50 µg/L, **then** proceed with pulsed operation of the system. **If not**, **then** continue full time treatment. **If not**, and treatment has occurred for at least ten years, **then** consider performing an evaluation to predict the fate of the remaining contamination and determine whether MCLs will be met by 2030.

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

This decision is to determine whether there is significant concentration rebound after system has been shut down completely or entered pulse pumping mode. **If yes**, **then** continue operation. **If yes**, and system has operated for more than ten years, **then** an engineering evaluation should be performed to evaluate whether continued operation of the system is warranted (see Decision subunit 4d. to help with this decision). **If no**, and significant rebound is observed within a one-year time period, **then** petition for system shutdown and continue with Monitored Natural Attenuation (MNA).

Decision 4

Has the groundwater cleanup goal of meeting MCLs been achieved?

If the concentration of VOCs in groundwater are less than MCLs, **then** petition for the end of monitoring. **If not**, **then** continue monitoring.

Step 6: Specify Acceptable Error Tolerances

Table 12.8.1 summarizes the decision and possible decision errors for this project.

Table 12.8.1. Decisions, Potential Decision Errors, and Potential Consequences

Decision	Inputs	Potential Errors Based on Data	Potential Consequences
Is the BNL Groundwater Contingency Plan triggered?	See Step 3 for inputs.	(1) Trigger Contingency Plan unnecessarily. (2) Fail to trigger Contingency Plan when it should have been triggered.	(1) Unnecessary administrative process, project delays. (2) Lost time in addressing problem, loss of stakeholder confidence.
Does the existing contaminant plume represent a potential risk to downgradient receptors?	See Step 3 for inputs.	(1) Data indicate the plume represents a risk when it does not. (2) Data indicate the plume does not represent a risk when it does.	(1) Wasted resources conducting technical evaluations and possible system modifications. (2) Potential risk to downgradient receptors.
Is the remediation system adequate to intercept and treat the existing contamination to prevent impacts to potential downgradient receptors?	See Step 3 for inputs.	(1) Data indicate the system is not adequate when it will be. (2) Data indicate the system is adequate when it will not be.	(1) Wasted resources conducting technical evaluations and possible system modifications. (2) Potential bypass of contaminants.
Are there off-site radionuclides that would trigger additional actions?	See Step 3 for inputs.	(1) Data indicate evidence for a plume when one does not exist. (2) Data indicate no evidence for a plume when one exists.	(1) Wasted resources evaluating and implementing additional actions. (2) Potential risk to downgradient receptors.

Step 7: Optimize the Design

Number and Locations of Wells

The well network consists of seven wells located both on and off site. The location of the wells is shown in Figure 12.8-1.

Parameters and Frequency

A summary of the 2025 sampling program is provided in Table 12.8.2.

Table 12.8.2. Proposed 2025 Sampling Schedule for the OU III North Street Monitoring Wells

Well	Sampling Frequency	Parameters
000-108	Annual	8260 Low Level
000-154	Annual	8260 Low Level
000-212	Annual	8260 Low Level
000-343	Annual	8260 Low Level
000-465	Annual	8260 Low Level
000-472	Annual	8260 Low Level
000-474	Annual	8260 Low Level

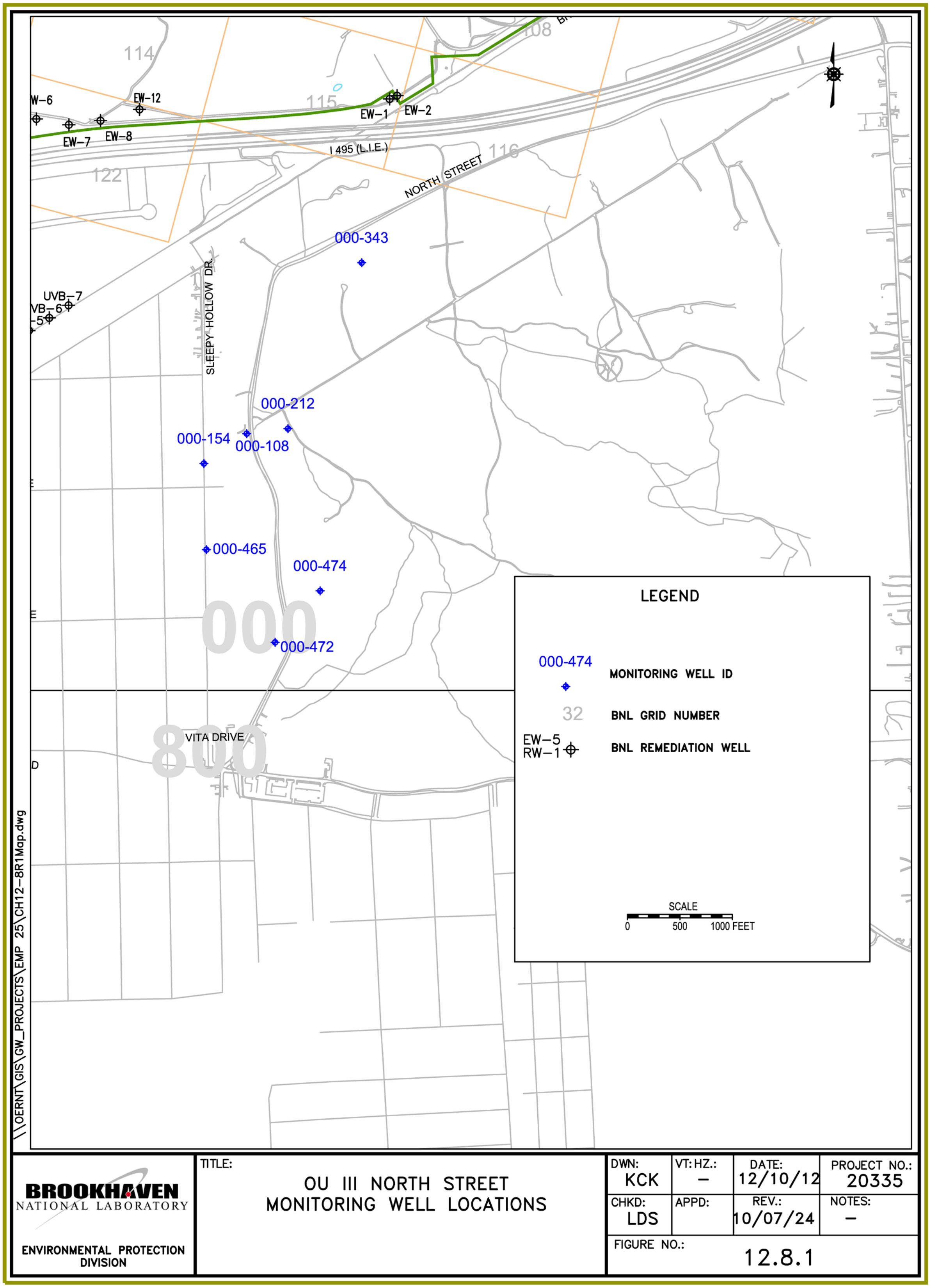

Figure 12.8.1 OU II North Street Monitoring Well Locations

See Appendix B for the monitoring program for this Data Quality Objective.

Intentionally Left Blank

12.9 OU III NORTH STREET EAST

DQO START DATE January 1, 2003

IMPLEMENTATION DATE January 1, 2025

POINT OF CONTACT Brian Barth (631) 344-2242
Vincent Racaniello (631) 344-5436

SUMMARY OF CHANGES

There are no proposed changes to the Operable Unit (OU) III North Street East groundwater remediation system groundwater monitoring program for calendar year 2025.

Maintain quarterly sampling frequency for the 12ethylene dibromide (EDB) monitoring wells using Method 504, except for upgradient perimeter well 115-42 which is sampled semi-annually. Maintain annual volatile organic compound (VOC) sampling using Method 8260 Low Level for all wells except for 115-42 and 000-138.

Prepare a petition for system shutdown if EDB concentrations remain below the DWS through the third quarter of 2024.

DESCRIPTION AND TECHNICAL BASIS

The OU III North Street East remediation system consists of two groundwater extraction wells and four diffusion wells (to be shared with the OU III North Street system) located east of North Street, south of the Long Island Expressway (LIE), and north of Moriches-Middle Island Road, in East Yaphank, New York. The extraction wells are designed to remediate VOC contamination in the middle portion of the Upper Glacial aquifer.

The contamination in this area had migrated off-site prior to the start-up of the OU I (RA V) South Boundary treatment system in December 1996 and consists primarily of 1,1,1-trichloroethane (1,1,1-TCA), 1,1-Dichloroethylene (1,1-DCE), and trichloroethylene (TCE). The contamination consists of commingled plumes from several sources, including the Current Landfill and the former Hazardous Waste Management Facility (HWMF). The plume is migrating in a southerly direction with groundwater flow. In September 2019, this system was modified to incorporate two new extraction wells to pump and treat EDB contamination that was first observed in this area in 2015.

This system is designed to achieve the OU III Record of Decision (ROD) objectives of minimizing plume growth and meeting Maximum Contaminant Levels (MCLs) in the Upper Glacial Aquifer in 30 years or less. The system will address the highest VOC concentration portion of the plume (above 50 micrograms per liter [µg/l]).

The monitoring well network for the OU III North Street East project consists of 12 wells, all of which are located off site and south of the LIE. Well locations are shown on Figure 12.9.1. The wells will be sampled quarterly for EDB and annually for VOCs. The monitoring schedule is provided in Table 12.1.1.

DRIVERS FOR MONITORING BEING CONDUCTED UNDER THIS CHANGE

___ Compliance
___ Support Compliance
___ Surveillance
_x_ Restoration

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

A VOC plume that could represent a potential risk to human health or the environment has been defined south of the BNL site. In response, a groundwater remediation system has been constructed to treat this plume. Data are needed to verify that the remediation is occurring according to plan. Based on groundwater modeling, the extraction wells are scheduled to operate for up to ten years.

The detection of EDB in perimeter well 000-394 above the Drinking Water Standard (DWS) in August 2015 has resulted in a modification of the treatment system for remediation of EDB contamination.

Step 2: Identify the Decision

- Were unexpected levels or types of contamination detected?
- Has the downgradient migration of the plume been controlled?
- Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?
- Have the groundwater cleanup goals been achieved?

Step 3: Identify Inputs to the Decision

The project was divided into five decision subunits to reflect the categories of wells for which decisions will be made with respect to the VOC contamination. The identified subunits and the decisions supported by each are:

- Plume core wells (Decisions 1, 3, and 4)
- Plume perimeter wells, used to define the extent of the plume (Decisions 1 and 2)
- Bypass detection wells (Decisions 1 and 2)

The inputs necessary for the decisions include:

- Direction and velocity of groundwater flow
- Analytical results for VOCs in groundwater
- Location of existing wells relative to flow patterns (Figure 12.9.1)
- Evaluation of capture zone for extraction wells
- Action levels

- Variability of data

Step 4: Define the Study Boundaries

As currently defined, the spatial boundaries of the study area are defined by:

- LIE to the north
- East of North Street
- North of Moriches–Middle Island Road
- Upper Glacial aquifer

Section 12.1 details the general sampling frequency based on the phase the monitoring program is in.

Step 5: Develop the Decision Rules

Decision 1

Were unexpected levels or types of contamination detected?

Analytical results from wells in all subunits will be utilized for this decision. Future sample results will be evaluated in context with historic data for each sampling event. As part of that evaluation, circumstances that would require implementation of the BNL Groundwater Contingency Plan (EM-SOP-309) would be ascertained for each sampled well. Examples of such circumstances are unusually high contaminant concentrations, detection of previously undetected contaminants, and detection of contaminants in previously "clean" wells.

If conditions dictate, **then** the BNL Groundwater Contingency Plan will be implemented.

Decision 2

Has the downgradient migration of the plume been controlled?

This decision applies to the plume perimeter and bypass detection wells. If the cleanup goals have not been met, then it must be verified that the plume is not growing. Plume growth is defined as an increase in total VOC concentration in plume fringe or bypass detection wells to above 50 μg/L (if currently less than 50 μg/L) or a significant increase in total VOC concentration (if currently above 50 μg/L).

If the trend in each plume perimeter and bypass detection well has a negative or zero slope, based on the four most recent consecutive samples, this trend is consistent with professional judgment, and the total VOC concentration is less than 50 μg/L, **then** continue to operate the system. **If not**, **then** consider an engineering evaluation or operational adjustments to optimize system operation.

Decision 3

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

In order to shut down the treatment system, the shutdown criteria of reaching less than 50 μg/L TVOCs for at least four consecutive sampling rounds must be met in the core monitoring and extraction wells.

3a. Are TVOC concentrations in plume core wells above or below 50 ug/L and are EDB concentrations above or below 0.05 ug/L?

If the total VOC concentration in each plume core well has been reduced to less than 50 µg/L in less than seven to ten years of active remediation, **then** proceed with pulsed operation of the system. **If not**, and treatment has occurred for less than seven to ten years, **then** continue treatment. **If not**, and treatment has occurred for at least seven to ten years, **then** perform an engineering evaluation to predict the fate of the remaining contamination and determine whether MCLs will be met by 2030.

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

This decision is to determine whether there is significant concentration rebound after system has been shut down completely or entered pulse pumping mode. **If yes**, **then** an engineering evaluation should be performed to evaluate whether continued operation of the system is warranted (see Decision subunit 4d. to help with this decision). **If no**, significant rebound is observed within a one-year time period, **then** petition for system shutdown and continue with Monitored Natural Attenuation (MNA).

Decision 4

Have the groundwater cleanup goals been achieved?

If the mean concentration of TVOCs in groundwater, calculated from analytical results from all plume core wells for the most recent sampling event, is less than 50 µg/L, and if the mean TVOC concentration of each contaminant of concern in groundwater in each plume core well, computed from measurements over the previous two years, is less than 50 µg/L, and pulsing of the remediation system has not resulted in significant rebound of contaminant concentrations, **then** petition for system shutdown and continue with MNA until MCLs are met. **If not**, **then** consider the need for continued remediation.

Step 6: Specify Acceptable Error Tolerances

Table 12.9.1 summarizes the decision and possible decision errors for this project.

Table 12.9.1. Decisions, Potential Decision Errors, and Potential Consequences

Decision	Inputs	Potential Errors Based on Data	Potential Consequences
Is the Contingency Plan triggered?	See Step 3 for inputs.	(1) Trigger Contingency Plan unnecessarily. (2) Fail to trigger Contingency Plan when it should have been triggered.	(1) Unnecessary administrative process; project delays. (2) Lost time in addressing problem; loss of stakeholder confidence.
Is plume growth controlled?	See Step 3 for inputs.	(1) Determine plume is controlled when it is not. (2) Determine plume is not controlled when it is.	(1) Premature petition for system shutoff; project delays. (2) Continue remediation longer than necessary; wasted resources.
Can the groundwater treatment system be shut down?	See Step 3 for inputs.	(1) Determine system can be shut down when operation should continue. (2) Determine to continue operating system when shut down is warranted.	(1) Plume growth continues; ultimate project delays. (2) Wasted resources; project delays.
Is the system operating as planned?	See Step 3 for inputs.	(1) Determine system operating as planned when it is not. (2) Determine system isn't operating as planned when it is.	(1) Premature petition for system shutoff; potential to have to restart system. (2) Continue remediation that is no longer effective.

Step 7: Optimize the Design

Number and Locations of Wells

The monitoring well network for the OU III North Street East project consists of 12 wells, all of which are located off site south of BNL.

Parameters and Frequency

A summary of the proposed 2025 sampling program for this project is provided in Table 12.9.2.

Table 12.9.2. Proposed 2025 Sampling Schedule for the North Street East Monitoring Wells

Well ID	Sampling Frequency	Parameters
000-394	Annually Quarterly	8260 Low Level EPA 504 EBD
000-138	Quarterly	EPA 504 EBD
115-42	Semi-annual	EPA 504 EBD
000-551	Annually Quarterly	8260 Low Level EPA 504 EBD
000-552	Annually Quarterly	8260 Low Level EPA 504 EBD
000-553	Annually Quarterly	8260 Low Level EPA 504 EBD
000-554	Annually Quarterly	8260 Low Level EPA 504 EBD
000-555	Annually Quarterly	8260 Low Level EPA 504 EBD
000-563	Annually Quarterly	8260 Low Level EPA 504 EBD
000-564	Annually Quarterly	8260 Low Level EPA 504 EBD
000-565	Annually Quarterly	8260 Low Level EPA 504 EBD
000-566	Annually Quarterly	8260 Low Level EPA 504 EBD

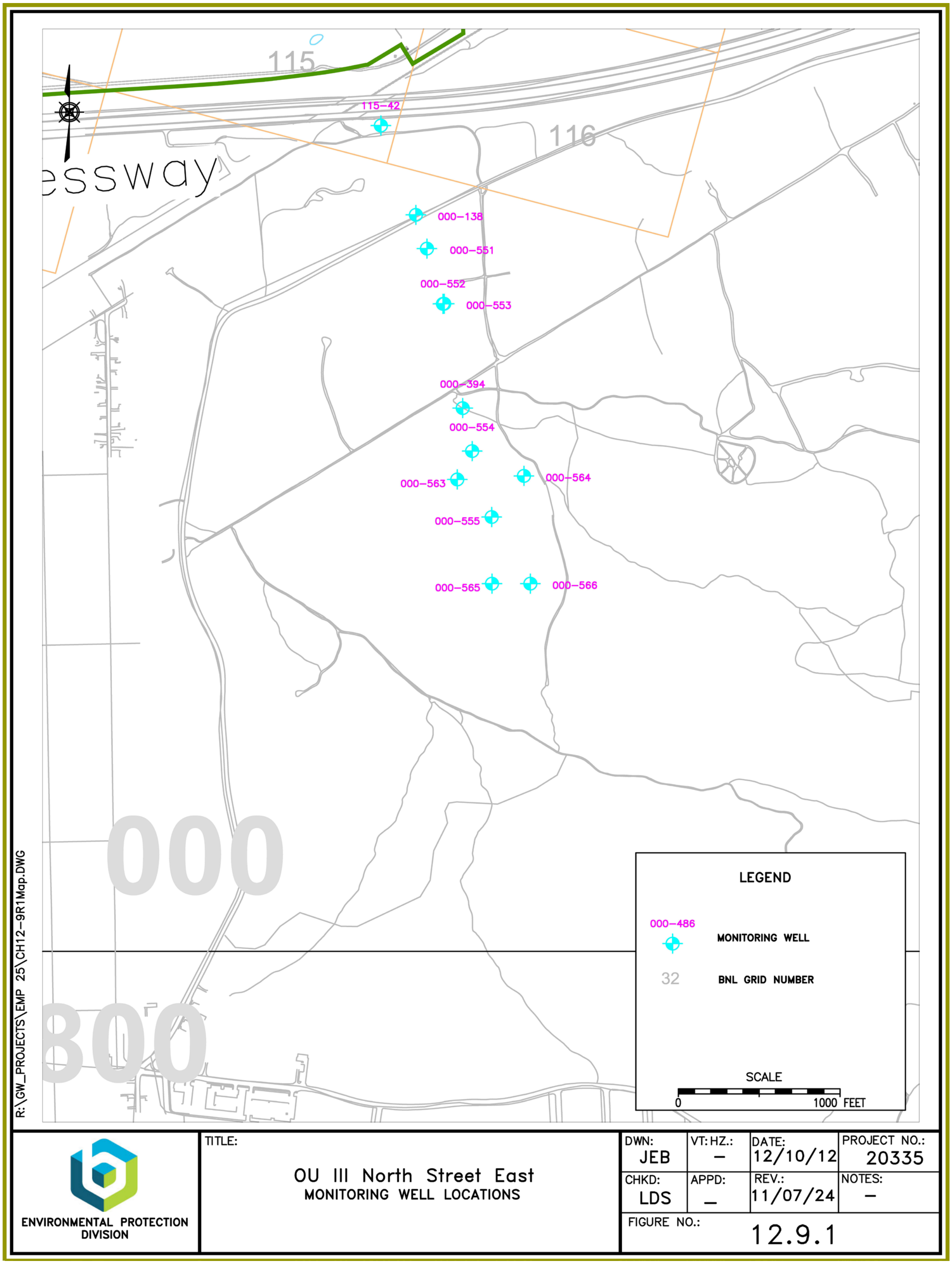

Figure 12.9.1 OU III North Street East Monitoring Well Locations

See Appendix B for the monitoring program for this Data Quality Objective.

12.10 OU III Long Island Power Authority (LIPA)

DQO Start Date January 1, 2003

Implementation Date January 1, 2025

Point of Contact Brian Barth (631) 344-2242
Vincent Racaniello (631) 344-5436

Summary of Changes

The proposed change for the Operable Unit (OU) III Long Island Power Authority (LIPA) treatment system groundwater monitoring program for calendar year 2025 is to:

Maintain the current monitoring schedule for the LIPA monitoring wells pending approval of the LIPA system is received from the regulators. Upon approval, begin the proposed post closure monitoring schedule of wells 000-130, 000-131, 000-425, 000-448, and 000-449 on an annual basis.

Description and Technical Basis

The OU III LIPA remediation system consists of three groundwater extraction wells that are located south of the Brookhaven National Laboratory (BNL) boundary and Long Island Express- way (LIE) along the LIPA right of way between Rowlinson Drive and Starlight Drive; this system addresses volatile organic compound (VOC) contamination in the Upper Glacial aquifer and an extraction well located along Starlight Drive in the vicinity of Rowlinson Drive in North Shirley that treats VOCs in the Magothy aquifer. One of the extraction wells is designed to remediate carbon tetrachloride contamination entering the upper portion of the Magothy aquifer. During system design, a determination was made to combine the Airport and LIPA projects into a single groundwater treatment system. The water from the three LIPA and the one Magothy pumping well is piped approximately 6,000 feet to a combined groundwater treatment system at Brookhaven Airport. These areas of contamination had already migrated south of the site boundary prior to the startup of the OU III South Boundary Pump and Treat System in 1997.

This treatment system is designed to achieve the OU III Record of Decision (ROD) objectives of minimizing plume growth and meeting MCL in the Upper Glacial aquifer in 30 years or less. The southernmost portions of this plume will be addressed by the Brookhaven Airport remediation system as it continues to travel south with the regional groundwater flow. The Magothy extraction well captures and treats the highest total volatile organic compound (TVOC) concentrations (>7,000 µg/L) identified in the upper-most portion of the Magothy aquifer.

The Upper Glacial monitoring well network for the OU III LIPA project consists of 17 wells. Seven of these wells are also part of the Magothy monitoring program. These wells monitor the Upper Glacial VOC plume south of the LIE to Waldorf Drive in the North Shirley residential area, and Upper Magothy VOC plume from the Industrial Park area south to Waldorf Drive, as well as the effectiveness of the groundwater treatment systems. The contaminants of concern associated with the OU III LIPA Upper Glacial and Magothy aquifer contamination project include, 1,1-Dichloroethylene (1,1-DCE), carbon tetrachloride, trichloreylene (1,1,1-TCE), and tetrachloeoethylene.

Well locations are shown on Figure 12.10.1. The monitoring schedule for 2025 is provided in Table 12.1.1.

DRIVERS FOR MONITORING BEING CONDUCTED UNDER THIS CHANGE

___ Compliance
___ Support Compliance
___ Surveillance
_x_ Restoration

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

VOC plumes that could represent a potential risk to human health or the environment have been defined south of the BNL site. In response, a groundwater remediation system has been constructed to treat these plumes in both the Upper Glacial and Magothy aquifers. Data are needed to verify that the remediation is occurring according to plan. Based on groundwater modeling, both the Upper Glacial and Magothy extraction wells are scheduled to operate for up to ten years.

Step 2: Identify the Decision

- Were unexpected levels or types of contamination detected?
- Has the downgradient migration of the plume been controlled?
- Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?
- Are TVOC concentrations in plume core wells above or below 50 ug/L?
- Has the groundwater cleanup goal of meeting MCLs been achieved?

Step 3: Identify Inputs to the Decision

The project was divided into eight decision subunits (four each for the Upper Glacial and Magothy systems) to reflect the categories of wells for which decisions will be made with respect to the VOC contamination. The identified subunits and the decisions supported by each are as follows:

Upper Glacial System:

- Plume core wells (Decisions 1, 2, 3, 4, and 5)
- Plume perimeter wells, used to define the extent of the plume (Decisions 1 and 5)
- Bypass detection wells (Decision 2)

Magothy System:

- Plume core wells (Decisions 1, 2, 4, and 5)
- Plume perimeter wells, used to define the extent of the plume (Decisions 1 and 3)
- Bypass detection wells (Decisions 1, 3, and 4)

The inputs necessary for the decisions include:

- Direction and velocity of groundwater flow
- Analytical results for VOCs in groundwater
- Location of existing wells relative to flow patterns (Figure 12.10.1)
- Evaluation of capture zone for extraction wells
- Action levels
- Analytical methods and detection limits described in the BNL Quality Assurance Program Plan
- Variability of data

Step 4: Define the Study Boundaries

As currently defined, the spatial boundaries of the study area are defined by:

- LIE to the north
- Waldorf Drive to the south
- Starlight Drive to the east
- Rowlinson Drive to the west
- Upper Glacial aquifer (Upper Glacial System)
- Upper Magothy aquifer (Magothy System)

Separate decisions will be made in the eight subunits described in Step 3. However, some of the decisions, such as system performance, are based on the entire system (Upper Glacial or Magothy). The temporal boundaries of the study area vary, based on the decision.

- *Plume Core:* Due to the need for frequent data collection during the system startup period, the timeframe for decisions for this subunit is 90 days.

- *Plume Perimeter:* Because the wells in this subunit define the plume horizontally, which is used to determine whether the plume is being captured, the timeframe for decisions is 90 days. The wells are screened outside the known extent of the plume at the depth of contamination in the plume core. Although the plume is not expected to shift laterally due to changing flow conditions, the decision timeframe for this area will be 90 days during the two-year system startup phase.

- *Bypass Detection Area:* Because the wells in this area indicate whether the plume capture performance objective is being met, the decision timeframe for this area is 90 days.

Step 5: Develop the Decision Rules

Decision 1

Were unexpected levels or types of contamination detected?

Analytical results from wells in all subunits will be utilized for this decision. Future sample results will be evaluated in context with historic data for each sampling event. As part of that evaluation, circumstances that would require implementation of the BNL Groundwater Contingency Plan (EM-SOP-309) will be ascertained for each sampled well. Examples of such circumstances are unusually high contaminant concentrations, detection of previously undetected contaminants, and detection of contaminants in previously "clean" wells.

If conditions dictate, **then** the BNL Groundwater Contingency Plan will be implemented.

Decision 2

Has the downgradient migration of the plume been controlled?

This decision applies to the plume perimeter and bypass detection wells.

If the cleanup goals have not been met, **then** it must be verified that the plume is not growing. Plume growth is defined as an increase in total VOC concentration in plume fringe or bypass detection wells to above 50 µg/L (if currently less than 50 µg/L) or a significant increase in total VOC concentration (if currently above 50 µg/L).

Decision 3

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

In order to shut down the treatment system, the shutdown criteria of reaching less than 20 µg/L TVOCs for at least four consecutive sampling rounds must be met in the core monitoring and extraction wells.

Decision 4

Are TVOC concentrations in plume core wells above or below 50 ug/?

If the total VOC concentration in each plume core well has been reduced to less than 50 µg/L, **then** proceed with pulsed operation of the system. **If not, then** continue treatment.

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

If yes, **then** continue operation. **If yes**, and system and the groundwater may not reach MCLs by 2030, **then** an engineering evaluation should be performed to evaluate whether continued operation of the system is warranted (see Decision subunit 4e. to help with this decision). **If** no significant rebound is observed within a one-year time period, **then** petition for system shutdown and continue with monitored natural attenuation (MNA).

Decision 5

Has the groundwater cleanup goal of meeting MCLs been achieved?

If the mean concentration of TVOCs in groundwater, calculated from analytical results from all plume core wells for the most recent sampling event, is less than 50 µg/L, and if the mean TVOC concentration of each contaminant of concern in groundwater in each plume core well, computed from measurements over the previous two years, is less than 50 µg/L, and pulsing of the remediation system has not resulted in significant rebound of contaminant concentrations, **then** petition for system closure and continue with MNA until MCLs are met. If not, then consider the need for continued remediation.

Step 6: Specify Acceptable Error Tolerances

Table 12.10.1 summarizes the decision and possible decision errors for this project.

Table 12.10.1. Decisions, Potential Decision Errors, and Potential Consequences

Decision	Inputs	Potential Errors Based on Data	Potential Consequences
Is the Contingency Plan triggered?	See Step 3 for inputs.	(1) Trigger Contingency Plan unnecessarily. (2) Fail to trigger Contingency Plan when it should have been triggered.	(1) Unnecessary administrative process, project delays. (2) Lost time in addressing problem, loss of stakeholder confidence.
Is plume growth controlled?	See Step 3 for inputs.	(1) Determine plume is controlled when it is not. (2) Determine plume is not controlled when it is.	(1) Premature petition for system shutoff, project delays. (2) Continue remediation longer than necessary, wasted resources.
Can the groundwater treatment system be shut down?	See Step 3 for inputs.	(1) Determine system can be shut down when operation should continue. (2) Determine to continue operating system when shut down is warranted.	(1) Plume growth continues, ultimate project delays. (2) Wasted resources, project delays.
Is the system operating as planned?	See Step 3 for inputs.	(1) Determine system operating as planned when it is not. (2) Determine system isn't operating as planned when it is.	(1) Premature petition for system shutoff, potential to have to restart system. (2) Continue remediation that is no longer effective.
Have the groundwater cleanup goals been met?	See Step 3 for inputs.	(1) Determine cleanup goals have been met then they are not. (2) Fail to determine cleanup goals are met when they are.	(1) Delay in making operational adjustments, avoidable growth of plume. (2) Wasted resources considering/ implementing operational adjustments.

Step 7: Optimize the Design

Number and Locations of Wells

The Upper Glacial monitoring well network for the OU III LIPA project consists of 17 monitoring wells. Seven of these wells are also part of the Magothy monitoring well network.

Parameters and Frequency

A summary of the proposed 2025 sampling program for this project is shown in Table 12.10.2.

Table 12.10.2 Proposed 2025 Sampling Frequency for the Upper Glacial and Magothy System Monitoring Well Locations

Well ID	Sampling Frequency	Parameters
000-101	Semi-Annual	8260 Low Level
000-102	Semi-Annual	8260 Low Level
000-104	Semi-Annual	8260 Low Level
000-105	Semi-Annual	8260 Low Level
000-130	Semi-Annual	8260 Low Level
000-131	Semi-Annual	8260 Low Level
000-425	Semi-Annual	8260 Low Level
000-445	Semi-Annual	8260 Low Level
000-446	Semi-Annual	8260 Low Level
000-447	Semi-Annual	8260 Low Level
000-448	Semi-Annual	8260 Low Level
000-449	Semi-Annual	8260 Low Level
000-450	Semi-Annual	8260 Low Level
000-451	Semi-Annual	8260 Low Level
000-452	Semi-Annual	8260 Low Level
000-458	Semi-Annual	8260 Low Level
000-459	Semi-Annual	8260 Low Level

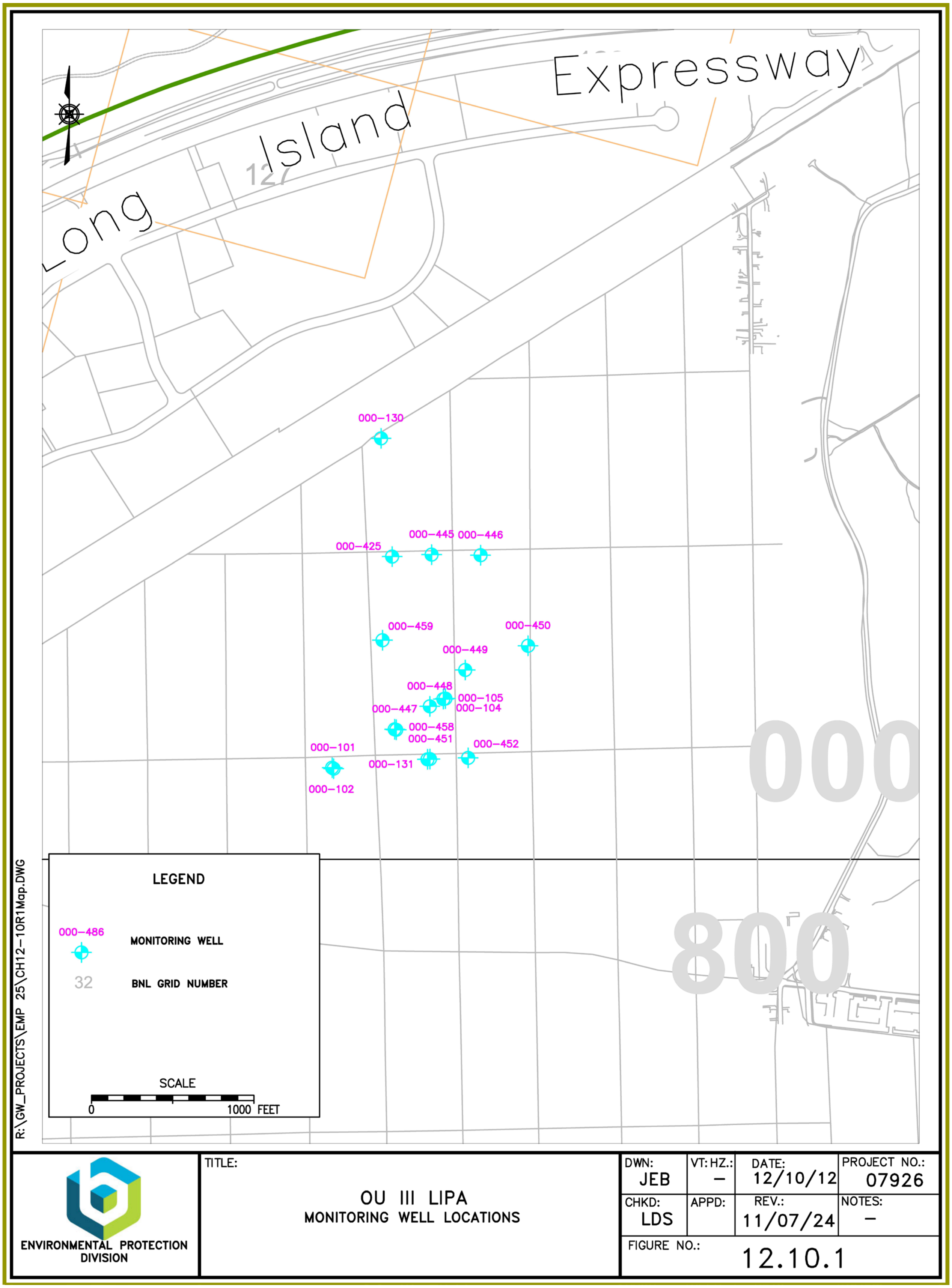

Figure 12.10.1 OU III LIPA Monitoring Well Locations

See Appendix B for the monitoring program for this Data Quality Objective.

12.11 OU III AIRPORT

DQO START DATE January 1, 2003

IMPLEMENTATION DATE January 1, 2025

POINT OF CONTACT Brian Barth (631) 344-2242
Vincent Racaniello (631) 344-5436

SUMMARY OF CHANGES

There are no proposed changes for the Operational Unit (OU) III Airport Pump and Treat System groundwater monitoring program for calendar year 2025.

DESCRIPTION AND TECHNICAL BASIS

The OU III Airport remediation system consists of six groundwater extraction wells along the northern boundary of the Brookhaven Airport. The wells are designed to remediate VOC contamination residing in the deep portion of the Upper Glacial aquifer. The contamination in this area had migrated off site prior to the startup of the OU I (RA V) South Boundary treatment system in December 1996 and consists primarily of 1,1,1-trichloroethane (1,1,1-TCA), tetrachloroethylene (PCE), and carbon tetrachloride (CCl4). The contamination consists of commingled plumes from several sources, including the chemical/animal holes, former landfill, and OU IV area. The plume is migrating in a southerly direction with groundwater flow.

This system is designed to achieve the OU III Record of Decision (ROD) objectives of preventing or minimizing plume growth and meeting Maximum Contaminant Levels (MCL) in the Upper Glacial aquifer by 2030. The system will address the highest VOC concentration portion of the plume (above 50 µg/L).

The monitoring well network for the OU III Airport project consists of 31 wells, all of which are located from Crestwood Drive to the northern portion of the Brookhaven Airport between Wellwood Drive and Sleepy Hollow Drive. Well locations are shown on Figure 12.11.1. The wells will be sampled quarterly and analyzed for VOCs. The monitoring schedule is provided in Table 12.11.2.

DRIVERS FOR MONITORING BEING CONDUCTED UNDER THIS CHANGE

___ Compliance
___ Support Compliance
___ Surveillance
X Restoration

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

A VOC plume that could represent a potential risk to human health or the environment has been defined south of the Brookhaven National Laboratory (BNL) site. In response, a groundwater remediation system has been constructed to treat this plume. Data are needed to verify that the remediation is occurring according to plan.

Step 2: Identify the Decision

- Were unexpected levels or types of contamination detected?
- Has the downgradient migration of the plume been controlled?
- Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?
- Are TVOC concentrations in plume core wells above or below 10 ug/L for the OU III Airport?
- Has the groundwater cleanup goal of meeting MCLs been achieved?

Step 3: Identify Inputs to the Decision

The project was divided into five decision subunits to reflect the categories of wells for which decisions will be made with respect to the VOC contamination. The identified subunits and the decisions supported by each are:

- Plume core wells (Decisions 1, 2, 3, 4, and 5)
- Plume perimeter wells, used to define the extent of the plume (Decisions 1 and 2)
- Bypass detection wells (Decisions 1 and 4)

The wells included in each subunit are shown in Table 12.1.2. The inputs necessary for the decisions include:

- Direction and velocity of groundwater flow
- Analytical results for VOCs in groundwater
- Location of existing wells relative to flow patterns (Figure 12.37.1)
- Evaluation of capture zone for extraction wells
- Action Levels
- Analytical methods and detection limits as described in the BNL Quality Assurance Program Plan (QAPP)
- Variability of data

Step 4: Define the Study Boundaries

As currently defined, the spatial boundaries of the study area are defined by:

- Crestwood Drive to the north
- East of Lockwood Drive
- West of Girald Drive
- Northern portion of Brookhaven Airport
- Upper Glacial aquifer

Section 12.1 details the general sampling frequency based on the phase of the monitoring program.

Step 5: Develop the Decision Rules

Decision 1

Were unexpected levels or types of contamination detected?

Analytical results from wells in all subunits will be utilized for this decision. Future sample results will be evaluated in context with historic data for each sampling event. As part of that evaluation, circumstances that would require implementation of the BNL Groundwater Contingency Plan (EM-SOP-309) would be ascertained for each sampled well. Examples of such circumstances are unusually high contaminant concentrations, detection of previously undetected contaminants, and detection of contaminants in previously "clean" wells.

If conditions dictate, **then** the BNL Groundwater Contingency Plan will be implemented.

Decision 2

Has the downgradient migration of the plume been controlled?

This decision applies to the plume perimeter and bypass detection wells.

If the cleanup goals have not been met, **then** it must be verified that the plume is not growing. Plume growth is defined as an increase in total VOC concentration in plume perimeter or bypass detection wells to above 10 µg/L (if currently less than 10 µg/L) or a significant increase in total VOC concentration (if currently above 50 µg/L).

If the trend in each plume perimeter and bypass detection well has a negative or zero slope based on the four most recent consecutive samples and this trend is consistent with professional judgment and the total VOC concentration is less than 10 µg/L, **then** continue to operate the system. **If not**, **then** consider an engineering evaluation or operational adjustments to optimize system operation.

Decision 3

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

In order to shut down the treatment system, the shutdown criteria of reaching less than 10 µg/L TVOCs for at least four consecutive sampling rounds must be met in the core monitoring and extraction wells.

Decision 4

Are TVOC concentrations in plume core wells above or below 10 ug/L for the Airport?

If the total VOC concentration in each plume core well has been reduced to less than 50 µg/L, **then** proceed with pulsed operation of the system. **If not, then** continue treatment. **If not**, and treatment has occurred for at least ten years, **then** perform an engineering evaluation to predict the fate of the remaining contamination and determine whether MCLs will be met by 2030.

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

If yes, **then** an engineering evaluation should be performed to evaluate whether continued operation of the system is warranted (see Decision subunit 4e. to help with this decision). **If** no significant rebound is observed within a one-year time period, **then** petition for system shutdown and continue with monitored natural attenuation (MNA).

Decision 5

Has the groundwater cleanup goal of meeting MCLs been achieved?

If the mean concentration of TVOCs in groundwater, calculated from analytical results from all plume core wells for the most recent sampling event, is less than 10 µg/L, and if the mean TVOC concentration of each contaminant of concern in groundwater in each plume core well, computed from measurements over the previous two years, is less than 10 µg/l, and pulsing of the remediation system has not resulted in significant rebound of contaminant concentrations, **then** petition for system shutdown and continue with MNA until MCLs are met. **If not**, **then** consider the need for continued remediation.

Step 6: Specify Acceptable Error Tolerances

Table 12.11.1 summarizes the decision and possible decision errors for this project.

Table 12.11.1. Decisions, Potential Decision Errors, and Potential Consequences

Decision	Inputs	Potential Errors Based on Data	Potential Consequences
Is the Contingency Plan triggered?	See Step 3 for inputs.	(1) Trigger Contingency Plan unnecessarily. (2) Fail to trigger Contingency Plan when it should have been triggered.	(1) Unnecessary administrative process; project delays. (2) Lost time in addressing problem; loss of stakeholder confidence.
Has the plume been controlled?	See Step 3 for inputs.	(1) Determine plume is controlled when it is not. (2) Determine plume is not controlled when it is.	(1) Premature petition for system shutoff; project delays. (2) Continue remediation longer than necessary; wasted resources.
Can the groundwater treatment system be shut down?	See Step 3 for inputs.	(1) Determine system can be shut down when operation should continue. (2) Determine to continue operating system when shut down is warranted.	(1) Plume growth continues–ultimate project delays. (2) Wasted resources; project delays.
Is the system operating as planned?	See Step 3 for inputs.	(1) Determine system operating as planned when it is not. (2) Determine system isn't operating as planned when it is.	(1) Premature petition for system shutoff; potential to have to restart system. (2) Continue remediation that is no longer effective.
Have the groundwater cleanup goals been met?	See Step 3 for inputs.	(1) Determine cleanup goals have been met then they are not. (2) Fail to determine cleanup goals are met when they are.	(1) Delay in making operational adjustments; avoidable growth of plume. (2) Wasted resources considering/ implementing operational adjustments.

Step 7: Optimize the Design

Number and Locations of Wells

The monitoring well network for the OU III Airport project consists of 31 wells, all of which are located between Crestwood Drive and the northern portion of Brookhaven Airport, as shown in Table 12-13.2.

Parameters and Frequency

A summary of the proposed 2025 sampling program for this project is shown in Table 12.11.2.

Well ID	Sampling Frequency	Parameters
000-428	Semiannually	8260 Low Level
800-100	Semiannually	8260 Low Level
800-101	Semiannually	8260 Low Level
800-102	Semiannually	8260 Low Level
800-103	Semiannually	8260 Low Level
800-104	Semiannually	8260 Low Level
800-105	Semiannually	8260 Low Level
800-106	Semiannually	8260 Low Level
800-108	Quarterly	8260 Low Level
800-126	Quarterly	8260 Low Level
800-127	Quarterly	8260 Low Level
800-128	Quarterly	8260 Low Level
800-129	Semiannually	8260 Low Level
800-130	Semiannually	8260 Low Level
800-131	Quarterly	8260 Low Level
800-133	Quarterly	8260 Low Level
800-43	Semiannually	8260 Low Level
800-44	Semiannually	8260 Low Level
800-50	Semiannually	8260 Low Level
800-59	Semiannually	8260 Low Level
800-60	Quarterly	8260 Low Level
800-63	Semiannually	8260 Low Level
800-90	Semiannually	8260 Low Level
800-92	Semiannually	8260 Low Level
800-94	Semiannually	8260 Low Level
800-95	Semiannually	8260 Low Level
800-96	Semiannually	8260 Low Level
800-97	Semiannually	8260 Low Level
800-98	Semiannually	8260 Low Level
800-99	Semiannually	8260 Low Level
800-138	Semiannually	8260 Low Level

Table 12.11.2. Proposed 2025 Sampling Frequency for the OU III Airport Monitoring Wells

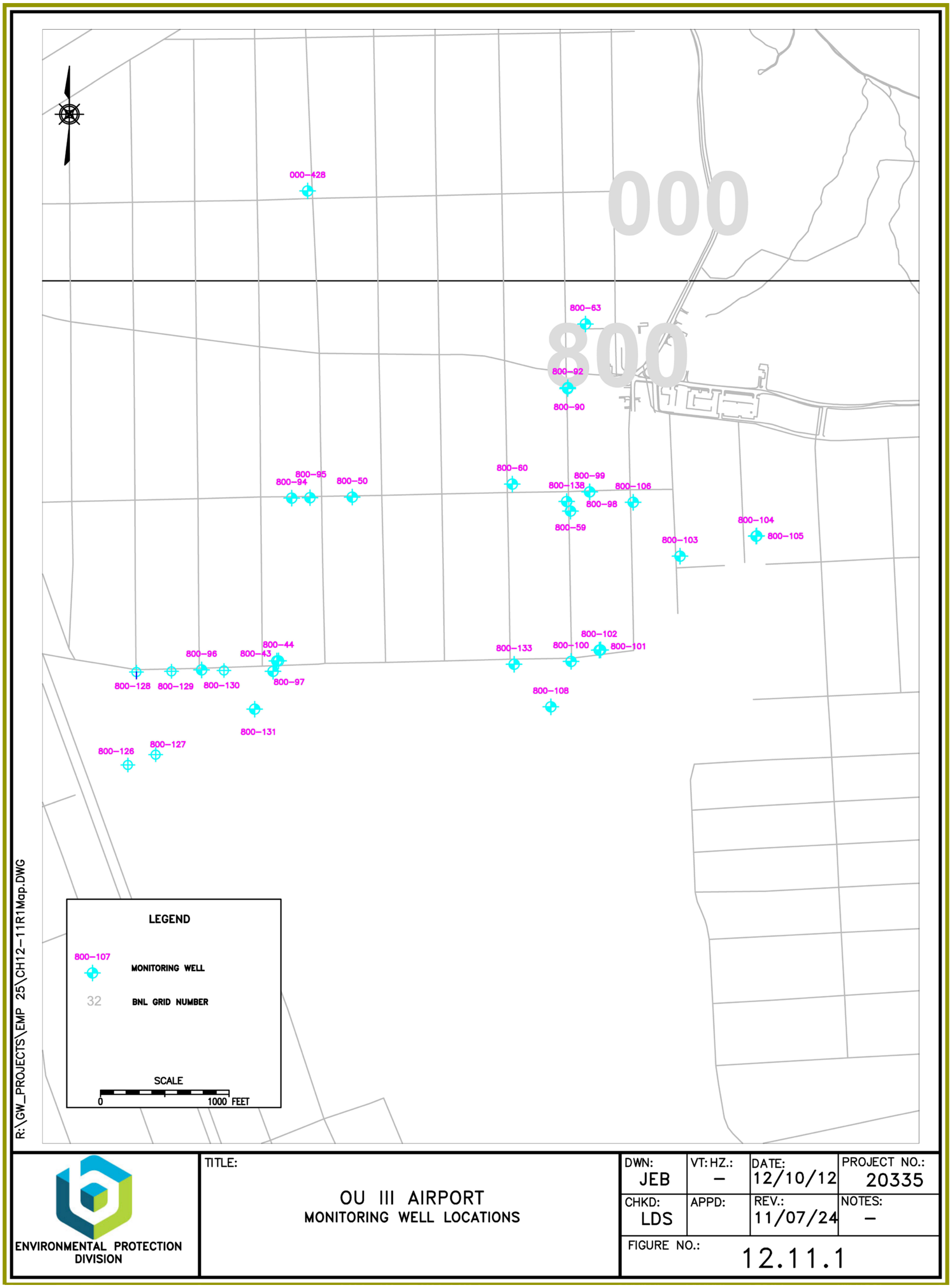

Figure 12.11.1 OU III Airport Monitoring Well Locations

See Appendix B for the monitoring program for this Data Quality Objective.

12.12 William Floyd Sentinel Monitoring

DQO START DATE January 1, 2003

IMPLEMENTATION DATE January 1, 2025

Point of Contact Brian Barth (631) 344-2242
Vincent Racaniello (631) 344-5436

SUMMARY OF PROPOSED CHANGES

There are no proposed changes to the William Floyd Sentinel Monitoring Program for calendar year (CY) 2025.

DESCRIPTION AND TECHNICAL BASIS

A network of six wells located near the western site boundary serve as sentinel wells for the Suffolk County Water Authority William Floyd Parkway Well Field located immediately west of this area. Monitoring well 109-03 was installed by the Suffolk County Department of Health Services.

The monitoring well network for this project consists of six wells that provide groundwater quality data upgradient of the William Floyd Well Field. Well locations are shown on Figure 12.12.1. The wells are sampled quarterly for analysis of volatile organic compounds (VOCs), polyfluoroalkyl substances (PFAS)/perfluorooctanoic acid (PFOA), 1,4-dioxane, gamma spectroscopy, tritium, and Sr-90, as shown in Table 12.1.1.

The contaminants of concern associated with the sources monitored by the William Floyd Sentinel Wells are VOCs and PFAS. During CY 2020, all analyte concentrations were less than the New York State groundwater standards.

DRIVERS FOR MONITORING BEING CONDUCTED UNDER THIS CHANGE

____ Compliance
____ Support Compliance
____ Surveillance
_X_ Restoration

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

Groundwater beneath the western portion of the BNL site has been impacted by low levels of VOCs and PFAS from both known and unknown sources. A groundwater remediation system is under construction to treat PFAS/PFOA originating from the Current Firehouse. This data will provide for early warning of contaminants migrating towards the public well supply field.

Step 2: Identify the Decision

The decisions for the project are:

- Is the contamination naturally attenuating as expected?
- Has the groundwater cleanup goal of meeting maximum contaminant levels (MCLs) been achieved?

Step 3: Identify Inputs to the Decision

The inputs necessary for the decision include:

- Direction and velocity of groundwater flow
- Analytical results in groundwater
- Locations of existing wells relative to flow patterns (Figure 12.12.1)
- Regulatory drivers (OU III Record of Decision [ROD])
- Action levels (New York State groundwater standards and/or baseline groundwater concentrations)
- Analytical methods and detection limits as described in the BNL Environmental Monitoring Plan
- Variability of data

Step 4: Define the Study Boundaries

The project decision unit limits are defined by:

- William Floyd Parkway on the west
- The firebreak path on the south

Section 12.1 details the general sampling frequency based on the phase the monitoring program is in.

Step 5: Develop the Decision Rules

Decision 1

Were unexpected levels or types of contaminants detected?

The sample results will be evaluated in context with historical data. As part of that evaluation, circumstances that would require implementation of the BNL Groundwater Contingency Plan (Environmental Monitoring Standard Operating Procedure [EM-SOP]-309) would be determined for each sampled well. Examples of such circumstances are unusually high contaminant concentrations, including detection of previously undetected contaminants and detection of contaminants in wells where those contaminants have not previously been detected.

If contaminants are detected in any well at unusually high concentrations (relative to the historical baseline) and the results are confirmed by resampling, **then** implement actions as prescribed in the BNL Groundwater Contingency Plan.

Table 12.12.1 summarizes the decision and possible decision errors for this project.

Table 12.12.1. Decisions, Potential Decision Errors, and Potential Consequences

Decision	Inputs	Potential Errors Based on Data	Potential Consequences
Is groundwater impacted by contaminants migrating off site?	See Step 1 for inputs.	(1) Data indicate that groundwater impacted by contaminants is flowing off site when that is not true. (2) Data indicate that there is not groundwater impacted by contaminants flowing off site when there is.	(1) Investigation and/or remediation of groundwater contamination may be undertaken by BNL when it is not warranted. (2) Delays in addressing contamination, possible actions by regulatory agencies.

Step 7: Optimize the Design

Number and Locations of Wells

The six wells are located to monitor on-site water quality immediately upgradient of the William Floyd Well Field.

Parameters and Frequency

The wells are sampled quarterly for analysis of VOCs, gamma spectroscopy, tritium, Sr-90, 1,4-dioxane, and PFAS/PFOA.

A summary of the proposed 2025 sampling program for this project is shown in Table 12.12.2

Table 12.12.2. Proposed 2025 Sampling Frequency for the Wm Floyd Sentinel Monitoring Sampling Program

Well	Sampling Frequency	Affected Parameters
109-03	Quarterly Annually Annually Annually Quarterly	8260 Low Level EPA 905 Sr-90 EPA 906 Tritium EPA 901 Gamma Spec 8270 SIM 1,4-dioxane, EPA 1633 PFAS/PFOA
117-01	Quarterly Annually Annually Annually Quarterly	8260 Low Level EPA 905 Sr-90 EPA 906 Tritium EPA 901 Gamma Spec 8270 SIM 1,4-dioxane, EPA 1633 PFAS/PFOA
117-02	Quarterly Annually Annually Annually Quarterly	8260 Low Level EPA 905 Sr-90 EPA 906 Tritium EPA 901 Gamma Spec 8270 SIM 1,4-dioxane, EPA 1633 PFAS/PFOA
117-04	Quarterly Annually Annually Annually Quarterly	8260 Low Level EPA 905 Sr-90 EPA 906 Tritium EPA 901 Gamma Spec 8270 SIM 1,4-dioxane, EPA 1633 PFAS/PFOA
117-05	Quarterly Annually Annually Annually Quarterly	8260 Low Level EPA 905 Sr-90 EPA 906 Tritium EPA 901 Gamma Spec 8270 SIM 1,4-dioxane, EPA 1633 PFAS/PFOA
117-06	Quarterly Annually Annually Annually Quarterly	8260 Low Level EPA 905 Sr-90 EPA 906 Tritium EPA 901 Gamma Spec 8270 SIM 1,4-dioxane, EPA 1633 PFAS/PFOA

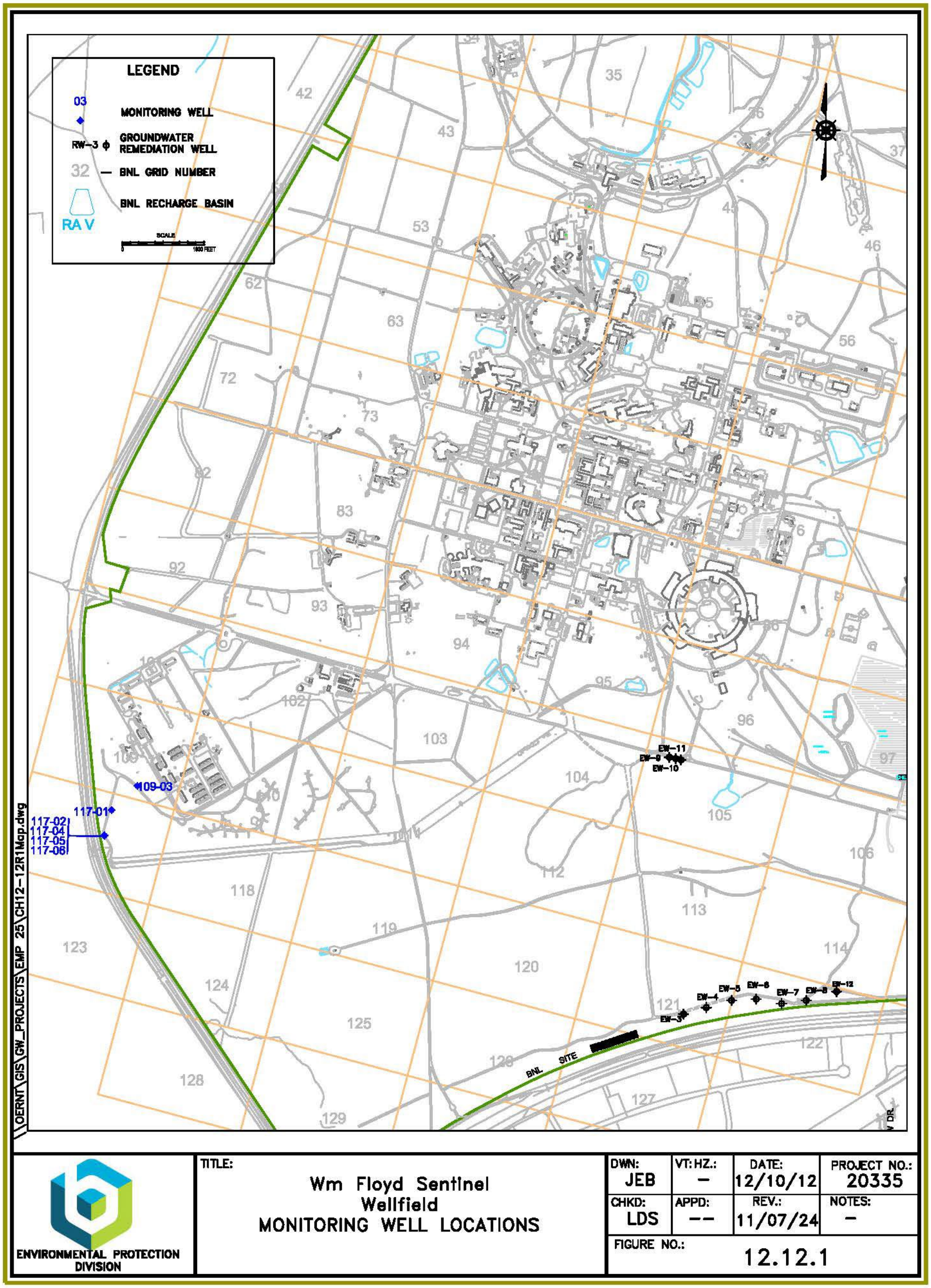

Figure 12.12.1 Wm Floyd Sentinel Monitoring Well Locations

See Appendix B for the monitoring program for this Data Quality Objective.

12.13 OU III SOUTH BOUNDARY RADIONUCLIDE

DQO START DATE January 1, 2003

IMPLEMENTATION DATE January 1, 2025

POINT OF CONTACT Brian Barth (631) 344-2242

SUMMARY OF CHANGES

Due to the lack of radionuclide detections above the Drinking Water Standard (DWS) for the last 20 years, a recommendation to discontinue further sampling for the Operable Unit (OU) III South Boundary and Western South Boundary Pump and Treat Systems was submitted to regulators and approved. The 48 monitoring wells that formerly comprised this program are listed in Table 12.13.1 and shown on Figure 12.13.1.

Table 12.13.1 2025 Sampling Frequency for the South Boundary Radionuclide Monitoring Wells.

Well	Sampling Frequency
000-280	Discontinue
114-06	Discontinue
114-07	Discontinue
121-06	Discontinue
121-07	Discontinue
121-08	Discontinue
121-09	Discontinue
121-10	Discontinue
121-11	Discontinue
121-12	Discontinue
121-13	Discontinue
121-14	Discontinue
121-18	Discontinue
121-19	Discontinue
121-20	Discontinue
121-21	Discontinue
121-22	Discontinue
121-23	Discontinue
122-02	Discontinue
122-04	Discontinue
122-05	Discontinue
122-09	Discontinue
122-10	Discontinue
122-15	Discontinue
122-16	Discontinue
122-17	Discontinue
122-18	Discontinue
122-19	Discontinue

Well	Sampling Frequency
122-20	Discontinue
122-21	Discontinue
122-22	Discontinue
122-31	Discontinue
122-32	Discontinue
122-33	Discontinue
121-42	Discontinue
126-01	Discontinue
126-11	Discontinue
126-13	Discontinue
126-14	Discontinue
126-15	Discontinue
126-16	Discontinue
127-04	Discontinue
127-06	Discontinue
127-07	Discontinue
130-02	Discontinue
130-03	Discontinue
130-04	Discontinue
130-08	Discontinue

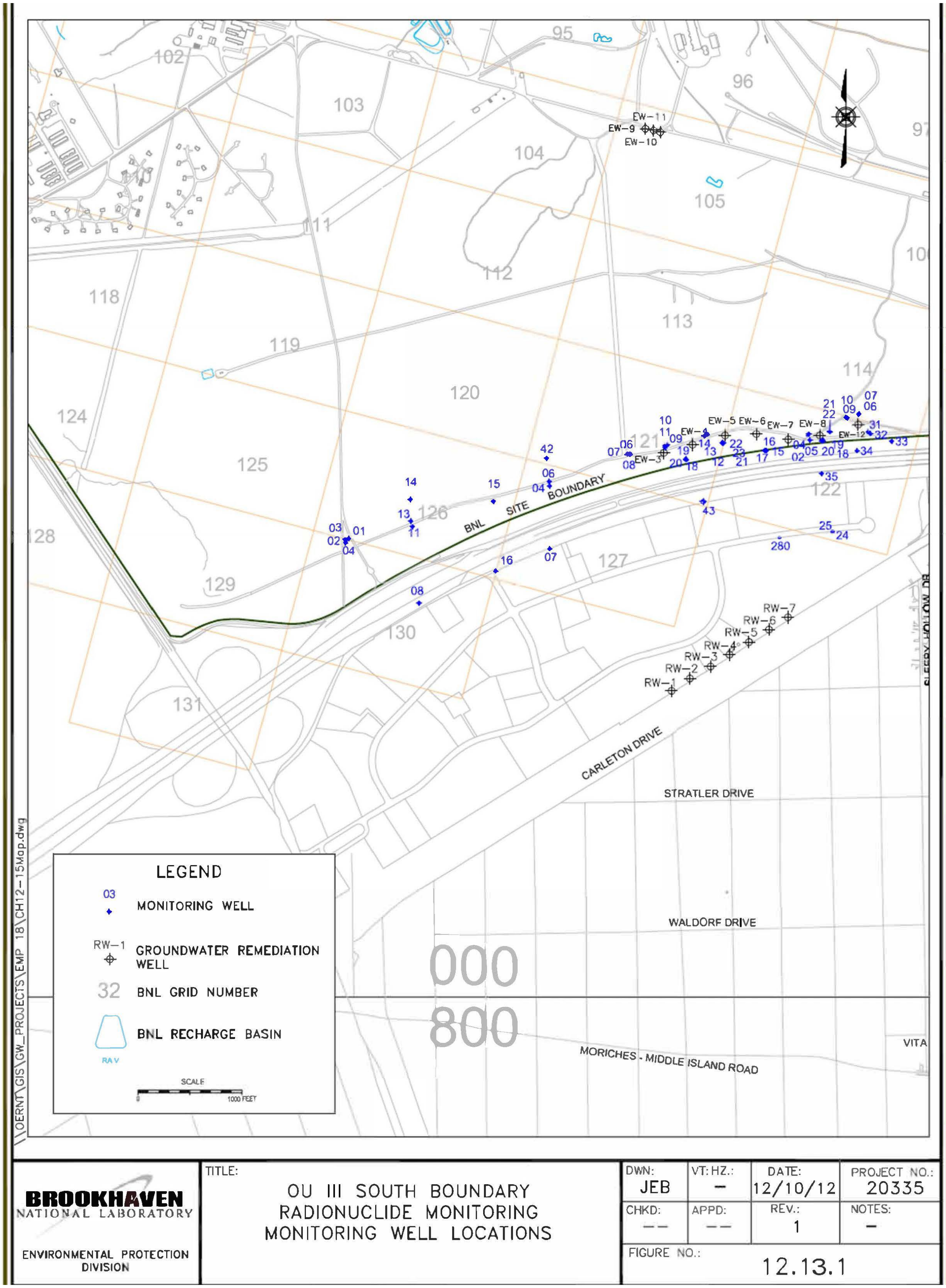

Figure 12.13.1 OU III South Boundary Radionuclide Monitoring Well Locations

See Appendix B for the monitoring program for this DQO.

12.14 OU III BROOKHAVEN GRAPHITE RESEARCH REACTOR WASTE CONCENTRATION FACILITY STRONTIUM-90

DQO START DATE January 1, 2003

IMPLEMENTATION DATE January 1, 2025

POINT OF CONTACT Brian Barth (631) 344-2242
Vincent Racaniello (631) 344-5436

SUMMARY OF CHANGES/PROPOSED CHANGES

The proposed changes for the Brookhaven Graphite Research Reactor (BGRR) Waste Concentration Facility (WCF) Groundwater Treatment System groundwater monitoring program in calendar year 2025 are as follows:

Discontinue sampling of existing monitoring wells 075-809, 075-810, 075-811, 075-415, 075-417, 075-419, 085-171, 085-285, 085-286, 085-287, 085-01, 085-406, 085-407, and 085-290 for Sr-90 analysis. This data was utilized to evaluate the presence of Sr-90 in the vicinity of extraction well FF-RW-A and is no longer needed.

DESCRIPTION AND TECHNICAL BASIS

The Operable Unit (OU) III BGRR/WCF project monitors the extent of multiple Sr-90 plumes in groundwater on site. Some of the wells included in the OU III BGRR/WCF network are also monitored for tritium as part of the OU III Area of Concern (AOC) 29 High Flux Beam Reactor (HFBR) Tritium program. The overlapping wells are sampled concurrently for both programs to avoid duplication of effort. As this summary only addresses the OU III BGRR/WCF project, evaluation of the sampling frequency and analytical parameters for the OU III HFBR Tritium project are conducted separately.

The current monitoring well network for the OU III BGRR/WCF project consists of 66 wells. The locations are shown in Figure 12.14.1. The wells are sampled annually to semi-annually for analysis of Sr-90. The monitoring schedule is provided in Table 12.14.2.

The analytical results show several distinct areas of elevated Sr-90: one emanating from the WCF and extending approximately 1,300 feet south and another beginning south of the BGRR and extending south approximately 1,200 feet. The third area of elevated Sr- 90 concentrations begins at the Pile Fan Sump area and extends south for approximately 600 feet. Variability in groundwater flow directions due to changes in pumping and recharge patterns in the plume vicinity over time have resulted in lateral spreading of the contamination.

In addition, evaluation of various scenarios for potable water supply at the BNL site has shown that if eastern supply wells 10, 11, and 12 are used as the primary source of potable water for an extended time, the capture zone for these supply wells may extend to near the

BGRR. This could result in the Sr-90 contamination being drawn into the supply wells. The BNL Water and Sanitary Planning Committee is charged with monitoring supply well usage across the site to minimize any impacts from changing groundwater flow on contaminant plumes.

DRIVERS FOR MONITORING BEING CONDUCTED UNDER THIS CHANGE

___ Compliance
___ Support Compliance
___ Surveillance
_X_ Restoration

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

In the Upper Glacial aquifer beneath the central portion of the BNL site, there is an area of groundwater contaminated by Sr-90. In response, groundwater characterization and remediation are in progress. Data are needed to continue to track the vertical and horizontal extent of the contamination.

Step 2: Identify the Decisions

The decisions for the project are:

- Is there a continuing source of contamination? If present, has the source area been remediated or controlled?
- Were unexpected levels or types of contamination detected?
- Has the downgradient migration of the plume been controlled?
- Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?

Step 3: Identify Inputs to the Decision

The inputs necessary for the decision include:

- Direction and velocity of groundwater flow
- Sr-90 analytical results in groundwater
- Locations of existing wells relative to flow patterns
- Regulatory drivers (OU III Record of Decision [ROD])
- Action levels (New York State groundwater standards and/or baseline groundwater concentrations)
- Analytical methods and detection limits as described in the BNL Environmental Monitoring Plan
- Variability of data
- Status of potential downgradient receptors
- Estimated retardation rate for Sr-90

Step 4: Define the Study Boundaries

Section 12.1 details the general sampling frequency based on the phase the monitoring program is in. The horizontal extent of the study area is defined by the area of the Upper Glacial aquifer downgradient of the BGRR/WCF with detectable activities of Sr-90. Due to the slow travel time for Sr-90 in groundwater, the timeframe for decisions is 180 days.

Step 5: Develop the Decision Rules

Decision 1

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

This decision applies to the plume perimeter and bypass detection wells.

If the cleanup goals have not been met, **then** it must be verified that the plume is not growing. Plume growth is defined as a significant increase in Sr-90 concentration in plume perimeter or bypass detection.

If the trend in each plume perimeter and bypass detection well has a negative or zero slope based on the four most recent consecutive samples and this trend is consistent with professional judgment, **then** continue to operate the system. **If not**, **then** consider an engineering evaluation or operational adjustments to optimize system operation.

Decision 2

Were unexpected levels or types of contamination detected?

Analytical results from all wells will be utilized for this decision. Future sample results will be evaluated in context with historic data for each sampling event. As part of that evaluation, circumstances that would require implementation of the BNL Groundwater Contingency Plan (Environmental Monitoring Standard Operating Procedure [EM-SOP]-309) would be ascertained for each sampled well. Examples of such circumstances are unusually high contaminant concentrations, detection of previously undetected contaminants, and detection of contaminants in previously "clean" wells.

If conditions dictate, **then** the BNL Groundwater Contingency Plan will be implemented.

Decision 3

Has the downgradient migration of the plume been controlled?

This decision applies to the plume core and bypass detection wells. **If** the system is performing as planned, **then** actual Sr-90 concentrations in plume core and bypass detection wells will compare well to predicted values, based on model runs. A significant difference between actual and predicted concentrations indicates the need for an evaluation of the reason for the difference.

If the system is performing as planned (based on groundwater model predictions, trend analysis, and expert judgment), **then** continue to operate. **If not**, **then** consider operational adjustments and/or engineering evaluation. Note: When the majority and/or "key" wells, as defined by a subject matter expert, are performing as planned, the system as a whole is considered to be properly operating.

Decision 4

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

All of the following decision subunits must be satisfied in order to shut down an extraction well.

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

This decision also applies to the plume core wells. **If** the Sr-90 concentration remain below 8 pCi/L, **then** it is reasonable to expect (based on model projections) that monitored natural attenuation of the remaining contamination in the plume core will be reduced further to meet the cleanup goals of restoring the Upper Glacial aquifer to Maximum Contaminant Level (MCL) by 2070. **If** the Sr-90 concentration remains above 8 pCi/L, **then** consider operational adjustments and/or engineering evaluation.

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

This decision is to determine whether there is significant concentration rebound after system has been shut down completely or entered pulse pumping mode. **If yes**, and system has operated for less than ten years, **then** continue operation. **If yes**, and system has operated for more than ten years, **then** an engineering evaluation should be performed to evaluate whether continued operation of the system is warranted. **If no**, significant rebound is observed within a one-year time period, **then** petition for system shutdown and continue with Monitored Natural Attenuation (MNA).

Step 6: Specify Acceptable Error Tolerances

Table 12.14-1 summarizes the decision and possible decision errors for this project.

Table 12.14-1. Decisions, Potential Decision Errors, and Potential Consequences

Decision	Inputs	Potential Errors Based on Data	Potential Consequences
Was the BNL Groundwater Contingency Plan triggered?	See Step 3 for inputs.	(1) Trigger Contingency Plan unnecessarily. (2) Fail to trigger Contingency Plan when it should have been triggered.	(1) Unnecessary administrative process; project delays. (2) Lost time in addressing problem; loss of stakeholder confidence.
Is the extent of the Sr-90 plume still defined by the existing monitoring well network?	See Step 3 for inputs.	(1) Data indicate the plume is not defined by existing wells when it is. (2) Data indicate the plume is defined by existing wells when it is not.	(1) Wasted resources evaluating, possibly constructing and sampling additional wells. (2) Potential bypass of contaminants and potential risk to downgradient receptors.
Can Sr-90 contamination impact existing or planned groundwater remediation systems?	See Step 3 for inputs.	(1) Data indicate the plume will impact systems when it will not. (2) Data indicate the plume will not impact systems when it will.	(1) Wasted resources conducting technical evaluations and possible system modifications. (2) Potential for inadequate treatment or system failure due to contamination beyond design limits.
Is the Sr-90 plume migrating toward BNL supply wells 10, 11 and 12?	See Step 3 for inputs.	(1) Data indicate the plume is migrating toward supply wells when it is not. (2) Data indicate the plume is not migrating toward supply wells when it is.	(1) Wasted resources conducting technical evaluations; loss of use of supply wells 10, 11 and 12. (2) Potential risk to receptors through ingestion of impacted water.
Is the plume controlled?	See Step 3 for inputs.	(1) Determine plume is controlled when it is not. (2) Determine plume is not controlled when it is.	(1) Premature petition for system shutoff; project delays. (2) Continue remediation longer than necessary; wasted resources.
Is the system performing as planned?	See Step 3 for inputs.	(1) Determine system is performing as planned when it is not. (2) Determine system is not performing as planned when it is.	(1) Delay in making operational adjustments; avoidable growth of plume. (2) Wasted resources considering/implementing operational adjustments.
Have asymptotic conditions been demonstrated?	See Step 3 for inputs.	(1) Determine asymptotic conditions reached when they are not. (2) Determine asymptotic conditions not reached when they are.	(1) Premature petition for system shutoff; project delays. (2) Continue remediation that is no longer effective.

Step 7: Optimize the Design

Number and Locations of Wells

The current sampling program consists of 66 monitoring wells.

Parameters and Frequency

Monitoring wells are sampled on either an annual or semiannual schedule. Well-specific 2025 sampling frequency and parameter information is provided in Table 12.14.2.

Table 12.14-2. Proposed 2025 Sampling Frequency for the BGRR Monitoring Wells

Well	Sampling Frequency	Parameters
065-06	Annual	8260 Low Level EPA 905 Sr-90
065-160	Annual	EPA 905 Sr-90
065-162	Annual	EPA 905 Sr-90
065-163	Annual	EPA 905 Sr-90
065-164	Annual	EPA 905 Sr-90
065-169	Semiannual	EPA 905 Sr-90 Cs-137
065-170	Annual	EPA 905 Sr-90 Cs-137
065-174	Annual	EPA 905 Sr-90
065-175	Semiannual	EPA 905 Sr-90
065-176	Annual	EPA 905 Sr-90
065-178	Annual	EPA 905 Sr-90
065-360	Annual	EPA 905 Sr-90
065-361	Annual	EPA 905 Sr-90
065-362	Annual	EPA 905 Sr-90
065-363	Annual	EPA 905 Sr-90
065-364	Annual	EPA 905 Sr-90
065-365	Annual	EPA 905 Sr-90
065-405	Semiannual	EPA 905 Sr-90
065-367	Annual	EPA 905 Sr-90
065-37	Semiannual	EPA 905 Sr-90 Cs-137 EPA 906 Tritium
065-38	Semiannual	EPA 905 Sr-90
065-39	Semiannual	EPA 905 Sr-90
075-189	Annual	EPA 905 Sr-90
075-193	Annual	EPA 905 Sr-90
075-194	Annual	EPA 905 Sr-90
075-201	Annual	EPA 905 Sr-90
075-39	Annual	EPA 905 Sr-90

Well	Sampling Frequency	Parameters
075-40	Annual	EPA 906 Tritium
075-41	Annual	EPA 905 Sr-90
075-46	Annual	EPA 905 Sr-90
075-47	Semiannual	EPA 905 Sr-90
075-48	Semiannual	EPA 905 Sr-90
075-664	Monthly	EPA 905 Sr-90
075-665	Annual	EPA 905 Sr-90
075-666	Annual	EPA 905 Sr-90
075-669	Annual	EPA 905 Sr-90
075-670	Semiannual	EPA 905 Sr-90
075-671	Semiannual	EPA 905 Sr-90
075-672	Annual	EPA 905 Sr-90
075-673	Annual	EPA 905 Sr-90
075-674	Annual	EPA 905 Sr-90
075-675	Annual	EPA 905 Sr-90
075-681	Annual	EPA 905 Sr-90
075-682	Semiannual	EPA 905 Sr-90
075-683	Annual	EPA 905 Sr-90
075-684	Semiannual	EPA 905 Sr-90
075-85	Annual	EPA 905 Sr-90
075-86	Annual	EPA 905 Sr-90
075-87	Semiannual	EPA 905 Sr-90
075-705	Semiannual	EPA 905 Sr-90
075-706	Semiannual	EPA 905 Sr-90
075-707	Semiannual	EPA 905 Sr-90
065-401	Semiannual	EPA 905 Sr-90
075-699	Semiannual	EPA 905 Sr-90
075-700	Semiannual	EPA 905 Sr-90
065-402	Semiannual	EPA 905 Sr-90
075-701	Monthly	EPA 905 Sr-90
065-404	Semiannual	EPA 905 Sr-90
085-398	Semiannual	EPA 905 Sr-90
085-399	Semiannual	EPA 905 Sr-90
085-402	Semiannual	EPA 905 Sr-90
065-325	Semiannual	EPA 905 Sr-90
085-403	Semiannual	EPA 905 Sr-90
075-210	Semiannual	EPA 905 Sr-90
095-326	Semiannual	EPA 905 Sr-90
085-415	Semiannual	EPA 905 Sr-90

Figure 12.14.1OU III BGRR/WCF Monitoring Well Locations

See Appendix B for the monitoring schedule for this Data Quality Objective.

Intentionally Left Blank

12.15 CHEMICAL/ANIMAL HOLES STRONTIUM-90

DQO START DATE January 1, 2003

IMPLEMENTATION DATE January 1, 2025

POINT OF CONTACT Brian Barth (631) 344-2242
Vincent Racaniello (631) 344-5436

SUMMARY OF CHANGES

There are no proposed changes for the Chemical/Animal Holes Strontium-90 (Sr-90) Treatment System groundwater monitoring program for calendar year 2025.

DESCRIPTION AND TECHNICAL BASIS

Between 1960 and 1966, waste, glassware containing chemical and radioactive waste, and animal carcasses containing radioactive tracers were disposed of in in unlined pits (in some cases up to 30 feet below grade) in an area directly east of the Chemical/Animal Holes area. Used glassware continued to be disposed of in shallow pits directly north of this area from 1966 through 1981. Remediation of the impacted soil in the Chemical/Animal Holes area, including waste excavation, treatment, and disposal, was completed in September 1997.

The monitoring well network for the Chemical/Animal Holes consists of 17 wells. There are three bypass detection wells located immediately downgradient from extraction well EW-3 (106-120, 106-121, and 106-122). No upgradient wells are sampled as part of this program. The wells comprising the Chemical/Animal Holes program are listed in Table 12.15.2. Well locations are shown in Figure 12.15.1. The wells have been sampled annually to semi-annually for Sr-90 analysis.

Sr-90 has routinely been detected downgradient of the Chemical/Animal Holes at levels exceeding the New York State groundwater standard. None of the sentinel wells contained Sr-90 at levels exceeding the New York State groundwater standard.

In February 2003, a Sr-90 Pilot Study began operation. The objective of this study was to evaluate the effectiveness of extraction and treatment of Sr-90 in groundwater prior to implementation of the final remedy. The Sr-90 Pilot Study, now known as the Chemical/Animal Holes Sr-90 Treatment System, currently extracts groundwater at a rate of between five to 15 gallons per minute, treats it with an ion exchange system, and discharges the groundwater to dry wells located just east of the treatment system building. In 2007, two additional extraction wells (EW-2 and EW-3) were installed. In 2018, the system was approved for shutdown and the extraction wells were placed in standby mode.

DRIVERS FOR MONITORING BEING CONDUCTED UNDER THIS CHANGE

____ Compliance
____ Support Compliance
____ Surveillance
_X_ Restoration

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

The Chemical/Animal Holes area has been an historic source of Sr-90 contamination to groundwater. In response, BNL has conducted remediation (waste excavation, treatment, and disposal) to eliminate future releases. Data are needed to confirm that the soil remediation was adequate and to track existing contaminant plumes downgradient of the Chemical/Animal Holes area. In addition, data are required during the design process in the immediate pilot study area for design decisions and potential system modifications. The pilot study was targeted for the area of high Sr- 90 concentrations.

Problem Statement: Existing Sr-90 plume has degraded groundwater quality downgradient of the Chemical/Animal Holes area and could impact downgradient receptors. Data are needed to:

- Verify that the soil source areas have been remediated.
- Track the distribution of the remaining Sr-90 concentrations that was addressed by the treatment system.
- Verify the effectiveness of the treatment system in removing Sr-90 from the groundwater.

Step 2: Identify the Decisions

- Is there a continuing source of contamination? If present, has the source area been remediated or controlled?
- Were unexpected levels or types of contamination detected?
- Has the downgradient migration of the plume been controlled?
- Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?
- Have the groundwater cleanup goals of meeting drinking water standards been achieved?

Step 3: Identify Inputs to the Decision

The inputs necessary for the decision include:

- Direction and velocity of groundwater flow
- Sr-90 results in groundwater
- Locations of existing wells relative to flow patterns
- Regulatory drivers (Operable Unit [OU] III ROD)
- Action Levels (New York State groundwater standards and/or baseline groundwater concentrations)
- Analytical methods and detection limits as described in the BNL Environmental Monitoring Plan
- Estimated retardation rate for Sr-90
- Variability of data

Step 4: Define the Study Boundaries

The decision unit limits for this project are the area impacted by detectable activities of Sr-90 from the Chemical/Animal Holes and Former Landfill areas. The vertical limits are from the water table surface to the deep zone of the Upper Glacial aquifer.

Section 12.1 details the general sampling frequency based on the phase of the monitoring program. Due to the low-travel velocity for Sr-90 in groundwater, decisions for most wells will be made on a timeframe of 365 days. Since wells 097-313, 097-314, and 097-315 are located within critical areas to be addressed by the ongoing treatment system, decisions will be made using a timeframe of 180 days to ensure that the design of the system will be effective.

Step 5: Develop the Decision Rules

Decision 1

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

If the detected Sr-90 activities are consistent with the groundwater model results and professional judgment, **then** continue monitoring. **If not**, **then** consider refining the conceptual model and/or conducting an evaluation to determine whether outside factors (such as additional contaminant sources) are affecting the results.

Decision 2

Were unexpected levels or types of contamination detected?

Analytical results from all wells will be utilized for this decision. Future sample results will be evaluated in context with historic data for each sampling event. As part of that evaluation, circumstances that would require implementation of the BNL Groundwater Protection Contingency Plan (Environmental Monitoring Standard Operating Procedure [EM-SOP]-309) would be ascertained for each sampled well. Examples of such circumstances are unusually high contaminant concentrations, detection of previously undetected contaminants, and detection of contaminants in previously "clean" wells.

If conditions dictate, **then** the BNL Groundwater Protection Contingency Plan may be implemented.

Decision 3

Has the downgradient migration of the plume been controlled?

This decision applies to the plume perimeter and sentinel wells. If the system is performing as planned, actual Sr-90 concentrations in plume perimeter and sentinel wells will compare well to predicted values, based on model runs. A significant difference between actual and predicted concentrations indicates the need for an evaluation for the reason for the difference. **If** the system is performing as planned (based on groundwater model predictions, trend analysis, and expert judgment), **then** continue to operate. **If not**, **then** consider operational adjustments and/or an engineering evaluation. Note: When the majority and/or "key" wells, as defined by a subject matter expert, are performing as planned, the system as a whole is considered to be properly operating.

Decision 4

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

The clean-up objective is to reach maximum contaminant levels (MCLs) in the aquifer by 2040 via hydraulic control and treatment of the highest concentration Sr-90 within the capture zone of Sr-90 extraction wells. Groundwater modeling will be performed to demonstrate that the Sr-90 concentrations remaining in the groundwater after system shutdown would naturally attenuate to below MCLs by 2040. **If** evaluation of analytical results for Sr-90 in any upgradient or plume core well sample, in conjunction with historic analytical results and trends, indicates that the treatment system has met the shutdown criteria, **then** a petition for shutdown will be issued to the regulatory agencies.

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

If the Sr-90 concentration in each plume core well has been reduced to less than 8 μg/L, **then** proceed with pulsed operation of the system. **If not**, and treatment has occurred for less than ten years, **then** continue treatment. **If not,** and treatment has occurred for at least ten years, **then** consider performing an engineering evaluation to predict the fate of the remaining contamination and determine whether MCLs will be met by 2040.

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

This decision is to determine whether there is significant concentration rebound after the system has been shut down completely or entered pulse pumping mode. **If yes**, **then** restart operation. **If yes**, and system has operated for more than ten years, **then** an engineering evaluation should be performed to evaluate whether continued operation of the system is warranted. **If no**, and significant rebound is observed within a one-year time period following pulsed pumping, **then** petition for system shutdown and continue with monitored natural attenuation (MNA).

Decision 5

Has the groundwater cleanup goal of meeting drinking water standards_been achieved?

If the concentration of Sr-90 in groundwater after system shutdown remains less than 8 pCi/L for several years, **then** petition for system closure. **If not**, **then** consider the need for continued remediation.

Step 6: Specify Acceptable Error Tolerances

Table 12.15.1 summarizes the decision and possible decision errors for this project.

Table 12.15.1. Decisions, Potential Decision Errors, and Potential Consequences

Decision	Inputs	Potential Errors Based on Data	Potential Consequences
Is the BNL Groundwater Protection Contingency Plan triggered?	See Step 3 for inputs.	(1) Trigger Contingency Plan unnecessarily. (2) Fail to trigger Contingency Plan when it should have been triggered.	(1) Unnecessary administrative process, project delays (2) Lost time in addressing problem, loss of stakeholder confidence.
Is the high-concentration Sr-90 plume addressed by the treatment system?	See Step 3 for inputs.	(1) Data indicate plume is not located in treatment system area when it is. (2) Data indicate plume is located in treatment system area when it is not.	(1) Wasted resources modifying system design, potentially inaccurate results/. (2) Potential ROD goals not being met.

Step 7: Optimize the Design

Number and Locations of Wells

The existing monitoring well network of 17 wells is sufficient.

Parameters and Frequency

Fourteen monitoring wells in the groundwater monitoring program are sampled on an annual schedule and analyzed for Sr-90. The remaining three monitoring wells are sampled and analyzed for Sr-90 on a semi-annual basis. A summary of the proposed 2025 sampling program for this project is shown in Table 12.15.2.

Table 12.15.2. Proposed 2025 Sampling Frequency for the Chemical/Animal Holes Monitoring Wells

Well ID	Sampling Frequency	Parameters
097-313	Semi-annual	EPA 905 Sr-90
097-314	Semi-annual	EPA 905 Sr-90
097-315	Semi-annual	EPA 905 Sr-90
106-100	Annual	EPA 905 Sr-90
106-101	Annual	EPA 905 Sr-90
106-103	Annual	EPA 905 Sr-90
106-104	Annual	EPA 905 Sr-90
106-105	Annual	EPA 905 Sr-90
106-119	Annual	EPA 905 Sr-90
106-125	Annual	EPA 905 Sr-90
106-136	Annual	EPA 905 Sr-90
106-16	Annual	EPA 905 Sr-90
106-49	Annual	EPA 905 Sr-90
106-94	Annual	EPA 905 Sr-90
106-95	Annual	EPA 905 Sr-90
106-98	Annual	EPA 905 Sr-90
106-99	Annual	EPA 905 Sr-90

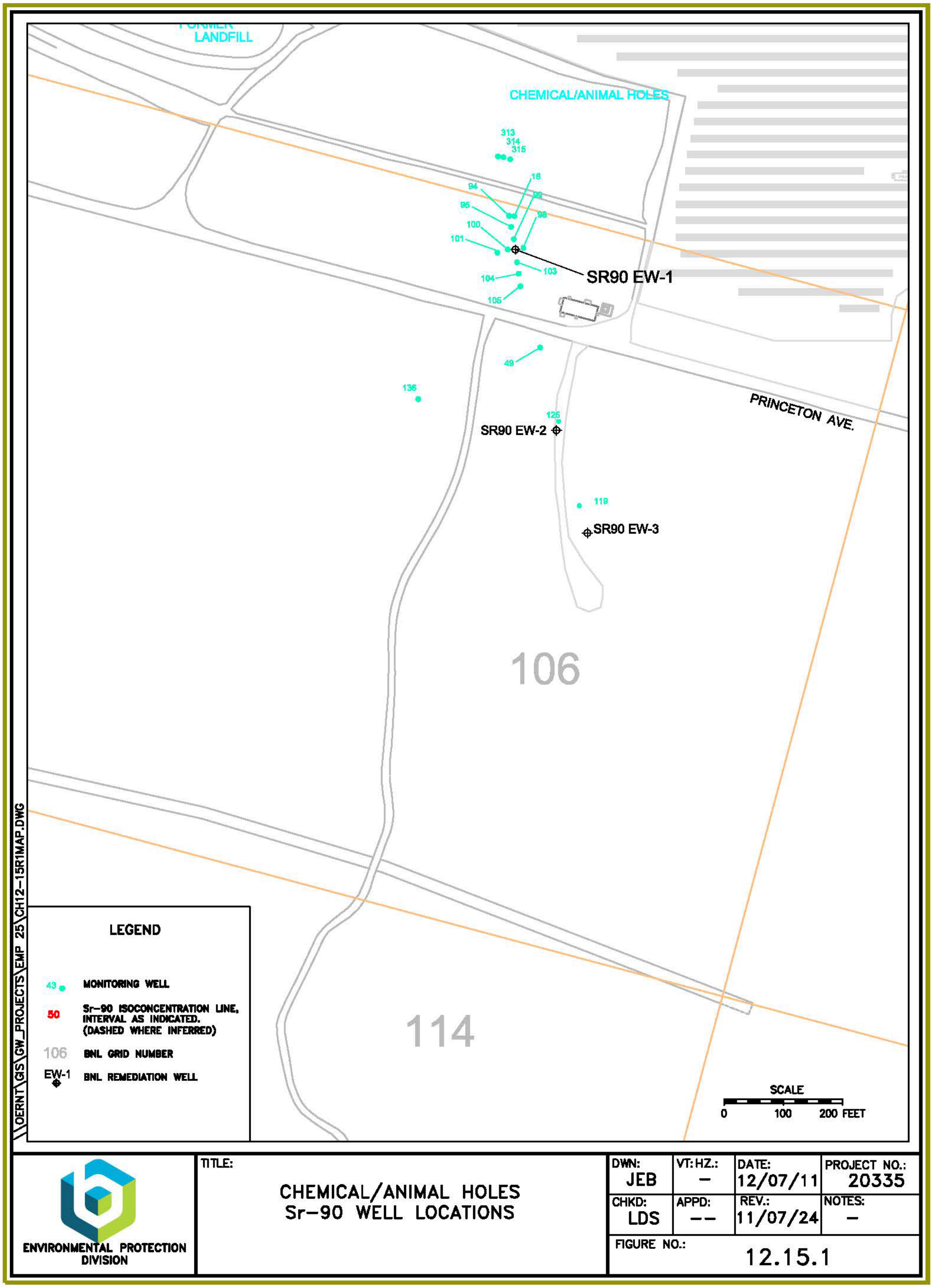

Figure 12.15.1. Chemical/Animal Holes Sr-90 Well Locations

See Appendix B for the monitoring program for this Data Quality Objective.

12.16 OU III HIGH FLUX BEAM REACTOR

DQO START DATE January 1, 2003

IMPLEMENTATION DATE January 1, 2025

POINT OF CONTACT Brian Barth (631) 344-2242
Vincent Racaniello (631) 344-5436
James Milligan (631) 344-4458

SUMMARY OF CHANGES

There are no changes for the High Flux Beam Reactor (HFBR) tritium groundwater monitoring program for calendar year 2025.

DESCRIPTION AND TECHNICAL BASIS

In late 1996, tritium was detected in wells near the HFBR. The source of the release was traced to the HFBR spent fuel pool. In response, the fuel rods were removed from the pool for off-site disposal, the spent fuel pool was drained, and the HFBR was removed from service in 1997. Also, numerous monitoring wells were constructed to characterize the tritium plume downgradient of the HFBR. In May 1997, operation of a three-well groundwater extraction system began. This system was constructed on Princeton Avenue, approximately 3,500 feet downgradient of the HFBR to capture the tritium contamination and ensure that off-site migration of the plume would not occur. Extracted water was recharged through the RA V recharge basin.

As described in the Operable Unit (OU) III Record of Decision (ROD), the selected remedy to address the HFBR tritium plume included implementation of monitoring and low-flow extraction programs to prevent or minimize plume expansion. Because it had been demonstrated that the remaining tritium plume would naturally attenuate to below drinking water standards before reaching the BNL site boundary, the extraction system was initially placed on standby status in September 2000.

In 2007, the detection of tritium at concentrations above 25,000 pCi/L in wells at the Chilled Water Plant Road and above 20,000 pCi/L in wells along Weaver Drive necessitated the reactivation of the Princeton Avenue pumping system. After tritium concentrations in areas south of Cornell Avenue decreased to less than 20,000 pCi/L, the system was placed back on standby status in May 2013.

In 2016, monitoring was reduced to 34 wells in the immediate vicinity of the HFBR because the tritium concentrations south of Cornell Avenue attenuated to <20,000 pCi/L over the past several years. In late 2018, the monitoring well network for the OU III HFBR project was reduced to ten wells that provide groundwater quality data in the source area. The ten wells consist of three existing wells and seven recently installed wells. Well locations are shown in Figure 12.16.1. The wells are sampled quarterly for analysis of tritium.

DRIVERS FOR MONITORING BEING CONDUCTED UNDER THIS CHANGE

____ Compliance
____ Support Compliance
____ Surveillance
_X_ Restoration

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

Groundwater beneath the BNL site has been impacted by tritium from historical leakage from the HFBR spent fuel pool. Data are needed to verify that the tritium is naturally degrading according to the attenuation model.

Step 2: Identify the Decision

The decisions for the project are:

- Is there a continuing source of contamination? If present, has the source area been remediated or controlled?
- Were unexpected levels or types of contamination detected? Is the plume attenuating as expected?
- Has the downgradient migration of the plume been controlled?
- Can individual extraction wells or the entire treatment system be shut down or placed in pulse pumping operation?

Step 3: Identify Inputs to the Decision

The project was divided into two decision subunits to reflect the categories of wells for which decisions will be made with respect to the tritium plume. The identified subunits and the deci sions supported by each are:

- Plume core wells located within the high concentration segment of the plume (Decisions 1, 2, 3, and 5)
- Perimeter wells located outside the high concentration segment of the plume and contain tritium at low or non-detect activities (Decisions, 2, 3, and 4)

The inputs necessary for the decision include:

- Direction and velocity of groundwater flow
- Tritium analytical results in groundwater
- Locations of existing wells relative to flow patterns
- Action levels defined in the OU III ROD

- Analytical methods and detection limits
- Variability of data

Step 4: Define the Study Boundaries

The project decision unit limits are defined by:

- Rutherford Drive on the north
- Cornell Avenue on the south
- Wells 075-11 and 075-288 on the east
- Well 075-40 on the west
- Upper Glacial aquifer

Section 12.1 details the general sampling frequency based on the phase of the monitoring pro- gram. Due to variability in groundwater flow direction for different areas of the plume and the specific actions to be taken in response to certain observed conditions (as specified in the ROD), the project was divided into geographic segments based on the timeframe for decisions to be made for wells in these areas. The segments and timeframes for each decision subunit within the area were:

- *HFBR Area:* This segment encompasses the wells around the HFBR, including upgradient wells and the area extending to approximately 250 feet south of Temple Place. The decision timeframe for plume core and perimeter wells in the HFBR area is 90 days, due to the expected slow change in tritium activities for these wells. For the outer perimeter wells, decisions will be made using a 365-day timeframe, because perimeter wells are located between the outer perimeter wells and the plume core wells.

- *RA V Recharge Basin:* Since the treatment system has been placed in stand by status, monitoring around the recharge basin has been discontinued.

- *Brookhaven Avenue:* This segment is downgradient of the HFBR area and includes the wells along Brookhaven Avenue, except those around the RA V basin. Wells in this area measure the rate of attenuation. Decisions for plume core and perimeter wells will be made using a 90-day timeframe. As with the HFBR area, the decision timeframe for outer perimeter wells in this segment is 365 days. Due to the attenuation of the tritium plume, monitoring in this area has been discontinued. If upgradient concentrations increase, monitoring can be re-initiated.

- *Rowland Street:* This segment includes the wells along Rowland Street. Evaluation of data from these wells measures plume attenuation. Therefore, a timeframe for decisions of 90 days for plume core and perimeter wells in this area is warranted. As with the HFBR area, the decision timeframe for outer perimeter wells in this segment is 365 days. Due to the attenuation of the tritium plume, monitoring in this area has been discontinued. If upgradient concentrations increase, monitoring can be re-initiated.

- *Chilled Water Plant Road and Weaver Drive:* The wells in these two segments are located along and east of the Chilled Water Plant Road (Chilled Water Plant Road segment) and along Weaver Drive and Grove Street (Weaver Drive segment). Because data from wells in these segments will be utilized to determine whether the contingency actions specified in the ROD will be implemented, the decision timeframe for plume core and perimeter wells in these segments is 90 days. As with the HFBR area and Rowland Street segments, the decision timeframe for outer perimeter wells in these segments is 365 days. Due to the attenuation of the tritium plume, monitoring in this area has been discontinued. If upgradient concentrations increase, monitoring can be re-initiated.

- *Princeton Avenue:* This segment includes outer perimeter wells downgradient of the plume along Princeton Avenue and Middle Road. As with the other outer perimeter wells, because perimeter wells are located between these wells and the plume core wells, the decision timeframe is 365 days. Due to the attenuation of the tritium plume, monitoring in this area has been discontinued. If upgradient concentrations increase, monitoring can be re-initiated.

Due to improving plume conditions, all monitoring south of Cornell Avenue has been discontinued.

Step 5: Develop the Decision Rules

Decision 1

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

Analytical results from plume core wells immediately downgradient of the HFBR source area will be utilized for this decision. Future sample results will be evaluated in context with historic data for each sampling event. **If** plume core wells located in the source area continue to show elevated levels of contaminants with no decreasing trend, **then** an evaluation of the source area will be conducted to determine whether additional source controls are needed.

Future sample results will be evaluated in context with historic data for each sampling event. As part of that evaluation, circumstances that would require implementation of the BNL Groundwater Contingency Plan would be ascertained for each sampled well. Examples of such circumstances are unusually high tritium concentrations. **If** these conditions occur, **then** the Contingency Plan will be implemented.

Decision 2

Were unexpected levels or types of contamination detected?

For each future sampling event, sample results will be evaluated in context with historic data. As part of that evaluation, circumstances that would require implementation of the BNL Groundwater Contingency Plan (Environmental Monitoring Standard Operating Procedure [EM-SOP]-309) would be ascertained for each sampled well. Examples of such circumstances are unusually high tritium concentrations, or the detection of tritium in previously “clean” wells.

If conditions dictate, **then** the BNL Groundwater Contingency Plan will be implemented.

Decision 3

Is the plume attenuating as expected?

If the detected tritium concentrations are consistent with the attenuation model, groundwater model results, and professional judgment, **then** continue attenuation monitoring. **If not**, **then**

consider refining the conceptual model or conducting an engineering evaluation to determine if other actions are required.

Decision 4

Has the downgradient migration of the plume been controlled?

If concentrations of tritium north of Cornell Avenue increase to a level where it is determined that downgradient plume may exceed 25,000 pCi/L in wells at the Chilled Water Plant Road or above 20,000 pCi/L in wells along Weaver Drive, sampling will resume in a select number of downgradient wells. Exceedances of these activities will necessitate implementation of specific actions described in the ROD.

If the detected tritium activity exceeds 25,000 pCi/L in perimeter wells at the Chilled Water Plant Road or 20,000 pCi/L in perimeter wells at Weaver Drive, **then** implement the response actions prescribed in the OU III ROD.

Decision 5

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

If tritium concentrations from Weaver Drive to extraction well EW-16 drop below 20,000 pCi/L, **then** EW-16 will be placed in stand-by mode.

5a. Are tritium concentrations in extraction wells above or below the 20,000 pCi/L DWS?

If the tritium concentration in each plume core well has been reduced to less than 2,000 pCi/L, **then** proceed with pulsed operation of the system. **If not, then** continue treatment.

5b. Is there a significant concentration rebound in extraction wells following shutdown?

This decision is to determine whether there is significant concentration rebound after the system has been shut down completely or entered pulse pumping mode. **If yes**, **then** continue operation. **If no**, significant rebound is observed within a two-year time period, **then** petition for system shutdown and continue with monitored natural attenuation (MNA).

Decision 6

Has the groundwater cleanup goal of meeting MCLs been achieved?

If the concentration of tritium in groundwater remains less than 20,000 pCi/L for several years, **then** petition for system closure. **If not**, **then** consider the need for continued remediation.

Step 6: Specify Acceptable Error Tolerances

Table 12.16-1 summarizes the decision and possible decision errors for this project.

Step 7: Optimize the Design

Given the current knowledge of the position of the plume, based on the extensive volume of historical data, the sampling frequencies have been reduced in the following manner:

- Due to the attenuation of the plume, the monitoring program is now limited to ten wells in the immediate vicinity of the HFBR where tritium concentrations occasionally exceed 20,000 pCi/L. Therefore, sampling of 24 monitoring wells located south of Temple Place has been discontinued.

Number and Locations of Wells

The network of ten wells used for the HFBR Groundwater Monitoring Program is shown in Figure 12.16.1. Table 12.16.1 presents the decision subunits.

Table 12.16-1. Decisions, Potential Decision Errors, and Potential Consequences

Decision	Inputs	Potential Errors Based on Data	Potential Consequences
Is the BNL Groundwater Contingency Plan triggered?	See Step 3 for inputs.	(1) Trigger Contingency Plan unneces- sarily. (2) Fail to trigger Contingency Plan when it should have been triggered.	(1) Unnecessary administrative process, project delays. (2) Lost time in addressing problem, loss of stakeholder confidence.
Is the tritium plume growth minimized?	See Step 3 for inputs.	(1) Data indicate that the plume is growing when it is not. (2) Data indicate that the plume is not growing when it is.	(1) Wasted resources, loss of stakeholder confidence. (2) Potential bypass of tritium, project delays, potential risk to downgradient receptors.
Are observed conditions consistent with attenuation model?	See Step 3 for inputs.	(1) Data indicate that conditions are not consistent with model when they are. (2) Data indicate that conditions are consistent with model when they are not.	(1) Wasted resources conducting attenuation model refinements. (2) Potential bypass of tritium, project delays, potential risk to downgradient receptors.
Is the tritium plume migrating toward the zone of influence of BNL water supply wells 10, 11, and 12?	See Step 3 for inputs.	(1) Data indicate that the plume is migrating toward the supply wells when it is not. (2) Data indicate that the plume is not migrating toward the supply wells when it is.	(1) Wasted resources conducting continued unnecessary moni- toring. (2) Potential bypass of tritium, project delays, potential risk to receptors.

Has any segment of the plume migrated beyond the current monitoring network?	See Step 3 for inputs.	(1) Data indicate that plume has migrated beyond the network when it has not. (2) Data indicate that plume has not migrated beyond the network when it has.	(1) Wasted resources conducting evaluation of alternatives. (2) Potential bypass of tritium, project delays, potential risk to downgradient receptors.

Note: See also Table 12.16.2 for sampling frequency and affected parameters.

Parameters and Frequency

The 2025 monitoring schedule is shown in Table 12.16.2. The analytical parameters and sampling frequency currently conducted for this project are considered adequate.

Table 12.16.2. Proposed 2025 Sampling Frequency for the HFBR Monitoring Wells

Well	Sampling Frequency	Parameters
075-11	Quarterly	EPA 906 Tritium
075-288	Quarterly	EPA 906 Tritium
075-40	Quarterly	EPA 906 Tritium
075-802	Quarterly	EPA 906 Tritium
075-803	Quarterly	EPA 906 Tritium
075-804	Quarterly	EPA 906 Tritium
075-805	Quarterly	EPA 906 Tritium
075-806	Quarterly	EPA 906 Tritium
075-807	Quarterly	EPA 906 Tritium
075-808	Quarterly	EPA 906 Tritium

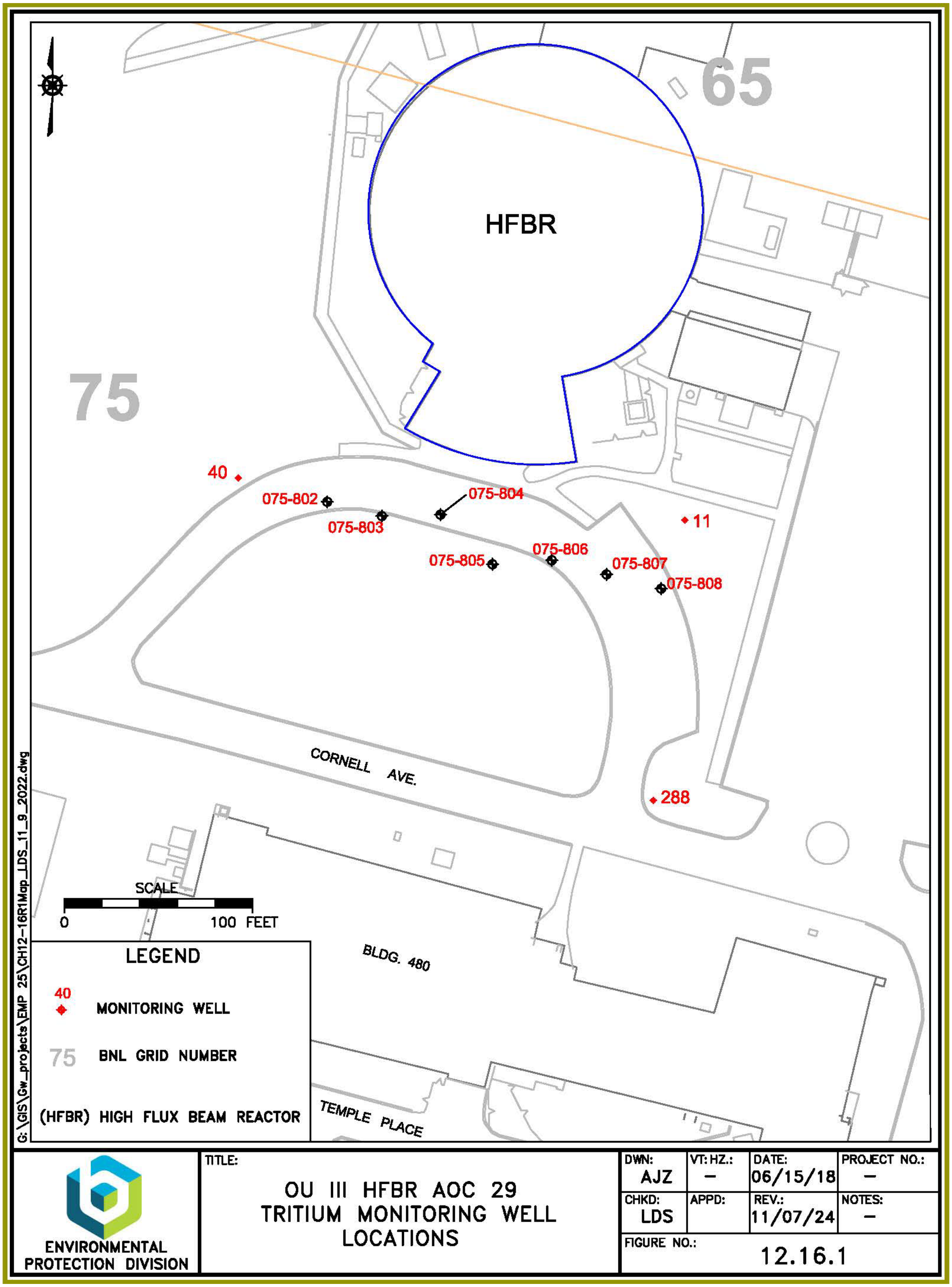

Figure 12.16.1 OU III HFBR AOC 29 Tritium Monitoring Well Locations

See Appendix B for the monitoring program for this Data Quality Objective.

12.17 OU IV Area of Concern 6 – Building 650 Sump Outfall Area

DQO Start Date January 1, 2003

Implementation Date January 1, 2025

Point of Contact Brian Barth (631) 344-2242
Vincent Racaniello (631) 344-5436

Summary of Changes

There are no changes for the Operable Unit (OU) IV Area of Concern (AOC) 6 - Building 650 Sump Outfall Area monitoring program for calendar year (CY) 2025.

Description and Technical Basis

The OU IV AOC 6 project monitors a strontium-90 (Sr-90) plume emanating from contaminated soil within an area known as the Building 650 Sump Outfall Area. This area is a natural depression at the terminus of a discharge pipe from Building 650. The pipe conveyed discharges from decontamination of radioactively contaminated clothing and equipment that was conducted on an outdoor pad at Building 650 beginning in 1959. Impacted soil within the sump outfall area was excavated during CY 2002. Groundwater flow in this area is toward the south–southwest.

The monitoring well network for the OU IV AOC 6 project consists of 24 wells. The wells are located to monitor groundwater downgradient of the decontamination pad and Building 650 Sump Outfall Area. Some wells were constructed south of the leading edge of the plume to act as sentinel wells. Well locations are shown on Figure 12.17.1. In accordance with the Record of Decision (ROD) for OU IV, the wells are sampled semi-annually for analysis of Sr-90, gross alpha/beta, gamma spectroscopy, and tritium. A schedule is provided in Table 12.1.1.

In general, Sr-90 activity trends are stable for the wells within the plume, and in wells down-gradient of the plume.

Drivers for Monitoring Being Conducted under This Change

____ Compliance
____ Support Compliance
____ Surveillance
_X_ Restoration

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

Groundwater in the vicinity of Building 650 and the Building 650 Sump Outfall Area, and downgradient of these areas, has been impacted by Sr-90 at activities exceeding New York State groundwater standards. Data are needed to define the extent of the Sr-90 plume.

Step 2: Identify the Decision

The decisions for the project are:

- Is there a continuing source of contamination? If present, has the source area been remediated or controlled?
- Were unexpected levels or types of contamination detected?
- Is the plume naturally attenuating as expected?
- Has the groundwater cleanup goal of meeting maximum contaminant levels (MCLs) been achieved?

Step 3: Identify Inputs to the Decision

The inputs necessary for the decision include:

- Direction and velocity of groundwater flow
- Radionuclide analytical results in groundwater
- Locations of existing wells relative to flow patterns
- Action levels (New York State groundwater standards and/or baseline groundwater concentrations)
- Analytical methods and detection limits as described in the Brookhaven National Laboratory (BNL) Environmental Monitoring Plan
- Variability of data

Step 4: Define the Study Boundaries

The project decision unit limits are defined by:

- HO Basin (well 066-190) on the north
- Brookhaven Avenue on the south
- Railroad Street (wells 076-373 and 076-317) on the west
- HO Basin and RA V Basin on the east
- Shallow and mid-depth Upper Glacial aquifer

Section 12.1 details the general sampling frequency based on the phase of the monitoring program.

Step 5: Develop the Decision Rules

Decision 1

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

Analytical results from plume core wells will be utilized for this decision. Future sample results will be evaluated in context with historic data for each sampling event. **If** plume core wells located in the source area continue to show elevated levels of contaminants with no decreasing trend, **then** an evaluation of the source area will be conducted to determine if the source should be remediated or controlled.

Decision 2

Were unexpected levels or types of contamination detected?

For each future sampling event, sample results will be evaluated in context with historic data. As part of that evaluation, circumstances that would require implementation of the BNL Groundwater Contingency Plan (Environmental Monitoring Standard Operating Procedure [EM- SOP]-309) would be ascertained for each sampled well. Examples of such circumstances are unusually high contaminant concentrations, detection of previously undetected contaminants, and detection of contaminants in previously "clean" wells.

If conditions dictate, **then** the BNL Groundwater Contingency Plan will be implemented.

Decision 3

Is the plume naturally attenuating as expected?

If performance objectives have not been met, **then** it must be determined whether Sr-90 activities in groundwater are consistent with the attenuation model (e.g., results are on track to attenuate to less than MCLs within 30 years).

If the detected Sr-90 activities are consistent with the attenuation model, groundwater model results and professional judgment, **then** continue monitoring. If not, consider refining the conceptual model and/or conducting an evaluation to determine whether outside factors (such as additional contaminant sources) are affecting the results.

Decision 4

Has the groundwater cleanup goal of meeting MCLs been achieved?

If the concentration of Sr-90 in groundwater is less than 8 pCi/L, **then** petition for the end of monitoring. **If not**, **then** continue monitoring.

Step 6: Specify Acceptable Error Tolerances

Table 12.17.1 summarizes the decision and possible decision errors for this project.

Table 12.17.1. Decisions, Potential Errors, and Potential Consequences

Decision	Inputs	Potential Errors Based on Data	Potential Consequences
Is the BNL Groundwater Contingency Plan triggered?	See Step 3 for inputs.	(1) Trigger Contingency Plan unnecessarily. (2) Fail to trigger Contingency Plan when it should have been triggered.	(1) Unnecessary administrative process; project delays. (2) Lost time in addressing problem; loss of stakeholder confidence.
Are performance objectives met?	See Step 3 for inputs.	(1) Data indicate that performance objectives have not been met when they have. (2) Data indicate that performance objectives have been met when they have not.	(1) Wasted resources conducting continued unnecessary monitoring. (2) Potential bypass of contaminants, project delays, potential risk to downgradient receptors.
If not, are observed conditions consistent with attenuation model?	See Step 3 for inputs.	(1) Data indicate that conditions are not consistent with model when they are. (2) Data indicate that conditions are consistent with model when they are not.	(1) Wasted resources conducting attenuation model refinements and introducing supplements. (2) Potential bypass of contaminants, project delays; potential risk to downgradient receptors.

Step 7: Optimize the Design

Number and Locations of Wells

The existing monitoring well network consists of 24 wells. Locations are shown in Figure 12.17.1.

Parameters and Frequency

A summary of the 2025 sampling program for this project is provided in Table 12.17.2.

Table 12.17.2. Proposed 2025 Sampling Frequency for the AOC 6 Project Monitoring Wells

Well ID	Sampling Frequency	Parameters
066-189	Annually	EPA 905 Sr-90
076-07	Annually	EPA 905 Sr-90
076-04	Annually	EPA 905 Sr-90
076-181	Annually	EPA 905 Sr-90
076-182	Annually	EPA 905 Sr-90
076-184	Annually	EPA 905 Sr-90
076-22	Annually	EPA 905 Sr-90
076-24	Annually	EPA 905 Sr-90
076-13	Annually	EPA 905 Sr-90
076-168	Annually	EPA 905 Sr-90
076-169	Annually	EPA 905 Sr-90
076-25	Annually	EPA 905 Sr-90
076-262	Annually	EPA 905 Sr-90
076-06	Annually	EPA 905 Sr-90
076-28	Annually	EPA 905 Sr-90
076-317	Annually	EPA 905 Sr-90
076-373	Annually	EPA 905 Sr-90
076-415	Annually	EPA 905 Sr-90
076-416	Annually	EPA 905 Sr-90
076-418	Annually	EPA 905 Sr-90

076-419	Annually	EPA 905 Sr-90
076-420	Annually	EPA 905 Sr-90
076-421	Annually	EPA 905 Sr-90
076-20	Annually	EPA 905 Sr-90

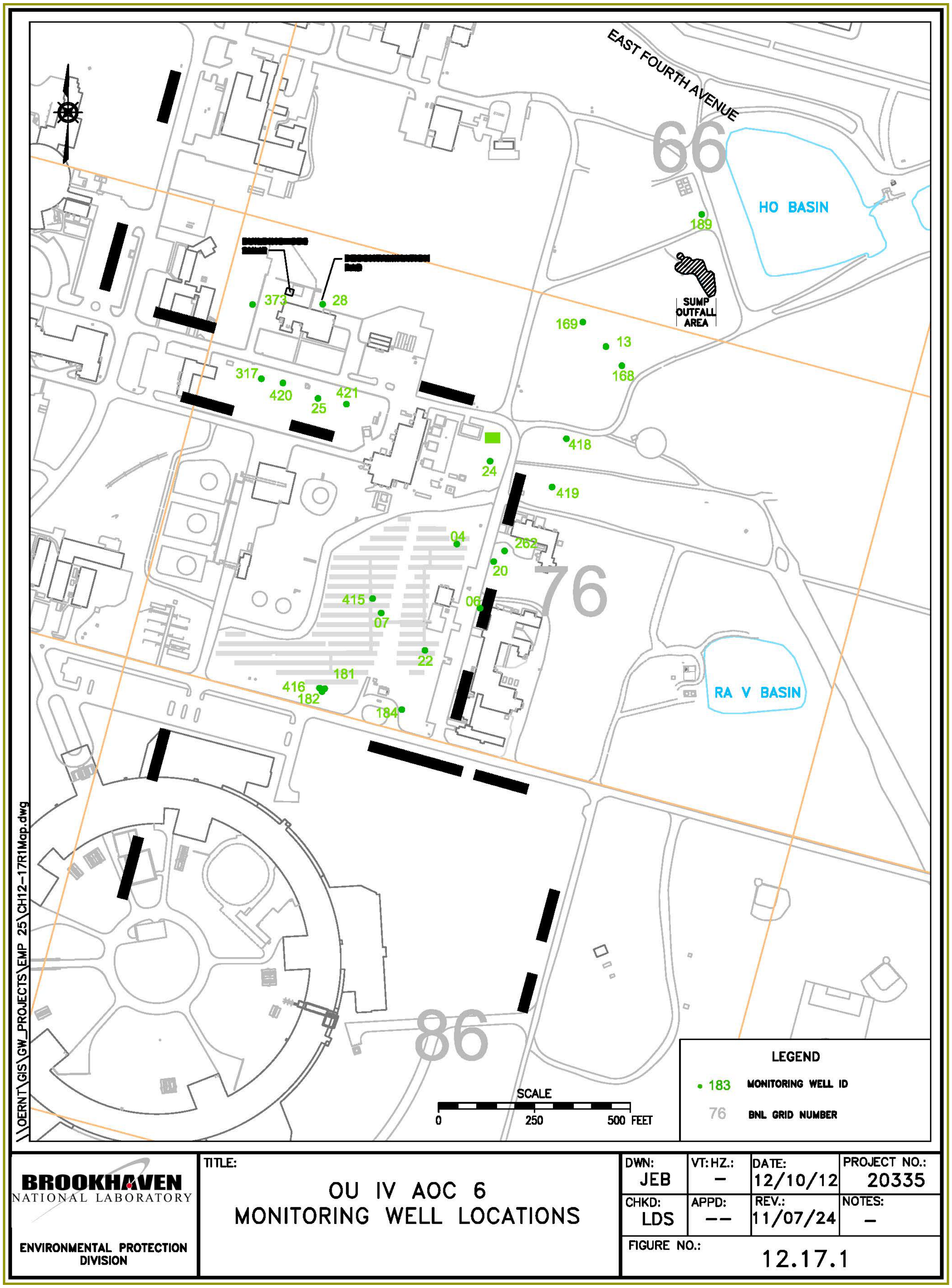

Figure 12.17.1 OU IV AOC 6 Monitoring Well Locations

See Appendix B for the monitoring program for this Data Quality Objective.

Intentionally Left Blank

12.18 OU VI Ethylene Dibromide

DQO Start Date January 1, 2003

Implementation Date January 1, 2025

Point of Contact Brian Barth (631) 344-2242
Vincent Racaniello (631) 344-5436

Summary of Proposed Changes

There are no proposed changes for the Operable Unit (OU) VI Ethylene Dibromide (EDB) Treatment System groundwater monitoring programs for calendar year (CY) 2025.

Description and Technical Basis

The monitoring well network for the OU VI EDB Project consists of 26 wells. This includes three new wells installed during 2021. Well locations are shown in Figure 12.18.1. The wells are sampled for EDB analysis. Table 12.18.2 shows the monitoring schedule for CY 2025.

The contaminant of concern associated with the OU VI plume is EDB.

Drivers for Monitoring Being Conducted under This Change

____ Compliance
____ Support Compliance
____ Surveillance
_X_ Restoration

Data Quality Objective Analysis

Step 1: State the Problem

There is an existing plume of groundwater contaminated by EDB that has migrated south of the BNL Site boundary. In response, a groundwater remediation system is currently being designed. Data are needed to confirm the vertical and horizontal extent of the EDB plume so that the design of the remediation system can be optimized.

Step 2: Identify the Decision

The decisions for the project include:

- Is there a continuing source of contamination? If present, has the source area been remediated or controlled?
- Were unexpected levels or types of contamination detected?
- Has the downgradient migration of the plume been controlled?
- Can individual extraction wells or the entire treatment system be shut down or placed in

pulsed pumping operation?
- Have the groundwater cleanup goal of meeting maximum contaminant levels (MCLs) been achieved?

Step 3: Identify Inputs to the Decision

The inputs necessary for the decision include:

- Direction and velocity of groundwater flow
- EDB analytical results in groundwater
- Locations of existing wells relative to flow patterns (Figure 12.18.1)
- Regulatory drivers (OU I Record of Decision [ROD])
- Action levels (New York State groundwater standards and/or baseline groundwater concentrations)
- Analytical methods and detection limits as described in the BNL Environmental Monitoring Plan
- Variability of data
- Status of potential downgradient receptors

Step 4: Define the Study Boundaries

The horizontal extent of the study area is the existing EDB plume and wells immediately south of the Long Island Power Authority (LIPA) right-of-way. These limits are defined by wells 000-173/000-175 to the north, wells 000-519 and 000-508 to the south, well 000-524 to the east, and well 000-498 to the west. The vertical extent of the study area is the saturated thickness of the Upper Glacial aquifer.

Because the contaminant plume has already passed the southern BNL site boundary, tracking the plume configuration over time is of critical importance. The time frame to consider analytical results is 90 days.

Step 5: Develop the Decision Rules

Decision 1

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

Analytical results from plume core wells will be utilized for this decision. Future sample results will be evaluated in context with historic data for each sampling event. **If** plume core wells located in the source area continue to show elevated levels of contaminants with no decreasing trend, **then** an evaluation of the source area will be conducted to determine if the source should be remediated or controlled.

Decision 2

Were unexpected levels or types of contamination detected?

Analytical results from wells in all three subunits will be utilized for this decision. Future sample results will be evaluated in context with historic data for each sampling event. As part of that evaluation, circumstances that would require implementation of the BNL Groundwater Contingency Plan (Environmental Monitoring Standard Operating Procedure [EM-SOP]-309) would be ascertained for each sampled well. Examples of such circumstances are unusually high contaminant concentrations, detection of previously undetected contaminants, and detection of contaminants in previously "clean" wells.

If conditions dictate, **then** the BNL Groundwater Contingency Plan will be implemented.

Decision 3

Has the downgradient migration of the plume been controlled?

This decision applies to the perimeter and bypass detection wells. If the cleanup goals have not been met, it must be verified that the plume is not growing. Plume growth is defined as an increase in EDB concentration in perimeter or bypass detection wells to above 0.05 µg/L (if currently less than 0.05 µg/L).

If the trend in each perimeter and bypass detection well has a negative slope, based on the four most recent consecutive samples, this trend is consistent with professional judgment, and the EDB concentration is less than 0.05 µg/L, **then** continue to operate the system. **If not**, **then** consider an engineering evaluation or operational adjustments to optimize system operation.

Decision 4

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

If evaluation of analytical results for any contaminant of concern in any upgradient or plume core well sample, in conjunction with historic analytical results and trends indicates that the treatment system have met the shutdown criteria of achieving the cleanup goal by 2030, **then** a petition for shutdown will be issued to the regulatory agencies.

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

This decision also applies to the plume core wells. It is anticipated that approximately ten to 13 years of active groundwater treatment will reduce the mean EDB concentration to less than 0.05 µg/L.

If this occurs, **then** it is reasonable to expect (based on model projections) that monitored natural attenuation (MNA) of the remaining contamination in the plume core will be reduced further to meet the cleanup goals of restoring the Upper Glacial aquifer to MCLs by 2030. **If** the EDB concentration remains above 0.05 µg/L, **then** consider operational adjustments and/or engineering evaluation.

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

If yes, **then** continue operation. **If** yes and system has operated for more than 13 years, **then** an engineering evaluation should be performed to evaluate whether continued operation of the system is warranted. **If** no significant rebound is observed within a one-year time period, **then** petition for system shutdown and continue with MNA.

Decision 5

Have the groundwater cleanup goal of meeting MCLs been achieved?

If the mean concentration of EDB in groundwater, calculated from analytical results from all plume core wells for the most recent sampling event, is less than 0.05 µg/L, and if the mean EDB concentration of each contaminant of concern in groundwater in each plume core well, computed from measurements over the previous two years, is less than 0.05 µg/L, and pulsing of the remediation system has not resulted in significant rebound of contaminant concentrations, **then** petition for system shutdown and continue with MNA until MCLs are met. **If not**, **then** consider the need for continued remediation.

Step 6: Specify Acceptable Error Tolerances

Table 12.18.1 summarizes the decision and possible decision errors for this project.

Table 12.18.1. Decisions, Potential Decision Errors, and Potential Consequences

Decision	Inputs	Potential Errors Based on Data	Potential Consequences
Is the Contingency Plan activated?	See Step 3 for inputs.	(1) Trigger Contingency Plan unnecessarily. (2) Fail to trigger Contingency Plan when it should have been triggered.	(1) Unnecessary administrative process; project delays. (2) Lost time in addressing problem; loss of stakeholder confidence.
Is plume growth controlled?	See Step 3 for inputs.	(1) Determine plume is controlled when it is not. (2) Determine plume is not controlled when it is.	(1) Premature petition for system shutoff; project delays. (2) Continue remediation longer than necessary; wasted resources.
Is the system operating as planned?	See Step 3 for inputs.	(1) Determine system operating as planned when it is not. (2) Determine system isn't operating as planned when it is.	(1) Premature petition for system shutoff; potential to have to restart system. (2) Continue remediation that is no longer effective.
Can the groundwater treatment system be shut down?	See Step 3 for inputs.	(1) Determine system can be shut down when operation should continue. (2) Determine to continue operating system when shut down is warranted.	(1) Plume growth continues; ultimate project delays. (2) Wasted resources; project delays.

Step 7: Optimize the Design

Number and Locations of Wells

The monitoring well network for the OU VI EDB Project consists of 26 existing wells. The locations of the wells are shown in Figure 12.18-1.

Parameters and Frequency

EDB is sampled quarterly to annually, depending on the monitoring well. A summary of sampling parameters and frequency is provided in Table 12.18.2.

Table 12.18.2. Proposed 2025 Sampling Frequency for the Ethylene Dibromide Monitoring Wells

Well ID	Current Sampling Frequency	Parameters
000-173	Annually	EPA 504 EDB
000-175	Annually	EPA 504 EDB
000-178	Semi-annually	EPA 504 EDB
000-209	Annually	EPA 504 EDB
000-283	Semi-annually	EPA 504 EDB
000-284	Semi-annually	EPA 504 EDB
000-498	Semi-annually	EPA 504 EDB
000-499	Semi-annually	EPA 504 EDB
000-500	Quarterly	EPA 504 EDB
000-501	Semi-annually	EPA 504 EDB
000-507	Semi-annually	EPA 504 EDB
000-508	Quarterly	EPA 504 EDB
000-519	Quarterly	EPA 504 EDB
000-520	Semi-annually	EPA 504 EDB
000-524	Semi-annually	EPA 504 EDB
000-527	Quarterly	EPA 504 EDB
000-549	Quarterly	EPA 504 EDB
000-550	Quarterly	EPA 504 EDB
000-567	Quarterly	EPA 504 EDB
000-568	Quarterly	EPA 504 EDB
000-570	Quarterly	EPA 504 EDB
000-571	Quarterly	EPA 504 EDB
000-572	Quarterly	EPA 504 EDB
000-580	Quarterly	EPA 504 EDB
000-581	Quarterly	EPA 504 EDB
000-582	Quarterly	EPA 504 EDB

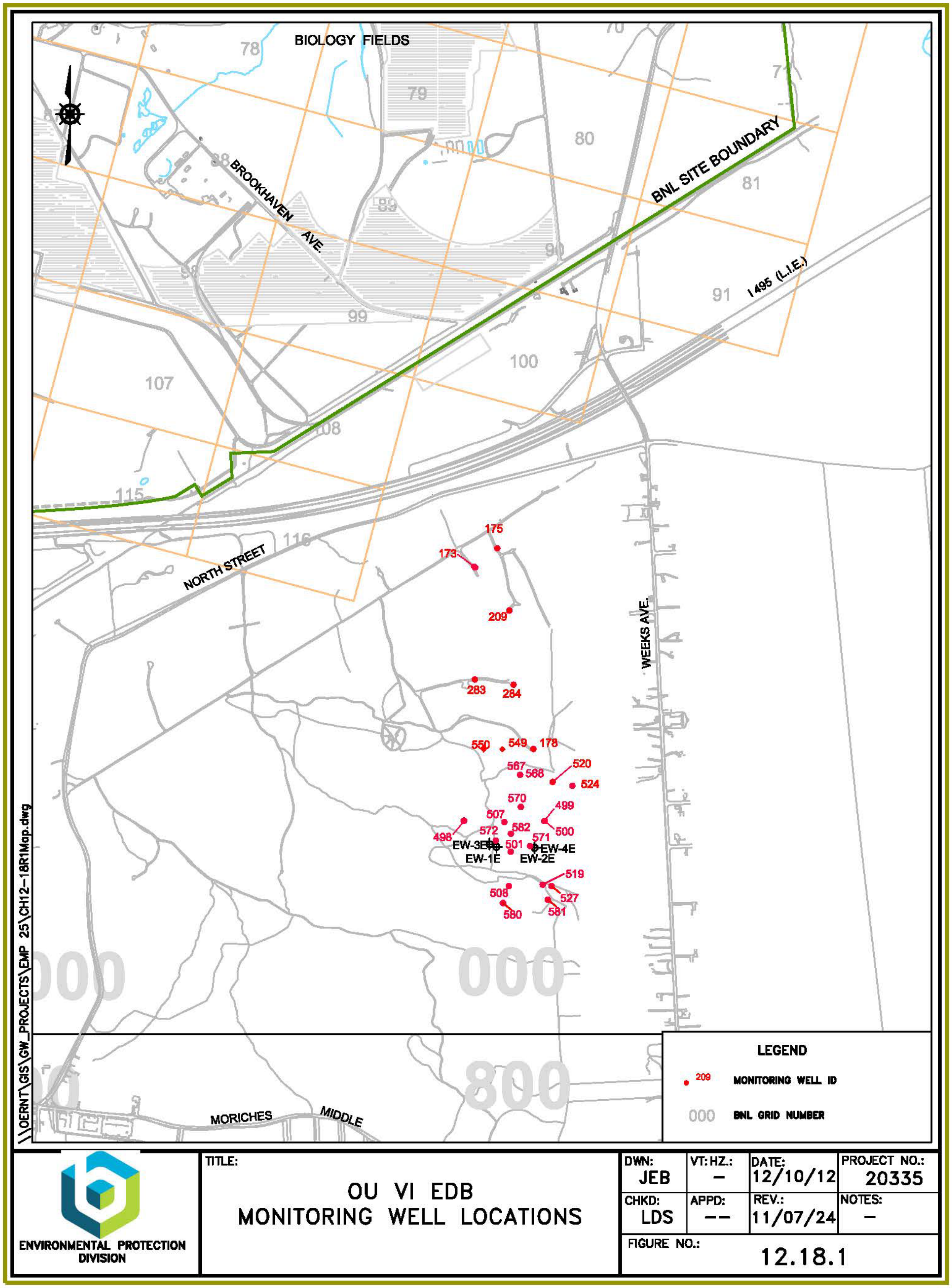

Figure 12.18.1 OU VI EDB Monitoring Well Locations

See Appendix B for the monitoring program for this Data Quality Objective.

12.19 SITE BACKGROUND

DQO START DATE January 1, 2003

IMPLEMENTATION DATE January 1, 2025

POINT OF CONTACT Brian Barth (631) 344-2242

SUMMARY OF PROPOSED CHANGES

There are no changes proposed for the for the Site Background monitoring program for calendar year 2025.

DESCRIPTION AND TECHNICAL BASIS

Background water quality at Brookhaven National Laboratory (BNL) has been monitored since 1996. The current program includes nine wells located in the northwestern portion of the BNL property (017-01, 017-03, 017-04, 018-01, 018-02, 018-04, 018-05, 034-02, and 034-03). Well locations are shown in Figure 12.19.1.

Samples are collected annually and analyzed for volatile organic compounds (VOCs). Analytical results are reviewed to determine whether contaminants from off-site, upgradient sources are being transported onto the BNL facility. Historically, low levels of VOCs (less than New York State groundwater standards) have been detected in the deeper portion of the Upper Glacial aquifer and in the Magothy aquifer.

DRIVERS FOR MONITORING BEING CONDUCTED UNDER THIS CHANGE

____ Compliance
____ Support Compliance
__X Surveillance
__X Restoration

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

Groundwater flow in the northwestern portion of the BNL facility within the shallow and deep portions of the Upper Glacial aquifer is typically toward the east to south-southeast and groundwater flow within the Magothy aquifer is toward the east-southeast. This is consistent with historic groundwater flow patterns at the BNL facility. Site Background wells are positioned to detect contamination migrating onto the BNL site.

PROBLEM STATEMENT

Data are needed to evaluate whether off-site, upgradient sources of groundwater contamination are impacting the BNL facility and to establish baseline/background levels of naturally occurring constituents, including metals and radionuclides, that are not impacted by BNL activities.

Step 2: Identify the Decision

Were unexpected levels or types of contamination detected?

Step 3: Identify Inputs to the Decision

The inputs necessary for the decision include:

- Direction and velocity of groundwater flow
- Locations of existing wells relative to flow patterns (Figure 12.19.1)
- Analytical methods and detection limits as described in the BNL Environmental Monitoring Plan (EMP)
- Variability of data

Step 4: Define the Study Boundaries

The study boundaries for the Site Background program are the northwestern (upgradient) portion of the BNL facility and nearby off-site areas within the Upper Glacial and shallow Magothy aquifers.

Step 5: Develop the Decision Rules

Decision 1

Were unexpected levels or types of contamination detected?

The sample results will be evaluated in context with historical data. As part of that evaluation, circumstances that would require implementation of the Groundwater Contingency Plan (Environmental Monitoring Standard Operating Procedure [EM-SOP]-309) would be determined for each sampled well. Examples of such circumstances are unusually high contaminant concentrations, including detection of previously undetected contaminants and detection of contaminants in wells where those contaminants have not previously been detected.

If conditions dictate, **then** the BNL Groundwater Contingency Plan will be implemented.

Step 6: Specify Acceptable Error Tolerances

Table 12.19.1 summarizes the decision and possible decision errors for this project.

Table 12.19.1. Decisions, Potential Decision Errors, and Potential Consequences

Decision	Inputs	Potential Errors Based on Data	Potential Consequences
Is groundwater quality at BNL being impacted by off-site, upgradient source(s) of contamination?	See Step 3 for inputs.	(1) Data indicate the existence of an upgradient source when one does not exist (data indicate detected contamination is from an off-site source when it is not). (2) Data indicate that there is not an upgradient source when one does exist (data indicate detected contamination is from an on-site source when it is not).	(1) On-site contaminant source(s) will not be investigated and/or remediated and may continue to degrade groundwater quality. (2) Investigation and/or remediation of groundwater contamination may be undertaken by BNL when it is not warranted.

Because the wells included in the Site Background Program are located in the upgradient portion of the BNL facility, travel time for contamination detected in these wells to the nearest potential receptor (on-site potable supply wells) is estimated at ten years. It is therefore unlikely that decision error will result in adverse consequences to human health. The consequences of decision error relate primarily to possible enforcement actions for environmental degradation, erosion of stakeholder trust and BNL credibility, and wasted resources.

Step 7: Optimize the Design

Number and Locations of Wells

The number and locations of wells for this program are considered adequate.

PARAMETERS AND FREQUENCY

The analytical parameters and sampling frequency currently conducted for this project are considered adequate. Therefore, no modifications are recommended at this time. A summary of the proposed 2025 sampling frequency for the Site Background sampling program is provided in Table 12.19.2.

Table 12.19.2. Proposed 2025 Sampling Frequency for the Site Background Monitoring Wells

Well ID	Sampling Frequency	Parameters
017-01	Annually	8260 Low Level
017-03	Annually	8260 Low Level
017-04	Annually	8260 Low Level
018-01	Annually	8260 Low Level
018-02	Annually	8260 Low Level
018-04	Annually	8260 Low Level
018-05	Annually	8260 Low Level
034-02	Annually	8260 Low Level
034-03	Annually	8260 Low Level

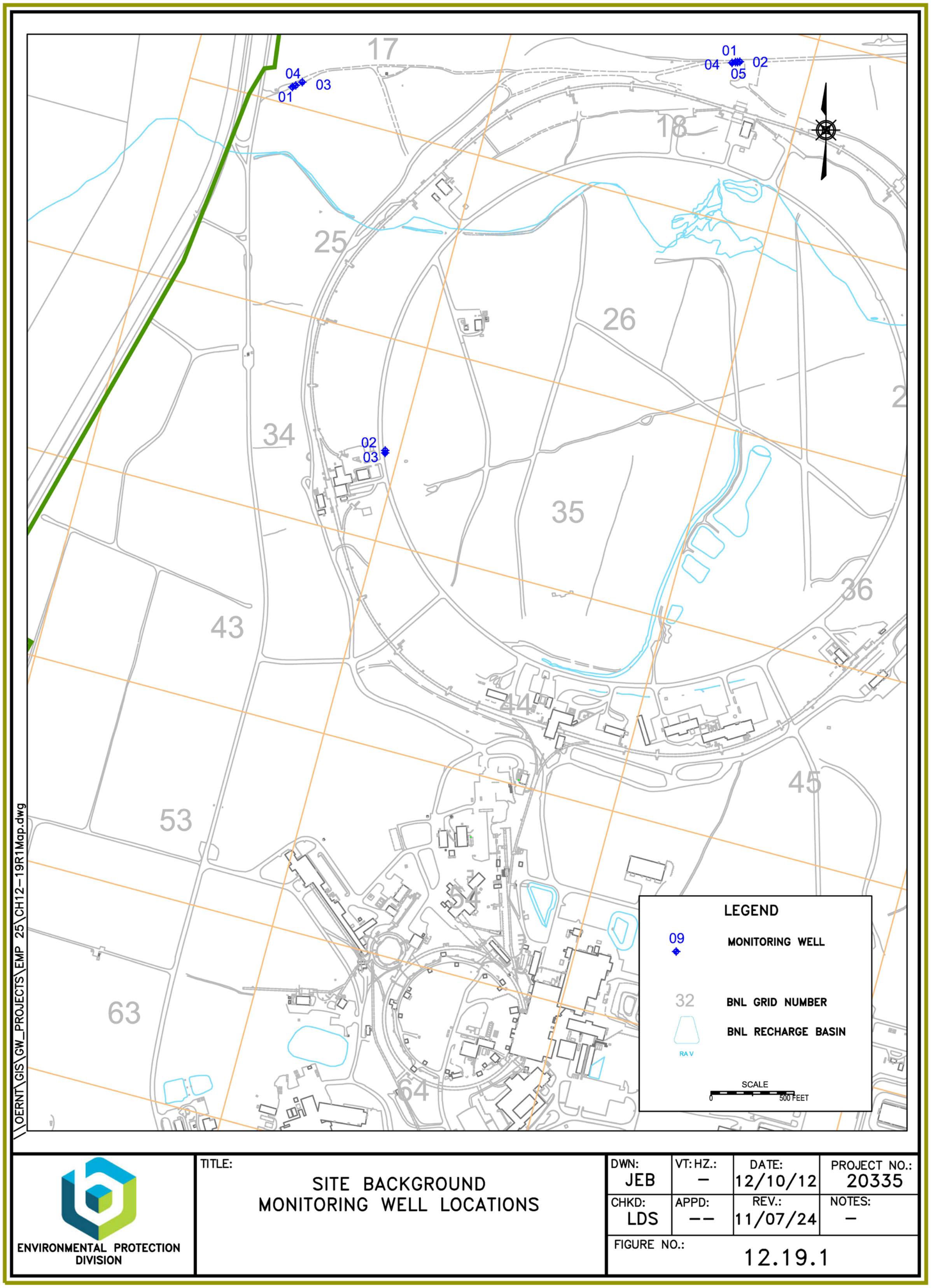

Figure 12.19.1 Site Background Monitoring Well Locations

See Appendix B for the monitoring program for this Data Quality Objective.

12.20 Current Landfill Post-Closure

DQO Start Date January 1, 2003

Implementation Date January 1, 2025

Point of Contact Brian Barth (631) 344-2242

James Milligan (631) 344-4458

Summary of Changes

The changes to the Current Landfill monitoring program for calendar year 2025 are to add PFAS EPA Method 1633 and 1,4-dioxane EPA Method 8270D SIM to the analytical list of parameters for all 12 monitoring wells on an annual basis with collection during the fourth quarter sampling round.

Description and Technical Basis

The Current Landfill operated from 1967 through 1990. Putrescible waste, sludge from the Brookhaven National Lab (BNL) Water Treatment Plant (WTP), anaerobic digester sludge from the BNL Sewage Treatment Plant (STP), and limited quantities of Laboratory waste were disposed in the landfill. The landfill was capped in accordance with the New York Code, Rules, and Regulations (NYCRR) Part 360 requirements in 1995.

The monitoring well network for the Current Landfill consists of 12 wells, including one upgradient well (087-09), three wells immediately downgradient of the landfill (087-11, 088-109, and 088-110), and eight wells further downgradient of the landfill (087-23, 087-24, 087-26, 087-27, 088-21, 088-22, 088-23, and 098-99). Well locations are shown in Figure 12.20.1. All wells except for 098-99 are sampled and analyzed for volatile organic compounds (VOCs), metals, and landfill leachate parameters. Samples from four wells are also analyzed for strontium-90 (Sr-90), tritium, and gamma spectroscopy. Well 098-99 is only sampled for VOCs.

Drivers for Monitoring Being Conducted Under This Change

_X_ Compliance (NYCRR Part 360)
_X_ Support Compliance
____ Surveillance
____ Restoration

Data Quality Objective Analysis

Step 1: State the Problem

The Current Landfill has been an historic source of contamination and remains a potential source of contaminants to groundwater. In response, BNL has constructed an engineered cap over the landfill to mitigate future releases.

Problem Statement: Potential failure of the landfill cap could lead to continued releases from the Current Landfill into groundwater at levels exceeding maximum contaminant levels (MCLs).

Step 2: Identify the Decision

- Are the controls effectively improving groundwater quality below and downgradient of the landfill?

Step 3: Identify Inputs to the Decision

The inputs necessary for the decision include:

- Direction and velocity of groundwater flow
- Comparison of pre- and post-capping groundwater quality by analysis of VOCs, metals, radionuclides, tritium, and landfill water quality parameter concentrations in groundwater
- Locations of existing wells relative to flow patterns
- Regulatory drivers (New York Codes, Rules, and Regulations [NYCRR] Part 360)
- Action Levels (MCLs and/or baseline groundwater concentrations)
- Analytical methods and detection limits as described in this Environmental Monitoring Plan (EMP)

Step 4: Define the Study Boundaries

The decision unit limits for this project are the immediate vicinity of the Current Landfill and the 12 wells that comprise the groundwater monitoring program. The period for which the decisions will be made depends on the individual parameters, as summarized in Table 12-20.1.

Table 12.20.1. Factors Affecting the Period for Decisions for the Current Landfill

Parameter	Historical Detection?	Relative Travel Time **	Above MCLs 2002–2024?	Trend 2002–2024	Time for Decision
VOCs	Yes	< 60 days	Yes	Stable	365 days
Tritium	Yes	< 60 days	No	Stable	365 days
Metals	Yes	Varies	Yes	Stable	2 years *
Sr-90	Yes	1,200 days	No	Stable	2 years *
Gamma spectroscopy	Yes	--	NA	Stable	2 years *
Leachate parameters	Yes	< 60 days	Yes	Stable	365 days

Notes:
* Based on trend.
** Relative travel time is approximate time for contamination to travel from waste pile to surrounding wells.

The periods over which decisions will be made were based on the low risk to potential receptors of contamination from the Current Landfill. The factors considered to determine that risk is low are:

- Engineered control (landfill cap) is a proven conventional technology with a low failure rate
- Low travel velocities for contaminants
- Absence of downgradient receptors
- Resource has already been degraded
- A groundwater pump and treat system has operated downgradient of the Current Landfill (to address historical releases from the landfill)

Step 5: Develop the Decision Rules

Decision 1

Are the controls effectively eliminating further discharges below the landfill?

The sample results will be evaluated in context with historic data for each sampling event. As part of that evaluation, circumstances that would require implementation of the BNL Groundwater Contingency Plan would be ascertained for each sampled well. Examples of such circumstances are unusually high contaminant concentrations, detection of previously undetected contaminants, and detection of contaminants in previously "clean" wells.

If for any downgradient well, the current annual mean concentration for an individual contaminant of concern exceeds the mean concentration in that well computed from data collected from that well over the past three years, and is greater than MCLs, and this result is confirmed by resampling appropriate wells, as well as by an evaluation of upgradient and downgradient conditions, **then** an evaluation will be made as to whether an increase in sampling frequency for that parameter or parameter group (for example, metals) would be appropriate. In addition, consider conducting an engineering evaluation to determine whether the capping system is performing as planned. **If** the current annual mean concentration for an individual contaminant of concern does not exceed the mean concentration in that well computed from data collected from that well over the past three years, **then** continue detection monitoring.

Notes:
a. Use concentration plots over time to visually assess data for trends and model predictions.
b. Slope analysis suggests that the goal will be achieved within the planned period (two to ten years).
c. If the water quality for the majority and/or key wells (as defined by the subject matter expert) is improving as planned, then "the system" as a whole is considered to be properly operating.

Step 6: Specify Acceptable Error Tolerances

Table 12.20.2 summarizes the decision and possible decision errors for this project.

Table 12.20.2. Decisions, Potential Decision Errors, and Potential Consequences

Decision	Inputs	Potential Errors Based on Data	Potential Consequences
Are the controls effective at eliminating further discharges to groundwater below the Current Landfill?	See Step 3 for inputs.	(1) Data indicate controls are effective when they are not. (2) Data indicate controls are not effective when they are.	(1) A discrete VOC contaminant slug of up to 300 feet long and 300 feet wide could exist and not be detected. (2) Delay in notifying stakeholders and taking corrective actions, prolonged operation of the OU I RA V groundwater treatment system.

There are no potential receptors immediately downgradient of the Current Landfill and groundwater travel time to the site boundary is approximately ten to 15 years. In addition, a groundwater treatment system is already operating and treating historical releases from the landfill.

Due to these factors, it is very unlikely that decision error will result in adverse consequences to human health or noncompliance with the Operable Unit (OU) I Record of Decision (ROD). The consequences of decision error relate primarily to possible enforcement actions for environmental degradation and erosion of stakeholder trust and BNL credibility.

Step 7: Optimize the Design

Number and Locations of Wells

The 12 monitoring wells around the landfill are adequate considering the potential consequences of a decision error. The current network was developed using expert judgment, groundwater models, and particle-tracking computer codes. No refinements are recommended at this time since the groundwater flow direction has been relatively constant in this area in recent years and the potential source is relatively small in size.

Parameters and Frequency

A summary of the proposed 2025 sampling program for this project is shown in Table 12.20.3.

Table 12.20.3. Proposed 2025 Sampling Frequency for the Current Landfill Monitoring Wells

Well ID	Sampling Frequency	Parameters
087-09	Semi-annual Annual for PFAS, and 1,4-dioxane	8260Low Level, *Wet Chem, TAL Metals, Cyanide 1633PFAS, 8270SIM 1,4-dioxane
087-11	Semi-annual Annual for PFAS, and 1,4-dioxane l	8260Low Level, *Wet Chem, TAL Metals, Cyanide 1633PFAS, 8270SIM 1,4-dioxane
087-23	Semi-annual. Annual for Rad. Annual for PFAS, and 1,4-dioxane	8260Low Level, *Wet Chem, TAL Metals, Cyanide, EPA 901 Gamma Spec, EPA 906 Tritium, EPA 905 Sr-90 1633PFAS 8270SIM for 1,4-dioxane
087-24	Quarterly (8260), Semi-annual Annual for PFAS, and 1,4-dioxane	8260Low Level, *Wet Chem, TAL Metals, Cyanide 1633PFAS, 8270SIM 1,4-dioxane
087-26	Semi-annual Annual for PFAS, and 1,4-dioxane	8260Low Level, *Wet Chem, TAL Metals, Cyanide 1633PFAS, 8270SIM 1,4-dioxane
087-27	Semi-annual, Annual for Rad Annual for PFAS, and 1,4-dioxane	8260Low Level, *Wet Chem, TAL Metals, Cyanide, EPA 901 Gamma Spec, EPA 906 Tritium, EPA 905 Sr-90 1633PFAS, 8270SIM 1,4-dioxane
088-21	Semi-annual, Annual for Rad Annual for PFAS, and 1,4-dioxane	8260Low Level, *Wet Chem, TAL Metals, Cyanide, EPA 901 Gamma Spec, EPA 906 Tritium, EPA 905 Sr-90 1633PFAS, 8270SIM 1,4-dioxan
088-22	Annual	8260Low Level, *Wet Chem, TAL Metals, Cyanide 1633PFAS, 8270SIM 1,4-dioxan
088-23	Annual	8260Low Level, *Wet Chem, TAL Metals, Cyanide

		1633PFAS, 8270SIM 1,4-dioxan
088-109	Quarterly (8260), Semi-annual, Annual for Rad Annual for PFAS, and 1,4-dioxane	8260Low Level, *Wet Chem, TAL Metals, Cyanide, EPA 901 Gamma Spec, EPA 906 Tritium, EPA 905 Sr-90 1633PFAS, 8270SIM 1,4-dioxan
088-110	Semi-annual Annual for PFAS, and 1,4-dioxane	8260Low Level, *Wet Chem, TAL Metals, Cyanide 1633PFAS, 8270SIM 1,4-dioxan
098-99	Quarterly Annual for PFAS, and 1,4-dioxane	8260 Low Level 1633PFAS, 8270SIM 1,4-dioxan

*Wet Chem includes: TSS/TDS/Sulfates/Chlorides/Alkalinity/TKN/Total Nitrogen/Nitrates/Nitrites/Ammonia

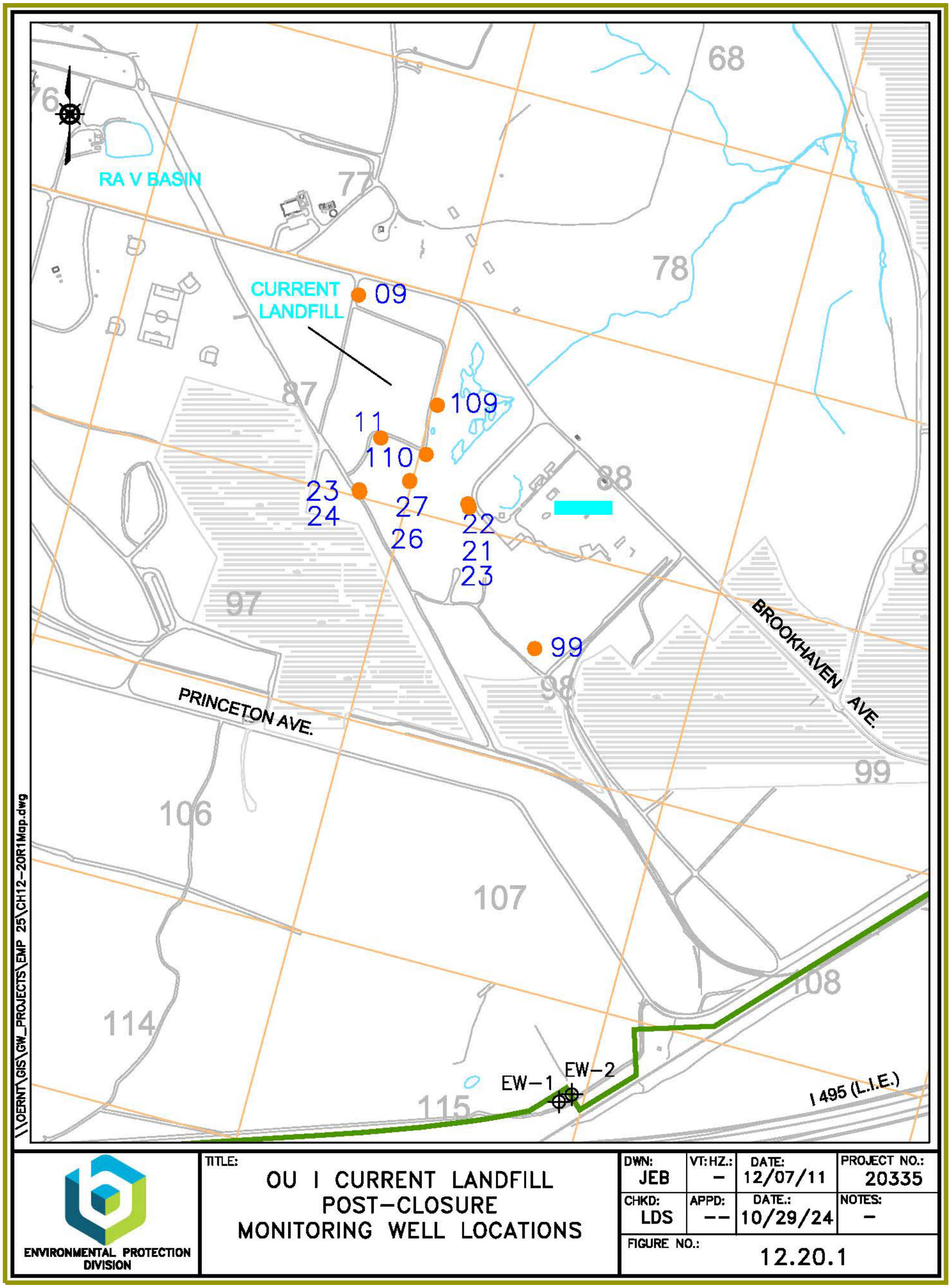

Figure 12.20.1 OU I Current Landfill Post-Closure Monitoring Well Locations

See Appendix B for the monitoring program for this Data Quality Objective.

12.21 GROUNDWATER ELEVATION MONITORING

DQO START DATE January 1, 2003

IMPLEMENTATION DATE January 1, 2025

POINT OF CONTACT Brian Barth (631) 344-2242

SUMMARY OF PROPOSED CHANGES

There are no new changes proposed for Groundwater Elevation Monitoring in calendar year (CY) 2025.

BACKGROUND

During CY 2021, the groundwater elevation measurements were obtained during two measurement events. The first was a smaller set of measurements in the southwest portion of the site which was obtained in early September to measure the influence of the William Floyd Public Supply Well Field during their peak pumping period. The routine annual monitoring program consisted of the collection of water level data using approximately 185 wells that are screened in the shallow Upper Glacial aquifer where water-pumping and recharge operations have significant transient impacts to groundwater flow directions and gradients. Multiple years of monitoring hydraulic heads in the deep Upper Glacial aquifer and the upper Magothy aquifer have demonstrated that groundwater flow directions and gradients are stable under a variety of pumping and recharge conditions; therefore, routine monitoring is not required. As necessary, Brookhaven National Laboratory (BNL) will collect water level data from wells screened in the deep Upper Glacial aquifer and upper Magothy aquifer to evaluate flow directions and gradients.

DESCRIPTION AND TECHNICAL BASIS

The purpose of the groundwater elevation monitoring program is to characterize the groundwater flow directions and rates across the BNL site and nearby off-site areas in multiple aquifers of interest to the groundwater protection and cleanup programs. The aquifers or sub-aquifers are:

- *Shallow Upper Glacial aquifer*: This portion of the aquifer is first to be impacted by any BNL releases and is currently contaminated in portions of the site. Groundwater flow direction and rate vary, depending on the discharge area (e.g., Peconic River, Carmans River, or Moriches Bay), as well as BNL water supply well and groundwater remediation well pumping and recharge basin operations.

- *Deep Upper Glacial aquifer*: This portion of the Upper Glacial aquifer is utilized by BNL's water supply wells and is also contaminated in certain on-site and off-site areas. The deep Upper Glacial aquifer is also the target of numerous groundwater remediation systems. Groundwater flow direction and rate vary, depending on the discharge area (e.g., Peconic River, Carmans River, or Moriches Bay), as well as BNL water supply well and groundwater remediation well pumping and, to a lesser extent, recharge basin operations.

- *Upper Magothy aquifer*: This aquifer is contaminated in isolated off-site areas. It is also utilized by the Suffolk County Water Authority (SCWA) for off-site community water supply purposes (BNL's plumes are not an immediate threat to these supply wells). The Magothy aquifer tends to have different flow patterns and rates (i.e., more east-southeast and slower) than the Upper Glacial aquifer.

In previous years, synoptic groundwater elevation measurements were collected from approximately 740 wells on an annual basis. In 2019, the program for the annual collection of water level measurements from approximately 185 wells was reduced significantly. Most of the wells included in the groundwater elevation monitoring program are located on site, although off- site wells constructed by BNL and by the United States Geological Survey are also measured. In addition, because wells in some areas are more closely spaced than necessary for the groundwater elevation monitoring program, only a representative number of wells are monitored and not all existing wells are included in the program.

The resulting groundwater elevation data are used to develop groundwater elevation contour maps. The information contained on these maps is utilized to evaluate horizontal groundwater flow directions and rates throughout the BNL site. These data are used to confirm that monitoring and extraction wells are located properly, to confirm that existing remediation systems are effective at capturing the targeted contamination, and that monitoring of operational and engineered controls for groundwater protection is capable of rapidly detecting an unexpected release of contamination.

DRIVERS FOR MONITORING BEING CONDUCTED UNDER THIS CHANGE

_X Compliance
_X Support Compliance
_X Surveillance
_X Restoration

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

To monitor groundwater quality and the effectiveness of groundwater protection and cleanup activities, comprehensive groundwater flow information is required. Data are needed on an annual basis to evaluate groundwater flow directions and rates and horizontal gradients in the shallow portion of the Upper Glacial aquifer on-site and off-site. On a less frequent basis, BNL will also need to collect water level data in deep Upper Glacial and upper Magothy aquifer wells to evaluate groundwater flow directions and rates, as well as horizontal and vertical gradients between multiple aquifer segments.

Step 2: Identify the Decision

This project generates comprehensive and regional data inputs for decisions to be made in various groundwater remediation and groundwater protection projects. These decisions are not discussed here. The decisions related to this project are:

- Are the groundwater flow direction and rate data developed for this project of sufficient level of detail and confidence to support other projects?

- Is the groundwater flow system approaching a steady state condition that could justify changes in monitoring?

Step 3: Identify Inputs to the Decision

The groundwater flow inputs generated by this project that are necessary for decisions in other projects include:

- Quarterly depth to water measurements in selected wells, measured to the nearest 0.01 foot
- Measuring point elevations for measured wells, measured to the nearest 0.01 foot
- Locations of measured wells

Step 4: Define the Study Boundaries

Because wells located throughout the BNL site and off site are included in this program, the study boundaries are the groundwater watershed areas for the Upper Glacial and upper Magothy aquifers in the vicinity of the BNL site.

Step 5: Develop the Decision Rules

Decision 1

Are the groundwater flow direction and rate data developed for this project of sufficient level of detail and confidence to support other projects?

These decision rules should be applied for water levels in the shallow portion of the Upper Glacial aquifer. The data generated for each measurement round will be reviewed by BNL hydrogeologists with respect to historic data and pumping and recharge rates for supply wells and existing remediation systems.

If data generated for each measurement round are considered adequate as input for decisions to be made for other projects, **then** utilize the data for project-specific decisions. Otherwise, consider modifying the suite of wells that are measured to address the identified data gap(s).

Decision 2

Is the groundwater flow system approaching a steady state condition that could justify changes in elevation monitoring?

If, significant change in groundwater flow directions or gradients is observed during any four consecutive measuring periods, **then** continue with the existing monitoring program for that aquifer segment.

If significant change in groundwater flow direction or gradient is not observed during any four consecutive measuring periods, **then** apply expert judgment to consider reducing monitoring frequency or the number of wells used to collect the measurements.

Step 6: Specify Acceptable Error Tolerances

Table 12.21.1 summarizes the decision and possible decision errors for this project.

Table 12.21.1. Decisions, Potential Decision Errors, and Potential Consequences

Decision	Inputs	Potential Errors Based on Data	Potential Consequences
Are the groundwater flow direction and rate data developed for this project of sufficient level of detail and confidence to support other projects?	See Step 3 for in-puts.	(1) Data indicate data are sufficient when they are not. (2) Data indicate data are not sufficient when they are.	(1) Potential for decision or monitoring errors in other projects due to inadequate data. (2) Wasted resources considering/ implementing operational or monitoring adjustments in other projects.
Is the groundwater flow system approaching a steady state condition that could justify changes in elevation monitoring?	See Step 3 for in-puts.	(1) Data indicate that the ground-water system is approaching a steady state condition when it is not. (2) Data indicate that the ground-water system is not approaching a steady state condition when it is.	(1) Potential for variations in groundwater flow direction to be missed due to decreased monitoring frequency; loss of stakeholder trust. (2) Wasted resources conducting unnecessary water level monitoring.

Step 7: Optimize the Design

Number and Locations of Wells

Groundwater Elevation Monitoring program for the collection of water level data will use approximately 225 on-site and off-site monitoring wells that are screened in the shallow portions of the Upper Glacial aquifer. As necessary, BNL may periodically take water level measurements from deep Upper Glacial and upper Magothy aquifer wells to evaluate flow directions and gradients.

Frequency

Based on the volume of historic water level data, a full synoptic round of water level measurements from approximately 185 shallow Upper Glacial aquifer wells are collected annually. Additional measurement rounds will be added as necessary if conditions warrant.

See Appendix B for the monitoring program for this Data Quality Objective.

Table 12.22.1 Facility Groundwater Monitoring Schedule

Project	Sample Event	Start Date	End Date	# of Wells
Alternating Gradient Synchrotron Facility	4th Qtr.	10/01/2025	12/15/2025	48
Alternating Gradient Synchrotron Facility – g-2 Tritium Source Area and Plume	2nd Qtr.	04/01/2025	04/30/2025	5
	4th Qtr.	10/01/2025	10/31/2025	5
Brookhaven Linac Isotope Producer	2nd Qtr.	04/01/2025	05/15/2025	3
	4th Qtr.	10/01/2025	11/15/2025	4
Relativistic Heavy Ion Collider	1st Qtr.	02/01/2025	02/28/2025	13
	3rd Qtr.	08/01/2025	08/31/2025	13
Waste Management Facility	1st Qtr.	02/01/2025	02/26/2025	10
	3rd Qtr.	08/01/2025	08/31/2025	10
Sewage Treatment Plant	4th Qtr.	11/01/2025	11/15/2025	8
Motor Pool	4th Qtr.	10/01/2025	10/31/2025	2
Major Petroleum Facility (MPF) (a)	2nd Qtr.	04/01/2025	04/30/2025	8
	4th Qtr.	10/01/2025	10/31/2025	8
National Synchrotron Light Source-II	4th Qtr.	12/01/2025	12/31/2025	4

Notes:
(a) Monthly floating product measurements are also obtained from MPF wells.

Table 12.22.2 Monitoring Well Locations and Analyses

Well ID	Area	Sub Area	Decision Subunit	EPA 8260 VOCs	EPA 8270 Semi-VOCs	Metals	EPA 900 Gross Alpha/Beta	EPA 901 Gamma Spec	EPA 906 Tritium	EPA 905 Sr-90	Floating Product	Frequency (events/year)
064-46	BLIP		Upgradient						X			1
064-47	BLIP		Downgradient						X			2
064-48	BLIP		Downgradient						X			2
064-67	BLIP		Downgradient						X			2
054-08	AGS	NSRL	Downgradient						X			1
054-191	AGS	NSRL	Downgradient						X			1
064-51	AGS	Booster Beam Stop	Downgradient						X			1
064-52	AGS	Booster Beam Stop	Downgradient						X			1
064-03	AGS	B-914	Downgradient						X			1
064-53	AGS	B-914	Downgradient						X			1
064-54	AGS	B-914	Downgradient						X			1
054-62	AGS	Bkgd. J-10 Beam Stop	Upgradient						X			1
054-63	AGS	J-10 Beam Stop	Downgradient						X			1
054-64	AGS	J-10 Beam Stop	Downgradient						X			1
054-65	AGS	g-2 Beam Stop/Plume Source	Upgradient						X			1
054-66	AGS	g-2 Beam Stop	Downgradient						X			1

054-67	AGS	g-2 Beam Stop	Downgradient						X			1
054-68	AGS	g-2 Beam Stop	Downgradient						X			1
054-124	AGS	g-2 Beam Stop	Downgradient						X			1
054-125	AGS	g-2 Beam Stop	Downgradient						X			1
054-127	AGS	Fm. U-Line Target	Upgradient						X			1
054-128	AGS	Fm. U-Line Target	Downgradient						X			1
054-129	AGS	Fm. U-Line Target	Downgradient						X			1
054-130	AGS	Fm. U-Line Target	Downgradient						X			1
054-168	AGS	Fm. U-Line Stop	Downgradient						X			1
054-169	AGS	Fm. U-Line Stop	Downgradient						X			1
054-69	AGS	B-912	Upgradient						X			1
055-14	AGS	B-912	Upgradient						X			1
065-120	AGS	B-912	Downgradient						X			1
065-125	AGS	B-912	Downgradient						X			1
065-126	AGS	B-912	Downgradient						X			1
065-195	AGS	B-912	Downgradient						X			1
055-31	AGS	B-912	Downgradient						X			1
055-15	AGS	B-912	Downgradient						X			1
055-16	AGS	B-912	Downgradient						X			1
065-192	AGS	B-912	Downgradient						X			1
055-29	AGS	B-912	Downgradient						X			1
055-30	AGS	B-912	Downgradient						X			1
055-32	AGS	B-912	Downgradient						X			1
065-121	AGS	B912/g-2 Tritium Plume	Downgradient						X			1

065-122	AGS	B912/g-2 Tritium Plume	Downgradient						X			1
065-193	AGS	B-912/g-2 Tritium Plume	Downgradient						X			1
065-123	AGS	B-912/g-2 Tritium Plume	Downgradient						X			1
065-124	AGS	B-912/g-2 Tritium Plume	Downgradient						X			1
065-194	AGS	B-912/g-2 Tritium Plume	Downgradient						X			1
065-321	AGS	B-912/g-2 Tritium Plume	Downgradient						X			1
065-322	AGS	B-912/g-2 Tritium Plume	Downgradient						X			1
065-323	AGS	B-912/g-2 Tritium Plume	Downgradient						X			1
065-324	AGS	B-912/g-2 Tritium Plume	Downgradient						X			1
064-55	AGS	E-20 Catcher	Downgradient						X			1
064-56	AGS	E-20 Catcher	Downgradient						X			1
064-80	AGS	E-20 Catcher	Downgradient						X			1
054-07	AGS/g-2	g-2 Tritium Plume Source	Downgradient						X			2
054-184	AGS/g-2	g-2 Tritium Plume Source	Downgradient						X			2
054-185	AGS/g-2	g-2 Tritium Plume Source	Downgradient						X			2
064-95	AGS/g-2	g-2 Tritium Plume Source	Downgradient						X			2
054-126	AGS/g-2	g-2 Tritium Plume Source	Downgradient						X			2
025-01	RHIC	B/Y Beam Stop Area	Upgradient						X			2
025-03	RHIC	B/Y Beam Stop Area	Downgradient						X			2
025-04	RHIC	B/Y Beam Stop Area	Downgradient						X			2
025-05	RHIC	B/Y Beam Stop Area	Downgradient						X			2

025-06	RHIC	B/Y Beam Stop Area	Downgradient						X			2
025-07	RHIC	B/Y Beam Stop Area	Downgradient						X			2
025-08	RHIC	B/Y Beam Stop Area	Downgradient						X			2
034-05	RHIC	B/Y Collimator Area	Downgradient						X			2
034-06	RHIC	B/Y Collimator Area	Downgradient						X			2
043-01	RHIC	B/Y Collimator Area	Downgradient						X			2
043-02	RHIC	B/Y Collimator Area	Downgradient						X			2
044-13	RHIC	B/Y Collimator Area	Downgradient						X			2
044-14	RHIC	B/Y Collimator Area	Downgradient						X			2
044-29	RHIC	W-Line Stop	Downgradient						X			2
102-05	Motor Pool	Gasoline USTs	Downgradient	X							X	1
102-06	Motor Pool	Gasoline USTs	Downgradient	X							X	1
055-03	WMF	Bkgd.	Upgradient	X		X	X	X	X			2
055-10	WMF	Bkgd.	Upgradient	X		X	X	X	X			2
056-21	WMF	RCRA Bldg.	Downgradient	X		X	X	X	X	X		2
056-22	WMF	Rad. Bldg.	Downgradient	X		X	X	X	X	X		2
056-23	WMF	Rad. Bldg.	Downgradient	X		X	X	X	X	X		2
066-84	WMF	Rad. Bldg.	Downgradient	X		X	X	X	X	X		2
066-220	WMF	RCRA Bldg.	Downgradient	X		X	X	X	X	X		2
066-221	WMF	RCRA Bldg.	Downgradient	X		X	X	X	X	X		2
066-222	WMF	Rad. Bldg.	Downgradient	X		X	X	X	X	X		2
066-223	WMF	Rad. Bldg.	Downgradient	X		X	X	X	X	X		2

066-224	WMF	Mixed Waste Bldg.	Downgradient									0
076-16	MPF	Tank Area	Downgradient	X	X						X(a)	2
076-17	MPF	Tank Area	Downgradient	X	X						X(a)	2
076-18	MPF	Tank Area	Downgradient	X	X						X(a)	2
076-19	MPF	Tank Area	Downgradient	X	X						X(a)	2
076-25	MPF	Tank Area	Upgradient	X	X						X(a)	2
076-378	MPF	Tank Area	Downgradient	X	X						X(a)	2
076-379	MPF	Tank Area	Downgradient	X	X						X(a)	2
076-380	MPF	Tank Area	Downgradient	X	X						X(a)	2
039-87	STP	Recharge Basins - Upgrade	Downgradient			X						1
039-88	STP	Holding Ponds/Recharge B	Downgradient			X						1
039-89	STP	Holding Ponds/Recharge B	Downgradient			X						1
039-90	STP	Holding Ponds	Downgradient			X						1
039-115	STP	Recharge Basins	Downgradient			X						1
048-08	STP	Recharge Basins	Downgradient			X						1
048-09	STP	Recharge Basins	Downgradient			X						1
048-10	STP	Recharge Basins	Downgradient			X						1
086-123	NSLS-II	Linac	Downgradient						X			1
086-124	NSLS-II	Linac	Downgradient						X			1
086-125	NSLS-II	Linac	Downgradient						X			1

086-126	NSLS-II	Linac	Downgradient						X			1

Notes:

AGS: Alternating Gradient Synchrotron

BLIP: Brookhaven Linear Isotope Producer

MPF: Major Petroleum Facility

NSLS-II: National Synchrotron Light Source II

NSRL: NASA Space Radiation Laboratory

RHIC: Relativistic Heavy Ion Collider

Sr-90: Strontium-90

STP: Sewage Treatment Plant

VOCs: Volatile Organic Compounds

WMF: Waste Management Facility

(a) Floating product determination measurements to be collected monthly

Intentionally Left Blank

12.23 GROUNDWATER MONITORING AT THE ALTERNATING GRADIENT SYNCHROTRON

DQO START DATE January 1, 2003

IMPLEMENTATION DATE January 1, 2025

Point of Contact Douglas Paquette (631) 344-7046

SUMMARY OF PROPOSED CHANGES

There are no proposed changes for calendar year 2025 to the groundwater monitoring program for the Alternating Gradient Synchrotron (AGS) area.

DESCRIPTION AND TECHNICAL BASIS

Brookhaven National Laboratory (BNL) monitors groundwater quality at the AGS facility to evaluate the effectiveness of engineered controls used to prevent rainwater infiltration into activated soil shielding. The monitoring program has demonstrated that groundwater quality had been impacted by tritium originating from activated soil shielding at the former g-2 experiment, former U-Line beam stop, and the former E-20 catcher. In these areas, rainwater was able to infiltrate activated soil shielding and leach tritium into the groundwater. Tritium concentrations were found to exceed the 20,000 pCi/L maximum contaminant level (MCL) in these three locations. BNL installed impermeable caps over the activated soil shielding areas to prevent additional rainwater infiltration.

Following these corrective actions, tritium concentrations in the former U-Line beam stop and the former E-20 catcher areas dropped to well below the 20,000 pCi/L standard. However, tritium is still periodically detected at concentrations slightly above 20,000 pCi/L in several wells down-gradient of the g-2 source area (see Data Quality Objective [DQO] Statement 12-35). Monitoring at other potential soil activation areas such as the J-10 beam stop, Booster beam stop, the NASA Space Radiation Laboratory (NSRL), Building 914 transfer tunnel, and Building 912 continue to demonstrate that groundwater has not been significantly impacted by these operations and that existing engineered controls are working. Monitoring well sampling frequency and methods of analysis are summarized in Tables 12.23.1 and 12.23.2.

DRIVERS FOR MONITORING

___ Compliance
___ Support Compliance
X Surveillance
X Restoration/IAG

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

Secondary particles are created near beam loss points, beam targets, and beam stops. These particles have the potential to escape into the soil surrounding the accelerator tunnels or into the soils' underlying target and beam stop areas in the experimental halls. Although considerable effort is taken to design appropriate shielding and other engineering controls into these systems, many secondary particles will still interact with the soil surrounding the tunnels and underlying floors. The types of radionuclides created from this interaction include tritium, beryllium-7, carbon-11, nitrogen-13, oxygen-15, and sodium-22.

Once present in soil, some of these radionuclides can leach downward into groundwater by means of rainwater percolation. Only radionuclides with long half-lives, namely tritium ($t_{1/2}$ = 12.3 years) and sodium-22 ($t_{1/2}$ = 2.6 years), are detected in the groundwater below the AGS. Tritium has been detected at concentrations that exceed the 20,000 pCi/L drinking water standard at several locations (e.g., g-2 and BLIP). Sodium-22 is rarely detected at concentrations above the 400 pCi/L drinking water standard and is only detected in wells located close to the source areas. BNL has taken steps to either reduce the amount of radioactivity produced in soil (by means of additional shielding or modifying operating procedures) or by the construction of impermeable caps to prevent the leaching of these materials to groundwater.

Another potential source of groundwater contamination is the inadvertent release of activated water from the AGS's primary cooling water systems. To reduce this threat, the piping systems have been modified to reduce the volume of water that can be exposed to beam line losses, and piping containing high levels of tritiated water is located inside facility structures where they can be visibly inspected.

The collection of groundwater samples from wells downgradient of the soil activation areas is required to demonstrate that the operational and engineered controls are effective in protecting groundwater quality. These controls include:

- Limiting the amount of soil activation by use of internal shielding material and beam focusing
- Primary cooling water management
- Installation and maintenance of impermeable caps (geomembrane, gunite, etc.)
- Storm water management

Step 2: Identify the Decision

Are the operational and engineered controls employed at the AGS complex effective in preventing the release of tritium and sodium-22 to groundwater at concentrations that exceed drinking water standards at the point of assessment (i.e., the closest wells downgradient of each identified soil activation area)?

Step 3: Identify Inputs to the Decision

The inputs necessary for the decision include:

- Current and planned operations at the AGS

- Modeled estimates or direct measurements on the amount of soil activation at each beam stop and target area
- Direction and velocity of groundwater flow
- Tritium concentrations in groundwater
- Locations of background and downgradient wells relative to each identified soil activation area
- Regulatory requirements (DOE Order 458.1)
- Action levels are defined by the BNL Groundwater Protection Contingency Plan.
- Analytical methods and detection limits:
  - Tritium: EPA Method 906
  - Gamma spectroscopy (optional analysis): EPA Method 901

In 2004, the routine testing of groundwater samples for sodium-22 was discontinued. Since that time, the focus has been placed on tritium because it is more mobile than sodium-22 and has a longer half-life. Therefore, the presence of tritium in groundwater is a better early indicator of a potential failure in an engineered control.

Step 4: Define the Study Boundaries

The decision for this monitoring program applies to the area in the immediate vicinity of the AGS complex and the nearest practicable monitoring points (i.e., "points of assessment") near each of the identified soil activation areas. The period for which decisions are made is 365 days. These timeframes are based on the following:

- The time required for tritium to migrate through the vadose zone and reach the groundwater table (by means of rainwater leachate) is likely to be between 30 to 60 days.
- Once the tritium migrates to groundwater, the typical travel time to the nearest downgradient well (i.e., point of assessment, typically 100 feet from the source) is likely to be between 130 to 275 days.
- Decision periods of 365 days are acceptable for areas where monitoring has demonstrated that current engineered and operational controls are effective (e.g., J-10 Beam Stop, Booster Beam Stop, Building 914 Transfer Tunnel, Former U-Line Target, former E-20 Catcher, and Building 912).

Step 5: Develop the Decision Rules

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

The sample results will be evaluated in context with historical data. As part of the evaluation, circumstances that would require the implementation of the BNL Groundwater Protection Contingency Plan would be ascertained for each sampled well or set of wells (see environmental monitoring [EM]-SOP-309 for details on plan implementation).

Step 6: Specify Acceptable Error Tolerances

Table 12.23.1. Decisions, Potential Errors, and Potential Consequences

Decision	Inputs	Potential Error Based on Data	Potential Consequences
Are controls effective at eliminating or controlling the leaching of tritium from activated soil shielding to the groundwater?	See Step 3 for inputs	(1) Data indicate controls are effective when they are not. (2) Data indicate controls are not effective when they are because of sampling or analytical error, or wells not properly located.	(1) A discrete slug of contamination, potentially up to several hundred feet long, could exist and not be detected* (2) Need to re-sample well and resulting additional unplanned costs; potential erosion of stakeholder confidence.

*Assumes results from one sample period were inaccurate.

Under certain operating conditions, the source water contributing area for potable supply wells 10, 11, and 12 can extend into the northern portion of the AGS facility. The groundwater travel time from the AGS to the closest supply well (well 10) is greater than two years. This would provide sufficient time to respond to a new contaminant release. Because of existing groundwater contamination in and near the AGS complex (e.g., g-2 tritium plume, the former Waste Concentration Facility Sr-90 plume, and the former Bubble Chamber area PFAS plume), BNL limits water withdrawals from well 10 to the extent possible by placing the well into a lag operating position. Furthermore, water withdrawn from supply wells 10, 11, and 12 is treated by granular activated carbon filters to remove PFAS and VOCs prior to its distribution.

Due to these factors and additional Land Use and Institutional Controls developed for the AGS area, it is unlikely that a decision error will result in adverse consequences to human health. Consequences associated with (short-term) decision errors for this program relate primarily to possible enforcement actions for environmental degradation, erosion of stakeholder trust, and loss of BNL credibility. Ultimately, a decision error could result in degradation of groundwater quality to such an extent as to require remedial action under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) or another regulatory program.

Step 7: Optimize the Design

Number and Locations of Wells

The wells located around the AGS are biased toward detecting contamination originating from activated soils associated with current and former beam stop and target areas (see Figure 12.23.1). The wells are located as close as possible to these potential source areas to allow for early detection of contaminant releases. The current approved monitoring network allows for the timely evaluation of potential impacts and is considered adequate for meeting the acceptable risk levels of stakeholders.

Parameters and Frequency

Groundwater quality in the AGS complex is routinely evaluated using approximately 50 monitoring wells. Over 20 years of analytical data are available to assess potential impacts from activated soil shielding and the effectiveness of engineered stormwater controls. Tritium and sodium-22 have been detected in groundwater downgradient of several activated-soil shielding areas. Whereas tritium had exceeded the 20,000 pCi/L drinking water standard in several areas prior to improvements in storm water controls, sodium-22 rarely exceeded the 400 pCi/L standard. Because tritium is easily leached from activated soils, is highly mobile in groundwater, and has a longer half-life, monitoring well samples are currently only analyzed for tritium. As necessary, samples may be periodically analyzed for sodium-22. Based upon proven effectiveness of the engineered storm water controls, groundwater samples only need to be collected annually.

Table 12.23.2. Comparison of 2024 and 2025 Monitoring Program

Well	Monitoring Sub-Area	CY 2024 Sampling Frequency	CY 2025 Sampling Frequency	Affected Parameters
054-08	NSRL beam stop	Annual	Annual	None
054-191	NSRL beam stop	Annual	Annual	None
064-51	Booster beam stop	Annual	Annual	None
065-52	Booster beam stop	Annual	Annual	None
064-03	Bldg 914	Annual	Annual	None
064-53	Bldg 914	Annual	Annual	None
064-54	Bldg 914	Annual	Annual	None
054-62	Bkgd. J-10 beam stop	Annual	Annual	None
054-63	J-10 beam stop	Annual	Annual	None
054-64	J-10 beam stop	Annual	Annual	None
054-65	g-2 beam stop/plume source	Annual	Annual	None
054-66	g-2 beam stop	Annual	Annual	None
054-67	g-2 beam stop	Annual	Annual	None
054-68	g-2 beam stop	Annual	Annual	None
054-124	g-2 beam stop	Annual	Annual	None
054-125	g-2 beam stop	Annual	Annual	None
054-127	U-line target	Annual	Annual	None
054-128	U-line target	Annual	Annual	None
054-129	U-line target	Annual	Annual	None
054-130	U-line target	Annual	Annual	None
054-168	U-line stop	Annual	Annual	None
054-169	U-line stop	Annual	Annual	None
054-69	Bldg 912/U-line stop	Annual	Annual	None
055-14	Bldg 912/U-line stop	Annual	Annual	None
065-120	Bldg 912	Annual	Annual	None
065-125	Bldg 912	Annual	Annual	None
065-126	Bldg 912	Annual	Annual	None
065-195	Bldg 912	Annual	Annual	None
055-15	Bldg 912	Annual	Annual	None
055-16	Bldg 912	Annual	Annual	None
065-192	Bldg 912	Annual	Annual	None
055-29	Bldg 912	Annual	Annual	None
055-30	Bldg 912	Annual	Annual	None
055-31	Bldg 912	Annual	Annual	None
055-32	Bldg 912	Annual	Annual	None
065-121	Bldg 912/g-2 plume	Annual	Annual	None
065-122	Bldg 912/g-2 plume	Annual	Annual	None
065-193	Bldg 912/g-2 plume	Annual	Annual	None
065-123	Bldg 912/g-2 plume	Annual	Annual	None
065-124	Bldg 912/g-2 plume	Annual	Annual	None
065-194	Bldg 912/g-2 plume	Annual	Annual	None
065-321	Bldg 912/g-2 plume	Annual	Annual	None
065-322	Bldg 912/g-2 plume	Annual	Annual	None
065-323	Bldg 912/g-2 plume	Annual	Annual	None
065-324	Bldg 912/g-2 plume	Annual	Annual	None
064-55	E-20 Catcher	Annual	Annual	None
064-56	E-20 Catcher	Annual	Annual	None
064-80	E-20 Catcher	Annual	Annual	None

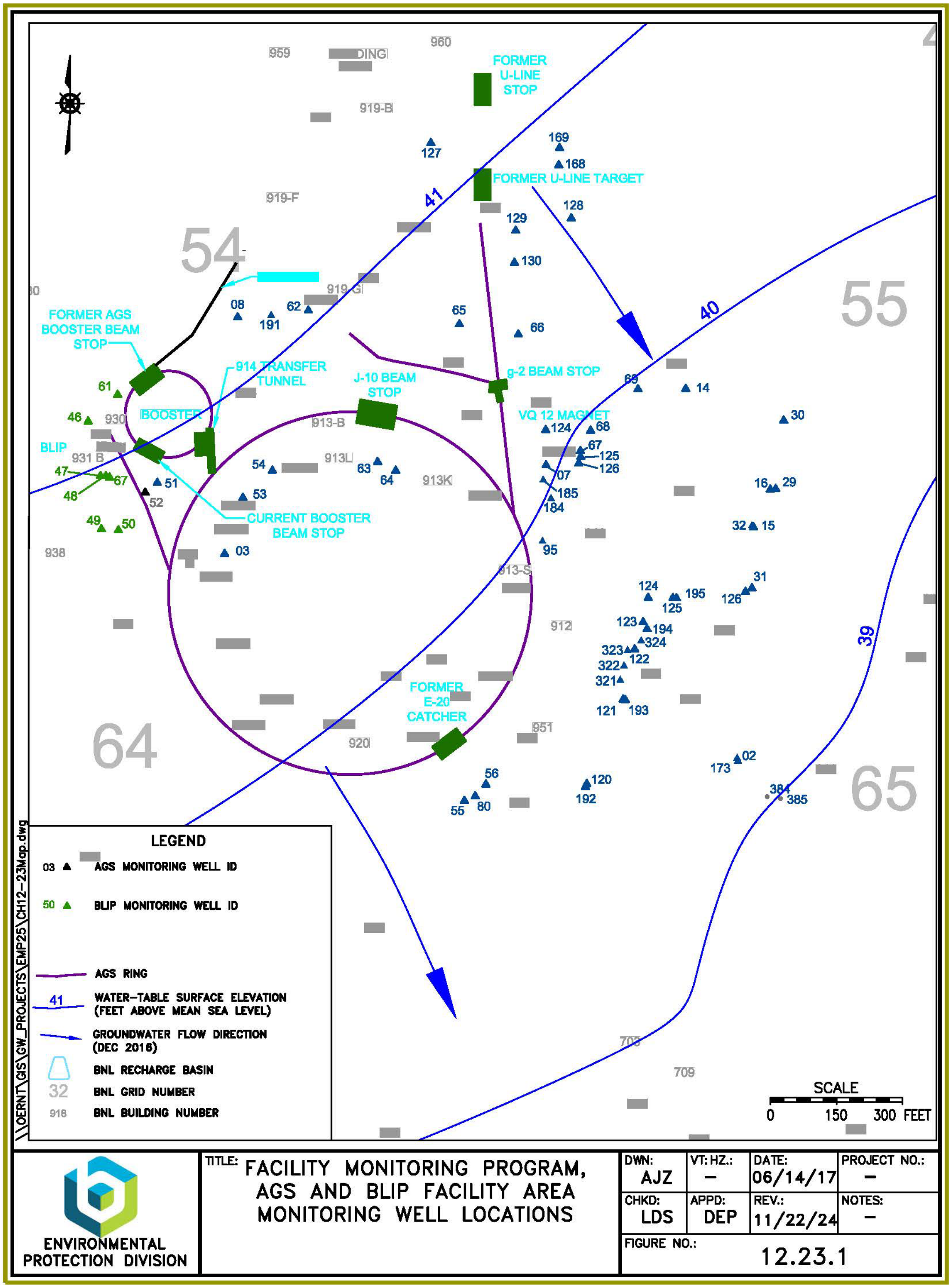

Figure 12.23.1 AGS and BLIP Facility Area Monitoring Well Locations

See Appendix B for the monitoring requirements for this DQO.

12.24 GROUNDWATER MONITORING AT THE BROOKHAVEN LINAC ISOTOPE PRODUCER

DQO START DATE January 1, 2003

IMPLEMENTATION DATE January 1, 2025

Point of Contact Douglas Paquette (631) 344-7046

SUMMARY OF PROPOSED CHANGES

There are no proposed changes for calendar year 2025 for the Brookhaven Linac Isotope Producer (BLIP) groundwater monitoring program.

DESCRIPTION AND TECHNICAL BASIS

The 1998 discovery of tritium and sodium-22 in groundwater downgradient of the BLIP indicated that rainwater was leaching these radionuclides from activated soil shielding located near the BLIP target vessel. To prevent continued rainwater infiltration, BNL made improvements to several engineered controls, including the reconnection of the building's rain gutters, sealing paved areas, construction of an impermeable cap, and the injection of a grouting material to reduce the permeability of the activated soils. In 2004 and 2015, the impermeable cap was extended over the Linac-to-BLIP spur in response to changes in beam line operations and the resulting increase in the size of the zone of activated soil shielding. Monitoring wells are used to evaluate the effectiveness of these engineered controls.

Since July 2006, tritium concentrations in groundwater downgradient of BLIP have remained below the 20,000 pCi/L drinking water standard. The g-2/BLIP/UST Record of Decision (ROD) requires continued groundwater monitoring to verify the effectiveness of the engineered controls. Because tritium concentrations have been continuously <20,000 pCi/L since mid-2006, in 2009 the monitoring frequency for the three wells immediately downgradient of BLIP was reduced from quarterly to semiannually, and monitoring of the upgradient well was reduced to annually. (Note: As described below, routine monitoring for Na-22 has been discontinued.) Monitoring well sampling frequency and methods of analysis are summarized in Tables 12.24.1 and 12.24.2.

DRIVERS FOR MONITORING

_X_ Compliance
___ Support Compliance
_X_ Surveillance
_X_ Restoration

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

Secondary particles created at the BLIP target vessel and along the Linac to BLIP beam line have activated some of the soils that surround portions of the vessel and tunnel walls. The types of radionuclides created from this interaction include tritium, beryllium-7, carbon-11, nitrogen-13, oxygen-15, and sodium-22. Some of these radionuclides can be leached downward into groundwater by means of rainwater percolation. Only radionuclides with long half-lives such as tritium ($t_{1/2}$ = 12.3 years) and sodium-22 ($t_{1/2}$ = 2.6 years) are detected in the groundwater below the BLIP. As noted previously, BNL has taken steps to prevent the leaching of these materials to groundwater by improving rainwater management.

During 1998, rainwater management initiatives included the reconnection of the building's rain gutters, sealing paved areas, and constructing an impermeable gunite cap. In conjunction with the Environmental Restoration program, in 2000, colloidal silica grout was injected into the activated soil area to reduce the permeability of the soil. As stated above, in 2004 and 2015, the impermeable cap was extended over the Linac-to-BLIP spur in response to changes in beam line operations and the resulting increase in the size of the zone of activated soil shielding in several areas along the beam line. Another potential source of groundwater contamination could be the inadvertent release of activated water from the BLIP's primary cooling water system. However, these water systems are located inside the BLIP building and can be visually inspected.

As defined in the g-2/BLIP/Underground Storage Tank (UST) ROD, the continued collection of groundwater samples from wells downgradient of the BLIP is required to demonstrate that the operational and engineered controls are effective in protecting groundwater quality. These controls include:

- Limiting the amount of soil activation by beam focusing
- Primary cooling water management
- Reducing the permeability of the activated soils using colloidal silica grout
- Installation and maintenance of impermeable caps (gunite and asphalt)
- Conveying storm water away from the building foundation

Step 2: Identify the Decision

Are the operational and engineered controls employed at BLIP effective at preventing additional releases of tritium and sodium-22 to groundwater at concentrations that exceed drinking water standards at the point of assessment (i.e., the closest downgradient wells)?

Step 3: Identify Inputs to the Decision

The inputs necessary for the decision include:

- Current and planned operations at BLIP
- Modeled estimates on the amount of soil activation near the target vessel
- Direction and velocity of groundwater flow
- Tritium concentrations in groundwater
- Locations of background and downgradient wells relative to the soil activation area
- Regulatory requirements are g-2/BLIP/UST ROD and DOE Order 458.1
- Action levels as described in the Groundwater Protection Contingency Plan
  - g-2/BLIP/UST ROD did not define any additional action levels
- Analytical methods and detection limits:
  - Tritium: EPA Method 906
  - Gamma spectroscopy (optional analysis for Na-22): EPA Method 901

Starting in 2004, the requirement for routine sodium-22 analyses was dropped from the monitoring program. Because tritium is more mobile than sodium-22 and has a longer half-life, the presence of high levels of tritium in groundwater would be a better early indicator of a failure in an engineered control.

Step 4: Define the Study Boundaries

The decision for this monitoring program applies to the area immediately downgradient of BLIP. The monitoring period is 180 days, based upon a semiannual monitoring frequency. This time frame is considered adequate based upon the following:

- The time required for tritium to migrate through the vadose zone and reach the groundwater table (by means of rainwater leachate) is likely to be 30 to 60 days.
- Once the radionuclides have migrated to groundwater, the typical travel time to the nearest downgradient well (i.e., point of assessments, which are located approximately 50 feet from the source) is 90 days.
- Because tritium at concentrations in downgradient monitoring wells have been less than the 20,000 pCi/L drinking water standard since early-2006, a decision period of 180 days is sufficient to evaluate the effectiveness of the engineered controls. Therefore, the three wells located immediately downgradient of BLIP will be sampled on a semiannual basis. The sampling frequency for the upgradient is annually.

Step 5: Develop the Decision Rules

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

The sample results will be evaluated in context with historical data. As part of the evaluation, circumstances that would require the implementation of the BNL Groundwater Protection Contingency Plan (either response Action Level 2 or 3 of the plan) would be ascertained for each sampled well or set of wells (see EM SOP-309 for details on plan implementation).

Step 6: Specify Acceptable Error Tolerances

Table 12.24.1. Decisions, Potential Errors, and Potential Consequences

Decision	Inputs	Potential Error Based on Data	Potential Consequences
Are controls effective at eliminating or controlling the leaching of tritium and sodium-22 from activated soil shielding to the groundwater?	See Step 3 for inputs.	(1) Data indicate controls are effective when they are not, (2) Data indicate controls are not effective when they are because of sampling or analytical error, or wells not properly located.	(1) A discrete slug of contamination potentially up to 100 feet long and 20 feet wide could exist and not be detected* (2) Need to re-sample well (as per Groundwater Contingency Plan). Potential erosion of stakeholder confidence.

*Assumes results from one sample period were inaccurate.

There are no potential receptors (i.e., potable water supply wells) immediately downgradient of the BLIP, and groundwater travel time to the nearest potential downgradient receptor (Potable Well 4, which is currently out of service) is greater than five years. Due to these factors, it is very unlikely that a decision error will result in adverse consequences to human health. Consequences associated with decision errors for this program relate primarily to possible enforcement actions for environmental degradation, erosion of stakeholder trust, and loss of BNL credibility. Ultimately, a decision error could result in degradation of groundwater quality to such an extent as to require additional remedial actions.

Step 7: Optimize the Design

Number and Locations of Wells

The wells near the BLIP are biased toward detecting contamination originating from activated soils adjacent to the target vessel and to evaluate potential contamination that could originate from upgradient sources such as the LINAC-to-BLIP beam line (Figure 12.24.1). Three downgradient wells (064-47, 064-48, and 064-67) are located as close as possible to the BLIP building to enable early detection of contaminant releases. The current monitoring well network is considered adequate for meeting the acceptable risk levels of stakeholders. Because the groundwater flow direction has been relatively constant in this area in recent years and the potential source is relatively small, no refinements are recommended.

Parameters and Frequency

Groundwater quality at BLIP is routinely evaluated using four monitoring wells. The primary focus of the monitoring program is the detection of tritium because it is easily leached from activated soils, is highly mobile in groundwater, and has a longer half-life.

Since early 2006, tritium concentrations in groundwater immediately downgradient of the BLIP facility have remained well below the 20,000 pCi/L drinking water standard. This sustained reduction in tritium concentrations suggests that the caps and other storm water controls are effectively preventing rainwater from infiltrating the activated soil shielding, and the amount of tritium remaining in the vadose zone close to the water table has declined due to the water table flushing mechanism and by natural radioactive decay. The sampling frequency for downgradient wells 064-47, 064-48, and 064-67 is semiannual.

Table 12.24.2. Comparison of CY 2024 and CY 2025 Monitoring Programs

Well	CY 2024 Sampling Frequency	CY 2025 Sampling Frequency	Affected Parameters
064-46*	Annually	Annually	None
064-47	Semiannually	Semiannually	None
064-48	Semiannually	Semiannually	None
064-67	Semiannually	Semiannually	None

*Upgradient well

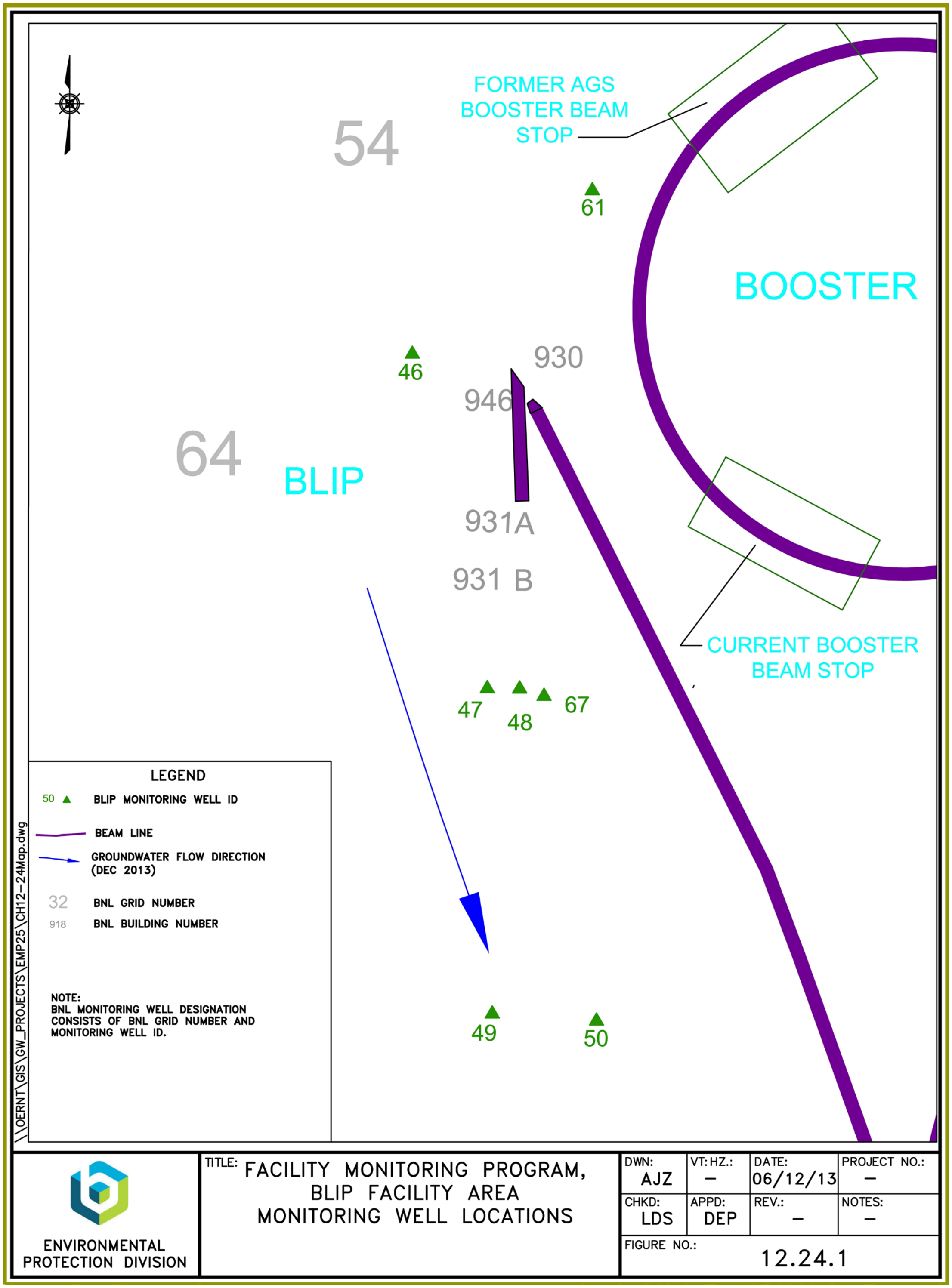

Figure 12.24.1 Facility Monitoring Program, BLIP Facility Area Monitoring Well Locations

See Appendix B for the monitoring program for this Data Quality Objective.

12.25 GROUNDWATER MONITORING AT THE RELATIVISTIC HEAVY ION COLLIDER

DQO START DATE January 1, 2003

IMPLEMENTATION DATE January 1, 2025

Point of Contact Douglas Paquette (631) 344-7046

SUMMARY OF PROPOSED CHANGES

There are no proposed changes in calendar year 2025 for the Relativistic Heavy Ion Collider (RHIC) monitoring program.

DESCRIPTION AND TECHNICAL BASIS

Brookhaven National Laboratory (BNL) uses 13 monitoring wells to evaluate the effectiveness of the engineered (e.g., caps) and operational controls designed to protect groundwater quality near activated soil shielding at the RHIC beam stop and collimator areas. Monitoring conducted to date indicates that the controls are effectively protecting the activated soils. RHIC monitoring wells are monitored semiannually. Monitoring well sampling frequency and methods of analysis are summarized in Tables 12.25.1 and 12.25.2.

DRIVERS FOR MONITORING

____ Compliance
____ Support Compliance
__X Surveillance
____ Restoration

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

Secondary particles created near the RHIC beam stops and collimators have the potential to escape into the soil surrounding the accelerator tunnel. Although considerable effort is taken to design appropriate shielding and other engineering controls into these systems, many secondary particles will still interact with soil surrounding the tunnels and underlying floors. The types of radionuclides created from this interaction include tritium, beryllium-7, carbon-11, nitrogen-13, oxygen-15, and sodium-22. Some of these radionuclides can leach downward into groundwater by means of rainwater percolation. These leaching processes are usually quite slow, and therefore, only radionuclides with long half-lives such as tritium ($t_{1/2}$ = 12.3 years) and sodium-22 ($t_{1/2}$ = 2.6 years) are likely to be detected in the groundwater. BNL has taken steps to reduce the amount of radioactivity produced in soil by means of additional shielding or modifying operating procedures and/or to prevent the leaching of these materials to groundwater by the construction of impermeable caps.

The collection of groundwater samples from wells located downgradient of the soil activation areas is required to demonstrate that the operational and engineered controls are effective in protecting groundwater quality. These controls include:

- Limiting the amount of soil activation by use of internal shielding material and beam focusing
- Installation and maintenance of impermeable geomembrane caps over each potential soil activation area (e.g., three beam stops and two collimators)
- Storm water management

Step 2: Identify the Decision

Are the operational and engineered controls employed at RHIC effective at preventing the release of tritium and sodium-22 to groundwater at concentrations that exceed drinking water standards at the point of assessment (i.e., the closest downgradient wells near each of the identified soil activation areas)?

Step 3: Identify Inputs to the Decision

The inputs necessary for the decision include:

- Current and planned operations at the RHIC
- Modeled estimates on the amount of soil activation at each beam stop and collimator
- Direction and velocity of groundwater flow
- Tritium concentrations in groundwater
- Locations of background and downgradient wells relative to each identified soil activation area
- Regulatory requirements (DOE Order 458.1)
- Action levels (as described in the Groundwater Protection Contingency Plan)
- Analytical methods and detection limits:
  - Tritium: Environmental Protection Agency (EPA) Method 906
  - Gamma spectroscopy for Na-22 (optional analysis): EPA Method 901

Starting in 2004, routine sodium-22 analyses were discontinued from the monitoring program. Focus is now placed on tritium analyses because tritium is more mobile than sodium-22 and has a longer half-life. Therefore, tritium's presence in groundwater would be a better early indicator of a failure in an engineered control.

Step 4: Define the Study Boundaries

The decision for this monitoring program applies to the area in the immediate vicinity of the beam stop and collimator areas within RHIC facility and the nearest practicable monitoring points (i.e., "points of assessment") near each of the identified potential soil activation areas. The period for which decisions are made is 180 days. These timeframes are based on the following:

- The time required for tritium to migrate through the vadose zone and reach the groundwater table (by means of rainwater leachate) is likely to be between 30 to 60 days.
- Once the radionuclides have migrated to groundwater, the typical travel time to the nearest downgradient well (i.e., point of assessment, typically 100 to 200 feet from the source) is approximately 130 to 260 days.

- Decision periods of 180 to 360 days are acceptable for areas where monitoring has demonstrated that current engineered and operational controls are effective.

Step 5: Develop the Decision Rules

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

The sample results will be evaluated in context with historical data. As part of the evaluation, circumstances that would require the implementation of the BNL Groundwater Protection Contingency Plan would be ascertained for each sampled well or set of wells (see EM-SOP-309 for details on plan implementation).

Step 6: Specify Acceptable Error Tolerances

Table 12.25.1. Decisions, Potential Errors, and Potential Consequences

Decisio n	Inputs	Potential Error Based on Data	Potential Consequences
Are controls effective at eliminating or controlling the leaching of tritium and sodium-22 from activated soil shielding to the groundwater?	See Step 3 for inputs.	(1) Data indicate controls are effective when they are not. (2) Data indicate controls are not effective when they are because of sampling or analytical error, or wells not properly located.	(1) A discrete slug of contamination, potentially up to several hundred feet long, could exist and not be detected* (2) Need to re-sample well and resulting additional unplanned costs; potential erosion of stake- holder confidence.

*Assumes results from one sample period were inaccurate.

There are no potential receptors (i.e., potable water supply wells) located immediately down-gradient of the RHIC beam stop and collimator areas, and groundwater travel time to the nearest potential downgradient receptor (Potable Well 10) is greater than five years. Due to these factors, it is very unlikely that a decision error will result in adverse consequences to human health. Consequences associated with decision errors for this program relate primarily to possible enforcement actions for environmental degradation, erosion of stakeholder trust, and loss of BNL credibility. Ultimately, a decision error could result in degradation of groundwater quality to such an extent as to require remedial action under Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) or other regulations.

Step 7: Optimize the Design

Number and Locations of Wells

The 13 wells located at the RHIC are biased toward detecting contamination originating from activated soils associated with the facility’s beam stops and collimators (Figure 12.25.1). The wells are located as close as possible to these potential source areas to enable early detection of contaminant releases. The current approved monitoring network is considered adequate for meeting the acceptable risk levels of stakeholders. No additional wells are recommended for this program.

Parameters and Frequency

Groundwater monitoring wells at the RHIC beam stop and collimator areas have been monitored at least semi-annually since their installation in 1999 and 2000. Because tritium is easily leached from activated soils, is highly mobile in groundwater, and has a longer half-life than the other radionuclides detected in activated soil shielding, the primary focus of the monitoring program is for the detection of tritium. For 2019, groundwater samples will be collected on a semi-annual (180 day) basis. Samples will be analyzed only for tritium. Should tritium be detected in any of the wells, samples could also be collected to test for the presence of sodium-22.

Table 12.25.2. Comparison of 2024 and 2025 Sampling Programs

Well ID	CY 2024 Sampling Frequency	CY 2025 Sampling Frequency	Affected Parameters
025-03	Semi-annual	Semi-annual	None
025-04	Semi-annual	Semi-annual	None
025-05	Semi-annual	Semi-annual	None
025-06	Semi-annual	Semi-annual	None
025-07	Semi-annual	Semi-annual	None
025-08	Semi-annual	Semi-annual	None
034-05	Semi-annual	Semi-annual	None
034-06	Semi-annual	Semi-annual	None
043-01	Semi-annual	Semi-annual	None
043-02	Semi-annual	Semi-annual	None
044-13	Semi-annual	Semi-annual	None
044-14	Semi-annual	Semi-annual	None
044-29	Semi-annual	Semi-annual	None

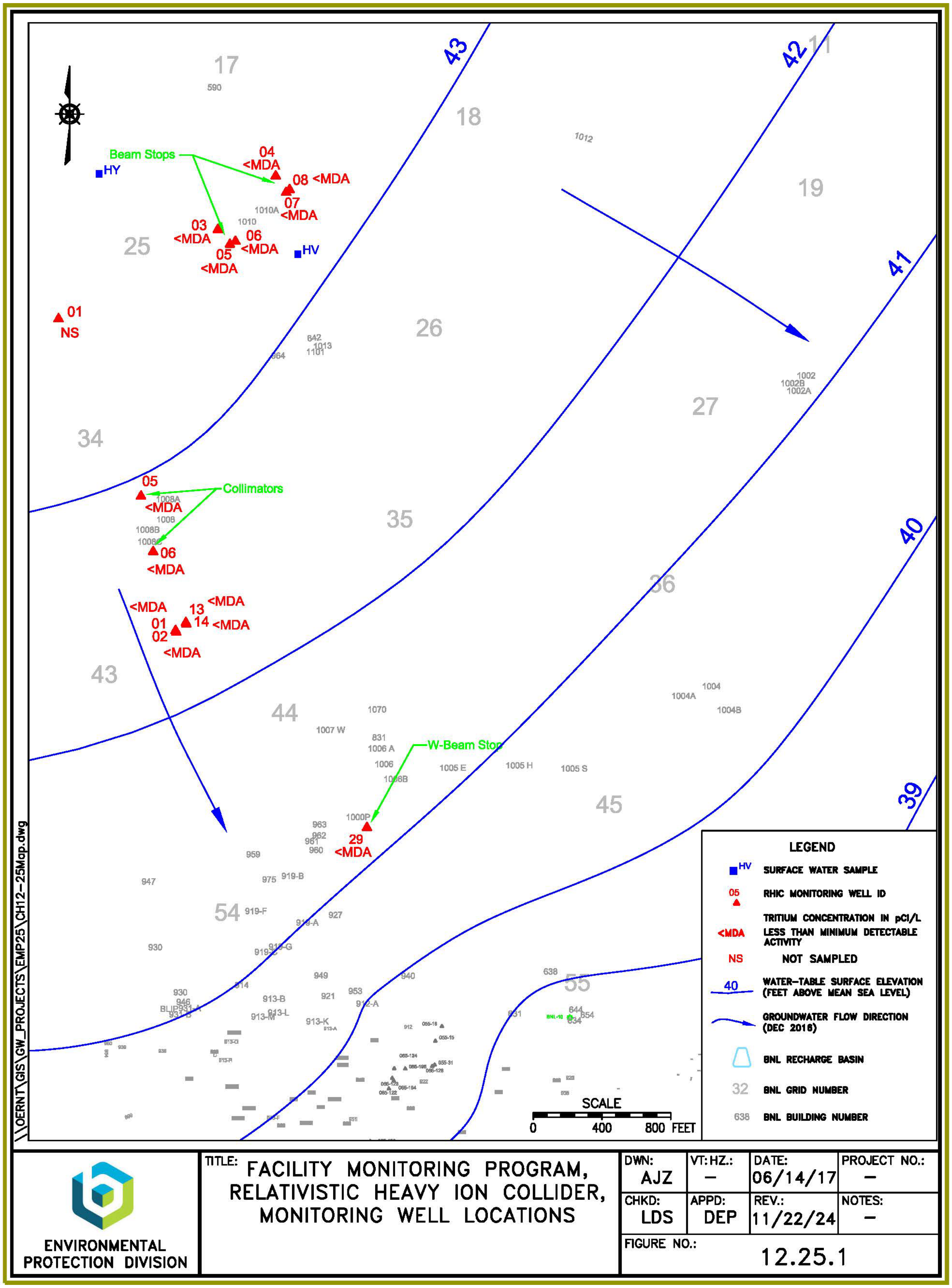

Figure 12.25.1 Facility Monitoring Program, RHIC, Monitoring Well Locations

See Appendix B for the Monitoring Program for this Data Quality Objective.

12.26 GROUNDWATER MONITORING AT THE WASTE MANAGEMENT FACILITY

DQO START DATE January 1, 2003

IMPLEMENTATION DATE January 1, 2025

Point of Contact Douglas Paquette (631) 344-7046

SUMMARY OF PROPOSED CHANGES

With observed changes in groundwater flow directions in the Waste Management Facility (WMF) area due to increased use of nearby water supply Wells 11 and 12 starting in 2020 and 2022, respectively, four monitoring wells (056-21, 056-22, 056-23, and 066-84) were re-incorporated into the routine (semiannual) groundwater monitoring program starting in calendar year (CY) 2023. These wells will continue to be sampled during CY 2025.

DESCRIPTION AND TECHNICAL BASIS

The WMF is designed to safely handle, repackage, and temporarily store Brookhaven National Laboratory (BNL)-derived waste prior to shipment to an off-site disposal or treatment facility. The WMF has been designed as a state-of-the-art facility, with administrative and engineered controls that meet all applicable federal, state, and local environmental protection requirements. Moreover, institutional controls such as spill prevention plans, operations management plans, maintenance, and personnel training ensure that the facility is operated in a manner that is protective of the environment and human health. The WMF currently consists of three buildings: Operations Building (Building 860), Reclamation Building (Building 865), and Resource Conservation and Recovery Act (RCRA) Waste Building (Building 855). The former Mixed Waste Building (Building 870) is no longer used for WMF operations. Monitoring well sampling frequency and methods of analysis are summarized in Tables 12.26.1 and 12.26.2.

In addition to administrative controls (e.g., procedures and contingency plans), engineering controls have been designed for these buildings and the outlying paved areas to ensure that any spills and leaks will be contained and detected prior to a release to the environment. Outdoor storage of hazardous or mixed waste only occurs within secondary containment. Sealed floors and isolated drainage areas mitigate potential accidental releases of liquid wastes in the Reclamation Building and the RCRA Building. All storage area floors are pitched inward to ensure that any spills remain inside the buildings.

For added protection, sealed concrete floors in liquid waste handling and storage areas are underlain by 20-mil. high-density polyethylene (HDPE) tertiary containment membranes with monitoring access pipes that can be used to determine whether any leakage occurs through the concrete from the storage cells.

Spills in paved areas would be mitigated by concrete curbs and isolated drainage. (Note: The drain at the east roadway exit from the yard adjacent to the Reclamation Building and the drain northeast of the Reclamation Building do not have isolation valves but lead to the stormwater system that discharges to the Recharge Basin HO-SPDES Outfall 003. This outfall is routinely monitored under the State Pollutant Discharge Elimination System [SPDES] permit).

There are no RCRA-regulated above or belowground tanks in the WMF. However, all above and belowground storage tanks that are used to store non-RCRA-regulated waste were designed, installed, and maintained in conformance with Article 12 of the Suffolk County Sanitary Code. The underground storage tanks at the Waste Reclamation building have never been used and there are no plans for their future use. These tanks have been officially taken out of service.

The WMF is located within two years of groundwater travel to BNL potable water supply Wells 11 and 12, which are just north of the WMF site. Because of the proximity of the WMF to Wells 11 and 12, it is imperative that the engineering and administrative controls discussed above ensure that waste handling operations at the WMF do not degrade the quality of the soils and groundwater in this area. The WMF groundwater monitoring program supplements the engineered and administrative controls by providing additional means of detecting potential contaminant releases from the WMF. The groundwater monitoring requirements are defined in the facility's RCRA Part B Permit.

To account for supply well pumping induced variations in groundwater flow pathways since the groundwater monitoring program was established in 1997, five new downgradient monitoring wells were installed in late 2007. The new wells were fully integrated into the WMF monitoring program in 2008. From 1997 through the fall of 2003, WMF monitoring wells were sampled quarterly for a wide variety of organic, inorganic, and radiological constituents. Monitoring results indicate that WMF operations have not impacted groundwater quality. Based on the low probability of an undetected release of either chemical or radiological contaminants from the WMF, the quarterly monitoring frequency was reduced to a semi-annual frequency in 2004.

The adequacy of the semi-annual groundwater monitoring program is based, in part, on the assumption that a low-volume contaminant release would slowly leach into the aquifer and not result in a rapid concentration increase between sample collection periods, and secondly, because the supply wells pump large volumes of water over a large area; considerable mixing of contaminated and uncontaminated water would result in the dilution of any contaminant(s). In accordance with the BNL Groundwater Protection Contingency Plan, the monitoring program will be reevaluated immediately if a significant contaminant release to the environment were to occur in the WMF area or if the monitoring wells within the WMF were to indicate that contaminants have been released from the facility due to a previously undetected spill or leak.

DRIVERS FOR MONITORING

_X_ Compliance
___ Support Compliance
___ Surveillance
___ Restoration

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

The collection of groundwater samples from wells located at the WMF is required to demonstrate that controls are effective in protecting groundwater quality by means of spill prevention and early detection. Outdoor storage of hazardous or mixed waste only occurs within secondary containment. Potential accidental releases of liquid wastes in the Reclamation Building, the RCRA Building, and the Mixed Waste Building are mitigated by sealed floors and isolated drainage areas. All storage area floors are pitched inward to ensure that any spills would remain inside the building. For added protection, sealed concrete floors in liquid waste handling and storage areas are underlain by HDPE tertiary containment membranes with monitoring access pipes that can be used to determine whether there has been any leakage through the concrete from the storage cells. Spills in paved areas would be mitigated by concrete curbs and isolated drainage. All liquid waste storage tanks were designed, installed, and maintained in conformance with Article 12 of the Suffolk County Sanitary Code.

Step 2: Identify the Decision

Are the operations of the WMF impacting groundwater quality? If so, do concentrations exceed drinking water standards at the point of assessment (i.e., the closest downgradient wells)?

Step 3: Identify Inputs to the Decision

The inputs necessary for the decision include:

- Current and planned operations at the WMF
- Direction and velocity of groundwater flow
- Contaminant concentrations in groundwater
- Locations of background and downgradient wells relative to known or potential source areas
- Regulatory requirements (DOE Order 458.1; NYSDEC RCRA Part B Permit)
- Action levels:
  - Detection of volatile organic compounds (VOCs) or radionuclides at concentrations exceeding levels outlined in the BNL Groundwater Contingency Plan
- Analytical methods and detection limits:
  - VOCs: EPA Method 524.2/624
  - Tritium: EPA Method 906
  - Gamma spectroscopy: EPA Method 901
  - Gross alpha/beta: EPA Method 900
  - Strontium-90: EPA Method 905 (optional analysis if required)
  - Anions: chlorates, sulphates, and nitrates
  - Metals: EPA Method 200 Series

Step 4: Define the Study Boundaries

The decision for this monitoring program applies to the area immediately downgradient of the WMF. A decision period of 180 days is sufficient to provide a secondary means of verifying that the operational and engineered controls in place at the WMF are effective. This timeframe is based on the following considerations:

- As described above, the WMF has several engineered and operational controls that are designed to prevent releases of contaminants to the environment. A more frequent monitoring program can be implemented if a leak is found or suspected.

- The time required for small volumes of contaminants to migrate through the vadose zone and reach the groundwater table is likely to be 90 days or more. It is important to note that most waste materials that are stored at the WMF are not readily mobile in soils. (See waste profile descriptions in the RCRA Part B Permit, pages 99 through 113.) Once contaminants have migrated to groundwater, the typical travel time to the nearest downgradient well (i.e., point of assessment, typically within 50 to 100 feet of a storage building) is 130 days.

Step 5: Develop the Decision Rules

Are the operational and engineered controls effective at preventing the release of contaminants to groundwater?

The sample results will be evaluated in context with historical data. As part of the evaluation, circumstances that would require the implementation of the BNL Groundwater Protection Contingency Plan (either response Action Level 2 or 3 of the plan) would be ascertained for each sampled well or set of wells (see EM-SOP-309 for details on plan implementation).

Step 6: Specify Acceptable Error Tolerances

Table 12.26.1. Decisions, Potential Errors, and Potential Consequences

Decision	Inputs	Potential Errors Based on Data	Potential Consequences
Are controls effective at eliminating or controlling the release of contaminants to soils and groundwater?	See Step 3 for inputs.	(1) Data indicate controls are effective when they are not. (2) Data indicate controls are not effective when they are because of sampling or analytical error, or wells not properly located.	(1) A discrete slug of contamination, potentially up to several hundred feet long, could exist and not be detected* (2) Need to re-sample well and resulting additional unplanned costs; potential erosion of stakeholder confidence.

* Assumes results from one sample period were inaccurate and all operational and engineered controls (i.e., inventory resolution, leak detection, secondary containment) were to fail.

BNL potable water supply wells 11 and 12 are located immediately adjacent to the WMF. Although it is possible that a decision error could result in adverse consequences to human health, the WMF is designed and operated in a manner that eliminates or limits any potential contaminant release to the environment. In addition to the groundwater monitoring program, the supply wells are also routinely monitored for the contaminants of concern in accordance with Safe Drinking Water Act (SDWA) requirements. Because these supply wells draw water from a large area (i.e., zone of contribution), it is likely that low-level contamination would undergo considerable dilution before entering the water distribution system. Furthermore, groundwater pumped from the supply wells is treated by granular activated carbon filtration prior to distribution.

Consequences associated with decision errors for this program relate primarily to impacts to BNL's water supply and possible enforcement actions for environmental degradation, erosion of stakeholder trust, and loss of BNL credibility. Ultimately, a decision error could result in degradation of groundwater quality to such an extent as to require the short-term or long-term shut down of the supply wells, and possible remedial actions under applicable New York State regulations.

Step 7: Optimize the Design

Number and Locations of Wells

The wells are located as close as possible to potential WMF source areas to allow for early detection of contaminant releases (see Figure 12.26.1). When the WMF monitoring program began in 1997, the predominant groundwater flow pathway in the WMF area was to the north. This northerly flow pattern was the result of a significant groundwater mound below recharge basin HO located to the south of the WMF and significant pumpage from water supply wells 11 and 12 located to the north of the WMF. To accommodate this northerly flow pathway, four monitoring wells were positioned between waste storage facilities and the potable supply wells, with the four remaining wells positioned to detect potential contamination from upgradient sources (e.g., Building 830, Basin HO, and the AGS research complex). However, starting in 1997, there was a significant reduction in cooling water discharges to basin HO and restrictions were placed on prolonged pumpage of water from supply wells 11 and 12. This resulted in a return to a more natural southeasterly flow pathway in the WMF area. In late 2007, five new downgradient monitoring wells were installed to account for this change in groundwater flow direction. With increased pumpage of supply Well 11 starting in 2020 and the return to service of supply Well 12 in early 2022, significant variations in groundwater flow directions within the WMF area are anticipated. To account for periodic changes in groundwater flow directions when the supply wells are active, monitoring wells 056-21 and 056-22 were reincorporated into the monitoring schedule in 2021, and wells 056-23, and 066-84 were reincorporated into the monitoring program starting in 2022. Because the monitoring well network is designed to act as a secondary means of verifying proper facility operation, the current approved monitoring network is considered adequate for meeting the acceptable risk levels of stakeholders.

Parameters and Frequency

Groundwater quality at the WMF area is evaluated using two upgradient and eight downgradient monitoring wells during a sample period. As described in the NYSDEC-approved groundwater monitoring plan for the WMF, the monitoring wells are sampled semi-annually. Samples are analyzed semi-annually for VOCs and radioactivity, and annually for anions and metals.

Table 12.26.2. Comparison of 2024 and 2025 Sampling Programs

Well	2024 Sampling Frequency	2025 Sampling Frequency	Affected Parameters
055-03 (Upgradient Well)	Semi-annual	Semi-annual	None
055-10 (Upgradient Well)	Semi-annual	Semi-annual	None
056-21 (Downgradient Well)	Semi-annual	Semi-annual	None
056-22 (Downgradient Well)	Semi-annual	Semi-annual	None
056-23 (Downgradient Well)	Semi-annual	Semi-annual	None
066-84 (Downgradient Well)	Semi-annual	Semi-annual	None
066-220 (Downgradient Well)	Semi-annual	Semi-annual	None
066-221 (Downgradient Well)	Semi-annual	Semi-annual	None
066-222 (Downgradient Well)	Semi-annual	Semi-annual	None
066-223 (Downgradient Well)	Semi-annual	Semi-annual	None
066-224 (Downgradient Well)	None (a)	None (a)	--

(a) Following the 2012 NYSDEC approval of the closure plan for the Mixed Waste building, this well is no longer sampled on a routine basis.

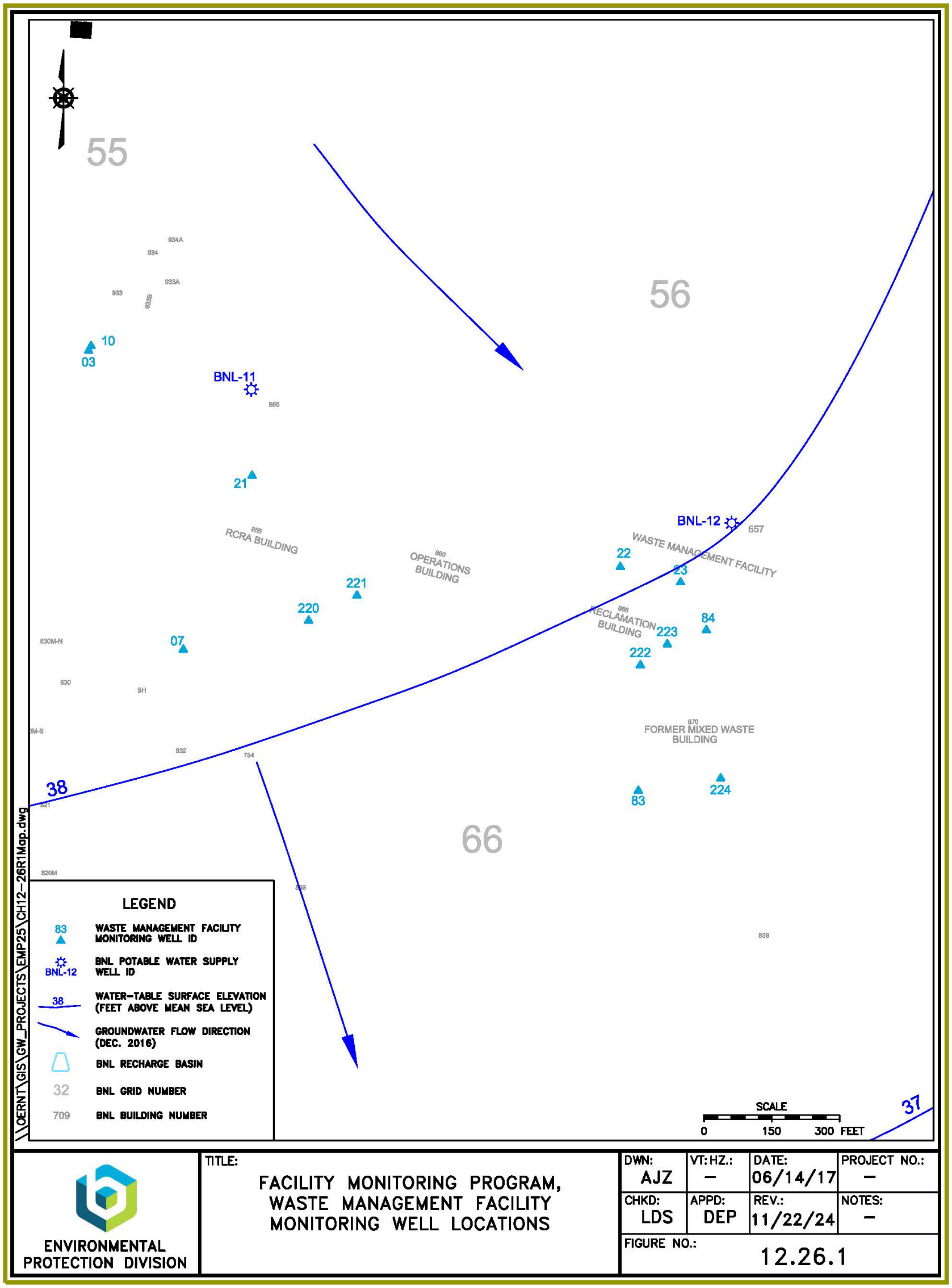

Figure 12.26.1 Facility Monitoring Program, Waste Management Monitoring Well Locations

12.27 GROUNDWATER MONITORING AT THE BROOKHAVEN MEDICAL RESEARCH REACTOR

DQO START DATE January 1, 2003

IMPLEMENTATION DATE January 1, 2025

Point of Contact Douglas Paquette (631) 344-7046

SUMMARY OF PROPOSED CHANGES

The Brookhaven Medical Research Reactor (BMRR) groundwater monitoring wells were sampled every two years, with the last sampling of the wells occurring in 2022. Because tritium was not detected during the past three sample periods (2018, 2020, and 2022), the monitoring program was discontinued starting in 2024. The monitoring wells will continue to be maintained for potential post-decommissioning/demolition surveillance.

DESCRIPTION AND TECHNICAL BASIS

Tritium was detected in groundwater downgradient of the BMRR when the monitoring began in 1997, but at concentrations below the 20,000 pCi/L drinking water standard (DWS). Tritium concentrations declined from a maximum of 17,100 pCi/L in 1999 to <2,500 pCi/L since 2002. To date, no other potential BMRR-related radionuclides have been detected in groundwater. Some residual tritium remains in the vadose zone below the facility, and it is expected that some amount will migrate into groundwater by natural processes (i.e., water table fluctuation) over many years. Operational and engineered controls were implemented in 1997; since that time, all nuclear fuel was removed from the BMRR, and all primary cooling water lines were drained.

DRIVERS FOR MONITORING

____ Compliance
____ Support Compliance
_X_ Surveillance
____ Restoration

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

Following the discovery of tritium in groundwater downgradient of the High Flux Beam Reactor (HFBR) in 1997, Brookhaven National Laboratory (BNL) installed groundwater monitoring wells at the BMRR to evaluate any potential impacts to groundwater quality. Tritium was detected at concentrations up to 17,100 pCi/L in several of the monitoring wells directly downgradient of the BMRR facility. A 1997 review of systems and operations within the BMRR facility identified two potential sources for the tritium detected in groundwater: (1) spills that occurred during the transfer of radioactive liquids to a former aboveground storage tank, and (2) a floor drain system and associated sump that had received primary cooling water on several occasions. Primary coolant contained tritium at a concentration up to 465 μCi/L. Although small-volume releases occurred while transferring liquids to an outdoor storage tank on several occasions, the most likely source for the tritium detected in groundwater is primary cooling water discharges to the floor drain system and an associated unlined 150-gallon SU-2 sump in the basement of the BMRR.

Reactor operations records indicated 16 spills or discharges totaling nearly 800 gallons of primary water to the floor drains or directly to the SU-2 sump. The last such discharge occurred in January 1987. Although most of the primary water that was discharged was properly disposed, qualitative leak-rate testing conducted in 1997 indicated that the sump and/or floor drain piping system were not entirely leak tight and some amount of radioactive water may have leaked to the underlying soils. Furthermore, until 1997, secondary (nonradioactive) coolant water was routinely discharged to the SU-2 sump and floor drain system. Leakage of secondary water could have provided sufficient water volume to drive the tritium through the unsaturated zone and into the groundwater beneath the reactor building.

To prevent potential future releases of radioactive materials to the soils and groundwater below the BMRR, the floor drain system was abandoned in 1997. BNL also sealed the SU-2 sump and a plastic container was installed in the sump pit. A liquid sensor installed in the sump is used to detect the presence of any liquids outside the plastic container. In addition, the BMRR facility has been designated for decommissioning and demolition. Issues related to the decommissioning and demolition are not addressed in this Data Quality Objective (DQO). All nuclear fuel was removed from the facility and the activated primary cooling water was drained in 2005.

Following the removal of the fuel and primary cooling water, continued groundwater surveillance was conducted to evaluate periodic small-scale releases of residual tritium from the vadose zone beneath the reactor facility. Based on an average groundwater flow velocity of 0.75 feet per day, the travel time from the point where contaminants may enter the soils below the reactor building, migrate through the vadose zone, and travel to the monitoring wells is likely to be greater than 100 days. Since 2002, tritium concentrations in groundwater have been <2,500 pCi/L. No other reactor-related radionuclides were detected in the groundwater. Tritium was not detected in groundwater samples collected during 2018, 2020 and 2022.

Step 2: Identify the Decision

Are the controls effective at eliminating further discharges to soils and groundwater below the BMRR (i.e., are performance objectives met)?

Step 3: Identify Inputs to the Decision

The inputs necessary for the decision include the following:

- Maintenance of reactor structure and future decontamination and decommissioning activities
- Direction and velocity of groundwater flow
- Regulatory driver (DOE Order 458.1)
- Action levels, as described in the BNL Groundwater Protection Contingency Plan
- Analytical methods and detection limits:
  - Tritium: EPA Method 906

Step 4: Define the Study Boundaries

The decision for this program applies to the area in the immediate vicinity of the BMRR facility. Until 2022, the period for which the individual decisions was 730 days (every two years), based on the following factors:

- Tritium was not detected in groundwater samples collected during 2018, 2020, and 2022.
- Currently, there are no pathways for new releases of tritiated water. (Note: The primary cooling water system was drained in 2005.)
- No other reactor-related radionuclides have been detected in groundwater.
- There are no nearby drinking water supply wells.

Because tritium was not detected in groundwater samples collected in 2018, 2020, and 2022, the BMRR monitoring program is being discontinued.

Step 5: Develop the Decision Rules

Are the controls effective at eliminating further discharges to soils and groundwater below the BMRR?

Because tritium was not detected in groundwater samples collected in 2018, 2020, and 2022, it is likely that the amount of residual tritium in the vadose zone below the BMRR has declined to negligible levels. Therefore, the BMRR monitoring program is being discontinued starting in 2024. The monitoring wells will be maintained for potential post-decommissioning/demolition surveillance.

Step 6: Specify Acceptable Error Tolerances

Table 12.27.1. Decisions, Potential Errors, and Potential Consequences

Decision	Inputs	Potential Error Based on Data	Potential Consequences
Are controls effective at eliminating or controlling the leaching of radionuclides to the groundwater?	See Step 3 for inputs.	(1) Data indicate controls are effective when they are not. (2) Data indicate controls are not effective when they are because of sampling or analytical error, or wells not properly located.	(1) A discrete slug of contamination potentially up to ~400 feet long and 30 feet wide could exist and not be detected* (2) Need to re-sample well (as per Groundwater Protection Contingency Plan). Potential erosion of stakeholder confidence.

* Assumes results from one sample period were inaccurate and operational and engineered controls (i.e., leak detection or secondary containment) were to fail. Note, however, that the primary cooling water system was completely drained in 2005.

There are no potential receptors immediately downgradient of the BMRR. Travel time to the nearest current potential downgradient receptor is greater than ten years. Furthermore, most homes south of BNL have been connected to public water. Contaminant concentrations have historically not exceeded the DWS and are not expected to exceed them in the future because the BMRR operations ended in 2000. The nuclear fuel has been removed and activated primary cooling water was removed during 2005. As discussed above, tritium was not detected in groundwater samples collected in 2018, 2020, and 2022. Therefore, it is very unlikely that decision error will result in adverse consequences to human health. The consequences of decision error relate primarily to possible enforcement actions for environmental degradation, erosion of stakeholder trust, and loss of BNL credibility. Ultimately, a decision error could result in degradation of groundwater quality to such an extent as to require remedial actions.

Step 7: Optimize the Design

Number and Locations of Wells

Three of the BMRR wells are biased toward surveillance of groundwater quality immediately downgradient of the facility. One well is immediately upgradient of the BMRR. The monitoring network is considered adequate for meeting the acceptable risk levels of stakeholders (see Figure 12.27.1). Because the groundwater flow direction has been relatively constant in this area in recent years and the potential source is relatively small in area, the number and locations of the wells are sufficient to properly monitor the facility.

Parameters and Frequency

The four BMRR surveillance wells were monitored semi-annually from 1997 through 2004, with samples tested for tritium, gross alpha, gross beta, gamma spectroscopy, and occasionally for Sr-90. Because tritium was not observed at concentrations above the DWS, and declining concentration trends, the frequency of monitoring was reduced to annually starting in 2005 and then biannually starting in 2007. Because tritium was not detected during the 2018, 2020, and 2022 sample periods, monitoring of the BMRR wells was suspended starting in 2024. See Table 12.27.2 for a comparison of the 2024 and 2025 monitoring programs.

Table 12.27.2. Comparison of 2024 and 2025 Monitoring Programs

Well	2024 Sampling Frequency	2025 Sampling Frequency	Affected Parameters
084-12	None (a)	None	Tritium
084-13	None (a)	None	Tritium
084-27	Nonel (a)	None	Tritium
084-28	None (a)	None	Tritium

(a): Sampling of the BMRR wells was suspended starting in 2024.

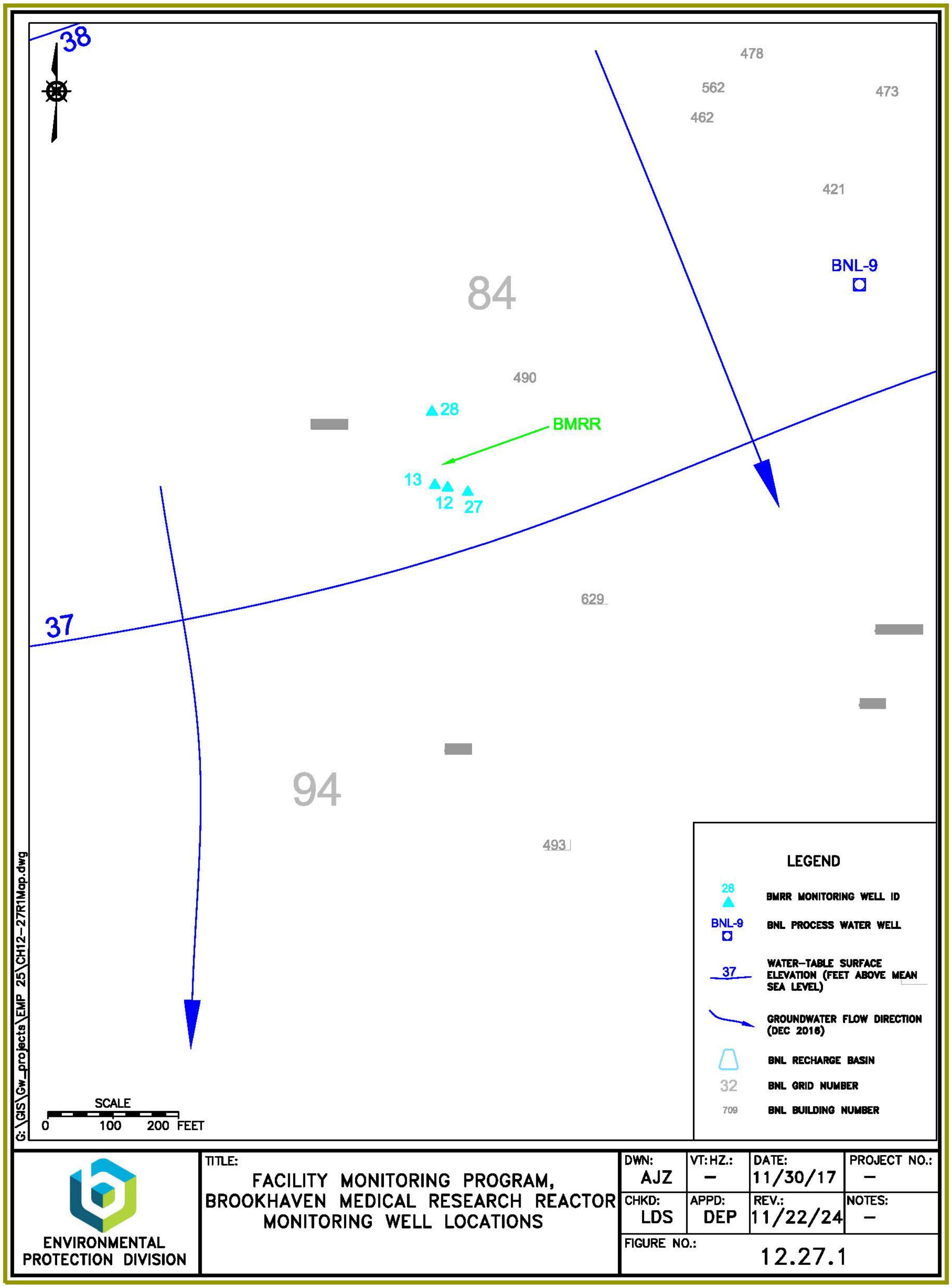

Figure 12.27.1 Facility Monitoring Program BMRR Well Locations

See Appendix B for the monitoring program for this DQO.

12.28 GROUNDWATER MONITORING AT THE SEWAGE TREATMENT PLANT

DQO START DATE January 1, 2003

Implementation Date January 1, 2025

Point of Contact Douglas Paquette (631) 344-7046

SUMMARY OF PROPOSED CHANGES

There are no proposed changes for calendar year 2025 for the groundwater monitoring program at the Sewage Treatment Plant (STP).

DESCRIPTION AND TECHNICAL BASIS

The monitoring program for the STP is conducted in accordance with BNL's State Pollutant Discharge Elimination System (SPDES) permit. In the fall of 2014, STP effluent discharges were directed away from the Peconic River to newly constructed recharge basins. In addition to directly monitoring the STP effluent, the groundwater monitoring program evaluates potential impacts that the effluent may have on specific metals concentrations in the groundwater near the filter beds. The groundwater sampling parameters and frequencies are defined in the SPDES permit. Monitoring well sampling frequency and methods of analysis are summarized in Tables 12.25.1 and 12.25.2.

DRIVERS FOR MONITORING

_X_ Compliance
___ Support Compliance
___ Surveillance
___ Restoration

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

The STP processes sanitary sewage for BNL facilities at an average of 0.72 million gallons per day (MGD) during non-summer months and approximately 1.25 MGD during summer months. Treatment of the sanitary waste stream includes primary treatment to remove settleable solids and floatable materials, aerobic oxidation for secondary removal of the biological matter and nitrification of ammonia, and secondary clarification. Oxygen levels are regulated during the treatment process; nitrogen can be biologically removed using nitrate-bound oxygen for respiration.

Water goes through a final treatment step at the STP filter building and is then discharged to the new recharge basins (SPDES Outfall 001). The discharge is regulated under NYSDEC SPDES permit #1-4788-00032/00072.

Two emergency holding ponds are used for the emergency storage of sanitary waste in the event of an upset condition or if the influent contains contaminants in concentrations exceeding BNL administrative limits and/or SPDES permit effluent release criteria. The holding ponds are equipped with fabric-reinforced plastic liners that are heat-welded along all seams. The first lined holding pond was constructed in 1978 and has a capacity of approximately four million gallons. A second four-million-gallon lined pond was constructed in 1989. The combined capacity of nearly eight million gallons enables BNL to divert all sanitary system effluent for approximately 12 days. As part of the Phase III STP Upgrades project in 2001, the original single liners were replaced with double liners and an integrated leak detection system.

Groundwater samples are used to demonstrate that operational and engineered controls are effective in protecting groundwater quality. These controls include the following:

- BNL has developed a comprehensive pollution prevention program, which includes worker education on proper use and disposal of hazardous materials. These programs are integrated into the BNL Standards-Based Management System (SBMS).

- In accordance with BNL's current SPDES permit, the Laboratory carefully monitors the effluent from the STP and is the primary means of ensuring that BNL’s engineered and operational controls are working.

Step 2: Identify the Decision

Are the operations of the STP impacting groundwater quality? If so, do concentrations exceed drinking water standards at the point of assessment (i.e., the closest downgradient wells)?

Step 3: Identify Inputs to the Decision

The inputs necessary for the decision include:

- Current and planned operations at the STP
- Direction and velocity of groundwater flow
- Sampling parameters and frequencies defined in the SPDES permit
- Locations of background and downgradient wells
- Regulatory requirements (DOE Order 458.1; DOE Order 436.1A; NYS SPDES Permit)
- Action levels, as described in the BNL Groundwater Contingency Plan
- Analytical methods and detection limits: Metals
- Nature of use of emergency holding ponds

Step 4: Define the Study Boundaries

The decision boundaries for this monitoring program apply to the area in the immediate vicinity of the STP facility, with specific emphasis on the new recharge basin area and the existing emergency holding ponds. The new SPDES permit issued in 2014 requires the collection of groundwater samples annually to determine the concentrations of specific metals (e.g., copper, iron, lead, mercury, nickel, silver, and zinc). The sampling frequency for the monitoring program is adequate based on the following:

- Influent and effluent of the STP are carefully monitored. A more frequent monitoring program can be implemented if a significant contaminant release to the sanitary system is discovered or suspected.

- Groundwater monitoring has generally demonstrated that STP operations are not significantly affecting groundwater quality in the area. All VOC, radionuclide, and anion concentrations have been below applicable water quality standards. Some metals, such as sodium, are occasionally detected at concentrations slightly above standards. However, prior testing detected the corrosion inhibitor TTA in the groundwater downgradient of the STP at concentrations that exceeded the NYS Ambient Water Quality Standard of 0.5 mg/L. BNL is no longer using TTA as a corrosion inhibitor.
- Once contaminants have migrated to groundwater, the travel time from the STP area to the site boundary is estimated to be greater than ten years. Although there is a potential for contaminated groundwater originating from the recharge basin areas to enter the Peconic River via groundwater discharge during certain hydrologic conditions, the time of travel is likely to be more than 180 days.
- There are no drinking water supply wells near the STP.
- The double liners and integrated leak detection system installed in the emergency holding ponds significantly reduce the risk of leaks of contaminated water that may be diverted to the ponds.

Step 5: Develop the Decision Rules

Are the operational and engineered controls effective at preventing the introduction of contaminants to the groundwater?

The sample results will be evaluated in context with historical data. As part of the evaluation, circumstances that would require the implementation of the BNL Groundwater Protection Contingency Plan or SPDES required notifications would be ascertained for each sampled well or set of wells (see EM-SOP-309 for details on plan implementation).

Step 6: Specify Acceptable Error Tolerances

Table 12.28.1. Decisions, Potential Errors, and Potential Consequences

Decision	Inputs	Potential Error Based on Data	Potential Consequences
Are controls effective at eliminating or controlling the discharge of contaminants to the groundwater?	See Step 3 for inputs.	(1) Data indicate controls are effective when they are not. (2) Data indicate controls are not effective when they are because of sampling or analytical error, or wells not properly located.	(1) A discrete slug of contamination potentially up to 300 feet long could exist and not be detected* (2) Need to re-sample well (as per Groundwater Contingency Plan). Potential erosion of stakeholder confidence.

* Assumes results from one sample period were inaccurate and one or more operational and engineered controls (i.e., SPDES monitoring, leak detection, secondary containment) were to fail.

There are no potable water supply wells immediately downgradient of the STP area, although during certain hydraulic conditions (i.e., seasonal water table rises), local groundwater can discharge into the nearby Peconic River. Groundwater travel time from the STP area to the BNL eastern boundary is greater than ten years and most residences east of BNL have been connected to public water. Therefore, it is very unlikely that a decision error will result in adverse consequences to human health. Consequences associated with decision errors for this program relate primarily to possible enforcement actions for environmental degradation, erosion of stakeholder trust, and loss of BNL credibility. Ultimately, a decision error could result in degradation of groundwater quality to such an extent as to require remedial actions under applicable NYS regulations.

Step 7: Optimize the Design

Number and Locations of Wells

The wells are as close as possible to the recharge basins and holding ponds to enable early detection of contaminant releases (see Figures 12.28.1). The monitoring program consists of one upgradient and six downgradient wells near the recharge basins. Three of the wells are near the emergency holding ponds. The monitoring network will be adequate for meeting the acceptable risk levels of stakeholders.

Parameters and Frequency

As defined in the SPDES permit, the six wells monitoring the recharge basin area are sampled annually (see Table 12.28.2). The groundwater samples are analyzed for total metals with the following metals being reported to NYSDEC under the SPDES permit: copper, iron, lead, mercury, nickel, silver, and zinc.

Table 12.28.2. Comparison of 2024 and 2025 Sampling Programs – SPDES Monitoring Program

Well	2024 Sampling Frequency	2025 Sampling Frequency	Affected Parameters
039-87(a)	Annual	Annual	None
039-88 (b)	Annual	Annual	None
039-89 (b)	Annual	Annual	None
048-08 (b)	Annual	Annual	None
048-09 (b)	Annual	Annual	None
048-10 (b)	Annual	Annual	None
039-115 (b)	Annual	Annual	None
039-90 (c)	None	None	---

(a) Upgradient well for recharge basin area
(b) Well sampling required by SPDES permit
(c) Holding pond monitoring well, not monitored under SPDES permit. Sampled as needed for surveillance program.

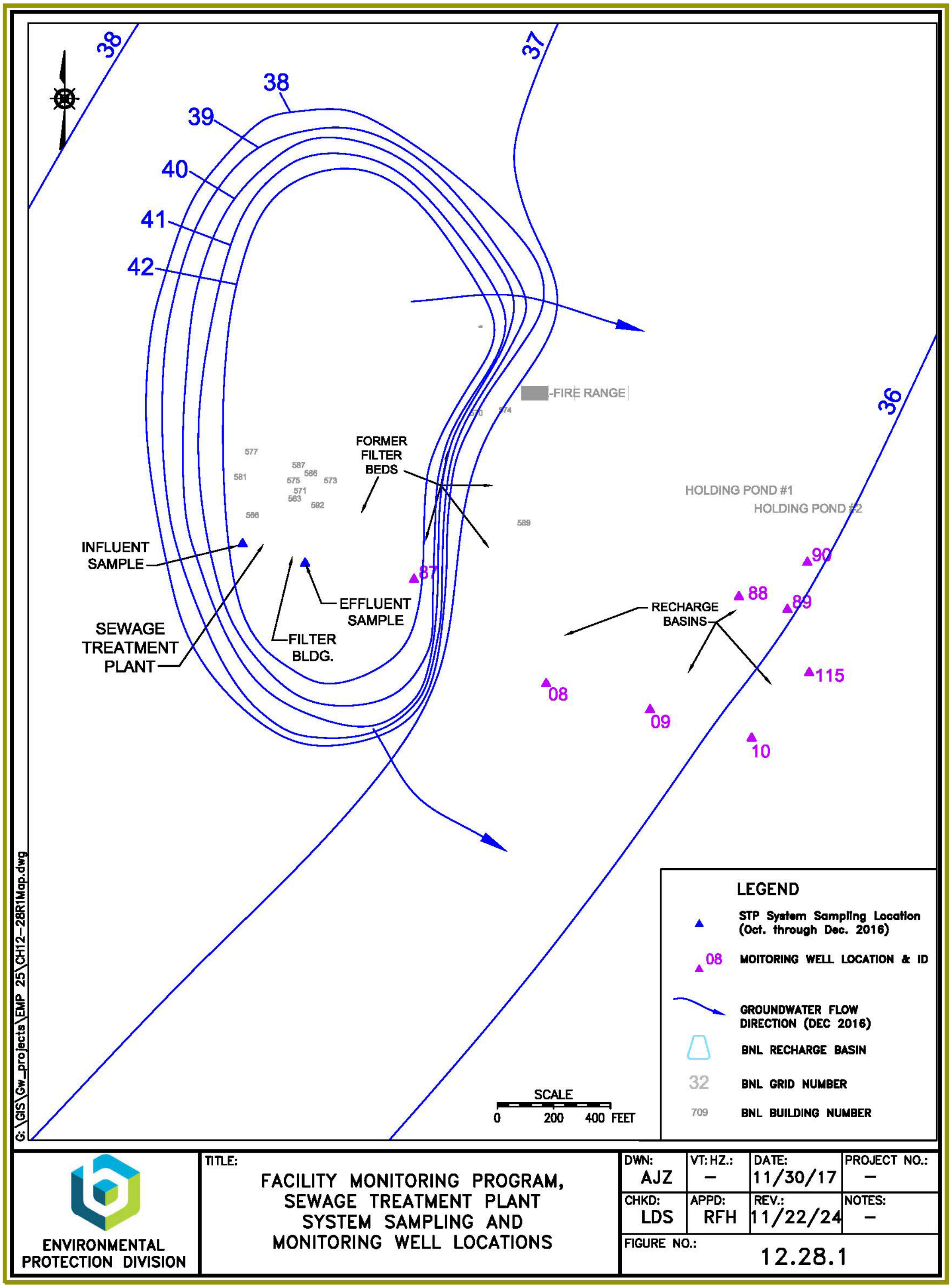

Figure 12.28.1 Sewage Treatment Plant System Sampling and Monitoring Well Locations

See Appendix B for the monitoring requirements for this Data Quality Objective.

12.29 GROUNDWATER MONITORING AT THE BNL MOTOR POOL FACILITY

DQO START DATE January 1, 2003

IMPLEMENTATION DATE January 1, 2025

Point of Contact Douglas Paquette (631) 344-7046

SUMMARY OF PROPOSED CHANGES

There are no proposed changes for calendar year 2025 for the groundwater monitoring program at the Motor Pool Facility.

DESCRIPTION AND TECHNICAL BASIS

In 1996, BNL installed two monitoring wells downgradient of the gasoline Underground Storage Tanks (USTs). Data from these wells indicate that current fuel storage and dispensing operations are not impacting groundwater quality. In 1999, the Laboratory installed six additional monitoring wells to evaluate the potential impact to groundwater quality from two oil spills. Although the monitoring results indicated that the two oil spills had not impacted groundwater quality, the degreasing agent 1,1,1-trichloroethane (TCA) and several gasoline by-products were observed.

Based on solvent handling and spill controls that have been in effect for the past 20 years, these contaminants are likely to have originated from historical small-scale spills resulting from vehicle maintenance activities. Semi-volatile organic compounds (SVOCs) were not detected in any samples, and sampling for these compounds was discontinued in 2002.

Although low levels of several VOCs continue to be detected in some Motor Pool area wells, since 2012 all VOC concentrations have been less than applicable drinking water standards. Starting in 2017, only wells 102-05 and 102-06, which monitor the underground storage tank area, will continue to be sampled. Monitoring well sampling frequency and methods of analysis are summarized in Tables 12.25.1 and 12.25.2.

DRIVERS FOR MONITORING

____ Compliance
____ Support Compliance
_X_ Surveillance
____ Restoration

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

Potential environmental concerns at the Motor Pool include the historical and current use of USTs for the storage of gasoline and waste oil, hydraulic fluids used for lift stations, and the use of solvents for parts cleaning. In August 1989, the USTs, pump islands, and associated piping were upgraded to conform to Suffolk County Article 12 requirements for secondary containment, leak detection devices, and overfill alarms. Following the removal of the old USTs, there were no obvious signs of soil contamination. The present tank inventory includes two 8,000-gallon USTs used for the storage of unleaded gasoline, one 260-gallon UST for waste oil, and one 3,000-gallon UST for No. 2 fuel oil. The facility also has five vehicle-lift stations. In 2002, the petroleum-based hydraulic fluid for the lifts was replaced with a vegetable-based product.

In December 1996, BNL removed an underground propane tank near the Site Maintenance Facility (Building 326). During this removal, the surrounding soils had a distinct petroleum staining and smell. The soil was contaminated from a previously unknown oil spill. Although approximately 60 cubic yards of contaminated soil were removed, there was clear evidence that contaminated soil remained. In February 1998, it was discovered that hydraulic fluid was leaking from one of the lift stations in Building 423. The lift was excavated and approximately 50 cubic yards of contaminated soil were removed. In response to a New York State Department of Environmental Conservation (NYSDEC) request, the Laboratory installed six new monitoring wells in the Motor Pool (Building 423/326) area to evaluate the potential impacts of the two spills.

Groundwater monitoring is conducted to verify that the operational and engineered controls are effective in protecting groundwater quality. These controls include:

- All USTs, pump islands, and associated piping conform to Suffolk County Article 12 requirements for secondary containment, leak detection devices, and overfill alarms.
- BNL maintains an inventory/accounting of gasoline stored in USTs at the Motor Pool.

Step 2: Identify the Decision

The decision for this monitoring program is:

Are the operations of the Motor Pool impacting groundwater quality? If so, do concentrations exceed water quality standards at the point of assessment (i.e., the closest downgradient well)?

Step 3: Identify Inputs to the Decision

The inputs necessary for the decision include:

- Current and planned operations at the Motor Pool
- Direction and velocity of groundwater flow
- VOC concentrations in groundwater
- Floating product determination measurements
- Locations of background and downgradient wells relative to known or potential source areas
- Regulatory requirements (DOE Order 436.1A [2023])
- Action levels (as described in the Groundwater Contingency Plan)
- Analytical methods and detection limits
  - VOCs (EPA Method 524.2)

Step 4: Define the Study Boundaries

The decision for this monitoring program applies to the area in the immediate vicinity of the Motor Pool/Site Maintenance Buildings. The period for which decisions are made is 365 days. This timeframe is based on the following:

- The USTs, pump islands, and associated piping were upgraded to conform to Suffolk County Article 12 requirements for secondary containment, leak detection devices, and overfill alarms. A more frequent monitoring program can be implemented if a leak is found or suspected. Vegetable-based products replaced petroleum-based hydraulic fluids in the vehicle lift stations, and all solvents are properly used, stored, and disposed of.

- The time required for contaminants from small-scale petroleum hydrocarbon spills and solvent spills to migrate through the vadose zone and reach the groundwater table is likely to be 30 or more days.
- Once contaminants have migrated to groundwater, the typical travel time to the nearest downgradient well (i.e., point of assessment, approximately 20 feet from the USTs or historical spill areas) is 30 days.
- Fifteen years of monitoring data have confirmed that the current operational and engineered controls have been effective. Therefore, decision periods of 365 days are sufficient to provide a secondary means of verifying that the current controls are effective, and to evaluate ongoing impacts from historical solvent, oil, and gasoline spills.

Step 5: Develop the Decision Rules

Are the operational and engineered controls effective at preventing the introduction of petroleum hydrocarbons and solvents to the groundwater?

The sample results will be evaluated in context with historical data. As part of the evaluation, circumstances that would require the implementation of the BNL Groundwater Protection Contingency Plan would be ascertained for each sampled well or set of wells (see EM-SOP-309 for details on plan implementation).

Step 6: Specify Acceptable Error Tolerances

Table 12.29.1. Decisions, Potential Errors, and Potential Consequences

Decision	Inputs	Potential Error Based on Data	Potential Consequences
Are controls effective at eliminating or controlling the leaching lead to the groundwater?	See Step 3 for inputs.	(1) Data indicate controls are effective when they are not. (2) Data indicate controls are not effective when they are because of sampling or analytical error, or wells not properly located.	(1) A discrete slug of contamination potentially up to 480 feet long and 20 feet wide could exist and not be detected.* (2) Need to re-sample well (as per Groundwater Contingency Plan). Potential erosion of stakeholder confidence.

* Assumes results from one sample period were inaccurate and all operational and engineered controls (i.e., inventory resolution, leak detection, secondary containment) were to fail.

There are no potential receptors (i.e., potable water supply wells) immediately downgradient of the Motor Pool area. Travel time from the Motor Pool area to the BNL southern boundary is greater than 15 years, and most residences south of BNL have been connected to public water. Therefore, it is very unlikely that a decision error will result in adverse consequences to human health. Consequences associated with decision errors for this program relate primarily to possible enforcement actions for environmental degradation, erosion of stakeholder trust, and loss of BNL credibility. Ultimately, a decision error could result in degradation of groundwater quality to such an extent as to require remedial actions under New York State regulations.

Step 7: Optimize the Design

Number and Locations of Wells

The wells at the Motor Pool are biased toward detecting contamination that could originate from the UST area and petroleum-contaminated soils associated with the spills discussed above (see Figure 12.29.1). The wells are as close as possible to these potential source areas to enable early detection of any contaminant releases. The current monitoring network is considered adequate for meeting the acceptable risk levels of stakeholders. Because the groundwater flow direction has been relatively constant in this area in recent years and the potential source is relatively small, no refinements are recommended. Since 2017, only wells 102-05 and 102-06, which monitor the underground storage tank area, have continued to be sampled.

Parameters and Frequency

Groundwater quality at the Motor Pool/Site Maintenance Facility area has been evaluated using monitoring wells that were installed during 1997-1999. Therefore, more than 15 years of analytical data are available to assess potential impacts from current operations and historical spills. Although low levels of several VOCs continue to be detected in some Motor Pool area wells, since 2012 all VOC concentrations have been less than applicable drinking water standards.

Groundwater samples are collected on an annual basis and are analyzed for VOCs. Floating product determination measurements are conducted in wells downgradient of the USTs.

Table 12.29.2. Comparison of CY 2024 and CY 2025 Sampling Programs

Well ID	2024 Sampling Frequency	2025 Sampling Frequency	Affected Parameters
102-05	Annual (a)	Annual (a)	None
102-06	Annual (a)	Annual (a)	None

(a): Wells downgradient of the USTs are also checked for floating product (FP).

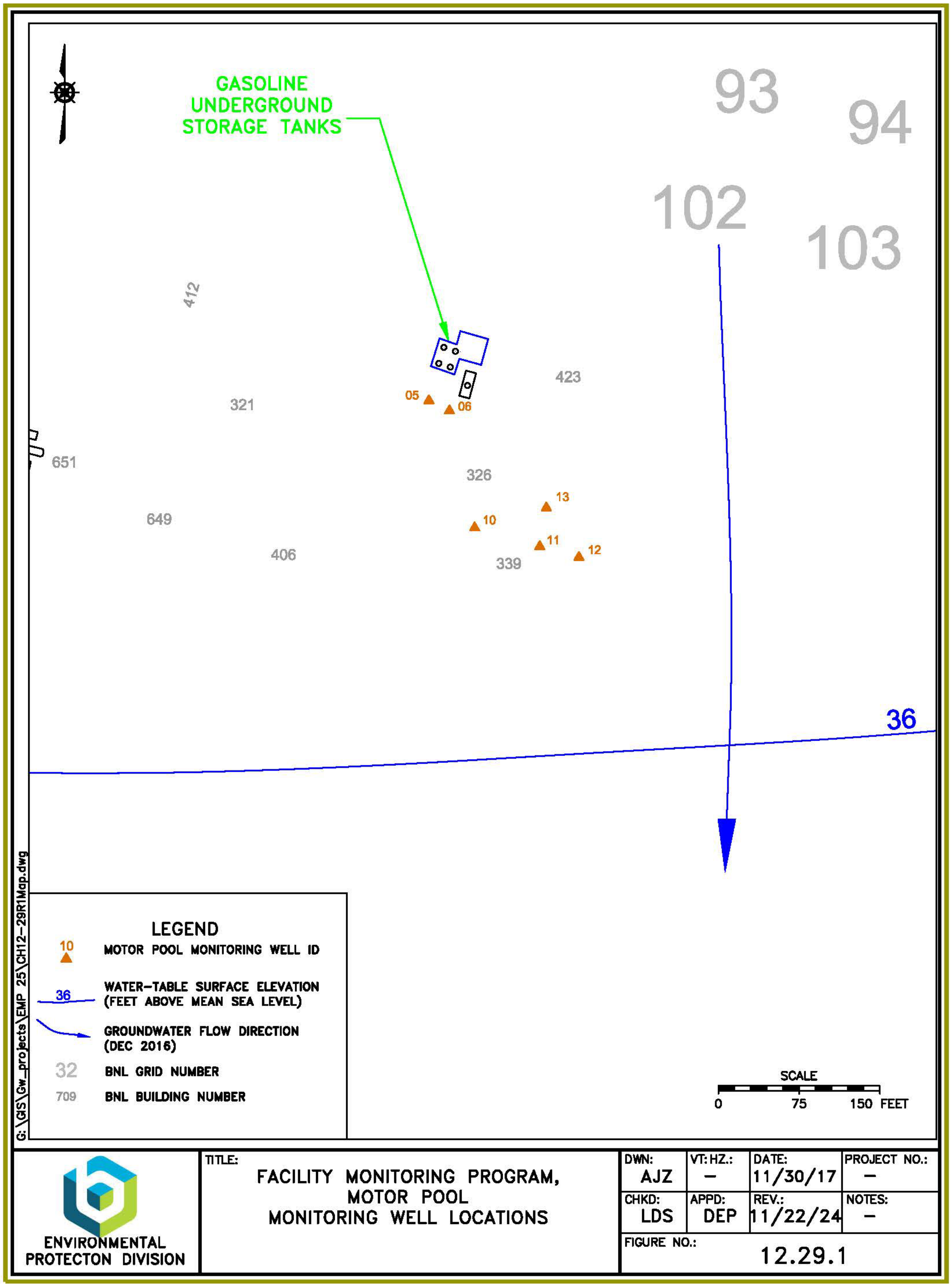

Figure 12.29.1 Facility Monitoring Program, Motor Pool Monitoring Well Locations

See Appendix B for the monitoring requirements for this Data Quality Objective.

12.30 GROUNDWATER MONITORING AT THE UPTON SERVICE STATION

DQO START DATE January 1, 2003

IMPLEMENTATION DATE January 1, 2025

Point of Contact Douglas Paquette (631) 344-7046

DESCRIPTION AND TECHNICAL BASIS

In 2018, car repair and fueling operations at the Service Station were discontinued, and the underground gasoline and waste oil storage tanks were removed. Groundwater monitoring at the facility was discontinued in 2019. No groundwater samples will be collected during 2025.

Parameters and Frequency

Prior to the facility's decommissioning, groundwater quality at the service station was evaluated using the four monitoring wells listed below.

Table 12.30.1. Comparison of 2024 and 2025 Sampling Programs at the Upton Service Station

Well	2024 Sampling Frequency	2025 Sampling Frequency	Affected Parameters
085-17	None	None	----
085-235	None	None	----
085-236	None	None	----
085-237	None	None	----

12.31 GROUNDWATER MONITORING AT THE MAJOR PETROLEUM FACILITY

DQO START DATE January 1, 2003

IMPLEMENTATION DATE January 1, 2025

Point of Contact Douglas Paquette (631) 344-7046

SUMMARY OF PROPOSED CHANGES

There are no proposed changes for calendar year 2025 to the Major Petroleum Facility (MPF) groundwater monitoring program.

DESCRIPTION AND TECHNICAL BASIS

In accordance with the New York State (NYS) operating license for the MPF, Brookhaven National Laboratory (BNL) routinely monitors groundwater quality downgradient of the MPF's bulk oil storage tanks. The monitoring program was initiated in the 1980s with five wells. Three additional wells were installed in 1999. In accordance with the operating license, the MPF wells are monitored semi-annually for volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs), and monthly for floating petroleum products. To date, no fuel-related compounds or floating products have been detected. Monitoring well sampling frequency and methods of analysis are summarized in Tables 12.25.1 and 12.25.2.

DRIVERS FOR MONITORING

_X_ Compliance
____ Support Compliance
____ Surveillance
____ Restoration

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

The MPF is the holding area for fuels used at the Central Steam Facility (CSF). Fuel oil for the CSF is held in a network of seven aboveground storage tanks, two of which are currently inactive. All fuel storage tanks are in bermed containment areas that have a capacity to hold >110 percent volume of the largest tank within each bermed area. The bermed areas have bentonite clay liners consisting of either Environmat (consisting of bentonite clay sandwiched between geotextile materials) or bentonite clay mixed into the native soils to form an impervious soil/clay layer. Nevertheless, there is a potential that small-scale leakage from the base of the tanks may go undetected.

The collection of groundwater samples from wells downgradient of the bulk storage area is required to demonstrate that current operational and engineered controls are effective in protecting groundwater quality. These controls include:

- The fuel storage tanks are connected to the CSF by aboveground pipelines that have secondary containment and leak detection devices.
- All fuel storage tanks are in bermed containment areas that have a capacity to hold >110 percent of the volume of the largest tank within each bermed area.
- The bermed areas have bentonite clay liners consisting of either Environmat (consisting of bentonite clay sandwiched between geotextile materials) or bentonite clay mixed into the native soils to form an impervious soil/clay layer.
- All fuel unloading operations were consolidated in one centralized building that has secondary containment features.
- BNL maintains an accurate inventory/accounting of fuel oil stored at the MPF.

Step 2: Identify the Decision

The decision for this monitoring program is:

Are the operations of the MPF impacting groundwater quality? If so, do concentrations exceed water quality standards at the point of assessment (i.e., the closest downgradient well(s)?

Step 3: Identify Inputs to the Decision

The inputs necessary for the decision include:

- Current and planned operations at the MPF
- Direction and velocity of groundwater flow
- SVOC concentrations in groundwater
- Floating product determination measurements
- Locations of background and downgradient wells relative to known or potential source areas
- Regulatory requirements: New York State Department of Environmental Conservation (NYSDEC) operating permit
- Action levels: detection of floating petroleum on the water table, or detection of SVOCs at concentrations exceeding levels outlined in the BNL Groundwater Contingency Plan
- Analytical methods and detection limits (as described in the Environmental Monitoring Plan)
- VOCs (EPA 8260)
- SVOCs (EPA Method 8270)
- Fuel inventory records

Step 4: Define the Study Boundaries

The decision for this monitoring program applies to the area in the immediately downgradient of the MFP. A decision period of 180 days is sufficient to provide a secondary means of verifying that the operational and engineered controls in place at the MPF are effective. This timeframe is based on the following:

- As described above, the MPF has several engineered and operational controls that are designed to prevent leakage of fuel oil to the environment. The monitoring frequency for the wells can be increased if a leak is found or suspected.

- The time required for contaminants from small-scale petroleum hydrocarbons to migrate through the vadose zone and reach the groundwater table is likely to be 90 or more days.

- Once contaminants have migrated to groundwater, the typical travel time to the nearest downgradient well (i.e., point of assessment, approximately 100 feet from the tanks) is on the order of 130 days.
- The MPF is outside the five-year capture zone for the BNL potable water supply wells.

Step 5: Develop the Decision Rules

Are the operational and engineered controls effective at preventing the introduction of petroleum hydrocarbons to the groundwater?

The sample results will be evaluated in context with historical data. As part of the evaluation, circumstances that would require the implementation of the BNL Groundwater Protection Contingency Plan would be ascertained for each sampled well or set of wells (see EM-SOP-309 for details on plan implementation).

Step 6: Specify Acceptable Error Tolerances

Table 12.31.1. Decisions, Potential Errors, and Potential Consequences

Decision	Inputs	Potential Error Based on Data	Potential Consequences
Are controls effective at eliminating or controlling the release of contaminants to the groundwater?	See Step 3 for inputs.	(1) Data indicate controls are effective when they are not. (2) Data indicate controls are not effective when they are because of sampling or analytical error, or wells not properly located.	(1) A discrete slug of contamination potentially up to 200 feet long and 20 feet wide could exist and not be detected.* (2) Need to re-sample well (as per Groundwater Contingency Plan). Potential erosion of stakeholder confidence.

* Assumes results from one sample period were inaccurate and all operational and engineered controls (i.e., inventory resolution, leak detection, secondary containment) were to fail.

There are no potential receptors (i.e., potable water supply wells) immediately downgradient of the MPF area. Groundwater travel time from the MPF area to the BNL southern boundary is greater than 15 years, and most residences south of BNL have been connected to public water. Therefore, it is very unlikely that a decision error will result in adverse consequences to human health. Consequences associated with decision errors for this program relate primarily to possible enforcement actions for environmental degradation, erosion of stakeholder trust, and loss of BNL credibility. Ultimately, a decision error could result in degradation of groundwater quality to such an extent as to require remedial actions under applicable NYS regulations.

Step 7: Optimize the Design

Number and Locations of Wells

The wells are as close as possible to potential MPF source areas to enable early detection of contaminant releases (see Figure 12.31.1). The current approved monitoring network is considered adequate for meeting the acceptable risk levels of stakeholders. Because the groundwater flow direction has been relatively constant in this area in recent years, and the potential source is relatively small, no refinements are recommended.

Parameters and Frequency

Groundwater quality at the MPF area is evaluated using eight monitoring wells. Multiple rounds of analytical data are available to assess potential impacts from past and current operations. No impacts from MPF operations have been observed to date. Low levels of several VOCs (e.g., 1,1,1-TCA) are occasionally detected in several MPF wells at concentrations exceeding the New York State Ambient Water Quality Standard (NYS AWQS) of 5 µg/L. These contaminants are thought to have originated from historical solvent spills near the CSF.

In accordance with the NYSDEC operating permit, groundwater samples are required to be collected on a semi-annual basis for VOCs (by EPA Method 8260) and SVOCs (by EPA Method 8270), and the wells are checked monthly for the presence of floating petroleum.

Table 12.31.2. Comparison of 2024 and 2025 Sampling Programs

Well	2024 Sampling Frequency	2025 Sampling Frequency	Affected Parameters
076-16	Semi-annual	Semi-annual (a)	None
076-17	Semi-annual	Semi-annual (a)	None
076-18	Semi-annual	Semi-annual (a)	None
076-19	Semi-annual	Semi-annual (a)	None
076-25	Semi-annual	Semi-annual (a)	None
076-378	Semi-annual	Semi-annual (a)	None
076-379	Semi-annual	Semi-annual (a)	None
076-380	Semi-annual	Semi-annual (a)	None

(a) Monitoring wells are also checked monthly for floating petroleum

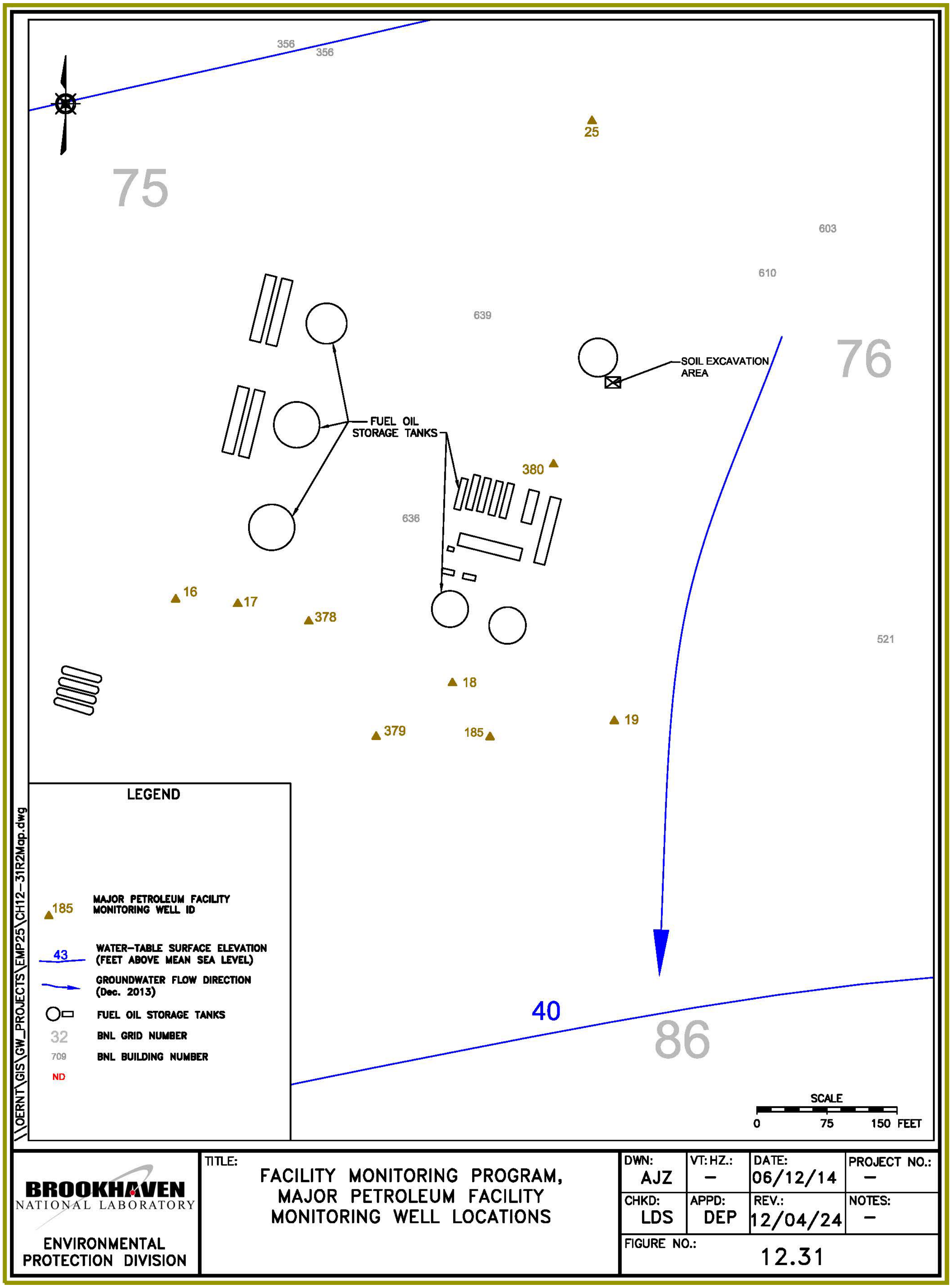

Figure 12.31.1 Upton Service Station Monitoring Well Locations

See Appendix B for the monitoring requirements for this Data Quality Objective.

12.32 Groundwater Monitoring For The G-2 Tritium Source Area

DQO Start Date January 2, 2008

Implementation Date January 1, 2025

Point of Contact Douglas Paquette (631) 344-7046

Summary of Proposed Changes

There are no proposed changes for calendar year 2025 for the g-2 Tritium Source Area monitoring program.

Description and Technical Basis

In November 1999, tritium was detected in the groundwater near the g-2 experiment at concentrations above the 20,000 pCi/L drinking water standard. Sodium-22 was also detected in the groundwater, but at concentrations well below the 400 pCi/L drinking water standard. An investigation into the source of the contamination revealed that the tritium and sodium-22 originated from activated soil shielding located adjacent to the g-2 target building where approximately five percent of the beam was inadvertently striking the beamline's VQ12 magnet. Rainwater was able to infiltrate the activated soils and carry tritium and sodium-22 into the groundwater.

To prevent additional rainwater infiltration into the activated soil shielding, a concrete cap was constructed over the soil shielding in December 1999. Other corrective actions included refocusing the beam and improved beam loss monitoring to reduce additional soil activation, stormwater management improvements, and additional groundwater monitoring. The g-2 experiment concluded its operations in 2001. The highest tritium concentration was detected during 2002 at 3,440,000 pCi/L.

Following the concurrence from the New York State Department of Environmental Conservation (NYSDEC), a Record of Decision (ROD) was signed by the U.S. Department of Energy (DOE) and the Environmental Protection Agency (EPA) in early 2007. This ROD requires continued routine inspection and maintenance of the impermeable cap, groundwater monitoring of the source area to verify the continued effectiveness of the storm water controls. Tritium concentrations in source area wells have been less than 40,000 pCi/L since 2015. Monitoring of the source area will continue for as long as the activated soils remain a potential threat to groundwater quality. Monitoring well sampling frequency and methods of analysis are summarized in Tables 12.25.1 and 12.25.2.

Drivers for Monitoring

___ Compliance
___ Support Compliance
_X_ Surveillance
_X_ Restoration/IAG

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

Although the cap and other stormwater controls appear to be effectively protecting the activated soils, long-term monitoring is required to verify the continued effectiveness of these controls. Monitoring data indicates that natural fluctuations in the position of the water table periodically flush small amounts of residual tritium that remains close to the water table. The amount of residual tritium will be reduced by this flushing mechanism and by natural radioactive decay. For the past several years, tritium concentrations in surveillance wells located immediately downgradient of the source area were <20,000 pCi/L.

Step 2: Identify the Decision

Are the engineered controls employed at the g-2 source area effective at preventing additional leaching of tritium from the activated soil shielding? Furthermore, are the tritium concentrations in groundwater declining at the rate and within the geographical area predicted by groundwater modeling?

Step 3: Identify Inputs to the Decision

The inputs necessary for the decision include:

- Direction and velocity of groundwater flow
- Tritium concentrations in groundwater
- Locations of background and downgradient wells
- Regulatory requirements: g-2/BLIP/UST ROD, DOE Order 458.1
- Action levels:
  - As defined in the g-2/BLIP/UST ROD, Brookhaven National Laboratory (BNL) will determine whether additional remedial actions are required if future tritium levels exceed 1,000,000 pCi/L in groundwater immediately downgradient of the g-2 source area.
- Analytical methods and detection limits:
  - Tritium: EPA Method 906

Note: The focus of the current monitoring program is on evaluating changes in tritium concentrations in groundwater immediately downgradient of the g-2 source area. Because tritium is more mobile than sodium-22 and has a longer half-life (12.6 years compared to 2.3 for sodium-22), the presence of tritium in groundwater is a better early indicator of a failure in an engineered storm water control. Based upon past results, it is expected that detectable levels of sodium-22 would only be observed in groundwater immediately downgradient of activated soil shielding source areas.

Step 4: Define the Study Boundaries

The decision for the g-2 source area monitoring program applies to the nearest monitoring wells, which are located near Building 912A, between 275 to 300 feet downgradient of the source. The period for which decisions are made is 90 days. This timeframe is based on the following:

- The time required for tritium to migrate through the vadose zone and reach the groundwater table (by means of rainwater leachate) is likely to be between 30 to 60 days.

- Once tritium has migrated into the groundwater, the tritium migrates at the same rate as groundwater (approximately 0.75 feet/day). The travel time between the source area and the nearest downgradient wells (near Building 912A) is expected to be approximately 365 days.

- Decision periods of 180 days are acceptable for the g-2 source area where historical monitoring has demonstrated that groundwater quality has already been significantly impacted. A decision period of 180 days is required to continually evaluate the effectiveness of engineered controls designed to prevent additional storm water infiltration.

Step 5: Develop the Decision Rules

Are engineered controls effective at preventing the leaching of radionuclides from activated soils to the groundwater? Is the plume attenuating at the rate and within the geographic area predicted by groundwater modeling?

The sample results are evaluated in context with historical data and the contingency requirements defined in the ROD. In accordance with the ROD, DOE will determine whether additional remedial actions are required for the g-2 source area or plume control if future tritium levels exceed 1,000,000 pCi/L within any section of the g-2 plume. Tritium concentrations in g-2 monitoring wells have not exceeded 1,000,000 pCi/L since January 2003, and tritium concentrations in source area wells have not exceeded 40,000 pCi/L since 2015. Monitoring has demonstrated that tritium concentrations currently decrease to less than 20,000 pCi/L via natural radioactive decay and dispersion entirely within the AGS area. The monitoring results are also evaluated in accordance with the BNL Groundwater Contingency Plan (EM-SOP-309).

Step 6: Specify Acceptable Error Tolerances

Table 12.32.1. Decisions, Potential Errors, and Potential Consequences

Decision	Inputs	Potential Error Based on Data	Potential Consequences
Are controls effective at eliminating or controlling the leaching of tritium from the g-2/VQ12 activated soil shielding to the groundwater?	See Step 3 for inputs	(1) Data indicate that source controls are effective when they are not. (2) Data indicate source controls are not effective when they are because of sampling or analytical error or wells not properly located.	(1) A slug of contamination potentially up to 100 feet long and 20 feet wide could exist and not be detected.* (2) Need to re-sample well and resulting additional unplanned costs. Potential erosion of stakeholder confidence.

*Assumes results from one sample period were inaccurate.

Although the g-2 source area is within a two-year capture zone of BNL potable supply Well 10, tritium concentrations in the g-2 source area have been less than 40,000 pCi/L since 2015. With the low tritium concentrations currently detected in groundwater, combined with dispersion and natural radioactive decay, it is unlikely that a decision error will result in adverse consequences to human health. Consequences associated with (short-term) decision errors for this program relate primarily to possible enforcement actions for continued environmental degradation, erosion of stakeholder trust, and loss of BNL credibility.

Parameters and Frequency

The g-2 source area are monitored as follows:

- Five downgradient wells located near Building 912A are sampled semiannually for tritium (Table 12.32.2). These are the closest wells downgradient of the g-2 source area.

- Ten wells located immediately downgradient of Building 912 are sampled annually for tritium as part of the AGS monitoring program (see Table 12.26.2). These wells are used to verify that tritium originating from the g-2 source area attenuates to <20,000 pCi/L by the time the impacted groundwater migrates past Building 912.

Table 12.32.2 below shows a comparison of the 2024 and 2025 monitoring program of the permanent wells.

Table 12.32.2. Comparison of 2024 and 2025 Monitoring Program – Permanent Wells

Well	Monitoring Sub-Area	2024 Sampling Frequency	2025 Sampling Frequency	Affected Parameters
054-65	Bkgd. g-2	Annual	Annual	None
054-07	g-2/VQ12 source	Semiannual	Semiannual	None
054-184	g-2/VQ12 source	Semiannual	Semiannual	None
054-185	g-2/VQ12 source	Semiannual	Semiannual	None
064-95	g-2/VQ12 source	Semiannual*	Semiannual*	None
054-126	g-2/VQ12 source	Semiannual	Semiannual	None

* Access to well 064-95 is periodically restricted because it is within a posted radiation area when AGS/RHIC is in operation.

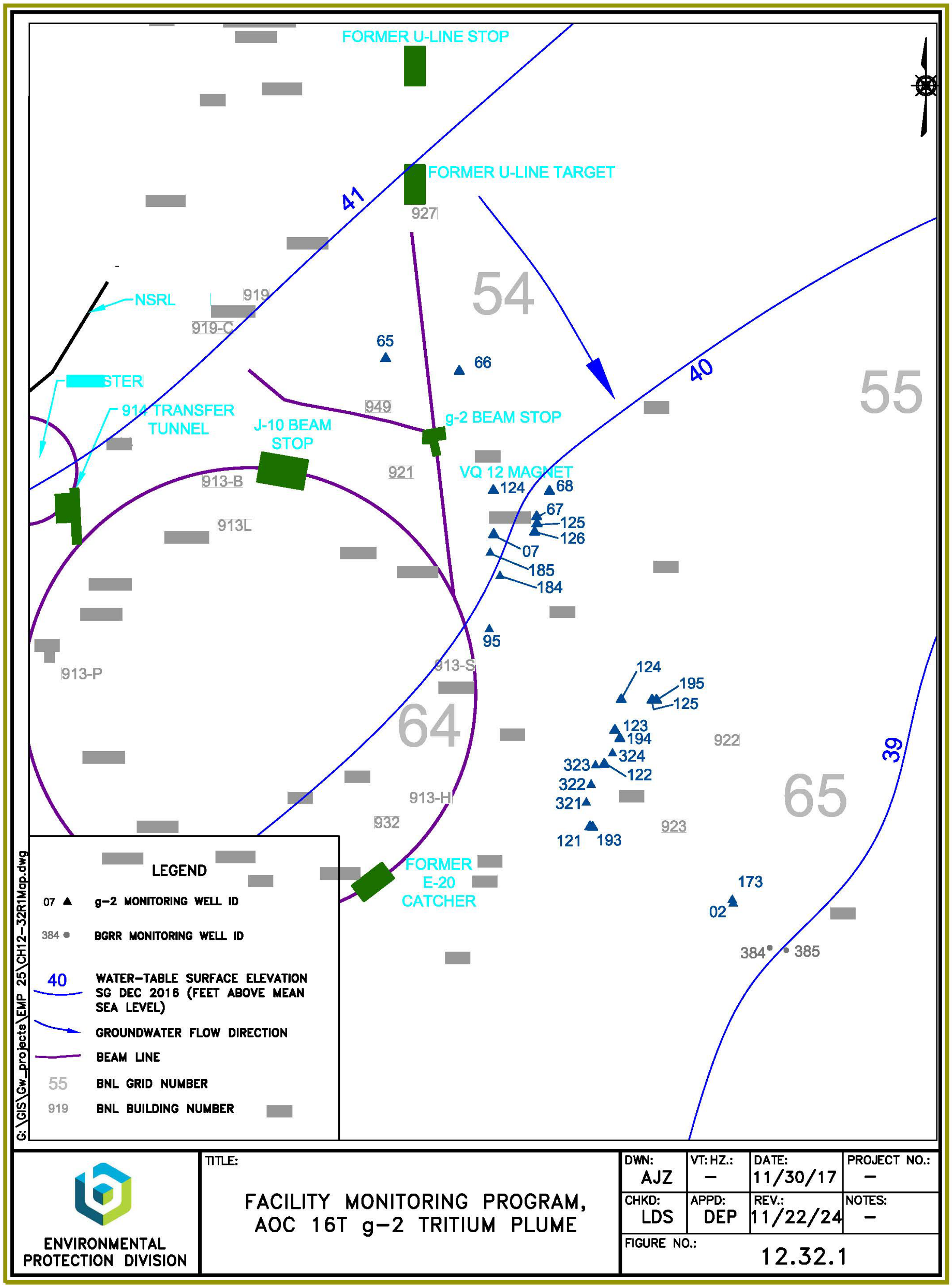

Figure 12.32.1 AOC 16T g-2 Tritium Plume

12.33 Groundwater Monitoring at the National Synchrotron Light Source II (NSLS-II)

DQO Start Date January 1, 2012

Implementation Date January 1, 2025

Point of Contact Douglas Paquette (631) 344-7046

Summary of Proposed Changes

For calendar year 2025, continue annual sampling of the wells that monitor the National Synchrotron Light Source II (NSLS-II) beam loss areas. However, discontinue sampling upgradient wells 076-18 and 076-19 located at the Major Petroleum Facility because sufficient data have been collected from these wells to verify that tritium is not present in the shallow groundwater upgradient of the NSLS-II facility.

Description and Technical Basis

Brookhaven National Laboratory (BNL) installed four downgradient monitoring wells to evaluate the effectiveness of the engineered and operational controls designed to protect groundwater quality near anticipated low-level activated soil shielding at the NSLS-II linear accelerator (Linac)/Booster facility. The Linac/Booster facility began startup testing operations in 2012, and full-facility operations began in late 2014. The interaction of neutrons with the soils below the tunnel floor and surrounding soil shielding (berm) have the potential to create very low levels of tritium and Na-22 in the adjacent soil shielding. There is also the potential to create very low levels of tritium in the water used to cool the magnets and other accelerator components. Monitoring well sampling frequency and methods of analysis are summarized in Tables 12.25.1 and 12.25.2.

Drivers for Monitoring

____ Compliance
____ Support Compliance
_X_ Surveillance
____ Restoration

Data Quality Objective Analysis

Step 1: State the Problem

High-energy particle interactions in water, air, and soil can produce radioactivity from spallation reactions or neutron capture in nitrogen, oxygen, or other materials. In high-energy proton accelerators, such as BNL's Alternating Gradient Synchrotron (AGS) and the Relativistic Heavy Ion Collider (RHIC), these interactions can produce significant environmental issues. However, electron accelerators, such as the NSLS-II, have significantly reduced potential for environmental impacts and can produce only about one to five percent of the induced activity of a proton accelerator.

Soil Activation: Although light source facilities throughout the world have not been found to create radiological environmental issues, analyses as required by the BNL Standards-Based Management System (SBMS) *Accelerator Safety* Subject Area have been conducted to estimate the rate of formation of tritium (^{3}H) and sodium-22 (^{22}Na) in the surrounding soils during the operation of the NSLS-II Linac, Booster, and Storage Ring.

In the calculations, the neutron source inside the accelerators is assumed to be at 1.2 m from the floor and 2 m from the inboard wall. The floor is 0.51 m of standard concrete in the Linac. A minimum concrete wall of 0.5 m is assumed before soil is encountered beyond the side walls. Using the methodology established in the BNL SBMS *Accelerator Safety* Subject Area, the leachable concentration created in the soil has also been calculated. Based upon published reports, it is assumed that nearly 100 percent of tritium and 7.5 percent of the Na-22 can be leached from activated soils by rainwater infiltration. A water concentration factor of 1.1 is taken due to the annual rainfall of 55 cm. (Note, the soil beneath the concrete floor is not exposed to rainfall, so the potential leaching of radioactive isotopes from the soil to the water table at these locations will be minimal.)

Table 12.33.1. Predicted Activity in NSLS-II Soil at Beam Loss Locations

Soil Loca-tion	Electron Loss (nC/s)	Electron Loss(e/s)	Neutron Flux (n/cm^2.s)	Neutron Flux (Av) (n/cm^2.s)	^{3}H (pCi/L)	^{3}H Leacha-ble (pCi/L)	^{22}Na (pCi/L)	^{22}Na Leacha-ble (pCi/L)
Linac Dump 230MeV	22	1.37E11	4.4E2	92	0.54	0.60	5.2	0.39
Linac Slit 230MeV	11	6.86E10	2.2E2	46	0.41	0.46	3.9	0.29
Booster Dump 3 GeV	15	9.36E10	3.9E3	815	4.83	5.31	46.7	3.50

Assumptions:

200 times per year the Linac and Booster are used to fill the Storage Ring from scratch. Each fill cycle lasts three minutes. Total operating time is 200 x 3 min = 10 hours.

500 hours per year of Linac and Booster study.

5,000 hours of top-off operation, 3 pulses per minute operation, effective hours of operation = 5,000 x 180/3,600 = 250 hours.

500 hours per year of operation for each beam dump and 760 hours of operation for the Linac slit.

These calculated values are well within the BNL-defined administrative Action Levels of 1,000 pCi/L for tritium and 100 pCi/L for sodium-22 (defined in the BNL *Accelerator Safety* Subject Area). Therefore, no additional engineered safeguards are required.

As a monitoring tool for soil activation levels near the Linac, about one-liter soil samples are positioned within the Linac enclosure near predicted high-loss points. These soil samples are tested periodically to estimate the buildup of sodium-22 and tritium in the surrounding soils. In addition, analysis of groundwater samples from wells installed downgradient of the Linac beam stop/Booster area are used to demonstrate that the operational and engineered controls at the NSLS-II are effective in protecting groundwater quality.

Cooling Water Activation: Activation of water used to cool the magnets and other accelerator components is estimated by a similar method. The primary reactions leading to the activation of cooling water are the bremsstrahlung interactions with ^{16}O in water. In the Linac, the highest beam loss point in a component with water cooling is the first bending magnet downstream of the Linac. Of the nuclides of concern for groundwater protection, tritium will attain saturation only after decades of operation. After 5,000 hours of continuous operation, the concentration of tritium in the Storage Ring Septum area will be only three percent of the saturation value, with an estimated concentration of only 5 pCi/L. Other smaller loss points, including the Linac bending magnet, will provide additional small increments to the total inventory of tritium within the system. The cooling water system will be tested periodically for tritium once operations have begun.

Step 2: Identify the Decision

Are the operational and engineered controls employed at NSLS-II effective at preventing the release of tritium and sodium-22 to groundwater at concentrations that exceed drinking water standards at the point of assessment (i.e., the closest wells downgradient of the identified potential soil activation areas at the Linac)?

Step 3: Identify Inputs to the Decision

The inputs necessary for the decision include:

- Current and planned operations at the NSLS-II
- Modeled estimates on the amount of soil activation at Linac beam loss areas
- Direction and velocity of groundwater flow
- Tritium concentrations in groundwater
- Locations of background and downgradient wells relative to each identified soil activation area
- Regulatory requirements: DOE Order 458.1, Radiation Protection of the Public and the Environment
- Action levels (as described in the BNL Groundwater Protection Contingency Plan)
- Analytical methods and detection limits:
  - Tritium: Environmental Protection Agency (EPA) Method 906
  - Gamma spectroscopy (optional analysis if tritium is detected): EPA Method 901

During 2011, the focus of the NSLS-II groundwater surveillance program was the collection of pre-operation samples to establish baseline values for tritium and Na-22. Following the initial beam line testing operations during 2012, only tritium is being analyzed because it is more mobile than sodium-22 and has a longer half-life (12.6 years compared to 2.6 years). Therefore, tritium's presence in groundwater would be a better early indicator of a failure in an engineered control.

Step 4: Define the Study Boundaries

The decision for this monitoring program applies to the area in the immediate vicinity of the NSLS-II Linac and Booster. The period for which decisions are made is 365 days. These timeframes are based on the following:

- The time required for tritium to migrate through the vadose zone and reach the groundwater table (by means of rainwater leachate) is likely to be between 30 to 60 days.

- Once tritium migrates into the groundwater, the typical travel time to the nearest downgradient well (i.e., point of assessment, ranging from 150 to 350 feet from the potential sources) is approximately 300 to 700 days.

- Decision periods of 365 days are acceptable for areas where monitoring has demonstrated that current engineered and operational controls are effective.

Step 5: Develop the Decision Rules

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

The sample results are evaluated in context with historical groundwater data, including data from upgradient wells, operations of the Linac/Booster area, and measured and estimated radioactivity buildup in soil shielding. As part of the evaluation, circumstances that would require the implementation of the BNL Groundwater Protection Contingency Plan would be ascertained for each sampled well or set of wells (see EM-SOP-309 for details on plan implementation).

Step 6: Specify Acceptable Error Tolerances

Table 12.33.2. Decisions, Potential Errors, and Potential Consequences

Decision	Inputs	Potential Error Based on Data	Potential Consequences
Are controls effective at eliminating or controlling the leaching of tritium and soium-22 from activated soil shielding to the groundwater?	See Step 3 for inputs.	Data indicate controls are effective when they are not.	A discrete slug of contamination potentially up to 100 feet long and 20 feet wide could exist and not be detected.*
		Data indicate controls are not effective when they are, due to sampling or analytical error, or wells not properly located.	Need to re-sample well (as per Groundwater Contingency Plan). Potential erosion of stakeholder confidence.

*Assumes results from one sample period were inaccurate.

There are no potential receptors (i.e., potable water supply wells) to potentially contaminated groundwater in the NSLS-II Linac/Booster area and the distance to the BNL property boundary is over one mile. Due to these factors, it is very unlikely that a decision error will result in adverse consequences to human health or the environment. Consequences associated with decision errors for this program relate primarily to possible enforcement actions for environmental degradation, erosion of stakeholder trust, and loss of BNL credibility. Ultimately, a decision error could result in degradation of groundwater quality to such an extent as to require remedial action under Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) or other regulations.

Step 7: Optimize the Design

Number and Locations of Wells

The wells located at the NSLS-II are biased toward detecting contamination originating from activated soils associated with the facility's Linac/Booster area (Figure 12.33.1). The wells are located as close as possible to these potential source areas to enable early detection of contaminant releases. The monitoring network installed in 2011 is considered adequate for meeting the monitoring requirements under DOE Order 458.1 and acceptable risk levels of stakeholders.

Parameters and Frequency

Groundwater quality in the NSLS-II Linac/Booster area is evaluated using four downgradient monitoring wells. Until 2023, two upgradient wells from the Major Petroleum Facility monitoring program were used to evaluate background tritium levels. Because tritium is easily leached from activated soils, is highly mobile in groundwater, and has a longer half-life (12.3 years compared to 2.6 for sodium-22), the primary focus of the operations phase of the groundwater monitoring program is the detection of tritium. Groundwater samples are collected on an annual (365 day) basis. Should tritium be detected in any of the wells, samples could also be tested for the presence of Na-22. Table 12.33.3 below shows a comparison of the 2024 and 2025 sampling programs.

Table 12.33.3. Comparison of 2024 and 2025 Sampling Programs

Well ID	CY 2024 Sampling Frequency	CY 2025 Sampling Frequency	Affected Parameters
076-18 (a)	Annual	None	Tritium
076-19 (a)	Annual	None	Tritium
086-123	Annual	Annual	None
086-124	Annual	Annual	None
086-125	Annual	Annual	None
086-125	Annual	Annual	None

(a) Well is part of the MPF monitoring program and was previously sampled to determine background tritium concentrations for the NSLS-II monitoring program.

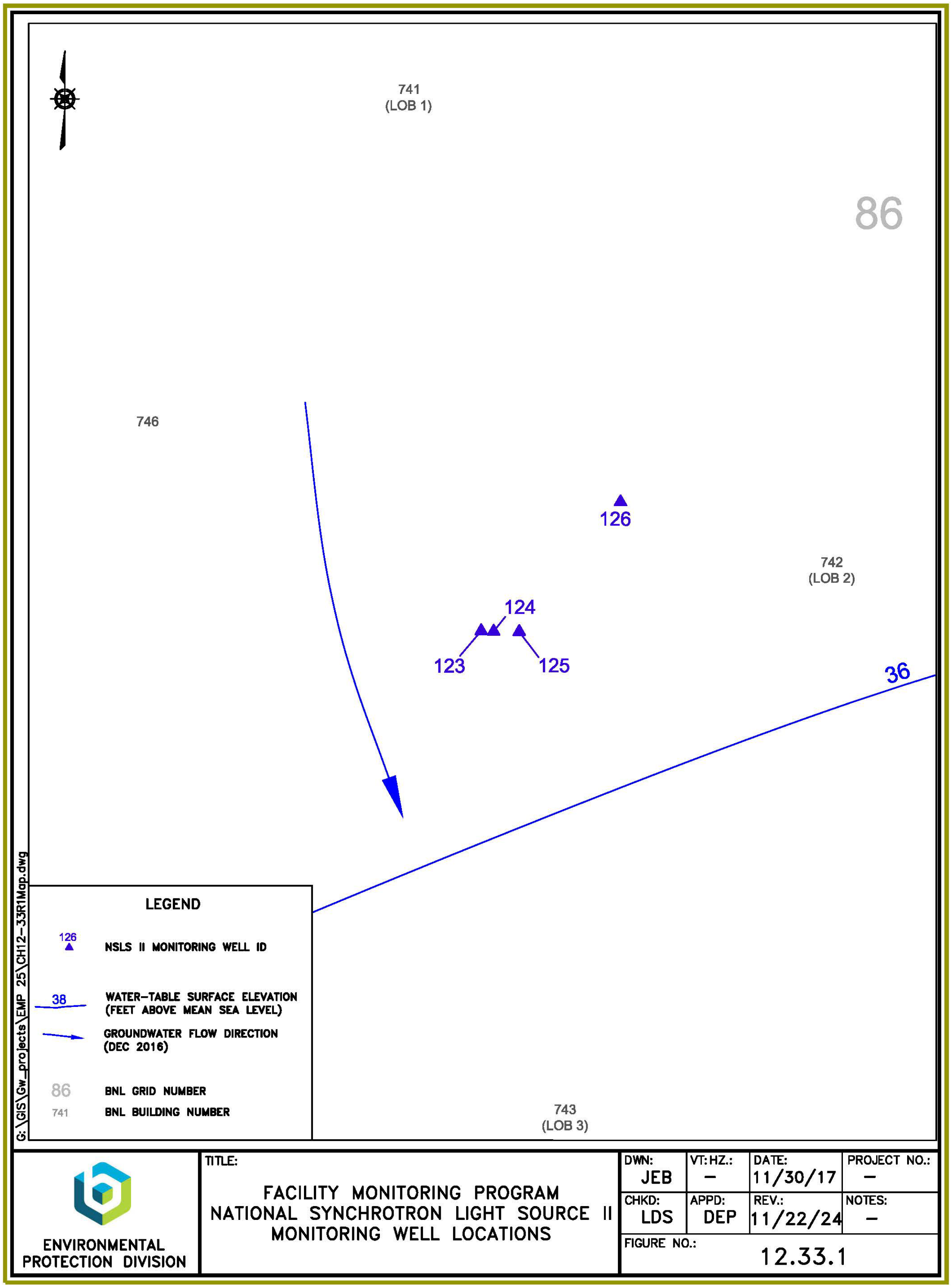

Figure 12.33.1 Facility Monitoring Program National Synchrotron Light Source II Monitoring Well Locations

See Appendix B for the monitoring program for this Data Quality Objective.

Intentionally Left Blank

12.34 OU X Former Firehouse Groundwater Treatment System

DQO START DATE January 1, 2023

IMPLEMENTATION DATE January 1, 2025

POINT OF CONTACT Douglas Paquette (631) 344-7046

SUMMARY OF PROPOSED CHANGES

Routine groundwater sampling activities related to the Former Firehouse polyfluoroalkyl substances (PFAS) treatment system began in January 2023. The monitoring program uses 42 wells to evaluate the effectiveness of the groundwater treatment system to remediate PFAS that were released to soil during firefighter training activities from 1966 through 1985. In addition to testing for PFAS, samples from select wells are also analyzed for 1,4-dioxane, which originated from the releases of the solvent 1,1,1-trichloroethane (TCA) in areas upgradient of the Former Firehouse (e.g., the Alternating Gradient Synchrotron [AGS]) and downgradient (e.g., the former Building 208 vapor degreaser facility).

DESCRIPTION AND TECHNICAL BASIS

Following the 2017 detections of PFAS in the BNL supply wells, BNL identified eight areas where Aqueous Film Forming Foam (AFFF) had been released to the ground during the period of 1966 through 2008. The available records indicated that routine firefighter training with foam occurred in three areas, at the Former Firehouse facility, at the Current Firehouse facility and at a former training area located west of BNL dormitory Building 170. Starting in 2018, BNL began a multiphase characterization effort to evaluate the impacts from the foam releases. High levels of PFAS were detected downgradient of the Former Firehouse training areas, with two PFAS chemicals, perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA), detected at concentrations up to 5,210 ng/L and 736 ng/L, respectively. The New York State (NYS) drinking water standards for PFOS and PFOA is 10 ng/L. National drinking water standards for PFOS (4 ng/L), PFOA (4 ng/L), and several other PFAS were promulgated during 2024.

The Former Firehouse (former Building 99) was in operation from 1947 through 1985. Available records indicate that firefighting foam was used for training as early as 1966. Firefighters practiced with foam primarily in a training area that was located immediately west of the firehouse. A second training area was located east of the firehouse, where firefighters would periodically practice extinguishing car fires using foam. There are no available records on foam formulations or on the amount used at the Former Firehouse. Most of the training area that was located to the west of the firehouse is presently occupied by Building 725 (currently used by the Computational Science Initiative), which was constructed in the early 1980s. The Former Firehouse structure was demolished in March 1986. Following demolition, low-level radiologically contaminated soils were excavated from this area. These actions were documented in the OU III ROD (AOC 22).

Although there is no known use of solvents at the Former Firehouse that could have released 1,4-dioxane, documented releases of TCA had occurred in upgradient areas in the AGS facility located to the north-northwest. Furthermore, TCA was released from the former Building 208 degreasing facility that was in an area currently occupied by the National Synchrotron Light Source II. Solvents (primarily tetrachloroethylene) had also been released in the former Building 96 area, also located south of the Former Firehouse.

The Former Firehouse Treatment System consists of three groundwater extraction wells and a liquid phase granular activated carbon (GAC) treatment system located in a new treatment building, identified as Building 557 on the south side of Building 598. The treatment system started operations in January 2023. Treated water from the GAC filtration system is recharged to the RA V recharge basin. The OU10 Former Firehouse groundwater monitoring program consists of a network of 42 wells located near and south of the Former Firehouse (Figure 12.34.1).

DRIVERS FOR MONITORING

____ Compliance
____ Support Compliance
____ Surveillance
_X_ Restoration

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

Groundwater in the vicinity of the Former Firehouse has been impacted by the release of AFFF that contained PFAS. In 2022, a groundwater remediation system was constructed to treat PFAS originating from the former foam training areas. The data obtained from this monitoring program will be used to verify the effectiveness of the treatment system to remediate the aquifer and to prevent further downgradient migration of the plume.

Step 2: Identify the Decision

The decisions for the project are:

- Were unexpected levels or types of contamination detected?
- Is the groundwater remediation system effectively capturing the PFAS plumes as expected?
- Has the downgradient migration of the plume been controlled?
- Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?
- Are PFOS/PFOA concentrations in plume core wells above or below 100 ng/L?
- Has the groundwater cleanup goal of meeting MCLs been achieved?

Step 3: Identify Inputs to the Decision

The inputs necessary for the decision include:

- Direction and velocity of groundwater flow
- Analytical results for PFAS using EPA Method 1633
- Analytical results for 1,4-dioxane in select wells using Method 8270D SIM
- Locations of the groundwater monitoring wells (Figure 12.34.1)
- Regulatory drivers that will be defined in the OU X Record of Decision (ROD)
- Action levels (NYS drinking water or groundwater standards or national drinking water standards once they have been promulgated)
- Up to 10 percent of the data analyzed by contract analytical laboratories will be validated using guidance provided from BNL EM-SOP-212, Chemical Data Validation, and U.S. Department of Defense, Data Validation Guidelines Module 6: Data Validation Procedure for Per- and Polyfluoroalkyl Substances Analysis by

QSM Table B-24, October 2022, or latest revision.

Step 4: Define the Study Boundaries

The project geographical limits are defined by the map boundaries depicted on Figure 12.34.1.

Separate decisions will be made in the monitoring subunits (e.g., core, perimeter, and bypass wells) described in the Former Firehouse Groundwater Treatment System O&M Manual. However, some of the decisions, such as system performance, are based on the entire system. The temporal boundaries of the study area may vary, based on the decision.

- *Plume Source Area:* Due to the need for frequent data collection during the system startup period, the timeframe for decisions for this subunit is 90 days.

- *Downgradient Plume Core and Perimeter:* The wells in this subunit define the plume horizontally, which is used to determine whether the plumes are being captured. Because the treatment system has only been in operation since January 2023, the appropriate timeframe for decisions is 180 days. The timeframe will likely be reduced to 90 days after the treatment system has been in operation for several years.

- *Bypass Detection Area:* The wells in this area indicate whether the plume capture performance objective is being met. Because the treatment system has only been in operation since January 2023, the timeframe for decisions is 180 days. The timeframe will likely be reduced to 90 days after several years of operation.

Section 12.1 details the general sampling frequency based on the phase the monitoring program is in.

Step 5: Develop the Decision Rules

Note: The decision rules discussed below are to be considered preliminary until the final cleanup objectives are defined in the OU X Record of Decision (ROD).

Decision 1

Were unexpected levels or types of contaminants detected?

The sample results will be evaluated in context with available characterization data gathered since 2018. As part of that evaluation, circumstances that would require implementation of the BNL Groundwater Contingency Plan (Environmental Monitoring Standard Operating Procedure [EM-SOP]-309) would be determined. Examples of such circumstances are unusually high contaminant concentrations, including detection of previously undetected contaminants that could impact treatment system operations (e.g., detection of high levels of 1,4-dioxane that could result in exceeding the treatment system discharge limit).

If the types or concentrations of contaminants detected in any well could impact treatment system operations, and their presence and concentrations are confirmed by resampling, **then** implement actions as prescribed in the BNL Groundwater Contingency Plan.

Decision 2

Has the downgradient migration of the plume been controlled?

This decision applies to the plume perimeter and bypass detection wells.

If the cleanup goals have not been met, **then** it must be verified that the plume is not growing. Plume growth is defined as an increase in PFOS and/or PFOA concentrations in plume perimeter or bypass detection wells to above the 100 ng/L capture goal (if currently less than 100 ng/L).

Note: The downgradient extent of the PFAS plume will be further characterized as part of the planned OU X Remedial Investigation. Plume migration is currently being contained near East Princeton Avenue by one extraction well.

Decision 3

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

To shut down the treatment system, the shutdown criteria of reaching less than 100 ng/L PFOS and PFOA for at least four consecutive sampling rounds must be met in the core monitoring and extraction wells.

Note: The shutdown criteria for this system may be modified following the Remedial Investigation/Feasibility Study.

Decision 4

Are PFOS or PFOA concentrations in plume core wells above or below 100 ng/L?

If the PFOS and PFOA concentration in each plume core well has been reduced to less than 100 ng/L, **then** proceed with pulsed operation of the system. **If not, then** continue full-time operation.

4a. Is there a significant concentration rebound in core wells and/or extraction wells following pulsed-pumping operations?

If yes, then continue treatment system operations. **If no** significant rebound is observed within a one-year period, then petition for system shutdown, maintain the system in an operationally ready mode, and continue with monitored natural attenuation (MNA).

Decision 5

Has the groundwater cleanup goal of meeting MCLs been achieved?

If PFOS and PFOA concentrations in all plume core wells are less than the 10 ng/L NYS MCL (or national standards once promulgated) over the previous two years and pulsing of the remediation system has not resulted in significant rebound of contaminant concentrations, **then** petition for system closure. If not, then consider the need for continued remediation.

Table 12.34.1 summarizes the decision and possible decision errors for this project.

Table 12.34.1. Decisions, Potential Decision Errors, and Potential Consequences

Decision	Inputs	Potential Errors Based on Data	Potential Consequences
Is the Contingency Plan triggered?	See Step 3 for inputs.	(1) Trigger Contingency Plan unnecessarily. (2) Fail to trigger Contingency Plan when it should have been triggered.	(1) Unnecessary administrative process, project delays. (2) Lost time in addressing problem, loss of stakeholder confidence.
Is plume growth controlled?	See Step 3 for inputs.	(1) Determine plume is controlled when it is not. (2) Determine plume is not controlled when it is.	(1) Premature petition for system shutoff, project delays. (2) Continue remediation longer than necessary, wasted resources.
Can the groundwater treatment system be shut down?	See Step 3 for inputs.	(1) Determine system can be shut down when operation should continue. (2) Determine to continue operating system when shut down is warranted.	(1) Plume growth continues, ultimate project delays. (2) Wasted resources, project delays.
Is the system operating as planned?	See Step 3 for inputs.	(1) Determine system operating as planned when it is not. (2) Determine system isn't operating as planned when it is.	(1) Premature petition for system shutoff, potential to have to restart system. (2) Continue remediation that is no longer effective.
Have the groundwater cleanup goals been met?	See Step 3 for inputs.	(1) Determine cleanup goals have been met then they are not. (2) Fail to determine cleanup goals are met when they are.	(1) Delay in making operational adjustments, avoidable growth of plume. (2) Wasted resources considering/ implementing operational adjustments.

Step 7: Optimize the Design

Number and Locations of Wells

The 42 wells are shown on Figure 12.34.1.

Parameters and Frequency

The goal for CY 2025 is to continue sampling ten source area wells for PFAS on a quarterly basis and the remaining 32 wells for PFAS. Eleven select wells will also be sampled for 1,4-dioxane on a semiannual basis. A summary of the CY 2025 sampling program for this project is shown in Table 12.34.2.

Table 12.34.2. Proposed 2025 Sampling Frequency for the Former Firehouse Groundwater Treatment System Monitoring Wells

Well	Sampling Frequency	Analytical Parameters
075-87	Semiannually	EPA 1633 PFAS
075-809	Quarterly	EPA 1633 PFAS
075-810	Quarterly	EPA 1633 PFAS
075-811	Quarterly	EPA 1633 PFAS
085-43	Semiannually	EPA 1633 PFAS
085-384	Semiannually	EPA 1633 PFAS
085-350	Semiannually	EPA 1633 PFAS
085-404	Quarterly	EPA 1633 PFAS
085-405	Quarterly	EPA 1633 PFAS
085-406	Quarterly	EPA 1633 PFAS
086-123	Semiannually	EPA 1633 PFAS
085-407	Quarterly	EPA 1633 PFAS
085-408	Quarterly	EPA 1633 PFAS
085-409	Quarterly	EPA 1633 PFAS
085-410	Quarterly	EPA 1633 PFAS
085-411	Semiannually	EPA 1633 PFAS
085-412	Semiannually	EPA 1633 PFAS
095-170	Semiannually	EPA 1633 PFAS
095-171	Semiannually	EPA 1633 PFAS
096-84	Semiannually	EPA 1633 PFAS
096-115	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
096-117	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
096-118	Semiannually	EPA 1633 PFAS
096-122	Semiannually	EPA 1633 PFAS
096-123	Semiannually	EPA 1633 PFAS
096-124	Semiannually	EPA 1633 PFAS
096-125	Semiannually	EPA 1633 PFAS
096-126	Semiannually	EPA 1633 PFAS
096-127	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
096-128	Semiannually	EPA 1633 PFAS
096-129	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
096-130	Semiannually	EPA 1633 PFAS
096-131	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
105-43	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
105-44	Semiannually	EPA 1633 PFAS
105-72	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
105-73	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
105-74	Semiannually	EPA 1633 PFAS
105-75	Semiannually	EPA 1633 PFAS
105-76	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
105-77	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
105-78	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS

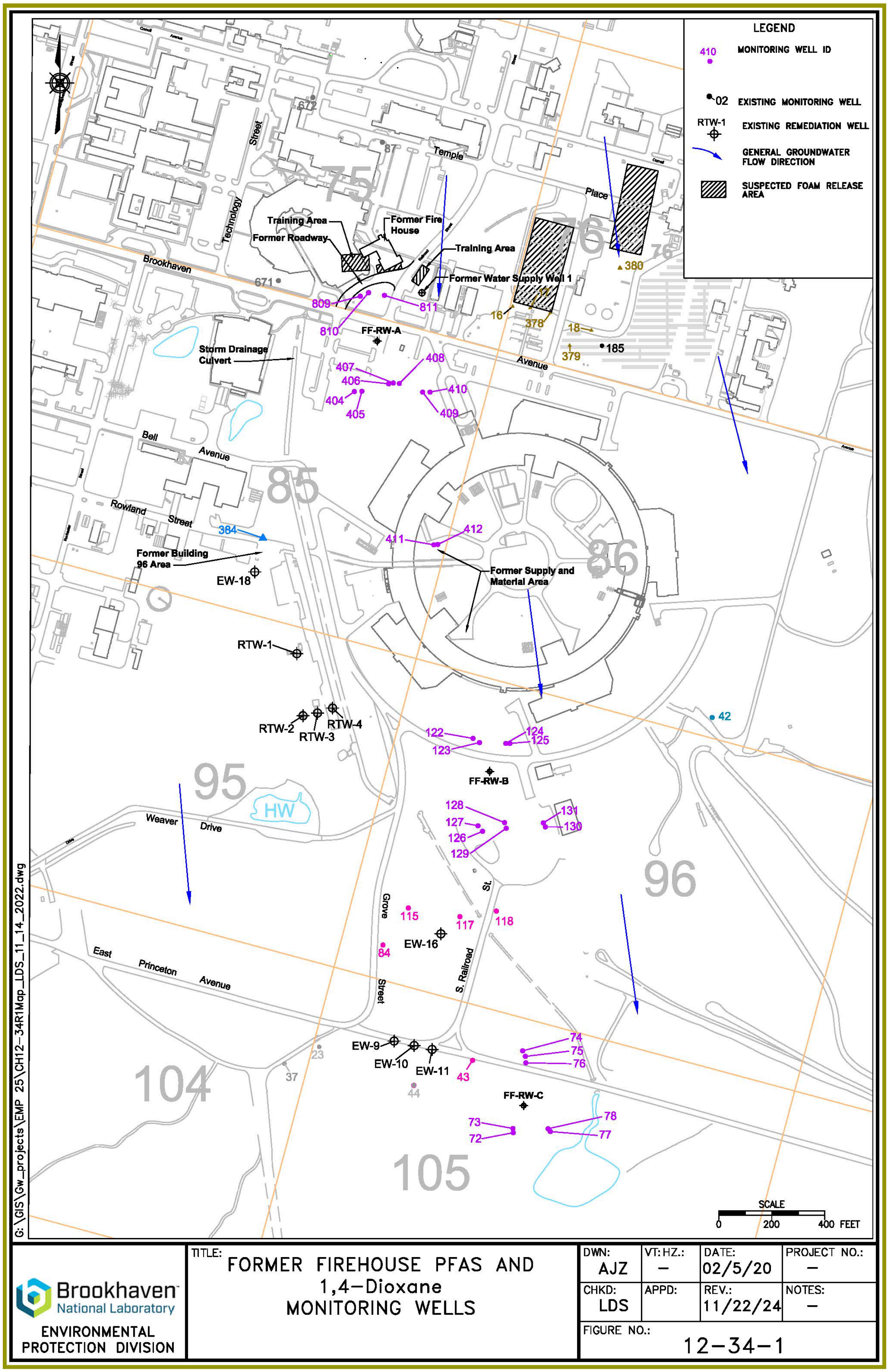

Figure 12.34.1. Locations of Former Firehouse Groundwater Treatment System Monitoring Wells

12.35 OU X Current Firehouse Groundwater Treatment System

DQO START DATE January 1, 2023

IMPLEMENTATION DATE January 1, 2025

POINT OF CONTACT William Dorsch (631) 344-5186

SUMMARY OF PROPOSED CHANGES

Routine sampling activities related to the Current Firehouse polyfluoroalkyl substances (PFAS) treatment system began in October 2022. The treatment system is designed to remediate PFAS plumes originating from firefighter training areas located at the Current Firehouse and west of Building 170. The monitoring program uses 77 wells to evaluate the effectiveness of the treatment system. In addition to testing for PFAS, samples from select wells are also analyzed for 1,4-dioxane, which originated from the releases of 1,1,1-trichloroethane (TCA) in areas upgradient of the Current Firehouse (e.g., Alternating Gradient Synchrotron) and the downgradient Paint Shop areas.

DESCRIPTION AND TECHNICAL BASIS

The Current Firehouse (Building 599) has been in continuous use since 1986. Firefighters trained with Aqueous Film Forming Foam (AFFF) that contained PFAS in the paved area along the north side of the firehouse, and in the adjacent grass and wooded areas to the north. The highest PFAS concentrations (with perfluorooctane sulfonic acid [PFOS] >10,000 ng/L) were detected downgradient of the eastern portion of the training area. A fire extinguisher training area was located to the northwest of the firehouse, and it is believed that foam had been used in this area as well. Foam released to the paved areas along the north side of the firehouse is known to have entered at least one of the drywells that are used for stormwater management. Furthermore, as part of routine maintenance of firetruck foam systems, foam may have been released to the floor drain system in the firehouse's high bay area. The floor drains are connected to BNL's sanitary system. The last known training event where AFFF was used occurred in 2008.

The parking lot west of Building 170 was used for firefighter training with AFFF from approximately 1986 through the early 1990s. During these practice sessions, foam would be directed to the pavement and the wood line area to the north. Because the parking lot is sloped to the west, foam would drain towards the western edge of the parking lot and possibly be directly sprayed into the wooded area to the west of the parking lot. The highest levels of PFOS and perfluorooctanoic acid (PFOA) were detected along the south side of the parking lot at concentrations of 8,470 ng/L and 66 ng/L, respectively. There are no available records on foam formulations or on the amount of foam that was released at the Current Firehouse or Building 170 training area. The New York State (NYS) drinking water standard for PFOS and PFOA is 10 ng/L. National drinking water standards for PFOS (4 ng/L), PFOA (4 ng/L), and several other PFAS were promulgated during 2024.

Startup testing of the Current Firehouse Treatment System began in October 2022. The monitoring well network for the Current Firehouse and Building 170 plumes consists of 77 wells (Figure 12.35.1).

DRIVERS FOR MONITORING

____ Compliance
____ Support Compliance
____ Surveillance
_X_ Restoration

DATA QUALITY OBJECTIVE ANALYSIS

Step 1: State the Problem

Groundwater in the vicinity of the former AFFF training areas at the Current Firehouse and Building 170 has been impacted by PFAS. In 2022, a remediation system was constructed to treat the PFAS contaminated groundwater. The data obtained from this monitoring program will be used to verify the effectiveness of the treatment system to remediate and prevent the continued downgradient migration of the plume. The data obtained from this program will also provide information needed to assess PFAS migration towards BNL's western supply well field as well as toward the Suffolk County Water Authority well field to the southwest of the BNL site.

Step 2: Identify the Decision

The decisions for the project are:

- Were unexpected levels or types of contamination detected?
- Is the groundwater remediation system effectively capturing the PFAS plumes as expected?
- Has the downgradient migration of the plume been controlled?
- Can individual extraction wells or the entire treatment system be shut down or placed in pulsed pumping operation?
- Are PFOS/PFOA concentrations in plume core wells above or below 100 ng/L?
- Has the groundwater cleanup goal of meeting MCLs been achieved?

Step 3: Identify Inputs to the Decision

The inputs necessary for the decision include:

- Direction and velocity of groundwater flow
- Analytical results for PFAS using EPA Method 1633
- Analytical results for 1,4-dioxane in select wells using Method 8270D SIM
- Locations of the groundwater monitoring wells (Figure 12.35.1)
- Regulatory drivers that will be defined in the OU X Record of Decision (ROD)
- Action levels (NYS drinking water or groundwater standards or national drinking water standards once they have been promulgated)
- Up to 10 percent of the data analyzed by contract analytical laboratories will be validated using guidance provided from BNL EM-SOP-212, Chemical Data Validation, and U.S. Department of Defense, Data Validation Guidelines Module 6: Data Validation Procedure for Per- and Polyfluoroalkyl Substances Analysis by QSM Table B-24, October 2022, or latest revision.

Step 4: Define the Study Boundaries

The project geographical limits are defined by the map boundaries depicted on Figure 12.35.1.

Separate decisions will be made in the monitoring subunits (e.g., core, perimeter, and bypass wells) described in the Current Firehouse Treatment System O&M Manual. However, some of the decisions, such as system performance, are based on the entire system. The temporal boundaries of the study area vary, based on the decision.

- *Plume Source Areas:* Due to the need for frequent data collection during the system startup period, the timeframe for decisions for this subunit is 90 days.

- *Downgradient Plume Core and Perimeter:* The wells in this subunit define the plume horizontally, which is used to determine whether the plumes are being captured. Because the treatment system has only been in operation since October 2022, an appropriate timeframe for decisions is 180 days. The timeframe will likely be reduced to 90 days after the system has been in operation for several years.

- *Bypass Detection Area:* The wells in this area indicate whether the plume capture performance objective is being met. Because the treatment system has only been in operation since October 2022, an appropriate decision timeframe for this area is 180 days. The timeframe will likely be reduced to 90 days after the system has been in operation for several years.

Section 12.1 details the general sampling frequency based on the phase the monitoring program is in.

Step 5: Develop the Decision Rules

Note: The decision rules discussed below are to be considered **preliminary** until the final cleanup objectives are defined in the OU X Record of Decision (ROD).

Decision 1

Were unexpected levels or types of contaminants detected?

The sample results will be evaluated in context with available characterization data gathered since 2018. As part of that evaluation, circumstances that would require implementation of the BNL Groundwater Contingency Plan (Environmental Monitoring Standard Operating Procedure [EM-SOP]-309) would be determined. Examples of such circumstances are unusually high contaminant concentrations, including detection of previously undetected contaminants that could impact treatment system operations (e.g., detection of high levels of 1,4-dioxane that could result in exceeding the treatment system discharge limit).

If the types or concentrations of contaminants detected in any well could impact treatment system operations, and their presence and concentrations are confirmed by resampling, **then** implement actions as prescribed in the BNL Groundwater Contingency Plan.

Decision 2

Has the downgradient migration of the plume been controlled?

This decision applies to the plume perimeter and bypass detection wells.

If the cleanup goals have not been met, **then** it must be verified that the plume is not growing. Plume growth is defined as an increase in PFOS and/or PFOA concentrations in plume perimeter or bypass detection wells to above the 100 ng/L capture goal (if currently less than 100 ng/L).

Note: The downgradient extent of the plumes will be further characterized as part of the planned

OU X Remedial Investigation. Plume migration is currently being contained at West Princeton Avenue by four extraction wells.

Decision 3

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

To shut down the treatment system, the shutdown criteria of reaching less than 100 ng/L PFOS and PFOA for at least four consecutive sampling rounds must be met in the core monitoring and extraction wells.

Note: The shutdown criteria for this system may be modified as a result of the Remedial Investigation/Feasibility Study.

Decision 4

Are PFOS or PFOA concentrations in plume core wells above or below 100 ng/L?

If the PFOS and PFOA concentration in each plume core well has been reduced to less than 100 ng/L, **then** proceed with pulsed operation of the system's extraction wells. **If not, then** continue full-time operation.

4a. Is there a significant concentration rebound in core wells and/or extraction wells following pulsed-pumping operations?

If yes, then continue treatment system operations. **If no** significant rebound is observed within a one-year period, then petition for system shutdown, maintain the system in an operationally ready mode, and continue with monitored natural attenuation (MNA).

Decision 5

Has the groundwater cleanup goal of meeting MCLs been achieved?

If PFOS and PFOA concentrations in all plume core wells are less than the 10 ng/L NYS MCL (or national standards once promulgated) over the previous two years and pulsing of the remediation system has not resulted in significant rebound of contaminant concentrations, **then** petition for system closure. If not, then consider the need for continued remediation.

Table 12.35.1 summarizes the decision and possible decision errors for this project.

Table 12.35.1. Decisions, Potential Decision Errors, and Potential Consequences

Decision	Inputs	Potential Errors Based on Data	Potential Consequences
Is the Contingency Plan triggered?	See Step 3 for inputs.	(1) Trigger Contingency Plan unnecessarily. (2) Fail to trigger Contingency Plan when it should have been triggered.	(1) Unnecessary administrative process, project delays. (2) Lost time in addressing problem, loss of stakeholder confidence.
Is plume growth controlled?	See Step 3 for inputs.	(1) Determine plume is controlled when it is not. (2) Determine plume is not controlled when it is.	(1) Premature petition for system shutoff, project delays. (2) Continue remediation longer than necessary, wasted resources.

Can the groundwater treatment system be shut down?	See Step 3 for inputs.	(1) Determine system can be shut down when operation should continue. (2) Determine to continue operating system when shut down is warranted.	(1) Plume growth continues, ultimate project delays. (2) Wasted resources, project delays.
Is the system operating as planned?	See Step 3 for inputs.	(1) Determine system operating as planned when it is not. (2) Determine system isn't operating as planned when it is.	(1) Premature petition for system shutoff, potential to have to restart system. (2) Continue remediation that is no longer effective.
Have the groundwater cleanup goals been met?	See Step 3 for inputs.	(1) Determine cleanup goals have been met then they are not. (2) Fail to determine cleanup goals are met when they are.	(1) Delay in making operational adjustments, avoidable growth of plume. (2) Wasted resources considering/ implementing operational adjustments.

Step 7: Optimize the Design

Number and Locations of Wells

The 77 wells are located to monitor groundwater quality downgradient of the Current Firehouse and Building 170 PFAS source areas are shown on Figure 12.35.1.

Parameters and Frequency

The goal for CY 2025 is to continue sampling 13 Current Firehouse and Building 170 source area wells for PFAS on a quarterly basis and the remaining 63 wells for PFAS. Twenty-one select wells will also be sampled for 1,4-dioxane on a semiannual basis. A summary of the CY 2025 sampling program for this project is shown in Table 12.35.2.

Table 12.35.2. Proposed 2025 Sampling Frequency for the Current Firehouse Groundwater Treatment System Monitoring Wells

Well	Sampling Frequency	Analytical Parameters
073-01	Semiannually	EPA 1633 PFAS
073-26	Quarterly	EPA 1633 PFAS
073-27	Quarterly	EPA 1633 PFAS
073-28	Quarterly	EPA 1633 PFAS
073-29	Quarterly	EPA 1633 PFAS
073-30	Quarterly	EPA 1633 PFAS
073-31	Quarterly	EPA 1633 PFAS
073-32	Quarterly	EPA 1633 PFAS
073-33	Quarterly	EPA 1633 PFAS
074-135	Quarterly	EPA 1633 PFAS
083-01	Semiannually	EPA 1633 PFAS
083-02	Semiannually	EPA 1633 PFAS
083-05	Semiannually	EPA 1633 PFAS
083-33	Semiannually	EPA 1633 PFAS
083-34	Semiannually	EPA 1633 PFAS
083-35	Semiannually	EPA 1633 PFAS
083-36	Semiannually	EPA 1633 PFAS
083-37	Semiannually	EPA 1633 PFAS

083-38	Semiannually	EPA 1633 PFAS
083-39	Semiannually	EPA 1633 PFAS
083-40	Semiannually	EPA 1633 PFAS
083-41	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
083-42	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
083-43	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
083-44	Semiannually	EPA 1633 PFAS
083-47	Semiannually	EPA 1633 PFAS
084-03	Semiannually	EPA 1633 PFAS
084-04	Semiannually	EPA 1633 PFAS
084-28	Semiannually	EPA 1633 PFAS
084-86	Semiannually	EPA 1633 PFAS
084-87	Semiannually	EPA 1633 PFAS
084-88	Semiannually	EPA 1633 PFAS
084-89	Semiannually	EPA 1633 PFAS
084-90	Semiannually	EPA 1633 PFAS
084-91	Semiannually	EPA 1633 PFAS
084-92	Semiannually	EPA 1633 PFAS
084-93	Semiannually	EPA 1633 PFAS
084-94	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
084-95	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
084-96	Semiannually	EPA 1633 PFAS
084-97	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
084-98	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
093-04	Quarterly	EPA 1633 PFAS
093-88	Semiannually	EPA 1633 PFAS
093-89	Semiannually	EPA 1633 PFAS
093-90	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
093-91	Semiannually	EPA 1633 PFAS
093-92	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
093-93	Quarterly	EPA 1633 PFAS
093-94	Quarterly	EPA 1633 PFAS
093-95	Quarterly	EPA 1633 PFAS
093-96	Semiannually	EPA 1633 PFAS
093-97	Semiannually	EPA 1633 PFAS
093-98	Semiannually	EPA 1633 PFAS
094-275	Semiannually	EPA 1633 PFAS
094-276	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
094-277	Semiannually	EPA 1633 PFAS
094-278	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
102-12	Semiannually	EPA 1633 PFAS
102-26	Semiannually	EPA 1633 PFAS
102-27	Semiannually	EPA 1633 PFAS
102-28	Semiannually	EPA 1633 PFAS
102-29	Semiannually	EPA 1633 PFAS
102-30	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
102-31	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
102-36	Semiannually	EPA 1633 PFAS
102-37	Semiannually	EPA 1633 PFAS
102-38	Semiannually	EPA 1633 PFAS
102-39	Semiannually	EPA 1633 PFAS
102-40	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
103-02	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
103-10	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
103-30	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
103-31	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
103-32	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS

103-33	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS
103-34	Semiannually	8270D SIM 1,4-dioxane, EPA 1633 PFAS

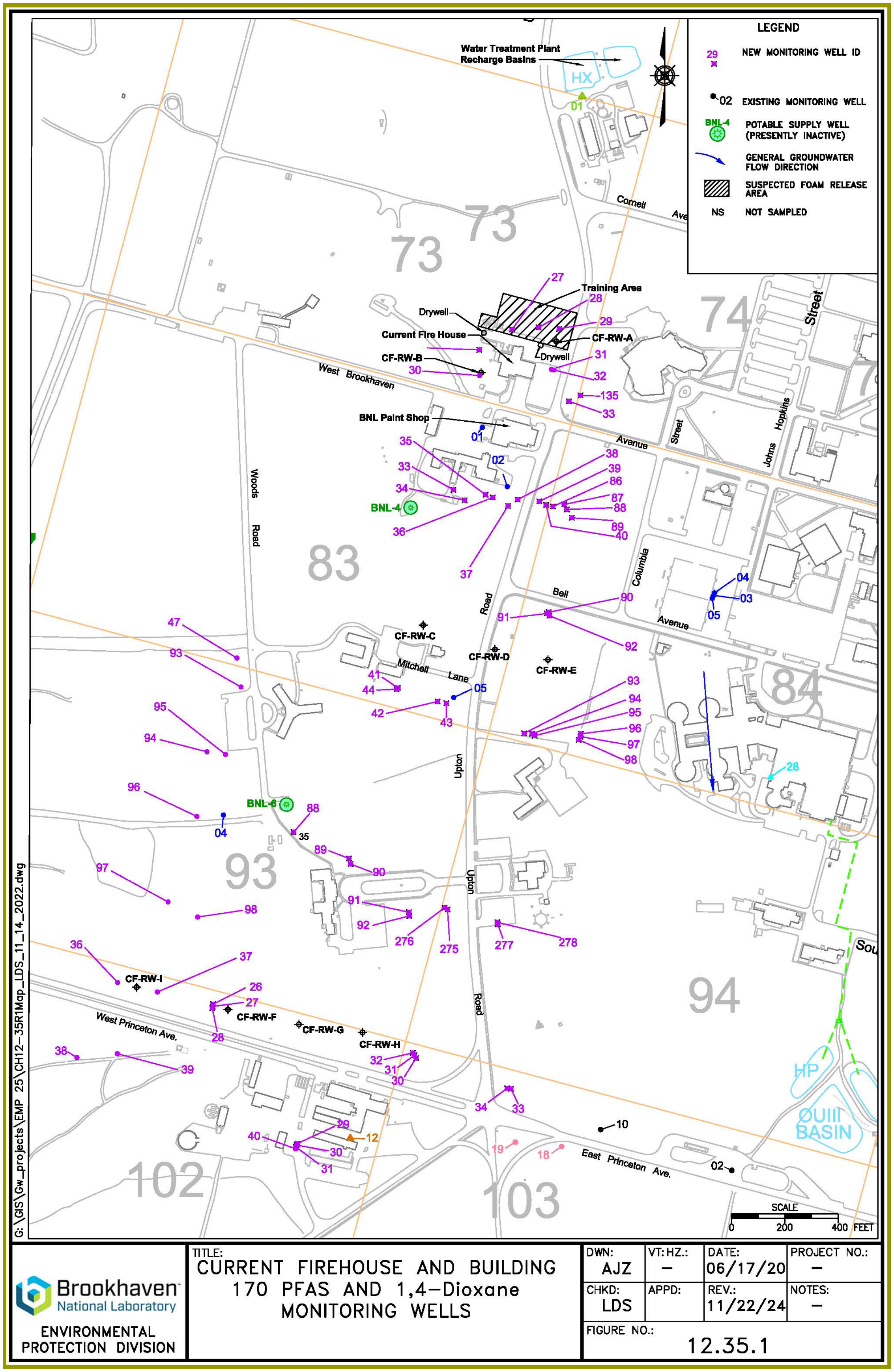

Figure 12.35.1 Current Firehouse Groundwater Treatment System Monitoring Well Locations.