Water Quality 5

Wastewater generated from operations at Brookhaven National Laboratory (BNL) is treated at the Sewage Treatment Plant (STP) before it is discharged to nearby groundwater recharge basins. Some wastewater may contain very low levels of radiological, organic, or inorganic contaminants. Monitoring, pollution prevention, and vigilant operation of treatment facilities ensure that these discharges comply with all applicable regulatory requirements and that the public, employees, and the environment are protected.

Analytical data for 2022 shows that the average gross alpha and beta activity levels in the STP discharge (EA, Outfall 001) were within the typical range of historical levels and were well below New York State Drinking Water Standards (NYS DWS). Tritium was not detected above the method detection limit (MDL) in the STP discharge during 2022; no cesium-137, strontium-90, or other gamma-emitting nuclides attributable to Laboratory operations were detected. Non-radiological monitoring of the STP effluent showed that all organic and inorganic parameters were within State Pollutant Discharge Elimination System (SPDES) effluent limits or other applicable standards.

The average concentrations of gross alpha and beta activity in stormwater and cooling water discharged to recharge basins were within typical ranges and no gamma-emitting radionuclides were detected. Disinfection byproducts continue to be detected at low concentrations above the MDL in discharges to recharge basins due to the use of chlorine and bromine for the control of algae and bacteria in potable and cooling water systems. Inorganics (e.g., metals) were detected; however, their presence is due primarily to sediment runoff in stormwater discharges.

The Peconic River did not flow offsite in 2022. Radiological data from Peconic River surface water sampling show that the average concentrations of gross alpha and gross beta activity from on-site locations were indistinguishable from control locations, and all detected levels were below the applicable NYS DWS. No gamma-emitting radionuclides attributable to Laboratory operations were detected either upstream or downstream of the former STP outfall, and tritium was not detected above MDL's in any of the surface water samples.

5.1 SURFACE WATER MONITORING PROGRAM

In addition to monitoring discharges to surface waters under the SPDES program described in Chapter 3, BNL routinely monitors surface water quality (including radionuclides) as part of its site Surveillance Program. Although discharges of treated wastewater from the Laboratory's STP into the headwaters of the Peconic River ceased in October 2014, the Laboratory continues to monitor surface water at several locations along the Peconic River to assess the impact that site operations may have on surface water quality.

On-site monitoring station HY is located upstream of all Laboratory operations and data provides information on the background water quality of the Peconic River for comparison to other sampling points that may show impact from Laboratory operations (see Figure 5-1). The Carmans River is monitored as a geographic control location for comparative purposes, as it is not affected by operations at BNL and is not connected to the Peconic River watershed. On the Laboratory site, the Peconic River is an intermittent, groundwater-fed stream. Off-site flow occurs only after periods of sustained precipitation and a concurrent rise in the water table, typically in the spring. There was no off-site flow in 2022.

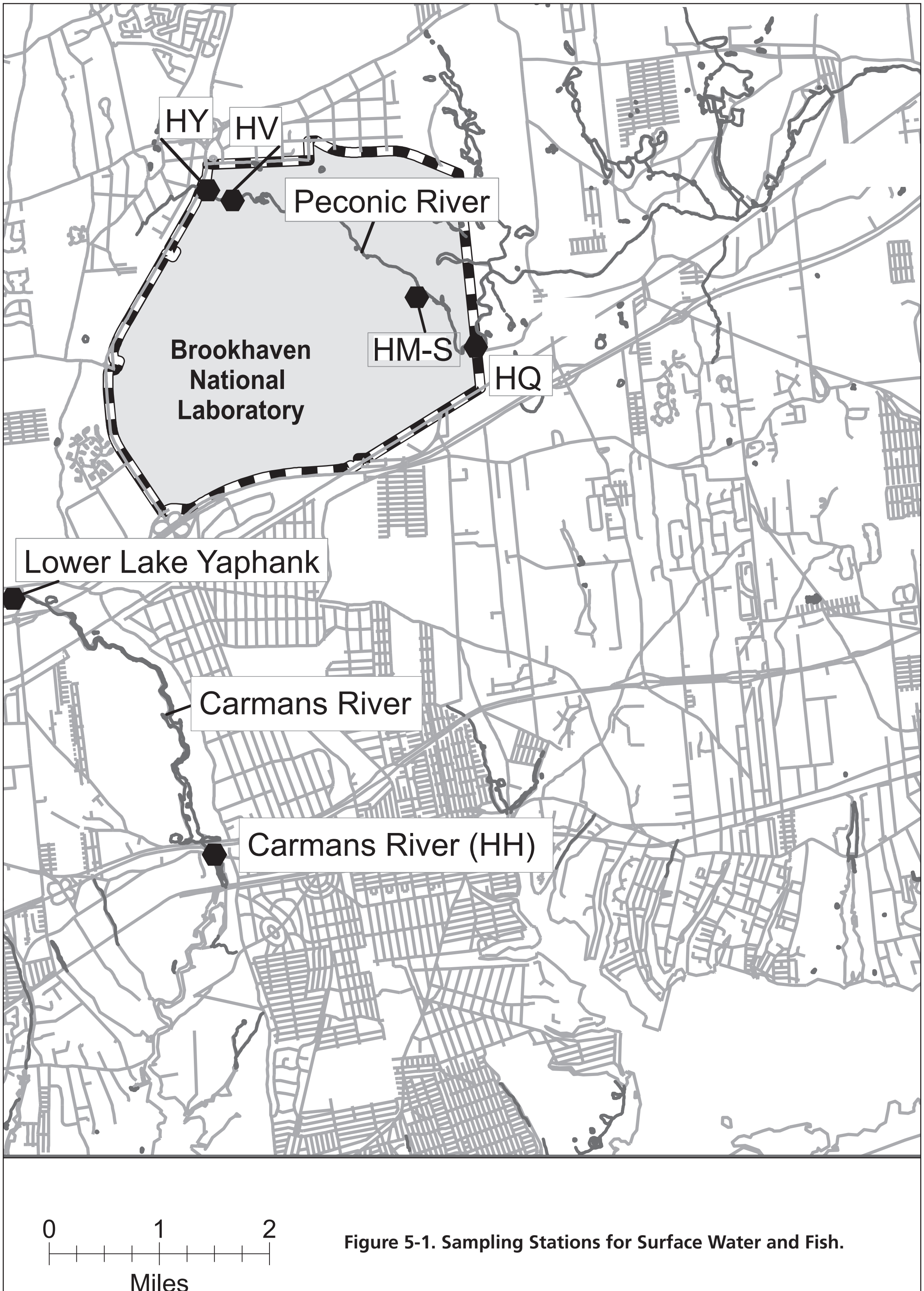

Figure 5-1. Sampling Stations for Surface Water and Fish.

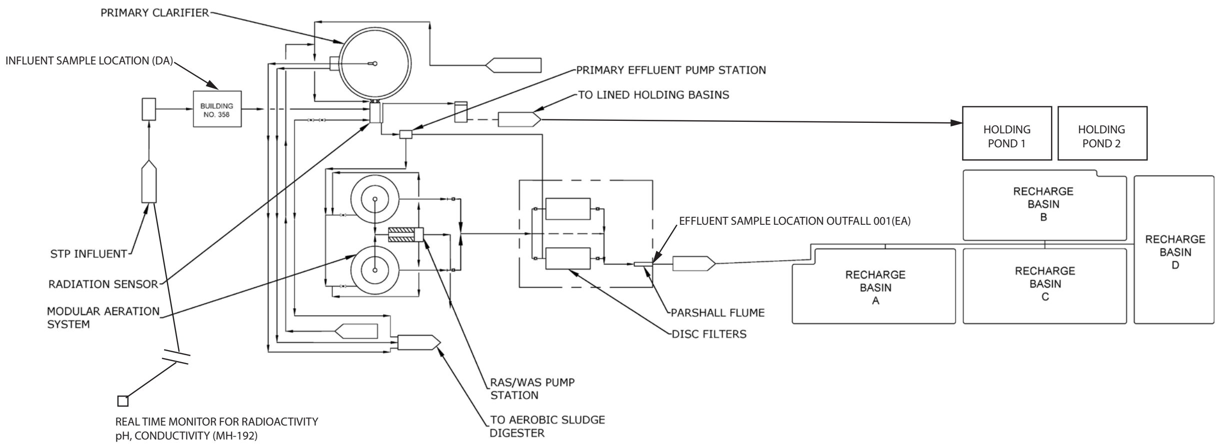

Figure 5-2. Schematic of BNL's Sewage Treatment Plant (Recharge Basin Discharge)

The fluctuating cycles with periods of flow and no-flow are indicative of the combined influences of precipitation and groundwater. The cycles can sometimes occur over short periods of time, but low groundwater levels often result in several years where no or little flow occurs.

Historical monitoring data indicates no significant variations in water quality throughout the Peconic River system on site, and pollution prevention efforts at the Laboratory have significantly reduced the risk of accidental releases. The following sections describe BNL's surface water monitoring and surveillance program.

5.2 SANITARY SYSTEM EFFLUENTS

The STP effluent (Outfall 001) is a discharge point authorized under BNL's SPDES permit that is issued by the New York State Department of Environmental Conservation (NYSDEC) (Section 3.6.1). Figure 5-2 shows a schematic of the STP with discharge of treated STP effluent to nearby groundwater recharge basins (Recharge Basins A-D). The Laboratory's STP treatment process includes three principal steps: 1) aerobic oxidation for secondary removal of biological matter and nitrification of ammonia, 2) secondary clarification, and 3) filtration for final solids removal. Tertiary treatment for nitrogen removal is also provided by controlling the oxygen levels in the aeration tanks. During the aeration process, the oxygen levels are allowed to drop to the point where microorganisms use nitrate-bound oxygen for respiration, which liberates nitrogen gas and consequently reduces the concentration of nitrogen in the STP discharge.

Solids separated in the clarifier are pumped to aerobic digesters for continued biological solids reduction and sludge thickening. Once the sludge in the aerobic digester reaches a solids content of six percent, the sludge is sampled to ensure it meets the waste acceptance criteria for disposal at the Suffolk County Department of Public Works Sewage Treatment Facility at Bergen Point, in West Babylon, New York.

Real-time monitoring of the sanitary waste stream for radioactivity, pH, and conductivity occurs at two locations. The first site, MH-192, is approximately one mile upstream of the STP and provides a minimum of 30 minutes to warn the STP operators that wastewater exceeding SPDES limits or BNL administrative effluent release criteria is en route to the STP. The second monitoring site is at the point where the STP influent enters the treatment process.

Based on the data collected by the real-time monitoring systems, any influent to the STP that may not meet SPDES limits and BNL effluent release criteria can be diverted to two double-lined holding ponds. The total combined capacity of the two holding ponds exceeds six million gallons, or approximately 18 days of flow. Diversion would

Table 5-1: Tritium and Gross Activity in Water at the Sewage Treatment Plant for 2022.

		Flow (liters)	Tritium (pCi/L)		Gross Alpha (pCi/L)		Gross Beta (pCi/L)	
			max.	avg.	max.	avg.	max.	avg.
January	*influent*	1.88E+07	< 320	< MDL	< 8.5	< MDL	5.1 ± 1.7	4.4 ± 1.2
	effluent	2.00E+07	< 334	< MDL	< 8.3	< MDL	9.2 ± 3.0	4.6 ± 3.0
February	*influent*	1.72E+07	< 376	< MDL	< 7.8	< MDL	9.8 ± 3.0	4.6 ± 3.5
	effluent	1.69E+07	< 383	< MDL	< 7.8	< MDL	5.2 ± 1.6	3.7 ± 1.3
March	*influent*	1.80E+07	< 355	< MDL	< 5.2	< MDL	6.1 ± 1.6	4.4 ± 1.2
	effluent	1.67E+07	< 355	< MDL	< 5.5	< MDL	6.1 ± 2.0	3.7 ± 1.9
April	*influent*	2.03E+07	< 359	< MDL	< 8.6	< MDL	5.0 ± 1.3	4.2 ± 0.8
	effluent	1.86E+07	< 358	< MDL	< 2.9	< MDL	3.1 ± 1.0	2.4 ± 0.5
May	*influent*	2.65E+07	< 341	< MDL	< 12.5	< MDL	7.7 ± 2.3	4.8 ± 1.8
	effluent	2.49E+07	< 340	< MDL	< 3.4	< MDL	21.6 ± 13.5	7.7 ± 7.0
June	*influent*	2.40E+07	< 467	< MDL	< 4.6	< MDL	8.3 ± 5.0	5.2 ± 2.7
	effluent	2.35E+07	< 338	< MDL	< 5.8	< MDL	4.2 ± 1.1	3.7 ± 0.5
July	*influent*	2.97E+07	< 338	< MDL	< 3.7	< MDL	4.5 ± 1.1	2.9 ± 1.2
	effluent	2.65E+07	< 330	< MDL	< 10.8	< MDL	4.9 ± 1.2	3.8 ± 0.9
August	*influent*	2.71E+07	< 397	< MDL	< 5.8	< MDL	4.8 ± 1.1	3.4 ± 0.9
	effluent	2.57E+07	< 341	< MDL	< 3.7	< MDL	5.3 ± 1.1	4.8 ± 0.4
September	*influent*	2.06E+07	< 339	< MDL	< 4.3	< MDL	6.1 ± 2.8	4.6 ± 1.1
	effluent	2.39E+07	< 349	< MDL	< 3.7	< MDL	4.5 ± 1.6	3.5 ± 0.9
October	*influent*	2.21E+07	< 354	< MDL	< 4.6	< MDL	3.1 ± 1.4	2.2 ± 0.8
	effluent	2.85E+07	< 390	< MDL	< 5.0	< MDL	4.2 ± 1.3	2.3 ± 1.6
November	*influent*	1.55E+07	< 306	< MDL	< 4.1	< MDL	6.5 ± 1.6	4.6 ± 1.3
	effluent	1.73E+07	< 290	< MDL	< 3.5	< MDL	5.0 ± 1.3	4.4 ± 0.7
December	*influent*	1.91E+07	< 373	< MDL	5.0 ± 3.2	< MDL	5.4 ± 1.5	4.0 ± 1.1
	effluent	1.86E+07	< 300	< MDL	< 4.0	< MDL	8.1 ± 2.0	4.4 ± 2.4
Annual Avg.	*influent*			17.3 ± 31.2		0.9 ± 0.6		4.1 ± 0.5
	effluent			23.6 ± 28.9		1.0 ± 0.5		4.1 ± 0.8
Total Effluent Release		**2.61E+08**		**6.2 mCi (a)**		**0.3 mCi**		**1.1 mCi**
Average MDL (pCi/L)				**363.4**		**5.9**		**2.5**
SDWA Limit (pCi/L)				**20,000**		**15**		**50 (b)**

Notes:
All values above MDL are reported with a 95% confidence interval.
Negative numbers occur when the measured value is lower than background (see Appendix B for description).
MDL = minimum detection limit
SDWA = Safe Drinking Water Act
(a) The total released value for tritium is a conservative calculation that is based on an average of the 95% confidence interval maximums as estimates of monthly average release concentrations. The majority of the effluent samples showed average concentrations less than zero and all results were less than the MDL.
(b) The drinking water standards were changed from 50 pCi/L (concentration based) to 4 mrem/yr (dose based) in 2003. As gross beta activity activity does not identify specific radionuclides, a dose equivalent cannot be calculated for the values in the table.

continue until the influent water quality would allow for the permit limits and release criteria to be met. Wastewater diverted to the holding ponds is tested and evaluated against the requirements for release. If necessary, the wastewater is treated and then reintroduced into the STP at a rate that ensures compliance with SPDES permit limits for non-radiological parameters or BNL effluent release criteria for radiological parameters. In 2022, there were no instances where influent water quality required diversion of wastewater to the holding ponds.

5.2.1 Sanitary System Effluent-Radiological Analyses

Wastewater at the STP is sampled at the inlet to the treatment process, Station DA, and at the STP outfall, Station EA, as shown in Figure 5-2. At each location, samples are collected on a flow-proportional basis; that is, for every 1,000 gallons of water treated, approximately four fluid ounces of sample are collected and composited into a five-gallon collection container. These samples are analyzed weekly for gross alpha and gross beta activity and for tritium. Samples collected from these locations are also composited and analyzed monthly for gamma-emitting radionuclides and strontium-90 (Sr-90: half-life, 29 years).

Although the STP discharge is not used as a direct source of potable water, the Laboratory applies the more stringent Safe Drinking Water Act (SDWA) standards for comparison purposes when monitoring the effluent, in lieu of Department of Energy wastewater criteria. Under the SDWA, water standards are based on a 4 mrem (40 µSv) dose limit. The SDWA specifies that no individual may receive an annual dose greater

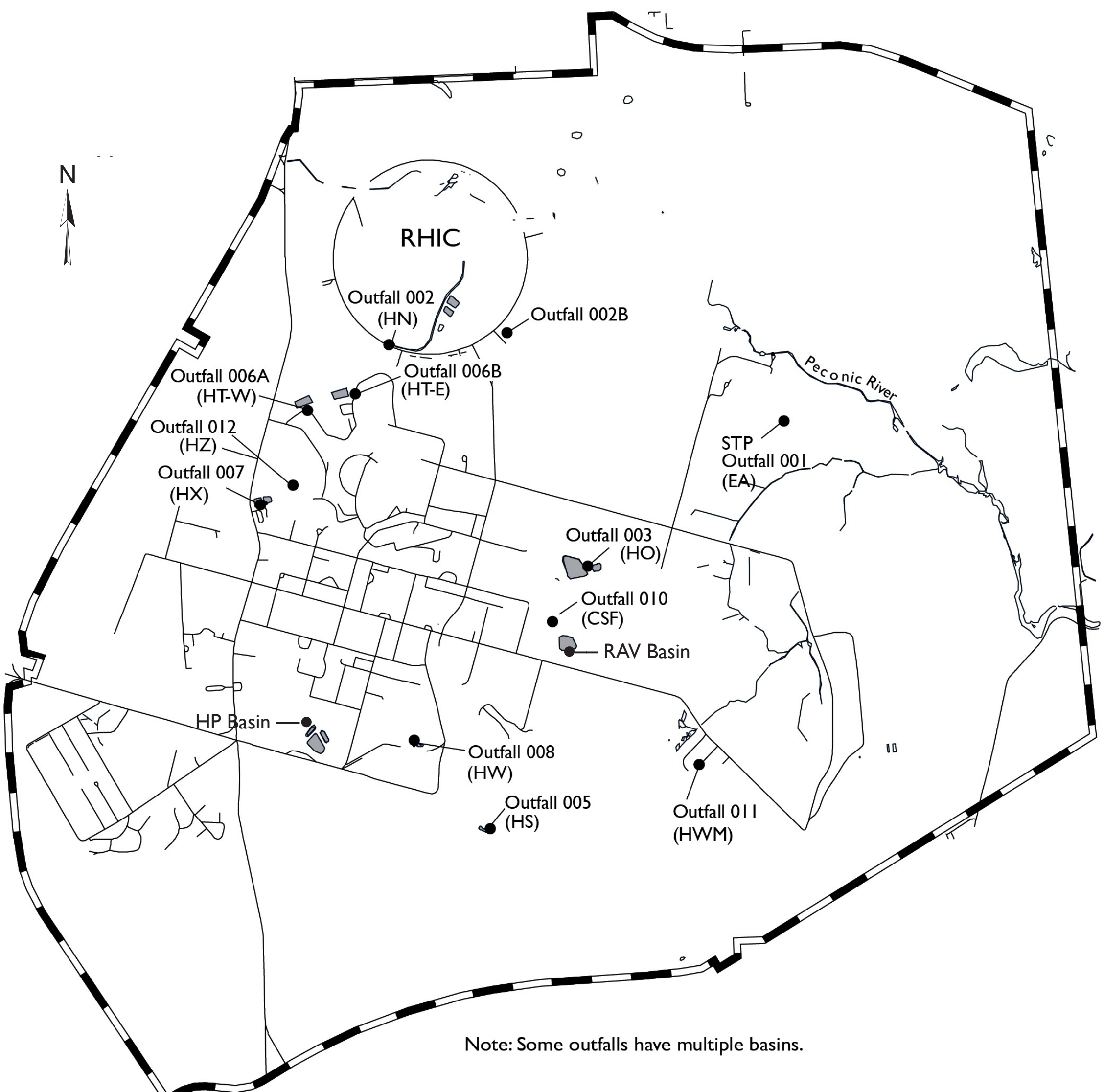

Figure 5-3. BNL Recharge Basin/Outfall Locations.

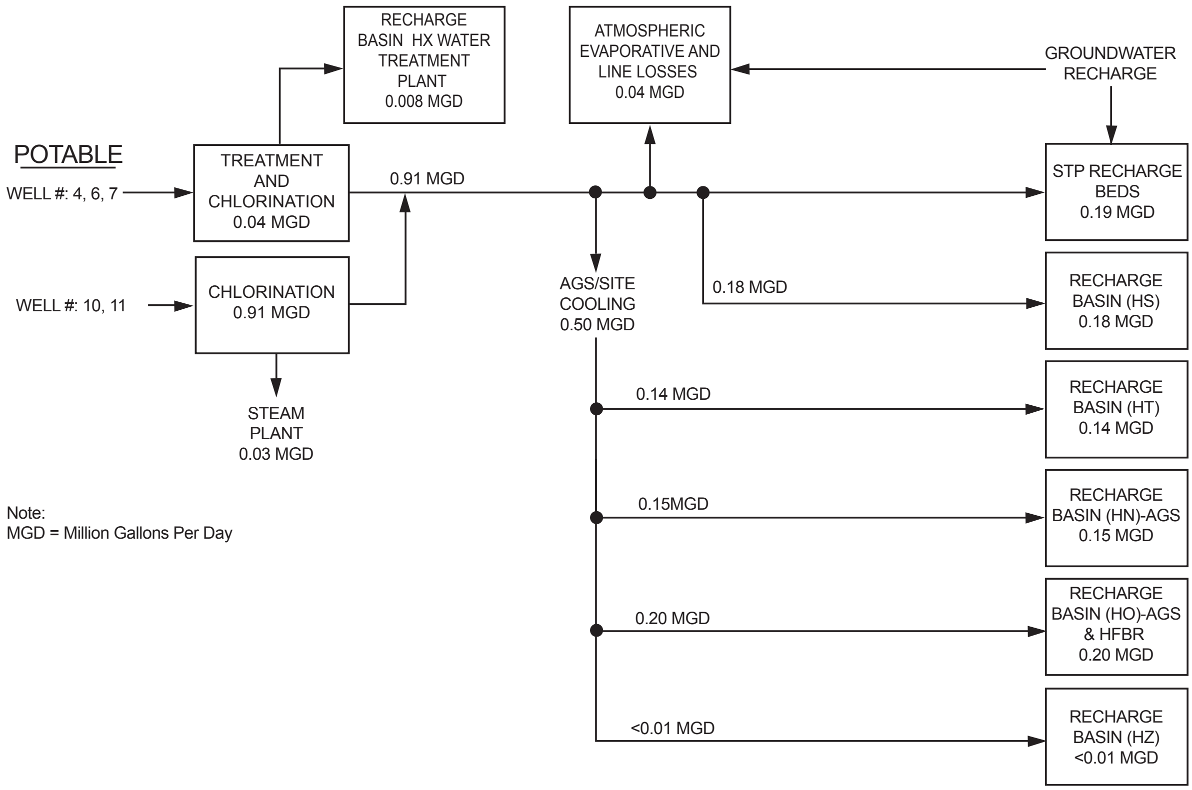

Figure 5-4. Schematic of Potable Water Use and Flow at BNL.

than 4 mrem from radionuclides that are beta or photon emitters, which includes up to 168 individual radioisotopes. BNL performs radionuclide-specific gamma analysis to ensure compliance with this standard. The SDWA annual average gross alpha activity limit is 15 pCi/L, including radium-226 (Ra-226: half-life, 1,600 years), but excluding radon and uranium. Other SDWA-specified drinking water limits are 20,000 pCi/L for tritium (H-3: half-life, 12.3 years), 8 pCi/L for Sr-90, 5 pCi/L for Ra-226 and Ra-228 (Ra-228: half-life, 5.75 years), and 30 µg/L for uranium. Gross alpha and beta activity measurements are used as a screening tool for detecting the presence of radioactivity.

Table 5-1 shows the monthly gross alpha and beta activity data and tritium concentrations for the STP influent and effluent during 2022. Annual average gross alpha and beta activity levels in the STP effluent were 1.0 ± 0.5 pCi/L and 4.1± 0.8 pCi/L, respectively. Both gross alpha and gross beta average concentrations were higher than those measured at the Carman's River control location (HH) reported in Table 5-5; however, they were well below the SDWA standards that are used for comparison purposes. Tritium was not detected above the MDL in the discharge of the STP (EA, Outfall 001) during 2022 with the average concentration being 23.6 ± 28.9 pCi/L and well below typical MDLs and the SDWA standard of 20,000 pCi/L. Conservative estimates of total release based on tritium, gross-alpha, and gross-beta in millicuries is provided in Table 5-1. In 2022, there were no gamma-emitting nuclides detected in the STP effluent.

5.2.2 Sanitary System Effluent – Nonradiological Analyses

Monitoring of the STP effluent for volatile organic compounds (VOCs), inorganics, and anions is conducted as part of the SPDES Compliance Program, which is discussed in further detail in Chapter 3.

5.3 PROCESS-SPECIFIC WASTEWATER

Wastewater that may contain constituents above SPDES permit limits or ambient water quality discharge standards must be held by the generating facility and characterized to determine the appropriate means of disposal. The analytical results are compared with the appropriate discharge limit, and the wastewater is only released to the sanitary system if the volume and concentration of contaminants in the discharge would not jeopardize the quality of the STP effluent and subsequently, potentially impact groundwater quality (BNL 2020).

The Laboratory's SPDES permit includes requirements for quarterly sampling and analysis of process-specific wastewater discharged from metal-cleaning operations in Building 498 and cooling tower discharges from Building 902. These operations are monitored for contaminants such as metals, cyanide, VOCs, and semi-volatile organic compounds. In 2022, analyses of these waste streams showed that, although several operations contributed contaminants (principally metals) to the STP influent in concentrations exceeding SPDES-permitted levels, these discharges did not affect the quality of the STP effluent.

Process wastewaters that are not expected to be of consistent quality and are not routinely generated are held for characterization before release to the sanitary system. The process wastewaters typically include purge water from groundwater sampling, wastewater from cleaning of heat exchangers, wastewater generated as a result of restoration activities, and other industrial wastewaters.

To determine the appropriate disposal method, samples are analyzed for contaminants specific to the process, and the concentrations are compared to the SPDES effluent limits and BNL's effluent release criteria (BNL 2020). If the concentrations are within limits, authorization for sewer system discharge is granted; if not, alternate means of disposal are used. Any waste that contains elevated levels of hazardous or radiological contaminants in concentrations that exceeded Laboratory effluent release criteria are sent to the BNL Waste Management Facility for proper management and off-site disposal.

5.4 RECHARGE BASINS

Recharge basins are used for the discharge of "clean" wastewater, including once-through cooling water, stormwater runoff, and cooling tower blowdown. These wastewaters are suitable for direct replenishment of the groundwater aquifer. Figure 5-3 shows the locations of the Laboratory's discharges to recharge basins (also called "outfalls" under BNL's SPDES permit). Figure 5-4 presents an overall schematic of potable water use at the Laboratory, and how much of this water is discharged to the 11 on-site recharge basins:

- Basin HZ receives stormwater and cooling water discharges from Bldg. 902.
- Basins HN, HT-W, and HT-E receive once-through cooling water discharges generated at the Alternating Gradient Synchrotron (AGS), Linear Accelerator, and Relativistic Heavy Ion Collider (RHIC), as well as cooling tower blowdown and stormwater runoff.
- Basin HS receives predominantly stormwater runoff, once-through cooling water from Building 555 (Chemistry Department), and minimal cooling tower blowdown from the Computational Science Initiative facility.
- Basin HX receives Water Treatment Plant filter backwash water.
- Basin HO receives cooling water discharges from the AGS and stormwater runoff from the area surrounding the High Flux Beam Reactor (HFBR).

Several other recharge areas are used exclusively for discharging stormwater runoff. These areas include Basin HW near the National Synchrotron Light Source II (NSLS-II) site, Basin CSF at the Central Steam Facility (CSF), and Basin HW-M at the former Hazardous Waste Management Facility (FHWMF). Recharge Basins HP and RAV are used for discharge of treated water from the groundwater remediation systems and are monitored under BNL's Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) equivalency permits.

Each of the recharge basins is a permitted point-source discharge under the Laboratory's SPDES permit and equivalency permits under the CERCLA program. Where required by the permit, the basins are equipped with a flow monitoring station, allowing for weekly recordings of flow rates. The specifics of the SPDES compliance monitoring program are provided in Chapter 3.

To supplement the monitoring program, samples are also routinely collected and analyzed under BNL's Environmental Surveillance Program for radioactivity, VOCs, metals, and anions. During 2022, water samples were collected semi-annually from all the basins listed above except for recharge Basin HX at the Water Treatment Plant (due to previously documented non-impact to groundwater from plant operations) and a recharge basin at the FHWMF (due to absence of operations at the FHWMF that could lead to the contamination of runoff).

5.4.1 Recharge Basins – Radiological Analyses

Discharges to recharge basins with the potential for radiological contamination were sampled semi-annually and analyzed for gross alpha and beta activity, gamma-emitting radionuclides, and tritium. The results are presented in Table 5-2. Gross alpha activity ranged from non-detect to 3.61 ± 1.45 pCi/L and gross beta activity ranged from non-detect to 4.37 ± 1.82 pCi/L. Low-level detections of beta activity are attributable to naturally occurring radionuclides, such as potassium-40 (K-40: half-life, 1.3E+09 years). No gamma-emitting nuclides attributable to BNL operations or tritium were detected in any discharges to recharge basins. All tritium values were below the MDL's and were well below the 20,000 pCi/L drinking water standard.

Table 5-2: Radiological Analysis of Samples from On-Site Recharge Basins (2022)

Basin		Gross Alpha	Gross Beta	Tritium
			(pCi/L)	
No. of samples		2	2	2
HN	*max.*	< 3.33	1.2 ± 0.47	< 399
	avg.	< MDL	1.07 ± 0.25	< MDL
HO	*max.*	< 2.88	2.63 ± 0.94	< 361
	avg.	< MDL	1.64 ± 1.94	< MDL
HS	*max.*	< 2.15	2.94 ± 0.94	< 394
	avg.	< MDL	1.59 ± 2.65	< MDL
HT-E	*max.*	1.72 ± 0.87	2.41 ± 0.74	< 342
	avg.	< MDL	1.68 ± 1.42	< MDL
HT-W	*max.*	< 4.27	1.99 ± 0.89	< 396
	avg.	< MDL	1.96 ± 0.06	< MDL
HW	*max.*	< 1.1	4.37 ± 1.82	< 376
	avg.	< MDL	3.6 ± 1.5	< MDL
HZ	*max.*	3.61 ± 1.45	2.49 ± 0.83	< 406
	avg.	< MDL	1.88 ± 1.2	< MDL
SDWA Limit		**15**	**(a)**	**20,000**

Notes:
See Figure 5-3 for recharge basin/outfall locations.
All values above MDL reported with a 95% confidence interval.
To convert values from pCi to Bq, divide by 27.03.
(a) The drinking water standard was changed from 50 pCi/L (concentration based) to 4 mrem/yr (dose based) in 2003. As gross beta activity does not identify specific radionuclides, a dose equivalent of this value cannot be calculated.
MDL = minimum detection limit
SDWA = Safe Drinking Water Act

5.4.2 Recharge Basins – Nonradiological Analyses

During 2022, discharge samples were collected semi-annually for water quality parameters, metals, and VOCs. Field-measured parameters (e.g., pH, conductivity, and temperature) were routinely monitored and recorded. The water quality and metals analytical results are summarized in Tables 5-3 and 5-4, respectively. The non-radiological analytical results are compared to groundwater discharge standards promulgated under Title 6 of the New York Codes, Rules, and Regulations (NYCRR), Part 703.6.

Low concentrations of disinfection byproducts were periodically detected above the MDL's in discharges to several of the basins throughout the year. Sodium hypochlorite and bromine, used to control bacteria in the drinking water and algae in cooling towers, can break down to various products including bromoform, chloroform, bromodichloromethane, and dibromochloromethane. Concentrations were above the 1 µg/L MDL for one or more of the breakdown products at Basins HO, HS, HT-W, and HN, the highest values all being under 11 µg/L, which was the highest value recorded for bromoform.

The analytical data presented in Table 5-3 show that, for 2022, the concentrations of all analytes

Table 5-3: Water Quality Data for On-site Recharge Basins (2022)

ANALYTE		Recharge Basin HN (RHIC)	HO (AGS/HFBR)	HS (s)	HT-W (Linac)	HT-E (AGS)	HW (s)	CSF (s)	HZ (s)	NYSDEC Effluent Standard	Typical MDL
No. of samples		2	2	2	2	2	2	2	2		
pH (SU)	*min.*	7.5	7.2	7.2	7.6	6.6	7.4	7.4	7.5	6.5 - 8.5	NA
	max.	7.9	8.0	7.6	8.2	7.6	8.3	8.3	7.8		
Conductivity (µS/cm)	*min.*	488	339	306	332	89	78	78	219	SNS	NA
	max.	554	409	419	377	903	387	408	438		
	avg.	521	374	362.5	354.5	496	232.5	243	328.5		
Temperature (Deg. C)	*min.*	7.3	10.6	6.9	15.7	8.2	6.4	8.3	8.8	SNS	NA
	max.	23.6	20.5	23.2	24.9	13.7	23.9	23.9	23.1		
	avg.	15.5	15.6	15.1	20.3	11.0	15.2	16.1	16.0		
Dissolved oxygen (mg/L)	*min.*	7.9	9.0	8.6	8.1	8.7	8.4	8.4	8.6	SNS	NA
	max.	11.6	11.2	11.9	9.1	12.3	12.5	12.1	11.7		
	avg.	9.7	10.1	10.3	8.6	10.5	10.4	10.2	10.2		
Chlorides (mg/L)	*min.*	93	76	89	68	7.9	11	7.8	27	500	11.9
	max.	120	82	460	120	1600	110	110	110		
	avg.	106.5	79	274.5	94	804.0	60.5	58.9	68.5		
Sulfates (mg/L)	*min.*	6.6	5.9	8.5	8.5	3.2	2.5	2.1	5.1	500	3.1
	max.	15	11	12	12	21	2.9	2.8	11		
	avg.	10.8	8.45	10.3	10.3	12.1	2.7	2.5	8.1		
Nitrate as nitrogen (mg/L)	*min.*	0.3	0.5	0.6	0.6	0.3	0.1	0.2	0.5	10	0.1
	max.	0.5	0.7	0.6	0.7	1.1	0.4	0.4	1.4		
	avg.	0.4	0.6	0.6	0.6	0.7	0.3	0.3	0.9		

Notes:
See Figure 5-3 for recharge basin/outfall locations.
NA = not applicable
(s) = stormwater
NYSDEC = New York State Department of Environmental Conservation
HFBR = High Flux Beam Reactor
AGS = Alternating Gradient Synchrotron
RHIC = Relativistic Heavy Ion Collider
Linac = Linear Accelerator
SNS = effluent standard not specified
MDL = method detection limit

were within effluent standards, except for chlorides. Historically, chlorides are found to be higher in samples collected during the winter and are attributed to road salt used to control snow and ice buildup. The period surrounding the high values correspond to precipitation events in February 2022. The data in Table 5-4 show that all parameters complied with the respective water quality or groundwater discharge standards. The data for sodium at basin HT-E coincides with the chlorides shown in Table 5-3, indicating road salts as the source.

5.4.3 Stormwater Assessment

Stormwater at BNL is managed by collecting runoff from paved surfaces, roofs, and other impermeable surfaces and directing it to recharge basins via underground piping and above-grade vegetated swales. Recharge Basin HS receives most of the stormwater runoff from the central, developed portion of the Laboratory site. Basins HN, HZ, HT-W, and HT-E receive runoff from the Collider-Accelerator complex. Basin HO receives runoff from the area surrounding the HFBR. Basin CSF receives runoff from the CSF area and along Cornell Avenue east of Renaissance Road. Basin HW receives runoff from the NSLS-II site, and HW-M receives runoff from the fenced area at the FHWMF.

Stormwater runoff at the Laboratory typically has elevated levels of inorganics (e.g., metals) and has a low pH. The inorganics are attributable

Table 5-4: Metals Analysis of Water Samples From BNL On-Site Recharge Basins (2022)

METAL		Recharge Basin **HO** (AGS)		**HT-E** (AGS)		**HT-W** (Linac)		**HZ** (stormwater)		**NYSDEC Effluent Limit or AWQS**	**Typical MDL**
Total (T) or Filtered (F)		T	F	T	F	T	F	T	F		
No. of samples		2	2	2	2	2	2	2	2		
Ag Silver (µg/L)	*min.*	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	50	2
	max.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
	avg.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
Al Aluminum (µg/L)	*min.*	< 50.0	< 50.0	85	< 50.0	< 50.0	< 50.0	220	< 50.0	2000	50
	max.	140	< 50.0	200	< 50.0	180	< 50.0	430	140		
	avg.	95	< 50	142.5	< 50	114	< 50	325	95		
As Arsenic (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	50	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Ba Barium (µg/L)	*min.*	24	23	<20	<20	40	37	<20	<20	2000	20
	max.	58	63	68	73	44	43	34	32		
	avg.	41	43	40	42	42	40	24.5	23		
Be Beryllium (µg/L)	*min.*	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	SNS	2
	max.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
	avg.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
Cd Cadmium (µg/L)	*min.*	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	10	2
	max.	< 2.0	< 2.0	2.0	2.0	< 2.0	< 2.0	2.0	2.0		
	avg.	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0		
Co Cobalt (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	5	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Cr Chromium (µg/L)	*min.*	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	100	10
	max.	< 10.0	< 10.0	10.0	10.0	< 10.0	< 10.0	< 10.0	< 10.0		
	avg.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
Cu Copper (µg/L)	*min.*	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	1000	10
	max.	< 10.0	< 10.0	< 10.0	< 10.0	18.0	10.0	190	170		
	avg.	< 10.0	< 10.0	< 10.0	< 10.0	11.1	< 10.0	103	88.1		
Fe Iron (mg/L)	*min.*	< 50	< 50	120	< 50	53	< 50	92	< 50	600	50
	max.	170	< 50	410	< 50	300	< 50	140	< 50		
	avg.	100	< 50	265	< 50	177	< 50	116	56		
Hg Mercury (µg/L)	*min.*	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	1.4	0.2
	max.	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
	avg.	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
Mn Manganese (µg/L)	*min.*	4.4	< 4.0	6.5	< 4.0	< 4.0	< 4.0	4.6	< 4.0	600	4
	max.	5	11	18	14	11	66	19	19		
	avg.	4.7	8	12.3	8.2	8	35.5	11.8	10.7		

(continued on next page)

Table 5-4: Metals Analysis of Water Samples From BNL On-Site Recharge Basins (2022) *(concluded).*

METAL		Recharge Basin HO (AGS)		HT-E (AGS)		HT-W (Linac)		HZ (stormwater)		NYSDEC Effluent Limit or AWQS	Typical MDL
Total (T) or Filtered (F)		T	F	T	F	T	F	T	F		
No. of samples		2	2	2	2	2	2	2	2		
Na Sodium (mg/L)	*min.*	53	53	7.9	8	55	52	22	21	SNS	0.25
	max.	57	55	860	910	83	80	71	71		
	avg.	55	54	434	459	69	66	46.5	46		
Ni Nickel (µg/L)	*min.*	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	200	10
	max.	< 10.0	10.0	10.0	10.0	< 10.0	< 10.0	10.0	10.0		
	avg.	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0		
Pb Lead (µg/L)	*min.*	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	50	3
	max.	< 3.0	< 3.0	< 3.0	< 3.0	3.0	< 3.0	19	13		
	avg.	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	11	8		
Sb Antimony (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	6	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Se Selenium (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	20	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
Tl Thallium (µg/L)	*min.*	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	SNS	5
	max.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0		
V Vanadium (µg/L)	*min.*	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	SNS	7
	max.	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0		
	avg.	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0		
Zn Zinc (µg/L)	*min.*	< 20.0	< 20.0	39	25	< 20.0	< 20.0	50	30	5000	20
	max.	22	20	90	76	54	23	220	200		
	avg.	21	< 20	64.5	50.5	37	21.5	135	115		

Notes:
See Figure 5-3 for recharge basin/outfall locations.
AGS = Alternating Gradient Synchrotron
AWQS = Ambient Water Quality Standards
Linac = Linear Accelerator
MDL = method detection limit

to high sediment content in stormwater (inorganics occur naturally in native soil). In an effort to further improve the quality of stormwater runoff on site, BNL has formal procedures for managing and maintaining outdoor work and storage areas. The requirements include covering of equipment and materials (e.g., road salt storage and bins/containers with potential to leak residual oils or any other hazardous materials) to prevent contact with stormwater, conducting an aggressive maintenance and inspection program, implementing erosion control measures during soil disturbance activities, and restoring these areas when operations cease.

Basin sediment sampling is conducted on a five-year testing cycle to ensure these discharges comply with regulatory requirements. Basin sediments were sampled in 2022 and data are presented in Chapter 6. The next sampling event will occur in 2027.

Table 5-5: Radiological Results for Surface Water Samples Collected Along the Peconic and Carmans Rivers (2022)

Sampling Station		Gross Alpha	Gross Beta	Tritium	Strontium-90
		(pCi/L)			
HY (headwaters) on site, west of the RHIC ring	*N*	2	2	2	2
	max	< 1.12	< 0.98	< 333	< 0.61
	avg	< MDL	< MDL	<MDL	<MDL
HV (headwaters) on site, inside the RHIC ring	*N*	2	2	2	1
	max	3.54 ± 1.20	5.44 ± 1.26	< 349	1.22 ± 0.48
	avg	2.03 ± 1.13	3.3 ± 1.17	< MDL	-
HM-S tributary, on-site	*N*	NS	NS	NS	NS
	max	-	-	-	-
	avg	-	-	-	-
HQ downstream of STP, at BNL site boundary	*N*	NS	NS	NS	NS
	max	-	-	-	-
	avg	-	-	-	-
Carmans River (HH) control Location, off-site	*N*	2	2	2	2
	max	< 1.91	< 1.65	< 340	0.72 ± 0.22
	avg	< MDL	< MDL	< MDL	0.49 ± 0.21
SDWA Limit (pCi/L)		**15**	**(a)**	**20,000**	**8**

Notes:
See Figure 5-1 sampling station locations.
All values reported with a 95% confidence interval.
To convert values from pCi to Bq, divide by 27.03.
MDL = minimum detection limit
N = number of samples analyzed
NS = not sampled due to dry conditions
RHIC = Relativistic Heavy Ion Collider
SDWA = Safe Drinking Water Act
(a) The drinking water standard was changed from 50 pCi/L (concentration based) to 4 mrem/yr (dose based) in 2003. Because gross beta activity does not identify specific radionuclides, a dose equivalent cannot be calculated for the values in the table.

5.5 PECONIC RIVER SURVEILLANCE

Several locations are monitored along the Peconic River to assess the overall water quality of the river and assess any impact from BNL operations. Sampling points along the Peconic River are identified in Figure 5-1. In total, four stations (two upstream and two downstream of the former STP discharge) were sampled in 2022. A sampling station along the Carmans River (HH) was also monitored as a geographic control location not affected by Laboratory operations or located within the Peconic River watershed. The following locations were monitored for radiological and non-radiological parameters:

Upstream sampling station:

- HY, on site, immediately east of William Floyd Parkway
- HV, on site, just east of the 10 o'clock experimental hall in the RHIC Ring, radiological only

Downstream sampling stations:

- HM-S, on site, at east firebreak south of main-stem of Peconic (no flow at this station in 2022)

HQ, on site, at east boundary of BNL (no offsite flow occurred in 2022)

Control location:

- HH, Carmans River

5.5.1 Peconic River – Radiological Analyses

During 2022, radionuclide analyses were performed on surface water samples collected from two of the four Peconic River sampling locations (HM-S and HQ were dry throughout the year) and the Carmans River control location. Stations HY and HV on the Peconic River allow for. radiological assessment of potential RHIC impacts and no other contributions from potential BNL operations enter the river until the tributary monitoring at HM-S. HQ sampling station is the final monitoring location before the river flows off site and when flowing is representative of all surface water flows from the BNL site.

In 2022, the Peconic River flow continued to be

Table 5-6: Water Quality Analytical Results for Surface Water Samples Collected Along the Peconic and Carmans Rivers (2022)

Analyte		Peconic River Station Locations HY	HM-S	HQ	Carmans River HH (Control)	NYSDEC Effluent Standard	Typical MDL
	No. of samples	2	NS	NS	2		
pH (SU)	*min.*	6.8	-	-	6.4	6.5 - 8.5	NA
	max.	7.0	-	-	6.4		
	avg.	6.9	-	-	6.4		
Conductivity (µS/cm)	*min.*	29.0	-	-	243.0	SNS	NA
	max.	498.0	-	-	246.0		
	avg.	263.5	-	-	244.5		
Temperature (deg C)	*min.*	8.4	-	-	12.7	SNS	NA
	max.	22.3	-	-	17.9		
	avg.	15.4	-	-	15.3		
Dissolved oxygen (mg/L)	*min.*	8.2	-	-	8.0	SNS	NA
	max.	11.8	-	-	12.1		
	avg.	10.0	-	-	10.1		
Chlorides (mg/L)	*min.*	3.6	-	-	40.9	250	0.8
	max.	130.0	-	-	45.0		
	avg.	66.8	-	-	43.0		
Sulfate (mg/L)	*min.*	1.3	-	-	12.0	250	1.1
	max.	1.7	-	-	12.1		
	avg.	1.5	-	-	12.1		
Nitrate as nitrogen (mg/L)	*min.*	0.1	-	-	2.5	10	0.1
	max.	0.2	-	-	2.5		
	avg.	0.2	-	-	2.5		

Notes:
See Figure 5-1 for monitoring locations.
HY = Peconic River headwaters, on site, east of Wm Floyd Pkwy.
HQ = Peconic River on site at east boundary
HM-S = Peconic River tributary at east firebreak
HH = Carmans River control location, off site
NYSDEC = New York State Department of Environmental Conservation
SNS = effluent standard not specified
NS = sample not taken due to dry conditions
MDL = method detection limit

low. Two samples were able to be taken at the upper sampling locations. The radiological data from Peconic River surface water samples are summarized in Table 5-5. Radiological analysis of water samples collected from all locations had very low concentrations of gross alpha and gross beta activity that were attributed to natural sources. All detected levels were below the applicable NYS DWS. Tritium values were below MDLs at all locations on the Peconic and Carmans Rivers. Sr-90 was detected detected above the detection limit but below the drinking water standard at station HV on the Peconic River and station HH on the Carmans River (1.22 pCi/L and 0.72 pCi/L, respectively). All other values were below MDLs.

5.5.2 Peconic River – Non-radiological Analyses

River water samples collected in 2022 were analyzed for water quality parameters (e.g., pH,

Table 5-7: Metals Analytical Results for Surface Water Samples Collected Along the Peconic and Carmans Rivers (2022)

METAL		Peconic River Locations						Carmans River HH (Control)		NYSDEC AWQS (a)	Typical MDL
		HY		HM-S		HQ					
	Total (T) or Dissolved (D)	T	D	T	D	T	D	T	D		
	No. of samples	2	2	NS	NS	NS	NS	2	2		
Ag Silver (µg/L)	*min.*	< 2.0	< 2.0	-	-	-	-	< 2.0	< 2.0	0.1	2
	max.	< 2.0	< 2.0	-	-	-	-	< 2.0	< 2.0		
	avg.	< 2.0	< 2.0	-	-	-	-	< 2.0	< 2.0		
Al Aluminum (µg/L)	*min.*	560	< 50.0	-	-	-	-	< 50.0	< 50.0	100	50
	max.	808	68	-	-	-	-	68	68		
	avg.	684	< 50.0	-	-	-	-	< 50.0	< 50.0		
As Arsenic (µg/L)	*min.*	< 5.0	< 5.0	-	-	-	-	< 5.0	< 5.0	150	5
	max.	< 5.0	< 5.0	-	-	-	-	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	-	-	-	-	< 5.0	< 5.0		
Ba Barium (µg/L)	*min.*	< 20.0	< 20.0	-	-	-	-	51	54	SNS	20
	max.	< 20.0	< 20.0	-	-	-	-	51.7	55.7		
	avg.	< 20.0	< 20.0	-	-	-	-	51.4	54.9		
Be Beryllium (µg/L)	*min.*	< 2.0	< 2.0	-	-	-	-	< 2.0	< 2.0	11	2
	max.	< 2.0	< 2.0	-	-	-	-	< 2.0	< 2.0		
	avg.	< 2.0	< 2.0	-	-	-	-	< 2.0	< 2.0		
Cd Cadmium (µg/L)	*min.*	< 2.0	< 2.0	-	-	-	-	< 2.0	< 2.0	1.1	2
	max.	< 2.0	< 2.0	-	-	-	-	< 2.0	< 2.0		
	avg.	< 2.0	< 2.0	-	-	-	-	< 2.0	< 2.0		
Co Cobalt (µg/L)	*min.*	< 5.0	< 5.0	-	-	-	-	< 5.0	< 5.0	5	5
	max.	< 5.0	< 5.0	-	-	-	-	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	-	-	-	-	< 5.0	< 5.0		
Cr Chromium (µg/L)	*min.*	< 10.0	< 10.0	-	-	-	-	< 10.0	< 10.0	34	10
	max.	< 10.0	< 10.0	-	-	-	-	< 10.0	< 10.0		
	avg.	< 10.0	< 10.0	-	-	-	-	< 10.0	< 10.0		
Cu Copper (µg/L)	*min.*	< 10.0	< 10.0	-	-	-	-	< 10.0	< 10.0	4	10
	max.	12.1	<10.0	-	-	-	-	< 10.0	< 10.0		
	avg.	<10.0	< 10.0	-	-	-	-	< 10.0	< 10.0		
Fe Iron (mg/L)	*min.*	0.7	< 0.05	-	-	-	-	0.4	0.1	0.3	0.05
	max.	1.1	< 0.05	-	-	-	-	0.5	0.1		
	avg.	0.9	< 0.05	-	-	-	-	0.4	0.1		
Hg Mercury (µg/L)	*min.*	< 0.2	< 0.2	-	-	-	-	< 0.2	< 0.2	0.2	0.2
	max.	< 0.2	< 0.2	-	-	-	-	< 0.2	< 0.2		
	avg.	< 0.2	< 0.2	-	-	-	-	< 0.2	< 0.2		
Mn Manganese (µg/L)	*min.*	15.9	4.3	-	-	-	-	98	98	SNS	4
	max.	18	5.8	-	-	-	-	144	149		
	avg.	17	5	-	-	-	-	121	123.5		
Na Sodium (mg/L)	*min.*	3.8	3.1	-	-	-	-	26	26.8	SNS	0.25
	max.	92.2	91	-	-	-	-	26.4	27		
	avg.	48	47.1	-	-	-	-	26.2	26.9		

(continued on next page)

Table 5-7: Metals Analytical Results for Surface Water Samples Collected Along the Peconic and Carmans Rivers *(concluded).*

METAL		Peconic River Locations						Carmans River HH (Control)		NYSDEC AWQS (a)	Typical MDL
		HY		HM-S		HQ					
	Total (T) or Dissolved (D)	T	D	T	D	T	D	T	D		
	No. of samples	2	2	NS	NS	NS	NS	2	2		
Ni Nickel (µg/L)	*min.*	< 10.0	< 10.0	-	-	-	-	< 10.0	< 10.0	23	10
	max.	< 10.0	< 10.0	-	-	-	-	< 10.0	< 10.0		
	avg.	< 10.0	< 10.0	-	-	-	-	< 10.0	< 10.0		
Pb Lead (µg/L)	*min.*	3.5	< 3.0	-	-	-	-	< 3.0	< 3.0	0.1	3
	max.	4	< 3.0	-	-	-	-	13	< 3.0		
	avg.	3.7	< 3.0	-	-	-	-	6.8	< 3.0		
Sb Antimony (µg/L)	*min.*	< 5.0	< 5.0	-	-	-	-	< 5.0	< 5.0	SNS	5
	max.	9.7	11.7	-	-	-	-	< 5.0	< 5.0		
	avg.	5.2	8.4	-	-	-	-	< 5.0	< 5.0		
Se Selenium (µg/L)	*min.*	< 5.0	< 5.0	-	-	-	-	< 5.0	< 5.0	4.6	5
	max.	< 5.0	< 5.0	-	-	-	-	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	-	-	-	-	< 5.0	< 5.0		
Tl Thallium (µg/L)	*min.*	< 5.0	< 5.0	-	-	-	-	< 5.0	< 5.0	8	5
	max.	< 5.0	< 5.0	-	-	-	-	< 5.0	< 5.0		
	avg.	< 5.0	< 5.0	-	-	-	-	< 5.0	< 5.0		
V Vanadium (µg/L)	*min.*	< 7.0	< 7.0	-	-	-	-	< 7.0	< 7.0	14	7
	max.	< 7.0	< 7.0	-	-	-	-	< 7.0	< 7.0		
	avg.	< 7.0	< 7.0	-	-	-	-	< 7.0	< 7.0		
Zn Zinc (µg/L)	*min.*	28	< 20.0	-	-	-	-	< 20.0	< 20.0	37	20
	max.	47.6	< 20.0	-	-	-	-	< 20.0	< 20.0		
	avg.	37.8	< 20.0	-	-	-	-	< 20.0	< 20.0		

Notes:
See Figure 5-1 sampling station locations.
AWQS = Ambient Water Quality Standards
SNS = effluent standard not specified for these elements in Class C surface waters
(a) NYS AWQS for Class C surface waters
NS - sample not collected due to dry conditions
MDL = method detection limit

temperature, conductivity, and dissolved oxygen), anions (e.g., chlorides, sulfates, and nitrates), metals, and VOCs. The analytical data for the Peconic River and Carmans River samples are summarized in Table 5-6 (water quality) and Table 5-7 (metals). No VOCs were found in any samples collected from the Peconic and Carmans Rivers in 2022. Water quality parameters measured in the three Peconic River locations and the Carmans River control location (HH) show that pH, temperature, conductivity, and dissolved oxygen levels were all within applicable NYS standards.

Ambient water quality standards (AWQS) for metallic elements are based on their solubility state. Certain metals are only biologically available to aquatic organisms if they are in a dissolved or ionic state, whereas other metals are toxic in any form (i.e., dissolved and particulate combined). In 2022, the BNL monitoring program continued to assess water samples for both the dissolved and particulate form. Dissolved concentrations were determined by filtering the samples prior to acid preservation and analysis.

Examination of the total (i.e., particulate form) metals data showed that aluminum, copper, iron, lead, and zinc were present in concentrations at

HY and/or HH that exceeded NYS AWQS. Aluminum was detected at concentrations exceeding the NYS AWQS at location HY on the Peconic River for unfiltered samples with dissolved levels falling below NYS AWQS. Iron was detected at both Peconic and Carmans River sampling stations at concentrations that were at or slightly exceeding the NYS AWQS in unfiltered samples with dissolved levels falling below NYS AWQS; iron and aluminum are found in high concentrations in native Long Island soil and, for iron, at high levels in groundwater. Copper, lead, and zinc at concentrations greater than the NYS AWQS were found in samples collected at station HY on the Peconic River and at station HH on the Carmans River (lead only). Filtration of the samples reduced concentration for all these metals to below the detection level, suggesting that suspended sediment was responsible for metals in the samples.

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