Annual Site Environmental Report

2022

Princeton Plasma Physics Laboratory

Operated by Princeton University For the U.S. Department of Energy
Under Contract DE-AC02-09CH11466

PPPL PRINCETON PLASMA PHYSICS LABORATORY

PPP-2023_267

U.S. DEPARTMENT OF ENERGY

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List of Exhibits in Text

NOTE: ***Data tables are located in Appendix A - 2022 Tables beginning on page 75.***
All tables as noted in the report are in Appendix A.

List of Acronyms

AEA	Atomic Energy Act of 1954
AFV	Alternative fuel vehicles
ALARA	As low as reasonably achievable
ARD	America Recycles Day (November 15th)
ASER	Annual Site Environmental Report
B1, B2	Bee Brook 1 (upstream of DSN001) and 2 (downstream of DSN001) (surface water stations)
BCG	Biota concentration guide
Bq	Becquerel
BTU/gsf	British Thermal Unit per gross square feet
^{o}C	Degrees Celsius
C- & D-	C & D-sites of James Forrestal Campus, currently site of PPPL
C1	Canal - surface water monitoring location (Delaware & Raritan Canal)
c-1,2-DCE	Cis-1,2-dichloroethylene
C&D	Construction and demolition (waste)
CAA	Clean Air Act
CAS	Coil Assembly and Storage building
CDX-U	Current Drive Experiment – Upgrade (at PPPL)
CEA	Classification Exception Area
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
Ci	Curie (3.7 ^{E10} Becquerel)
cm	Centimeter
cm^2	Centimeters squared
CO	Carbon monoxide
CO_2	Carbon dioxide (GHG)
CO_{2e}	Carbon dioxide equivalent
COD	Chemical oxygen demand
CPO	Chlorine-produced oxidants known as total residual chlorine
CWA	Clean Water Act
CXs	Categorical exclusions
CY	Calendar year
D-T	Deuterium-tritium
DART	Days away, restricted, transferred (case rate - safety statistic)
DATS	Differential atmospheric tritium sampler
DESC	Defense Energy Supply Center
DMR	Discharge monitoring report
DOE	Department of Energy
DOE-PSO	Department of Energy - Princeton Site Office
DOT	Department of Transportation
DPCC	Discharge Prevention Control and Containment
dpm	Disintegrations per minute
D&R	Delaware & Raritan (Canal)
DSN	Discharge serial number
E1	Surface water monitoring station (NJ American Water Company, potable water source)
E-85	Ethanol (85%) fuel
EDE	Effective dose equivalent

EHS	Extremely hazardous substance
EISA	Energy Independence and Security Act, Section 432
EML	Environmental Monitoring Laboratory (DOE)
EMS	Environmental Management System
EO	Executive Order
EPA	Environmental Protection Agency (US)
EPCRA	Emergency Planning and Community Right to Know Act
EPEAT	Electronic Product Environmental Assessment Tool
EPP	Environmentally Preferred Products
ESD	Environmental Services Division (PPPL)
ES&H	Environment, Safety, and Health
ESHD	Environment, Safety, & Health Directives
ESPC	Energy Savings Performance Contract
°F	Degrees Fahrenheit
FFCA	Federal Facility Compliance Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FY	Fiscal year (October 1 to September 30)
GGE	Gasoline gallon equivalent
GHG	Greenhouse gas
GP	General permit
GPD	Gallons per day
GPP	General plant projects
GSA	General Services Administration
gsf	Gross square feet
GSR	Green sustainable remediation
HAZMAT	Hazardous materials
HP	Health Physics Division of ES&H
HPSB	High performance and sustainable buildings
HT	Tritium (elemental)
HTO	Tritiated water or tritium oxide
IC25	Inhibition concentration
ILA	Industrial, landscaping, and agriculture
ISO14001	International Organization for Standardization 14001 (Environmental Management System – EMS)
ITER	International Thermonuclear Experimental Reactor (France)
JFC	James Forrestal Campus
JET	Joint European Torus facility (United Kingdom)
km	Kilometer
LEC	Liquid effluent collection (tanks)
LED	Light-emitting diode
LEED®	Leadership in Energy and Environmental Design
LEED®-EBOM	Leadership in Energy and Environmental Design - Existing Buildings Operations & Maintenance
LLW	Low-level waste
LSB	Lyman Spitzer Building (Formerly Laboratory Office Building)
LSRP	Licensed Site Remediation Professional
LOI	Letter of Interpretation (Wetlands)
LOTO	Lock-out, tag-out (electrical safety)

LSI	Lined surface impoundment
LTX	Lithium Tokamak Experiment
M1	Millstone River (surface water station)
MC&A	Material Control & Accountability (nuclear materials)
MEI	Maximally Exposed Individual
MG	Motor Generator (Building)
MGD	Million gallons per day
mg/L	Milligram per liter
MNA	Monitored Natural Attenuation
mrem	Milli roentgen equivalent man (per year)
MRX	Magnetic Reconnection Experiment
MSDS	Material Safety Data Sheet
msl	Mean sea level (in feet)
mSv	MilliSievert
MT (mt)	Metric ton (equivalent to 2,204.6 pounds or 1.10 tons)
MW	Monitoring well
MWh	Megawatt hour
MSW	Municipal solid waste
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic and Preservation Act
NIST	National Institute of Standards and Technology
NJ	New Jersey
N.J.A.C.	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection (prior to 1991 and after July 1994)
NJPDES	New Jersey Pollutant Discharge Elimination System
NOEC	No observable effect concentration
NOVs	Notice of violations
NO_x	Nitrogen oxides
NSTX-U	National Spherical Torus Experiment Upgrade
NVLAP	National Voluntary Laboratory Accreditation Program (NIST)
ODS	Ozone-depleting substances (Class I and II)
OPEX	Operating expenses (PPPL budget)
ORPS	Occurrence reporting and processing system (DOE accident/incident reporting system)
OSHA	Occupational Safety and Health Agency
P1, P2	Plainsboro 1 (Cranbury Brook) and 2 (Devil's Brook) (surface water stations)
PAA	Peracetic acid
PCs	Personal computer(s)
PCBs	Polychlorinated biphenyls
PCE	Perchloroethylene, tetrachloroethene, or tetrachloroethylene
pCi/L	PicoCuries per liter
PE	Professional engineer
PEARL	PPPL Environmental, Analytical, and Radiological Laboratory
PF1A	Poloidal field coil 1A
PFC	Plasma-facing component
PJM	Pennsylvania, Jersey, Maryland (Electric-power grid controllers/operators)
POTW	Publicly-owned treatment works

PPA	Power Purchase Agreement
PPPL	Princeton Plasma Physics Laboratory
PSTP	Preliminary Site Treatment Plan
PT	Proficiency test (laboratory certification)
PTE	Potential to emit (air emissions)
PUE	Power utilization or usage effectiveness
QA	Quality assurance
QA/QC	Quality assurance/quality control
RAA	Remedial Alternative Assessment
RASR	Remedial Action Selection Report
RAWP	Remedial Action Work Plan
RCRA	Resource Conservation and Recovery Act
REC	Renewable energy credits
redox	Oxidation-reduction (potential)
rem	Roentgen equivalent man
RESA	Research Equipment Storage and Assembly Building
RI	Remedial Investigation
RWHF	Radioactive Waste Handling Facility
SF_6	Sulfur hexafluoride (GHG)
SARA	Superfund Amendments and Reauthorization Act of 1986
SBRSA	Stony Brook Regional Sewerage Authority
SDWA	Safe Drinking Water Act
SESC	Soil erosion and sediment control
SO_2	Sulfur dioxide
SPCC	Spill Prevention Control and Countermeasure
SWPPP	Stormwater Pollution Prevention Plan
Sv	Sievert
SVOCs	Semi-volatile organic compounds
TCE	Trichloroethene or trichloroethylene
TFTR	Tokamak Fusion Test Reactor
TPHC	Total petroleum hydrocarbons
TRI	Toxic Release Inventory (CERCLA)
TSCA	Toxic Substance Control Act
TSS	Total suspended solids
TW	Test wells
UL-DQS	Underwriters Laboratories-DQS (Germany's first certification body)
US	United States
VOCs	Volatile organic compounds
WCR	Waste Characterization Report
$\mu g/L$	Micrograms per liter

Princeton Plasma Physics Laboratory (PPPL)
Certification of Monitoring Data for
Annual Site Environmental Report for 2022

Contained in the following report are data for radioactivity in the environment collected and analyzed by Princeton Plasma Physics Laboratory's Princeton Environmental, Analytical, and Radiological Laboratory (PEARL). The PEARL is located on-site and is certified for analyzing radiological and non-radiological parameters through the New Jersey Department of Environmental Protection's Laboratory Certification Program, Certification Number 12471. Non-radiological surface and ground water samples are analyzed by NJDEP certified subcontractor laboratories – SGS Accutest Laboratory. To the best of our knowledge, these data, as contained in the "Annual Site Environmental Report for 2022," are documented and certified to be correct.

Signed:

Mark Hughes Digitally signed by Mark Hughes Date: 2023.09.29 15:05:29 -04'00'

Mark Hughes,
Environmental Compliance Manager

Michelle Turnbach Digitally signed by Michelle Turnbach Date: 2023.09.29 15:09:58 -04'00'

Michelle Turnbach,
Environmental Data Scientist

Todd Sandt Digitally signed by Todd Sandt Date: 2023.10.02 06:28:38 -04'00'

Todd Sandt,
Head, Environmental Services Division

Approved:

Robert S Sheneman Digitally signed by Robert S Sheneman Date: 2023.09.29 15:35:58 -04'00'

Robert S. Sheneman
ES&H Director, Chief Safety Officer

Abstract

Princeton Plasma Physics Laboratory

Annual Site Environmental Report for Calendar Year 2022

This report provides the U.S. Department of Energy (DOE) and the public with information on the level of radioactive and non-radioactive pollutants (if any) that are added to the environment as a result of Princeton Plasma Physics Laboratory's (PPPL) operations. This report fulfills the annual public reporting requirements of DOE Order 231.1B. The results of PPPL's 2022 environmental surveillance and monitoring program are presented and discussed. The report also summarizes environmental initiatives, assessments, and community involvement programs that were undertaken in 2022. PPPL's on-site operations started to be restored in 2022, following curtailments in 2020 and 2021 for the global coronavirus (COVID-19) pandemic.

PPPL has engaged in fusion energy research since 1951 and at its current locations since 1958. The Laboratory's mission is to develop the scientific knowledge and advanced engineering to enable fusion to power the U.S. and the world, and to develop the understanding of plasmas from the nano- to the astrophysical scale. PPPL's primary experiment, the National Spherical Torus Experiment-Upgrade (NSTX-U) is a collaboration among national laboratories, universities, and national and international research institutions and is a major element in the US Fusion Energy Sciences Program. Its design tests the physics principles of spherical torus (ST) plasmas, playing an important role in the development of smaller, more economical fusion reactors. Due to previous operational issues, NSTX-U did not operate in 2022. PPPL is engaged in a project to replace key NSTX-U components and systems to enable the operation of this international magentic fusion user facility.

In 2022, PPPL's radiological environmental monitoring program measured tritium in the air at onsite sampling stations. Using highly sensitive air monitors, PPPL is capable of detecting small changes in the ambient levels of tritium. The operation of monitors located on D-site is used to demonstrate compliance with the National Emission Standard for Hazardous Air Pollutants (NESHAPs) regulations. Also included in PPPL's radiological environmental monitoring program, are water monitoring – ground, surface, and waste waters. PPPL's radiological monitoring program characterized the background levels of tritium in the environment and those data are presented in this report.

Ground water monitoring continued under New Jersey Department of Environmental Protection's (NJDEP) Site Remediation Program regulations. PPPL monitored for non-radiological contaminants, mainly volatile organic compounds (components of common degreasing solvents). In 2022, PPPL complied with permit limits for surface water and sanitary wastewater discharges. PPPL was honored with an award for EPEAT-certified electronics purchasing from the Global Electronics Council.

Executive Summary

Princeton Plasma Physics Laboratory

Annual Site Environmental Report for

Calendar Year 2022

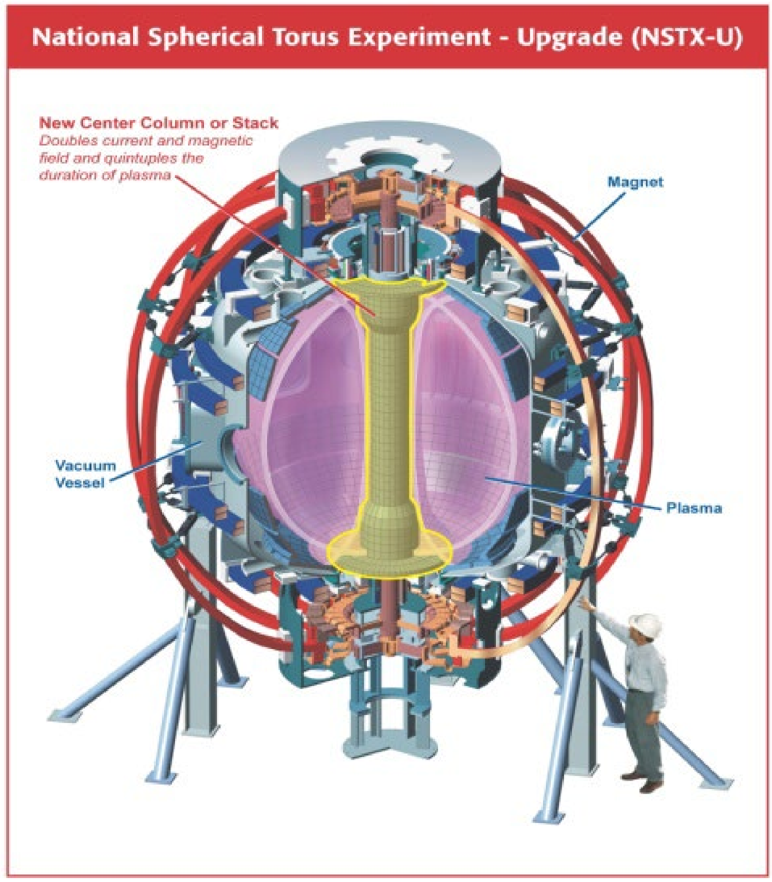
This report presents the results of environmental activities and monitoring programs at the Princeton Plasma Physics Laboratory (PPPL) for Calendar Year (CY) 2022. The report provides the U.S. Department of Energy (DOE) and the public with information on the level of radioactive and non-radioactive pollutants, if any, that are released into the environment resulting from PPPL operations. The report also summarizes environmental initiatives, assessments, and programs that were undertaken in 2022. The objective of the Site Environmental Report is to document PPPL's efforts to protect the public's health and the environment through its environmental protection, safety, and health programs.

Since 1951, the PPPL has engaged in fusion energy research. Fusion is the reaction that occurs in our sun as well as in other stars. During fusion reactions, the nuclei of hydrogen atoms in a plasma state (i.e., as an ionized gas) fuse or join, forming helium atoms, which releases neutrons and energy. Unlike the sun, PPPL's fusion reactions are magnetically confined within a vessel or reactor under vacuum conditions. The long-range goal of the U.S. Magnetic Fusion Energy Science program is to develop and demonstrate the practical application of fusion power as a safe, alternative energy source replacing power plants that burn fossil fuels. Energy from fusion power plants would boil water for steam that drives electric-generating turbines without the production of greenhouse gases (GHGs) and other air pollutants.

National Spherical Torus Experiment - Upgrade

2022 marked the twenty-fourth year of PPPL's flagship experiment, the National Spherical Torus Experiment (NSTX). The NSTX upgrade project (NSTX-U) was completed in 2016 at a cost of $94 million. Some of the major upgrades included a redesign of the center stack magnets and an addition of a second neutral beam box from the former Tokamak Fusion Test Reactor (TFTR). NSTX-U is among the most advanced spherical tokamaks in the world.

Unfortunately, due to disruptions to NSTX-U caused by events in 2015 and again in 2016, the experiment has not operated since late 2016. Engineering and quality assurance (QA) issues caused the disruptions to a major magnetic coil (poloidal field coil, PF1A) and other smaller components of the experiment. Systemic design verification and validation (DVV) and other reviews were conducted in 2017 and 2019 to identify potential latent system weaknesses. Following the completion of the reviews, a corrective action plan was developed and vetted by independent reviewers. With support from DOE and Princeton University, PPPL is working through the recovery project which will result in the revitalization of NSTX-U as an international fusion research user facility.



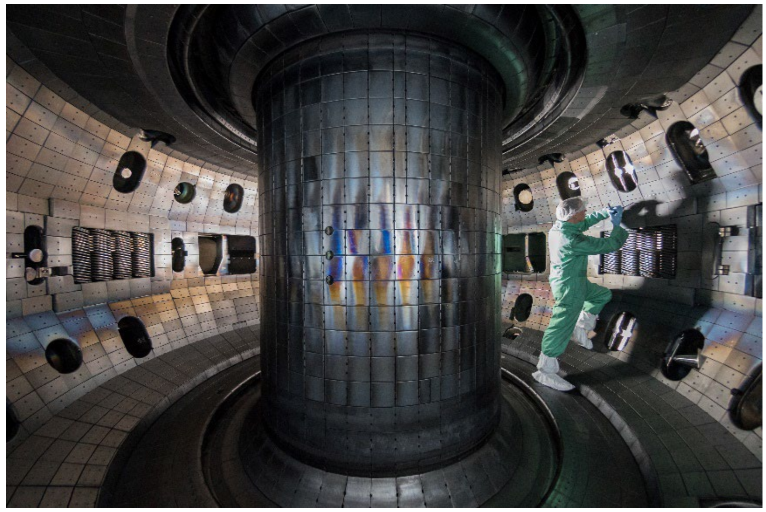
ITER - Cadarache, France

Source: ITER Organization/EJF Riche

International Thermonuclear Experimental Reactor or ITER in Latin means "the way" and is the name of the large international fusion experiment located in the Provence-Alpes-Côte-d'Azur region in southeastern France. Construction began in 2007 with a projected first plasma date of December 2025. When operational ITER will generate 10 times (Q10) the external power delivered to heat the plasma. PPPL, partnering with Oak Ridge National Laboratory, leads the U.S. ITER Project that coordinates U.S. ITER activities - lending to the project design, construction, and technical expertise. PPPL plays a major role in the international team designing and building plasma measurement and diagnostic systems.

International Collaboration & Other Plasma Physics Research

PPPL scientists and engineers collaborate with researchers from other fusion laboratories in the U.S. and around the world. Our international work supports work on the DIII-D experiment in San Diego, CA, the W-7X in Germany, and the EAST facility in China. In addition, PPPL's researchers study plasma astrophysical phenomena and conduct theoretical plasma physics studies and develop computer models to simulate plasma disruptions and other physical phenomena.



Source: DIII-D National Fusion Facility

PPPL Maximum Off-Site Dose in 2022

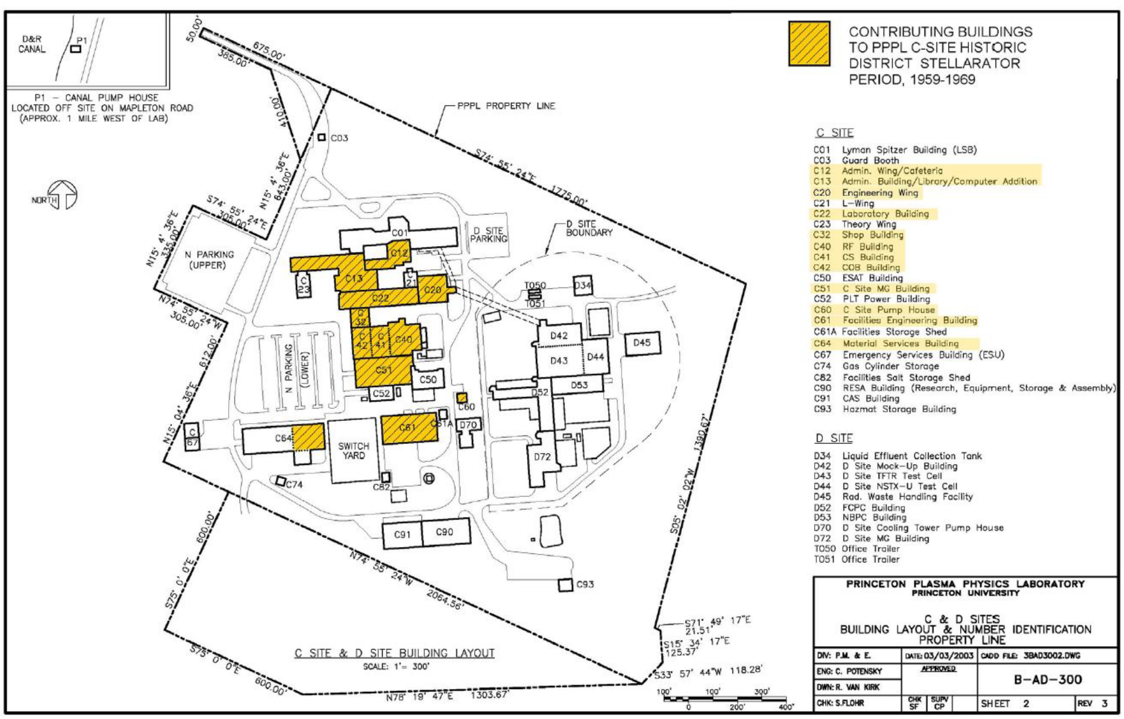
When the total maximum off-site dose for 2022 is calculated, PPPL's radiological contribution is a fraction of the 10 milli roentgen equivalent man per year (mrem/year) PPPL objective and the 100-mrem/year DOE limit. Based on the radiological monitoring program data, the dose results for 2022 were:

1. Maximally exposed individual (MEI) dose from all sources—airborne and liquid releases—was 1.05E-03 millirem (mrem) per year (1.05E-05 milliSievert [mSv] per year), as shown in Exhibit 5-1.
2. The collective effective dose equivalent (EDE) for the population living within 80 kilometers (km) was 1.51E-02 person- roentgen equivalent man (rem) (1.51E-04 person-sievert [Sv]), as shown in Exhibit 5-1.

Major Campus Improvement Projects

2021 saw the development and conceptual design of additional campus improvement projects envisioned by PPPL's Strategic and Campus Development Plans. They include critical infrastructure system improvements, new high-performance computing capabilities, and the construction of a new research and collaboration facility, known as the Princeton Plasma Innovation Center (PPIC). The project is currently in the design phase with construction set to begin in late 2023, along with the tear-down of the Theory Wing and part of the Administration

Building. The new building is targeted to for occupancy in 2026. DOE and Princeton University are committed to the comprehensive suite of campus improvements outlined in the Campus Development Plan. Because PPPL's original buildings are over 50 years old, an intensive-level resources survey was completed in 2020 to evaluate the PPPL campus under the National Historic Preservation Act (NHPA). The survey identified the original (circa 1958) PPPL C-Site Complex as a Historic District eligible for listing on the National Register of Historic Places. In accordance with 36 CFR Part 800, PPPL and USDOE-PSO shared these findings with the New Jersey Department of Environmental Protection Historic Preservation Office (NJDEP HPO) to determine how to mitigate the impacts that PPIC construction will have on these historic buildings. A Memorandum of Agreement (MOA) between USDOE-PSO, NJDEP HPO, Princeton University, and PPPL, stipulates that the Laboratory will be responsible to resolve adverse effects to eligible historic resources, identified as the PPPL C-Site Historic District, Stellarator Period, 1958-1969 (shown below), caused by construction of PPIC. In 2022 PPPL subcontracted experienced architectural and historic preservation firms to provide Historical American Buildings Survey (HABS) Level III documentation, development of a Public Outreach Plan, and for continued support for SHPO, public, and tribal consultations, to comply with NHPA Section 106 and the MOA.



PPPL C-SITE HISTORIC DISTRICT STELLARATOR PERIOD, 1959-1969

Princeton Plasma Physics Laboratory Campus, Contributing Buildings to PPPL C-Site historic District Stellarator Period highlighted in yellow.

In 2022, extensive work occurred for the Tritium System Deconstruction and Decommissioning (TSDD) project. This Science Laboratory Initiative (SLI) project will remove PPPL's legacy tritium systems that supported deuterium-tritium (D-T) experiments of the TFTR, which ceased operations in 1997 and was decommissioned between 2000 and 2002. The tritium systems were originally retained to support potential future D-T experiments but have subsequently been identified as high-risk equipment which contains most of the Lab's legacy tritium inventory. The removal and disposal of these systems began in early 2022. The project focused on the removal of the tritium handling system in the basement of D-site along with one of three neutral beam boxes that contain tritium in the test cell for disposal through a licensed disposal facility. The other two beam boxes will be moved to the mock-up building at D-site and will be safely stored in case their components are needed for NSTX-U. The TSDD project schedule experienced minor delays due to staffing shortages and supply chain delays caused by COVID-19 but is on schedule to be completed in late 2023.

PPPL Environmental Achievements and Activities in 2022

PPPL was recognized by the Global Electronics Council with an Electronic Product Environmental Assessment Tool (EPEAT) Purchaser Award for the acquisition of sustainable electronics for the ninth year in a row.

PPPL encourages its employees to practice environmental stewardship principles in their daily lives through their personal purchases and recycling activities as well as at work. Each year, the Laboratory hosts events such as Earth Week in April and America Recycles Day (ARD) in November when information on green products and recycling opportunities are provided. PPPL's "Green Team" designs programs and activities to help green PPPL and the whole community.

PPPL has maintained an Environmental Management System (EMS) program registered to the International Organization for Standardization (ISO) 14001 Standard since 2012. Registration to the ISO14001 Standard requires annual audits by an independent audit and registration firm. PPPL's EMS was first registered against the 2015 version of ISO14001 in 2016 and completed annual surveillance audits in 2017 and 2018. The recertification audit was delayed until 2020 to competitively bid the subcontract for EMS audit and registration services and was delayed once again due to curtailed operations stemming from the global coronavirus pandemic. In May 2021, PPPL was recertified to the ISO-14001:2015 standard, and an annual audit was completed in May 2022.

The Laboratory continues to promote all aspects of its environment, safety, and health (ES&H) program as it has in its fusion research program. Efforts are geared not only toward full compliance with applicable local, state, and federal regulations but also to achieve a level of excellence in ES&H performance. PPPL is an institution that serves other research facilities and the nation by providing valuable information gathered from its fusion research program.

Chapter 1

The DOE Princeton Plasma Physics Laboratory is a Collaborative National Center for plasma and fusion science. Its primary mission is to develop the scientific understanding and the key innovations which will lead to an attractive fusion energy source. Associated missions include conducting world class research along the broad frontier of plasma science and technology, while providing the highest quality of scientific education. These aims are embodied in our vision statement:

"Enabling a world powered by safe, clean and plentiful fusion energy while leading discoveries in plasma science and technology."

INTRODUCTION

1.1 Site Mission

The DOE's PPPL is a collaborative national center for fusion energy science, basic sciences, and advanced technology. The Laboratory has four major missions: (1) developing clean energy for all; (2) building innovative technologies, (3) contributing to a sustainable future, and (4) exploring the universe and beyond.

The National Spherical Torus Experiment Upgrade (NSTX-U) is a collaborative project among 30 U.S. laboratories, including DOE National Laboratories, universities, and institutions, and 28 international institutes from 11 countries. Also located at PPPL are smaller experimental devices, the Magnetic Reconnection Experiment (MRX), the Lithium Tokamak Experiment (LTX), and Hall Thruster, which investigate plasma physics phenomena. The next generation MRX device, the Facility for Laboratory Reconnection Experiment (FLARE) arrived at PPPL in August 2019 and is currently scheduled to be operational in late 2024.

As a part of both off and on-site collaborative projects, PPPL scientists assist fusion programs within the United States and in Europe and Asia. To further fusion energy and plasma science and technology, PPPL collaborates with other research laboratories across the globe on experiments including the Joint European Torus (JET) facility located in the United Kingdom, the Korean Superconducting Tokamak Advanced Research (KSTAR) facility located in South Korea, and the International Thermonuclear Experimental Reactor or ITER, which in Latin means "The Way," located in Cadarache, France. PPPL's main fusion experiment, the National Stellarator Tokamak Experiment Upgrade (NSTX-U), began in 2011 and was completed in May 2016. After a successful inauguration, it was taken offline to perform additional renovations, which are projected to be completed in the next few years.

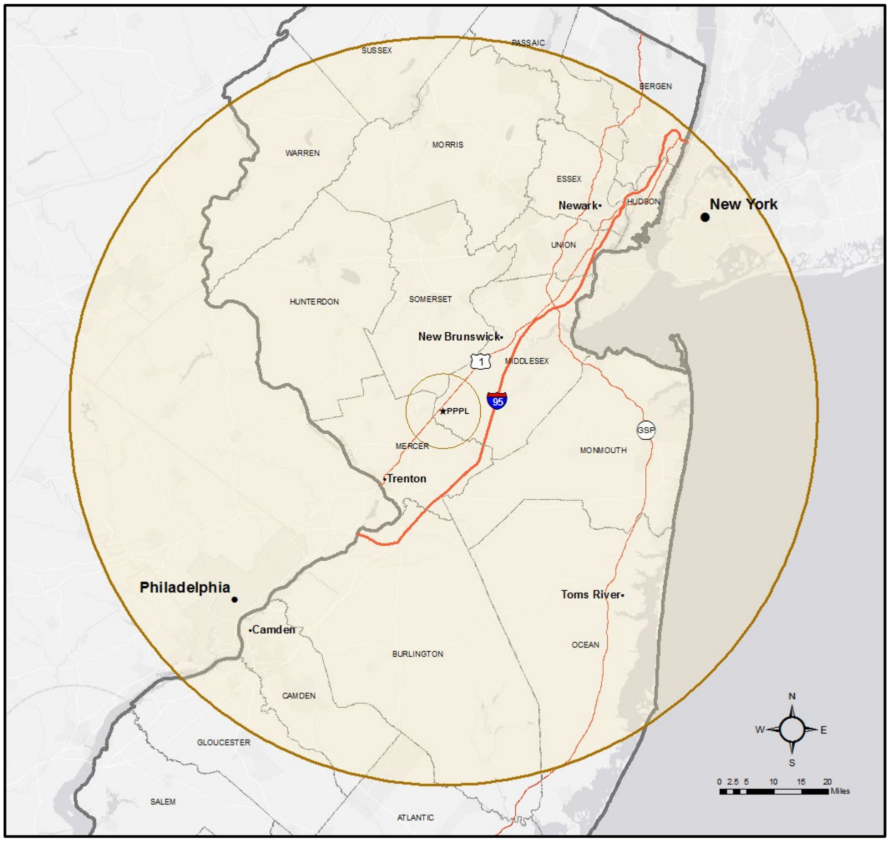
Following the impacts of the coronavirus pandemic, PPPL continued a cautious and purposeful return of on-site work activities in 2021 and into 2022 creating a new "normal" and implemented a phased return to normal operations based on public health conditions. A new "normal" work arrangement was established at PPPL to make sure that all staff are supported and connected no matter where they work. Three types of work arrangements were established: on-site, hybrid, and remote. This revolution transpired because staff population started to outgrow the available workspace, due to the reorganization of C-site working locations to make way for the new PPIC building. Additionally, flexible work arrangements enable PPPL to attract top talent regardless of location. These new arrangements are projected to enable on-site and collaborative research with minimal disruption PPPL's missions.

1.2 Site Location

The PPPL site is in the center of a highly urbanized Northeastern region. The closest urban centers are New Brunswick, 14 miles (22.5 km) to the northeast, and Trenton, 12 miles (19 km) to the southwest. Within a 50-mile (80 km) radius are the major urban centers of New York City, Philadelphia, and Newark (Exhibit 1-1).

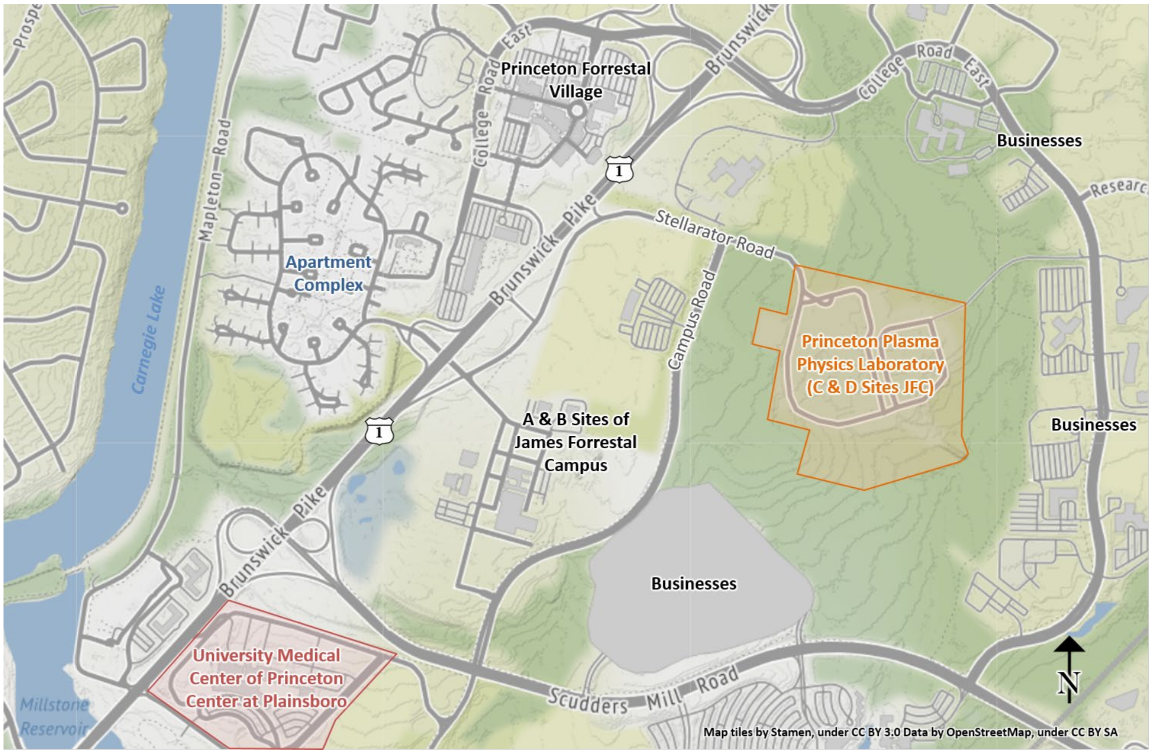
The site is in Plainsboro Township in Middlesex County (central New Jersey), adjacent to the municipalities of Princeton, Kingston, East and West Windsor, and Cranbury, New Jersey (NJ). The Princeton area continues to experience a sustained growth of new businesses located along the Route 1 corridor near the site. The Penn Medicine Princeton Medical Center at Plainsboro is located less than 2 miles Southwest of PPPL (Exhibit 1-2). Princeton University's main campus is approximately three miles Southwest of the site.

Exhibit 1-1. Region Surrounding PPPL (50-mile radius shown)



PPPL, then known as "Project Matterhorn", was first established on A- and B- sites of the James Forrestal Campus (JFC), Princeton University's research center named for Princeton graduate (Class of 1915) and the first Secretary of Defense, James Vincent Forrestal. Located east of U.S. Route 1 North, PPPL has occupied the C- and D-site location of JFC since 1959 (Exhibit 1-2). The alphabet designation was derived from the names of the Stellarator models, which were early plasma fusion devices.

Exhibit 1-2. PPPL James Forrestal Campus (JFC), Plainsboro, NJ



Surrounding the site are lands of preserved and undisturbed areas including upland forest, wetlands, open grassy areas, and a minor stream, Bee Brook, which flows along PPPL's eastern boundary. These areas are designated as open space in the JFC site development plan.

D-site is fully surrounded by a chain-linked fence for safety purposes. Access to D-site is limited to authorized personnel using card readers. PPPL's Site Protection Division controls access to C-site allowing the public and visitor access following an identification check. Vehicle inspections may occur prior to entrance.

Exhibit 1-3. Aerial View of PPPL

The aerial photo above (Exhibit 1-3) shows the general layout of the facilities at the C-sites and D-sites as viewed from the North; the former TFTR and current NSTX-U Test Cells are located at D-site (on the left side of the photo).

1.3 General Environmental Setting

The climate of central New Jersey is classified as a mid-latitude, rainy climate with mild winters, hot summers, and no dry season. In 2022, temperatures ranged from 4 degrees to 98 degrees Fahrenheit (°F) (-15.64 degrees Celsius [°C] to 36.7° C); representing an average departure from normal temperature (1981-2010) of -2.4° F (-16.4° C) according to National Oceanic and Atmospheric Administration (NOAA) local climatological data. Extreme temperatures typically occur once every five years. Approximately half the year, from late April until mid-October, the days are freeze-free [NOAA].

The typical regional climate is moderately humid with a total average precipitation of about 46.4 inches evenly distributed throughout the year. In 2022, the total rainfall for the year was 43.87 inches (111.43 centimeters [cm]), or 2.63 inches (6.68cm) below the average for the region.

The most recent archaeological survey was conducted in 1978 as part of the TFTR site environmental assessment study. Through historical records reviews, personal interviews, and field investigations, one projectile point and a stone cistern were found. The site had limited occupation during prehistoric times and has only in recent times been actively used for farming. No significant archeological resources were identified on-site. There are more significant examples of prehistoric occupation in areas closer to the Millstone River, which are within two miles of the site [Gr77].

Plans for the construction of the PPIC include the demolition of the Administration Building and Theory Wing. The Administration Building is original to the development of the Laboratory and, thus, is subject to the National Historic Preservation Act (NHPA). NHPA regulations require evaluation of public historical and cultural resources and coordination with the applicable State Historic Preservation Office (SHPO). In 2020 PPPL engaged a firm specializing in preservation architecture and historical resource management to assist with the evaluation of PPPL's historical buildings and the development of management plans to address NHPA requirements It was determined that the proposed demolition of the Admin and Theory buildings would have adverse impacts to National Register eligible resources. To comply with NHPA Section 106, PPPL subcontracted with an architectural and historic preservation firm in 2022 to complete historical documentation, preservation, and public outreach consulting services and provide Historical American Buildings Survey (HABS) Level III documentation, development of a Public Outreach Plan, and for continued support for SHPO, public, and tribal consultations.

1.4 Primary Operations and Activities

Several magnetic fusion experiments, including NSTX-U, MRX, and LTX, currently operate at PPPL. NSTX-U is the Laboratory's largest experiment and is located on D-site. The original NSTX experiment produced one million amperes of plasma current, setting a new world record for a spherical torus device. This device was designed to test the physics principles of spherical-shaped plasmas forming a sphere with a hole through its center. Plasma shaping is an important parameter for plasma stability and performance enabling viable fusion power. NSTX ceased operations in 2011 and was partially dismantled for major upgrades and renamed NSTX-U, which was finished in May of 2016. The new machine was operational for two months, until one of the coils failed when operations were ceased for repairs. The failed coil led to a full-scale investigation of the NSTXU's hundreds of intricate parts. Along the way, PPPL engineers determined other upgrades, improvements, and replacements that could make the machine more powerful, efficient, and precise. Today, the NSTX-U recovery project is now 76% complete. NSTX-U has twice the plasma heating power and magnetic confinement as the original experiment and will be able to extend plasma pulse duration by five times.

LTX continues to explore new paths for plasma energy efficiency and sustainability, after producing its first plasma in 2008. The primary goal of LTX is to investigate the properties of a lithium liquid coating for plasma surfaces or plasma-facing components (PFC). The previous experiment, Current Drive Experiment-Upgrade (CDX-U) held the lithium in a circular tray at the base of the vacuum vessel. The LTX liquid lithium was evaporated and deposited a thin layer inside the vacuum vessel and kept liquid by the heater in the shell. LTX-beta (LTX-β), an upgrade incorporating a new beam line, went online on April 30, 2019. As of August 1, 2022, LTX-β results have been promising and may lead to more extensive use of lithium in NSTX-U.

PPPL also coordinates a national program to unify research on liquid metal for future tokamaks and has conducted liquid metal experiments on tokamaks in Europe and Asia.

PPPL's MRX investigates the explosive process of magnetic reconnection, giving rise to astrophysical events that include auroras, solar flares, and geomagnetic storms. The process occurs when the magnetic field lines in plasmas break and violently reconnect. Generating and studying reconnection under controlled laboratory conditions can yield insights into solar outbursts and the formation of stars and greater control of experimental fusion reactions.

1.5 Relevant Demographic Information

Data derived from the U. S. Economic Development Administration shows an estimated 19 million people are living within a 50-mile radius of the laboratory, totaling 2,425 people per square mile. The 2020 United States (US) Census Bureau reported that Middlesex County has a population of 863,162. Adjacent counties have populations of 387,340 (Mercer), 643,615 (Monmouth), 345,361 (Somerset), and 575,345 (Union) [US21]. Other information gathered and updated from previous studies, conducted for TFTR, include socioeconomic information [Be87b] and an ecological survey, which were studies describing pre-TFTR conditions [En87].

Chapter 2

PPPL environmental goals are to fully comply with environmental regulations, to conduct our scientific research and operate our facilities in a manner protective of human health and the environment, and to promote sustainable practices wherever practicable. In 2022, PPPL accomplished these goals while operating within its permitted limits as documented in the following chapter. In addition, PPPL promotes good environmental practices through its Earth Day and America Recycles Day activities for its employees.

ENVIRONMENTAL COMPLIANCE SUMMARY AND ENVIRONMENTAL STEWARDSHIP

PPPL initiates actions that enhance and document compliance with these requirements. Compliance with applicable federal, state, and local environmental statutes or regulations, and Executive or DOE Orders is an important element of PPPL's primary mission.

2.1 Laws and Regulations

Exhibit 2-1 summarizes the environmental statutes and regulations applicable to PPPL's activities, as well as summarizes the 2022 compliance status and provides the Annual Site Environmental Report (ASER) sections where further details are located. The list of "Applicable Environmental Laws and Regulations – 2022 Status" conforms to PPPL's EMS Appendix B, "Summary of Legal and Other Requirements" [PPPL22a].

2.2 Site Compliance and Environmental Management System (EMS) Assessments

PPPL maintains the registration of its Environmental Management System (EMS) to the International Standard Organization ISO-14001:2015. A Stage 1 transition registration audit to a new independent registrar was scheduled for early 2020 but was postponed due to pandemic-related curtailment of onsite operations. The Stage 1 audit was conducted in May 2021 to reestablish PPPL to the ISO-14001:2015 standard. One minor nonconformance was found in that audit, which did not impact registration of PPPL's EMS. A surveillance audit was completed in May 2022, no findings were reported. Further discussion of the EMS program audits follows in Section 2.3 of this chapter [Cum23, ISO15, UL20].

2.3 Environmental Permits

The following Exhibit 2-1 "Applicable Environmental Laws and Regulations – 2022 Status" provides information about PPPL's compliance with applicable Federal and State environmental laws, regulation, DOE, and Executive Orders (EOs).

Exhibit 2-1. Applicable Environmental Laws and Regulations – 2022 Status

Environmental Restoration and Waste Management	2022 Status	ASER section(s)
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) provides the regulatory framework for identification, assessment, and if needed remediation of contaminated sites – either recent or inactive releases of hazardous waste (Also see Superfund Amendments Reauthorization Act under NJ Emergency Planning and Community Right-to-Know [EPCRA]).	The CERCLA inventory completed in 1993 [Dy93] warranted no further CERCLA actions. During 2022, PPPL was not involved in CERCLA-mandated clean-up actions. An on-going New Jersey-regulated ground water remediation project is discussed in Chapters 4 and 6.	*4.3.1 B* *6.5*
Resource Conservation and Recovery Act (RCRA) regulates the generation, storage, treatment, and disposal of hazardous wastes. RCRA also includes underground storage tanks containing petroleum and hazardous substances, universal waste, and recyclable used oil. (NJ-delegated program)	In 2022, PPPL shipped 16.2 tons of combined hazardous, universal, and Toxic Substance Control Act (TSCA) waste, of which 7.1 tons were recycled. The types of waste are highly variable each year; in 2022, incinerated quantities were classified in several hazard classes [San23a].	*4.2.1 B* *4.2.1 C*
Federal Facility Compliance Act (FFCA) requires the DOE to prepare "Site Treatment Plans" for the treatment of mixed waste, which is waste containing both hazardous and radioactive components.	In 1995, PPPL prepared a Preliminary Site Treatment Plan (PSTP). PPPL does not, nor does not expect to generate mixed waste in the future. An agreement among the regulators was reached to treat in the original accumulation container any potential mixed waste [PPPL95].	
National Environmental Policy Act (NEPA) covers how federal actions may impact the environment and an examination of alternatives to those actions	In 2022, PPPL performed NEPA reviews of twelve proposed activities. All these activities were determined to be categorical exclusions (CXs) in accordance with the regulations/guidelines of the Council on Environmental Quality (CEQ) [Str23].	
Toxic Substance Control Act (TSCA) governs the manufacture, use, and distribution of regulated chemicals listed.	In 2022, PPPL shipped 1,080 pounds of polychlorinated biphenyls (PCB) TSCA Hazardous Substances, which consisted of capacitors, ballast, and radio frequency (RF) filters. There were not any asbestos waste shipments in 2022 [San23a].	*4.2.1A*
Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) regulate the user and application of insecticides, fungicides, and rodenticides. (NJ-delegated program)	PPPL used limited quantities of pesticides/insecticides, herbicides, and fertilizers. A licensed subcontractor performs the application under the direction of PPPL's Facilities personnel [Kin23b].	*Exhibit 4-11* *4.5.3*
Oil Pollution Prevention provides the regulatory requirements for a Spill Prevention Control and Countermeasure (SPCC) Plan for petroleum-containing storage tanks and equipment.	The SPCC plan was reviewed and updated in 2016 [PPPL16a]. PPPL does not meet the threshold quantity of 200,000 gallons of petroleum (excluding transformer oil) for the requirements of a Discharge Prevention Control and Containment (DPCC) plan. PPPL experienced two reportable spills in 2022 [San23b].	*4.3.1*

Exhibit 2-1. Applicable Environmental Laws and Regulations – 2022 Status (continued)

Other Environmental Statutes	2022 Status	ASER section(s)
National Historic Preservation Act (NHPA) and New Jersey Register of Historic Places protect the nation and New Jersey's historical resources through a comprehensive historic preservation policy.	The Delaware & Raritan (D&R) Canal and the area within 100 yards are designated as National and New Jersey Historic Districts. PPPL's canal pump house is located within this historic district. [PPPL05]. In 2022 PPPL subcontracted experienced architectural and historic preservation firms to provide Historical American Buildings Survey (HABS) Level III documentation, development of a Public Outreach Plan, and for continued support for SHPO, public, and tribal consultations, to comply with NHPA Section 106 and the MOA between NJ Historic Preservation Office, DOE, PPPL, and Princeton University.	
EO 11988 Floodplain Management Programs covers the delineation of the 100- and 500-year floodplain and the prevention of development within the floodplain zones. (NJ-delegated program)	The 100- and 500-year floodplains are at 80 and 85 feet above mean sea level (msl), respectively. The majority of the PPPL site is located 100 feet above msl. The hazardous material storage building is in the flood hazard zone but is protected by concrete dikes [New Jersey Department of Environmental Protection (NJDEP)84].	
EO 11990 Protection of Wetlands; Wetlands Protection Act governs the activities that are allowable through the permitting system and mitigation requirements. (NJ-delegated program)	In 2015, PPPL and Princeton Forrestal Center received the wetlands delineation from NJDEP. Any regulated activities either in the wetlands or transition areas must receive approval prior to commencement [PPPL15b]. No new wetlands or transition area permits were required in 2022.	*4.5.1*
Clean Air Act (CAA) and New Jersey Air Pollution Control Act controls the release of air pollutants through permit and air quality limits and conditions. **National Emission Standards for Hazardous Air Pollutants (NESHAPs)** Environmental Protection Agency (USEPA) regulates the NESHAPs program for tritium (an airborne radionuclide) and boilers (<10 million BTUs). Greenhouse gas (GHG) emissions inventory tracking and reporting are regulated by EPA.	PPPL-DOE maintains air certificates/permits for the regulated equipment: 4 boilers, 4 emergency/standby generators (combined into a single permit), 1 dust collector, and a fluorescent bulb crusher. Two previous above-ground storage tank permits (< 10,000 gallons fuel oil) were canceled following guidance from an NJDEP inspection. PPPL is designated as a synthetic minor emitter and does not exceed air contaminant thresholds requiring a Title V permit. In 2022, PPPL prepared for the biennial boiler adjustment but was not requested by the delegated authority as described in 40 CFR Part 63, Subpart JJJJJJ. The annual 2021 boiler adjustment	*4.4*

Exhibit 2-1. Applicable Environmental Laws and Regulations – 2022 Status (continued)

	results were completed as required by the permit. Fuel consumption sulfur content for the generators and boilers are recorded; annual boiler emissions are calculated [Rog23b]. NESHAPs reports for tritium emissions are submitted annually [PPPL21b]. PPPL maintains an inventory of ozone-depleting substances (ODS) [Hug23e].	
NJ Soil Erosion and Sediment Control (SESC) Plan requires approval by the Freehold Soil Conservation District for any soil disturbance greater than 5,000 square feet.	No projects required soil erosion permits in 2022.	*4.5.2*

Other Environmental Statutes	2022 Status	ASER section(s)
NJ Comprehensive Regulated Medical Waste Management governs the proper disposal of medical wastes.	The last report was submitted to NJDEP in 2004. PPPL is no longer required to submit reports but continues to comply with the proper disposal of all medical wastes [San22b].	
NJ Endangered Species Act prohibits activities that may harm the existence of listed threatened or endangered species.	No endangered species were reported on PPPL or D&R Canal pump house sites. Cooper's hawks and Bald eagles have been sited within 1 mile; other endangered species, like the bog turtle, have been sighted in surrounding municipalities. [Am98, NJB97, NJDEP97, PPPL05].	
NJ EPCRA and Superfund Amendments Reauthorization Act (SARA Title III) require certain toxic chemicals emergency planning information, hazardous chemical inventories, and the reporting of environmental releases to federal, state, and local authorities.	PPPL submitted the required annual chemical inventory reports [Ger23].	*4.3.1 C* *Exhibit 4-7* *Exhibit 4-8*
NJ Regulations Governing Laboratory Certification and Environmental Measurements mandate that all required water analyses be performed by certified laboratories.	The PPPL Environmental, Analytical, and Radiological Laboratory (PEARL) maintained NJDEP certification for analyze immediately parameters. In May 2022, PPPL passed proficiency tests (PT) for pH and temperature but failed for total residual chlorine (chlorine-produced oxidants [CPO]) due to scheduling errors. The Environmental Services Division (ESD) implemented a corrective action to fix this problem. In September 2022, PPPL failed a second proficiency test. It was determined there were technical flaws in the calibration process. Corrective actions were implemented to rectify these deficiencies. In November 2022, a settlement agreement	*7*

	between PPPL and the NJDEP granted PPPL a third and final opportunity to pass a proficiency test for the year. After implementing the corrective actions of the previous two failed attempts, following manufacturer instructions, and internal calibration procedures, PPPL received acceptable total residual chlorine. In 2022, PPPL used the CPO method to analyze peracetic acid (PAA) because their results are proportional. PPPL's subcontracted analytical laboratory is a NJDEP-certified laboratory [PPPL23e].	

Exhibit 2-1 Applicable Environmental Laws and Regulations – 2022 Status (continued)

Water Quality and Protection	2022 Status	ASER section(s)
J **Safe Drinking Water Act (SDWA)** protects the public water supply by criteria standards and monitoring requirements.	PPPL conducts quarterly inspections of the potable water physical cross-connection system as required by the NJDEP permit. Potable water is supplied by NJ American Water Company [Sta23].	*4.1.4 A* *Exhibit 4-4*
Stormwater Management and the Energy Independence and Security Act of 2007 (EISA) & **D&R Canal Commission Regulations (Stormwater Water Quality)**	PPPL's Stormwater Pollution Prevention Plan (SWPPP) was revised in 2019, it provides guidance to reduce the impact of PPPL's operations on storm water quality [PPPL23c]. PPPL maintains stormwater best management practices structures such as rain gardens, grassed swales, vegetated cover, and a permitted retention basin.	
Clean Water Act (CWA) and NJ Pollution Discharge Elimination System (NJPDES) regulate surface and ground water (lined surface impoundment, LSI) quality by permit requirements and monitoring point source discharges.	In 2019, PPPL-DOE received from NJDEP the final NJPDES surface water discharge permit [NJDEP20]. PPPL completed its transition to PAA as a substitute for chlorine disinfection for industrial water and this parameter was added to PPPL's discharge monitoring program. In 2021, PPPL did not have any nonconformances. PPPL monitors sample point discharge serial number (DSN) - DSN003, known as the D&R Canal pump house backwash filter outfall.	*4.1.1* *Exhibits 4-1, 4-2, 4-3 and 4-5*
NJ Technical Standards for Site Remediation governs the soil/ground water assessments, remedial investigations, and clean-up actions for sites suspected of hazardous substance contamination.	PPPL began an investigation for the presence of chlorinated solvent chemicals in ground water in 1990. Over time, more than 20 monitoring wells were installed on-site to determine the contamination source and extent of the plume. Quarterly sampling of 9 wells and 1 sump is collected, and annual sampling of 12 wells and 2 sumps are collected in March with the results reported biennially to NJDEP under a Ground water Remedial Action Permit. In late 2019, PPPL closed 11 wells that were no longer being used.	*6.5*
EO 11988 – Floodplain Management & **EO 11990 – Protection of Wetlands**	See Floodplain Management Program (NJ delegated program) & Wetlands Protection Act (NJ delegated program)	

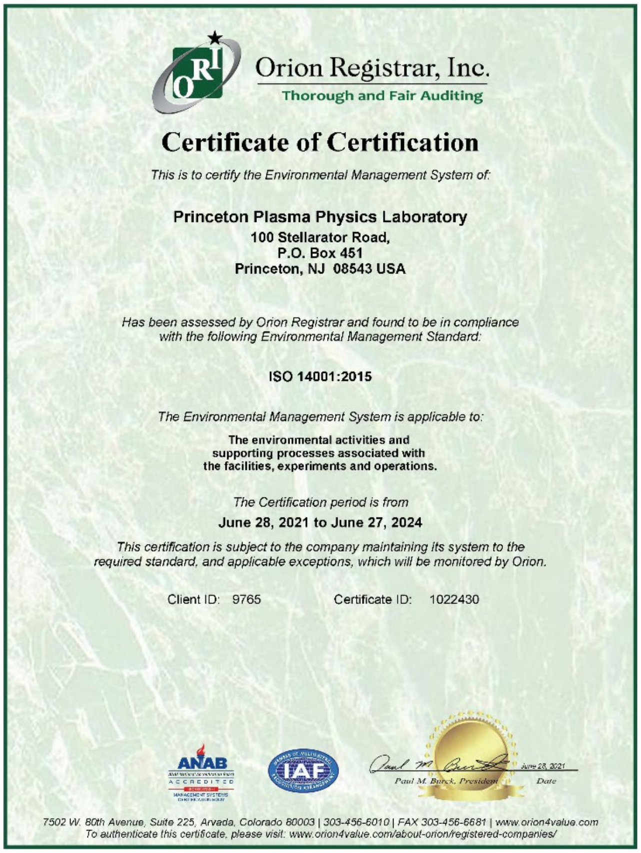
Exhibit 2-1 Applicable Environmental Laws and Regulations – 2022 Status (continued)

Regulatory Program Description	2022 Status	ASER section(s)
Migratory Bird Treaty Act DOE's 2013 Memorandum of Understanding and E.O. 13186, Responsibilities of Federal Agencies to Protect Migratory Birds states that actions are taken to protect migratory birds and conduct community outreach.	In 2022, PPPL took no migratory birds nor conducted any programs or actions that called for activities such as banding, marking, scientific collection, taxidermy, and/or depredation control.	
DOE Order 231.1B, *Environment, Safety, and Health Reporting*, requires the timely collection, analysis, reporting, and distribution of information on ES&H issues.	PPPL ES&H Department monitors/reports on environmental, safety, and health data and distributes the information via lab-wide e-mails, PPPL news articles, weekly Laboratory Management, DOE-Site Office, and staff meetings, and periodic ES&H Executive Board/sub-committees/Lab-wide meetings [DOE11c]. PPPL's ASER is required by this order.	
DOE Order 436.1, *Departmental Sustainability*, requires all applicable DOE elements to implement an ISO14001-compliant EMS and support departmental sustainability goals.	PPPL's EMS was originally developed in 2005 and is reviewed and updated periodically [DOE11a, PPPL16b, & 16c]. PPPL's EMS registration to the ISO14001:2015 standard lapsed in 2020 due to the transition to a new independent registrar and the need to delay on-site audits due to the coronavirus pandemic. Registration was re-established in May 2021.	*3*
DOE Order 435.1, Change 1, *Radioactive Waste Management*, provides guidance to ensure that DOE radioactive waste is properly managed to protect workers, the public, and the environment.	PPPL maintains a Low-Level Radioactive Waste Program Basis document to meet the requirements of DOE Order 435.1 and enable shipments to the Energy Solutions disposal facility in Clive, UT. Approval to ship to Energy Solutions was granted by DOE in July 2012 [DOE01, PPPL12].	*5.1.3*
DOE Order 458.1, *Radiation Protection*, provides protection of the public and the environment from exposure to radiation from any DOE facility. Operations and its contractors comply with the standards and requirements in this Order.	PPPL's policy is to maintain all radiation exposures "As Low as Reasonably Achievable" (ALARA). PPPL implements its radiation protection program as discussed in the Environmental Monitoring Plan Section 6, "Radiological Monitoring Plan." PPPL's contribution to radiation exposure is well below the DOE and PPPL limits [10 Code of Federal Regulations (CFR) 835, DOE01, DOE11b, PPPL13]	*5.1* *Exhibit 5-1*

Exhibit 2-1 Applicable Environmental Laws and Regulations – 2022 Status (continued)

Radiation Protection	2022 Status	ASER section(s)
Atomic Energy Act (AEA) governs plans for the control of radioactive materials	PPPL's "Nuclear Materials Control and Accountability (MC&A) Plan" describes the control and accountability system of nuclear material at PPPL. This plan provides a system of checks and balances to prevent/detect unauthorized use or removal of nuclear material from PPPL [PPPL13].	*5.2*
EO 13834, *Efficient Federal Operations* requires all Federal agencies to meet energy and environmental performance statutory requirements in a manner that increases efficiency, optimizes performance, eliminates unnecessary use of resources, and protects the environment.	PPPL reported through DOE Dashboard the fiscal year (FY) 2022 site sustainable data that addressed the goals, targets, and status of EO requirements [PPPL16c, PPPL18c].	*3*

2.4 External Oversight and Assessments



Orion Registrar, Inc.
Thorough and Fair Auditing

Certificate of Certification

This is to certify the Environmental Management System of:

Princeton Plasma Physics Laboratory
100 Stellarator Road,
P.O. Box 451
Princeton, NJ 08543 USA

Has been assessed by Orion Registrar and found to be in compliance with the following Environmental Management Standard:

ISO 14001:2015

The Environmental Management System is applicable to:

The environmental activities and supporting processes associated with the facilities, experiments and operations.

The Certification period is from
June 28, 2021 to June 27, 2024

This certification is subject to the company maintaining its system to the required standard, and applicable exceptions, which will be monitored by Orion.

Client ID: 9765 Certificate ID: 1022430

Paul M. Burck, President *Date*

7502 W. 80th Avenue, Suite 225, Arvada, Colorado 80003 | 303-456-6010 | FAX 303-456-6681 | www.orion4value.com
To authenticate this certificate, please visit: www.orion4value.com/about-orion/registered-companies/

Exhibit 2-2 EMS ISO 14001:2015 Certificate

In 2016, the International Organization for Standards (ISO) revised the EMS Standard as stated on their website:

ISO 14001:2015 helps an organization achieve the intended outcomes of its environmental management system, which provide value for the environment, the organization itself and interested parties. Consistent with the organization's environmental policy, the intended outcomes of an environmental management system include:

- *enhancement of environmental performance*
- *fulfilment of compliance obligations*
- *achievement of environmental objectives* [ISO15]

In November 2017, the Laboratory's EMS program underwent a comprehensive audit for re-certification issued by DQS-UL for the new ISO-14001 Certificate on January 4, 2018. The annual surveillance audit of PPPL's EMS against the International Standard Organization ISO-14001:2015 was completed in November 2018. A follow-up audit in February 2019 addressed all corrective actions from the 2018 audit and extended PPPL's ISO-14001 certificate. The transition to a new independent registrar was scheduled for early 2020 but was postponed due to pandemic-related curtailment of onsite operations. In May 2021, Orion Registrar, Inc. performed an initial certification audit of PPPL's EMS program against the ISO14001:2015 standard. During that audit, one minor nonconformance was found for several document revisions being past their three-year review cycle, which was corrected in 2022. The ISO-14001:2015 certificate was issued by Orion on May 24, 2021. An external surveillance audit was completed by Orion in May 2022, which resulted in no findings.

2.5 Emergency Reporting of Spills and Releases

Under New Jersey regulations, PPPL is required to call the Action Hotline to report any permit limits that are exceeded. There were two reportable incidents in 2022. On April 10, 2022, there was a 1-gallon B-20 biodiesel fuel leak from a stake body truck in a paved parking lot. On April 22, 2022, a high-reach forklift on a gravel area leaked 1 gallon of hydraulic oil. Both incidents were remediated and documented under NJDEP's Site Remediation Regulations [San22b].

2.6 Notice of Violations and Penalties

In 2022, there were no penalties or Notices of Violations (NOVs) for environmental occurrences at PPPL. The EPA tracks compliance with environmental regulations with Enforcement and Compliance History Online (ECHO). This system indicates that PPPL had violations in each quarter of 2022. PPPL continues to work with DEP and EPA to clarify and correct historic and current ECHO information.

2.7 Green and Sustainable Remediation (GSR)

The requirements of E.O. 13990 and DOE's 2021 Sustainability Report and Implementation Plan advocate green and sustainable remediation (GSR) practices [EO20, DOE21]. Currently, PPPL's remediation program is monitoring ground and surface water for contaminants and does not include treatment or remediation actions (See Ch. 4 and 6).

2.8 Adapting to Climate Change

As a relatively small facility in a temperate climate, PPPL is prepared for local weather events addressed in the latest PPPL Vulnerability Assessment and Resiliency Plan (VARP). On-site and nearby severe weather events/risks are identified, and the emergency planning and communication processes are adapted to be better prepared and able to respond [PPPL22c].

2.9 Environmental Justice

The DOE Office of Legacy Management defines environmental justice as, "the fair treatment and meaningful involvement of all people, regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies." PPPL is located within an overburdened community (OBC), as defined by the NJDEP's EJMAP tool. The community stressor level, which tabulates 26 environmental and public health stressors for all of New Jersey's block groups, is higher than the 50th percentile, which is likely due to the proximity of U.S. Rte. 1. PPPL's NEPA process evaluates every project's environmental impact on their potential to cause disruption to the surrounding

Exhibit 2-3 Earth Week 2022

earth week

community. PPPL works with local and state agencies to prevent an environmental imbalance within our local area. These considerations help to minimize additional environmental and public health stressors to the Lab's neighbors.

2.10 Environmental Stewardship

2.10.1 Earth Day at PPPL

On April 28, 2022, employees participated in hybrid celebration of Earth Day. The event focused on PPPL's sustainability efforts and recognized staff members who go above and beyond to recycle and reuse at work and at home. It ended with a presentation by guest speaker Ijeoma Nwagwu, Assistant Director for Sustainability at Princeton University, with a discussion on Princeton University's Sustainability Program. PPPL also asked employees to submit pictures of sustainable practices they are doing at home, some of the entries are shown in Figure 2-3. Another activity PPPL was able to reestablish after the pause due to the pandemic, was holding a site-wide grounds cleanup. As PPPL moves past the effects of the COVID-19 pandemic, the laboratory is excited to have more activities as it has in past Earth Day celebrations, like an electronics collection, clothing drives, and in-person presentations.

Each year, employees nominate their co-workers for their exceptional efforts to minimize waste, improve energy efficiency, and promote sustainable practices at PPPL. Forty (40) employees received the 2022 PPPL Green Machine Awards for the following projects:

- Reusing and recycling
- Going paperless and creating electronic workflows
- Using green products and green product purchasing
- Implementing sustainable practices at home

Exhibit 2-4 Earth Day Event

2.10.2 America Recycles Day at PPPL

Each year PPPL celebrates ARD (officially November 15th). On November 17, 2022, PPPL's Green Team, volunteers who promote recycling within their departments, hosted a hybrid celebration of ARD. The theme for ARD in 2022 was 'Zero Waste' and this brought the message of a cradle-to-cradle supply chain to light. This showed staff members recycling efforts at work and at home and a presentation on recycling given by Keynote speaker Amy Marpman, Director of Sustainability at SBM Management, whose message was reducing waste is a matter of changing processes. She also highlighted that PPPL is above standard when it comes to recycling, from having clear waste signage to initiatives for staff education, such as the America Recycles Day event. Another activity the Green Team organized was "caught green handed", where employees are recognized and awarded on the spot for doing sustainable things like using reusable food and drink containers or sorting waste correctly. Members of PPPL's Green Team also participated in a dumpster dive to evaluate how well staff recycle. The results found that PPPL staff are not often throwing recyclables into the trash, with only 2% of the trash being recyclable material. However, staff members were less vigilant when it came to recycling, with 11% of recycling content containing trash.

Exhibit 2-5. America Recycles Day

2.10.3 Environmental Awards

In 2022, PPPL received an EPEAT purchaser award for over 97% EPEAT purchase rate.

Chapter 3

The DOE Princeton Plasma Physics Laboratory maintains a formal Environmental Management System (EMS) which is registered under the ISO14001 international standard. ISO registration requires regular audits of the EMS by a qualified independent registration firm. Information on PPPL's environmental management programs is accessible online for employees and the public.

ENVIRONMENTAL MANAGEMENT SYSTEM

PPPL continues to make incremental progress toward the sustainability goals established by Presidential EOs and DOE Order 436.1 by integrating sustainability goals into its site-wide EMS. Since 2005, PPPL has focused on improving the sustainability of Laboratory operations and improving environmental performance. The "Sustainable PPPL" program capitalized on PPPL's existing EMS to move the Laboratory toward more sustainable operations. The EMS includes energy management, water conservation, renewable energy, GHG management, waste minimization, environmentally preferable purchasing, and facility operation programs to reduce environmental impacts and improve performance [PPPL22a]. PPPL will continue to proactively implement sustainability practices aimed at meeting, or exceeding, the sustainability goals in its EMS, DOE Orders, and EOs, while supporting its global research mission.

PPPL transitioned to a new ISO registrar beginning in late 2019. Auditors from Orion Registrar, Inc. conducted a Stage 1 Registration Audit of PPPL's EMS against the International Standard Organization ISO-14001:2015 in February 2020. The Stage 2 Registration Audit was postponed due to the pandemic until May 2021. In May 2021, Orion Registrar, Inc. performed the transition registration audit PPPL's EMS program against the ISO14001:2015 standard. During that audit, one minor nonconformance was found for several document revisions being past their three-year review cycle, which was corrected in 2022. The ISO-14001:2015 certificate was issued by Orion on May 24, 2021. A surveillance audit was completed by Orion in May 2022, no findings were reported.

3.1 DOE Sustainability Goals

In 2022, PPPL continued to address the energy, water, and environmental management goals from previous EOs and EO 13990, Climate Crisis; Efforts to Protect Public Health and

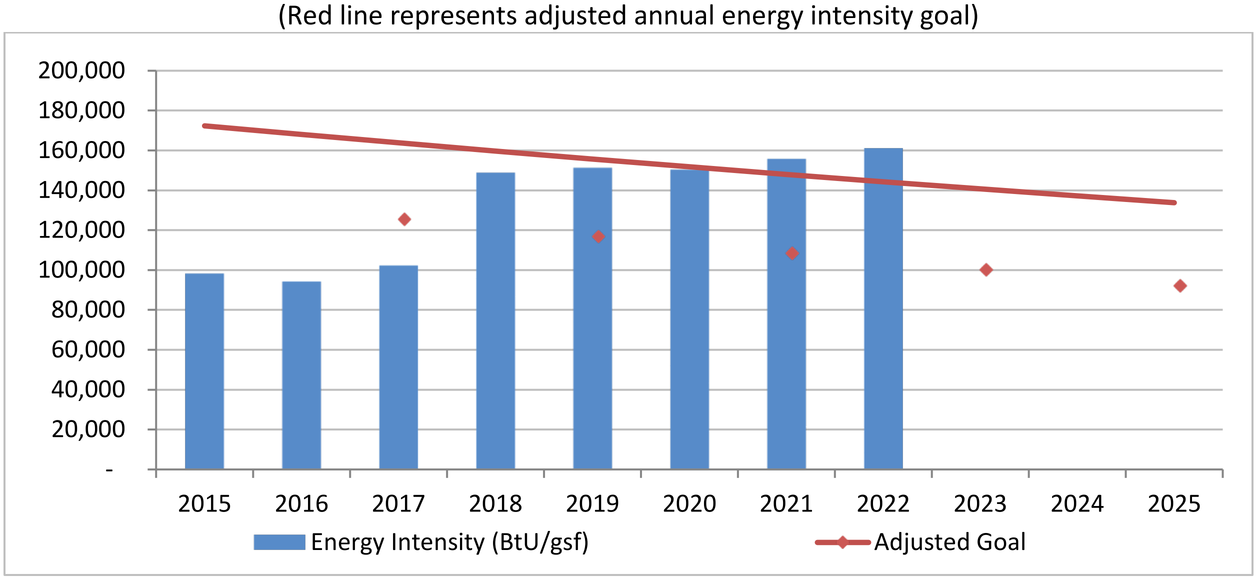
Environmental and Restore Science. PPPL completed its annual sustainability reporting for FY 2021, which summarized progress and outlined plans for meeting the departmental sustainability goals under previous EO 13834 and submitted the *DOE Sustainability Dashboard Report* and *Site Sustainability Plan* detailing our energy and environmental performance [PPPL21h].

3.1.1 Energy Efficiency

In 2022, PPPL experienced an increase of 3.4%% in energy intensity (British Thermal Units per gross square feet, BTU/gsf) for non-experimental energy use when compared to 2021 and 63.7%% increase compared to the 2015 baseline year (see Exhibit 3-1) [Hug23n]. Based on a review of previous measurements and determination between goal-subject building consumption and excluded building consumption, adjustments were made in FY 2018. This adjustment skewed the site's performance when reviewing energy intensity reporting in FY 2018-2022 versus the FY 2015 goal baseline. The goal has been adjusted based on PPPL's corrected electricity baseline values. It is important to note that PPPL has not experienced a significant change in gross building square footage, nor did we experience a dramatic increase in total energy usage. PPPL's non-experimental buildings still use less than one-half of the energy consumed in 2003. This was achieved through building automation, energy conservation measures, and equipment upgrades.

Exhibit 3-1. Annual Non-Experimental Energy Intensity in BTU/gsf

(Red line represents adjusted annual energy intensity goal)



PPPL continues to emphasize energy management as part of its facility operations and to leverage the success of non-experimental energy management to improve experimental efficiency. PPPL continues to carefully manage its central steam and chilled water plant to maximize efficiency and minimize GHG emissions. PPPL has standardized high-efficiency light-emitting diode (LED) lighting for all office and other space renovations and continues to evaluate and implement other energy efficiency projects where feasible. PPPL has also incorporated energy efficiency and green building practices into its long-term campus improvement plans, which include improvements to critical infrastructure systems, building renovations, and new construction.

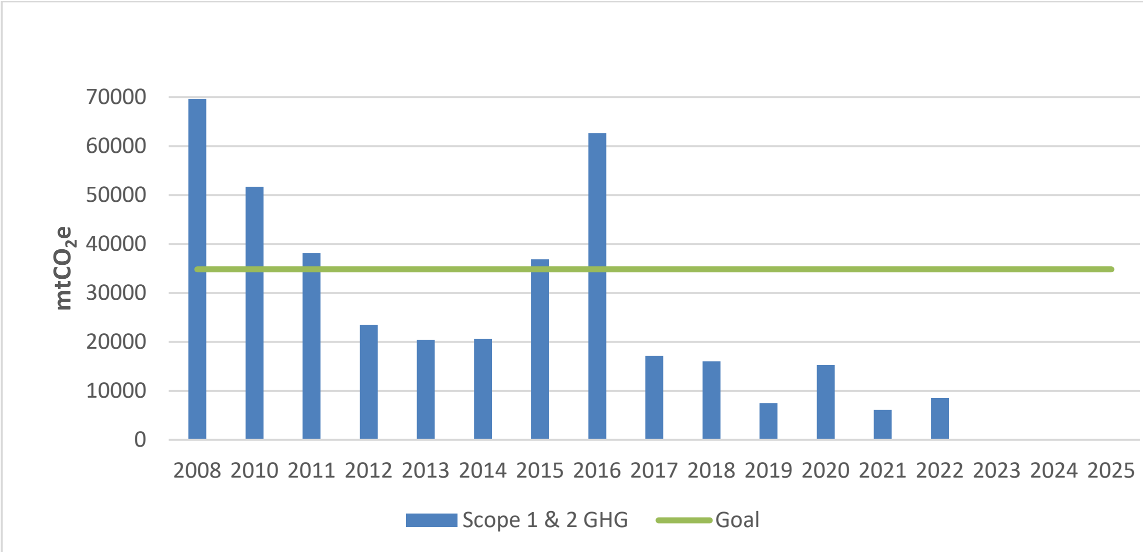
3.1.2 Renewable Energy

PPPL and DOE-Princeton Site Office (PSO) have pursued various on-site renewable energy generation projects for as much as 40% of non-experimental energy use over several years. The Energy Savings Performance Contract (ESPC) proposal received in FY 2008 and again in 2018 was not successful due to the need for significant up-front investment that PPPL could not gain an endorsement for. PSO and PPPL have also pursued a long-term Power Purchase Agreement (PPA) through the Defense Energy Supply Center (DESC). After more than a year of bidding and negotiations, DESC, PSO, PPPL, and the vendor were unable to develop a financially viable project. The ESPC and PPA processes at PPPL identified several significant statutory and management barriers to the cost-effective development of renewable power projects at DOE sites. The planned capital building and infrastructure renovation projects discussed in Section 3.2 will consider the inclusion of renewable energy capacity as applicable and practicable. PPPL did not purchase any renewable energy credits (RECs) in CY 2022. PPPL will look to continue to purchase RECs in the future to meet its renewable energy commitments and will pursue cost-effective renewable energy project opportunities within the context of the DOE Office of Science's portfolio approach to the departmental sustainability goals.

3.1.3 Greenhouse Gas Emissions

Between 2008 and 2022, PPPL reduced its Scope 1 and 2 GHG emissions by 84.4%. This significant reduction in GHG emissions is largely due to the focused efforts to control fugitive losses of sulfur hexafluoride (SF_6) and reduced emissions from on-site combustion of fuel through improved boiler operations, boiler control upgrade projects, and the use of natural gas as the primary fuel over fuel oil. SF_6 is a potent GHG that is a highly effective high voltage insulator (see Exhibit 3-2). The peak in GHG emissions seen in 2016 was caused by fugitive SF_6 emissions during NSTX-U experimental power system commissioning and start-up operations. PPPL did not release any SF_6 in 2022 because NSTX-U was not operating.

Exhibit 3-2. Summary of PPPL Scope 1 & 2 GHG Emissions between 2008 and 2021 ($mtCO_{2e}$)

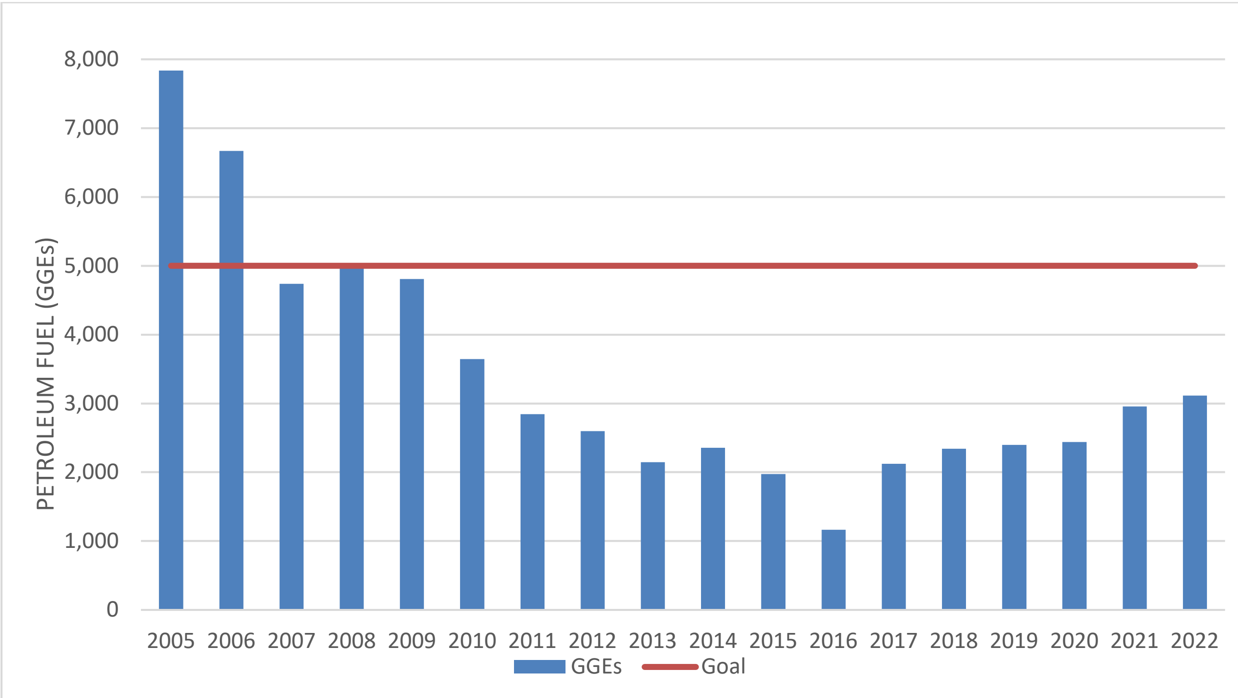


$mtCO_{2e}$ - metric ton carbon dioxide equivalent

3.1.4 Fleet Management

In 2022, PPPL's fleet petroleum fuel use was 60.3% below 2005 baseline levels (see Exhibit 3-3) exceeding the 20% Federal goal. PPPL continues to exceed the goal of 75% acquisition of alternative fuel vehicles (AFV) for its General Services Administration (GSA)-leased light-duty vehicles. PPPL specifies only AFVs as replacement lease vehicles through the GSA whenever a suitable AFV is available. PPPL's fleet includes gasoline-electric hybrid vehicles, AFVs - Ethanol 85% (E-85) or biodiesel 20% (B20) - and petroleum-fueled (gasoline & diesel) vehicles. In addition to the use of alternative fuels in its covered fleet vehicles, PPPL uses B20 in several pieces of heavy-mobile equipment, including a 15-ton forklift, backhoe, skid steer loader, and various utility vehicles run primarily on B20. PPPL will integrate hybrid and electric vehicles into its fleet as suitable vehicles become available.

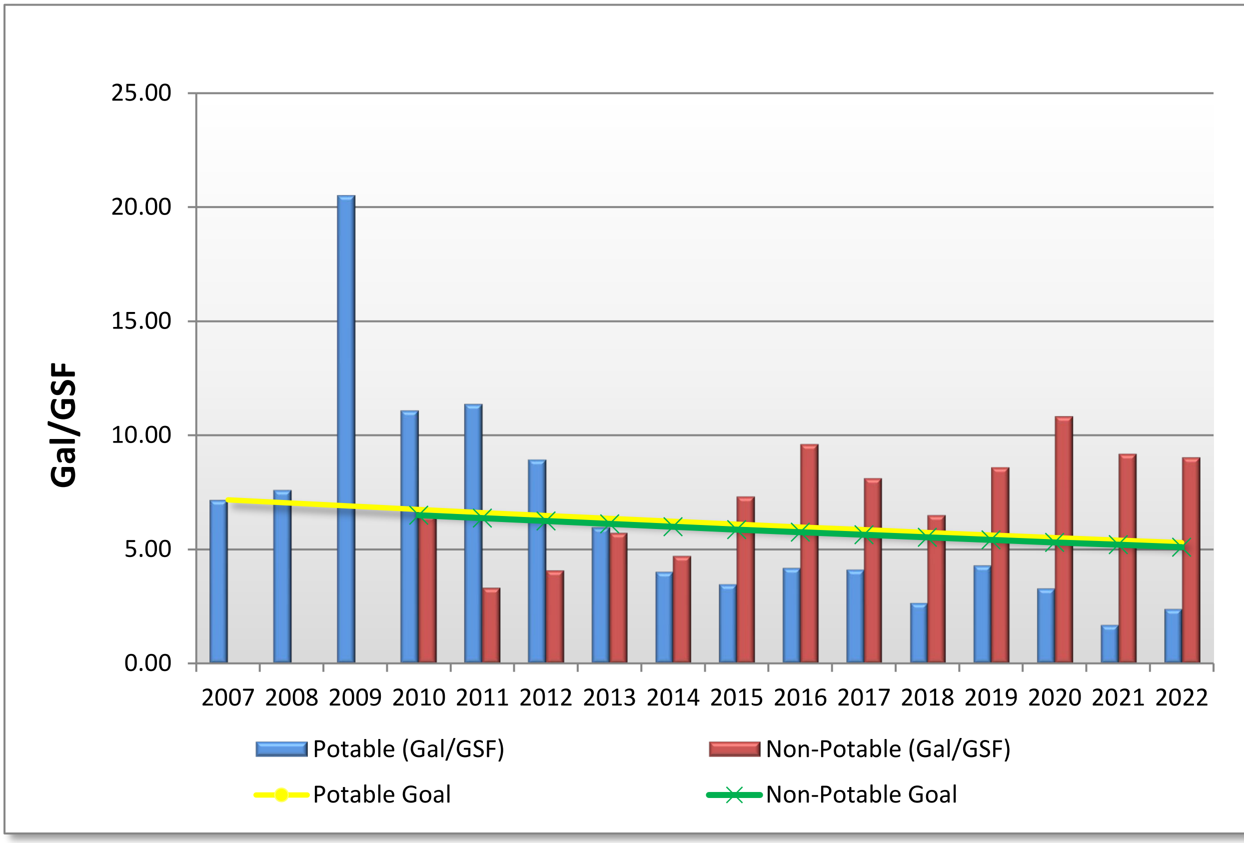
Exhibit 3-3. Annual Non-Exempt Fleet Petroleum Fuel Use between 2005 and 2022 (GGE)



3.1.5 Water Efficiency

PPPL has made significant progress in reducing its use of both potable and non-potable water. In recent years the Laboratory achieved an overall water use reduction of 30.3%% between 2007 and 2022. In 2021 a large portion of PPPL's staff were still working from home due to the COVID pandemic, in 2022 PPPL started to phase in more on-site staff, this resulted in an increment increase of water use. In 2022, PPPL used about 2.4 gallons/gross square feet (gsf) of potable water compared to about 1.7 gallons/gsf in 2021. There was also a slight increase in non-potable water intensity from 8.36 gallon/gsf in 2021 to 8.70 gallon/gsf in 2022 (see Exhibit 3-4). The Laboratory also continues to pursue water conservation pilot projects and to identify new opportunities for water conservation and has included the renovation and repair of certain water systems in the planned critical infrastructure upgrade project. Given the reductions already achieved additional savings may be incremental over several years, as the largest water efficiency opportunities have likely already been addressed.

Exhibit 3-4. PPPL Water Intensity (gallon/gsf)



3.2 Energy Efficient "Green" Buildings

The Lyman Spitzer Building (LSB), PPPL's main office building was awarded LEED®-Gold certification by the U.S. Green Building Council in April 2011 for meeting the rigorous Leadership in Energy and Environmental Design – Existing Buildings Operations & Maintenance (LEED®-EBOM) standard. The LSB represents approximately 16% of the current building space and certification of this building to the LEED®-EBOM standard is a major step toward the goal of having at least 15% of non-exempt building space meeting the Federal Guiding Principles for High Performance and Sustainable Buildings (HPSB).

PPPL continues to prioritize infrastructure projects on those buildings identified with the greatest potential for meeting the Guiding Principles to meet the 15% goal, with a long-term objective of 100% HPSB. PPPL and PSO are pursuing funding for a multi-year campus infrastructure investment program which includes renovation of critical infrastructure, renovation and reutilization of existing buildings, and construction of new buildings. These capital projects will be designed to meet or exceed the Federal Guiding Principles or LEED-Gold criteria to the maximum extent practicable. Renovations or other building improvements required to meet the Guiding Principles will be incorporated into PPPL's operating expenses (OPEX) and general plant projects (GPP) planning process for inclusion in out-year plans. A tabular summary of PPPL's performance against the comprehensive sustainability goals of DOE Order 436.1 is presented in Exhibit 3-5.

3.3 Sustainability Awards

PPPL has demonstrated its commitment to sustainability through its well-established environmental stewardship program. PPPL is often consulted by DOE Laboratories and other organizations for advice and experience in sustainable environmental performance. In 2022, PPPL was recognized by the Global Electronics Council with an EPEAT Purchaser Award for its strong commitment to the purchasing of EPEAT-certified electronics.

Exhibit 3-5: 2022 DOE Sustainability Goal Summary Table for PPPL

Prior DOE Goal	Current FY Efforts	Planned Efforts	Overall Risk of Non-Attainment
Energy Management			
Reduce energy use intensity (Btu per gross square foot) in goal-subject buildings.	PPPL's total energy consumption for goal subject and excluded assets increased in FY2022 compared to the FY2021 by 3.4%.	Maintain reductions, incremental improvements, incorporate into Campus Plan	Medium
EISA Section 432 continuous (4-year cycle) energy and water evaluations.	Updates to the completed evaluations for the identified covered facilities and any findings. This was updated in early March 2022 EISA.	25% of buildings evaluated each year.	Medium
Meter individual buildings for electricity, natural gas, steam, and water, where cost-effective and appropriate.	Whole-building metering, as required by EISA for electricity, natural gas, and water has been completed for all buildings where economic calculations showed that it was viable to install.	Additional sub-metering as cost-effective and programmatically appropriate. Current utility configuration doesn't allow building-level metering	Medium
Water Management			
Reduce potable water use intensity (gallon/gsf).	Increased potable water intensity by 37.9% from FY2021.	Maintain reductions, incremental improvements, incorporate into Campus Master Plan.	Low
Reduce non-potable freshwater consumption (gallon) for industrial, landscaping, and agricultural.	Reduced non-potable water consumption by 2.3% from FY2021.	Maintain reductions, incremental improvements as operations allow.	Medium

Prior DOE Goal	Current FY Efforts	Planned Efforts	Overall Risk of Non-Attainment
Waste Management			
Reduce non-hazardous solid waste sent to treatment and disposal facilities.	PPPL continues to exceed recycling goals for municipal solid waste (MSW) by achieving recycling rate of 59.7%.	Maintain performance, incremental improvements.	Low
Reduce construction and demolition materials and debris sent to treatment and disposal facilities.	PPPL continues to exceed the recycling goals for construction and demolition (C&D) waste by achieving recycling rate of 86.4%.	Maintain performance, incremental improvements.	Low
Fleet Management			
Reduce petroleum consumption.	40.1% of PPPL's non-emergency fleet fuel use is regular gas or diesel.	Maintain with incremental improvements	Low
Increase alternative fuel consumption.	59.9% of PPPL's non-emergency fleet fuel use is E85 and B20.	Maintain with incremental improvements	Low
Acquire alternative fuel and electric vehicles.	PPPL's preference is for Alternative Fueled Vehicles (AFVs) replacing existing fleet vehicles, when available from GSA.	Work with GSA to identify opportunities in vehicle lease program. Limited number of suitable vehicles.	Low
Clean & Renewable Energy			
Increase consumption of clean and renewable electric energy.	Met clean energy goals.	Continue purchasing RECs and evaluate future funding opportunities	Low
Increase consumption of clean and renewable non-electric thermal energy.	Met clean energy goals.	Continue purchasing RECs and evaluate future funding opportunities	Low

Prior DOE Goal	Current FY Efforts	Planned Efforts	Overall Risk of Non-Attainment
Sustainable Buildings			
Increase the number of owned buildings that are compliant with the Guiding Principles for Sustainable Buildings.	In previous years, within the FIMS system, PPPL has one building that has met LEED Gold certification status. PPIC building plans started in FY2019, will incorporate guiding principles for sustainable buildings. In FY2021, PPPL established a Facility and Infrastructure Advisory Council. The council is made up of representatives from various groups throughout the Laboratory to advise on the identification and prioritization of infrastructure projects.	Include Guiding Principles in facility repairs, renovations & new construction, and campus plan.	Low
Acquisition & Procurement			
Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring all sustainability clauses are included as appropriate.	PPPL's standard subcontract document Representations and Certifications Booklet includes the required sustainability clauses for federal acquisition of sustainable products and services.	Continue to promote sustainable acquisition goals.	Low
Efficiency & Conservation Measure Investments			
Implement life-cycle cost effective efficiency and conservation measures with appropriated funds and/or performance contracts.	Reports from the 25% of the covered facilities evaluated during this year's EISA energy and water evaluation review are anticipated to PPPL in the near future. These evaluations were delayed due operations curtailments resulting from the coronavirus pandemic.	Continue to explore opportunities for performance contracting	Medium
Electronic Stewardship & Data Centers			
Electronics stewardship from acquisition, operations, to end of life.	100% of computers utilize power management or duplex printing. Most monitors, printers, copiers, and MFDs use power management or duplex printing. 97.9% of eligible computer and imaging equipment purchases were EPEAT certified.	Continue to specify EPEAT default. Fully implement power management. Continue to re-use electronic assets internally & recycle through UNICOR or commercial vendor	Low

Prior DOE Goal	Current FY Efforts	Planned Efforts	Overall Risk of Non-Attainment
Increase energy and water efficiency in high-performance computing and data centers.	Efforts to reduce the energy consumed by computing resources through equipment upgrades, employee outreach/education, and the appropriate use of network power management solutions.	Utilize Princeton University high-performance computing resources. Incorporate goal into Campus Plan.	Medium
Adaptation & Resilience			
Implement climate adaptation and resilience measures.	Climate resilience and severe weather are integrated into lab-wide EMS, emergency plans, and operational procedures.	As PPPL continually improves its EMS it will include climate resilience in its environmental risks and opportunities evaluation.	Medium
Multiple Categories			
Reduce Scope 1 & 2 greenhouse gas emissions.	39.4% reduction from FY 2021.	Maintain reductions, increases anticipated with experimental operations	Low
Reduce Scope 3 greenhouse gas emissions.	41.6% of our Scope 3 emissions in FY2021 were from employee commuting.	Maintain reductions, incremental improvements as operations allow	Low

Chapter 4

The following sections briefly describe PPPL's environmental programs required by federal, state, or local agencies as well as with Executive and DOE orders. These programs were developed to comply with the environmental regulations governing PPPL's operations.

ENVIRONMENTAL NON-RADIOLOGICAL PROGRAM INFORMATION

4.1 Non-Radiological Water Programs: Environmental Monitoring

4.1.1 New Jersey Pollutant Discharge Elimination System (NJPDES) Program

A. Monthly Discharge Monitoring Reports (DMR)

In compliance with permit requirements of the New Jersey Pollutant Discharge Elimination System (NJPDES) permit, NJ0023922, PPPL and DOE-PSO submitted to NJDEP monthly discharge monitoring reports (DMRs) for DSN001, retention basin outfall, DSN003, and D&R Canal pump house filter backwash discharge. See Appendix Tables 16 & 17 for data.

In 2022, PPPL managed its NJPDES discharge to surface water (DSW) permit, which is effective from July 1, 2019 through June 30, 2024 [NJDEP19]. Prior to July 1, 2019, PPPL operated under the previous permit with the effective date of October 1, 2013.

In February of 2008, NJDEP issued a *Final Surface Water Minor Modification Permit Action* report. Key changes to the permit included eliminating loading requirements and quarterly monitoring for DSN001, additional annual and semi-annual Waste Characterization Reports (WCRs) from DSN001 and DSN003 as well as addition of *Ceriodaphnia dubia* (water flea) to the DSN001 Chronic Toxicity test requirements [NJDEP13, 19].

Current reporting requirements are summarized in Exhibit 4-2. Operating under the previous NJPDES permit, PPPL is required to provide an annual WCR for both DSN001 and DSN003. DSN001 also requires addition semiannual WCR reporting for metals and semi-volatile organic compounds (SVOC). DSN003 is still required to complete a full WCR once per permit cycle [NJDEP19]. For CY 2022, PPPL NJPDES compliance summary is presented in Exhibit 4-1 below.

In 2018, NJDEP informed PPPL that discharge limits for CPO were to be lowered to diminutive levels. As a result, and with NJDEP's support, PPPL transitioned to the use of PAA as the primary biocide in canal water system. There were no permit exceedances in 2022.

Exhibit 4-1. 2022 NJPDES Permitted Compliance NJPDES Permit NJ0023922

Outfall DSN001							
Parameter (1)	**Frequency**	**Permit Limit**	**# Permit Exceedance**	**# Samples Taken (4)**	**# Compliant Samples**	**Percent Compliance**	**Dates Exceeded**
Chemical Oxygen Demand (COD), mg/L	Monthly	50.0	0	16	16	100%	NA
Chlorine Produced Oxidants (CPO), mg/L	Monthly	0.011 Monthly Avg. 0.016 Daily Max.	0	2	2	100%	NA
Flow, million gallons per day (MGD)	Monthly	-	0	12	12	100%	NA
Peracetic Acid (PAA), mg/L	Monthly	-	0	10	10	100%	NA
Petroleum Hydrocarbons (TPHC), mg/L	Monthly	10.0 Avg. 15.0 Max.	0	16	16	100%	NA
pH, S. U.	Monthly	>6.0; <9.0	0	24	24	100%	NA
Phosphorus, total mg/L (2)	Monthly	-	0	16	16	100%	NA
Temperature °C	Monthly	30.0	0	24	24	100%	NA
Tetrachloroethylene (PCE), µg/L (3)	Monthly	0.703	0	16	16	100%	NA
Total Suspended Solids (TSS), mg/L	Monthly	50.0	0	16	16	100%	NA
Outfall DSN003							
Flow, gallons per day (GPD)	Monthly	0	0	12	12	100%	NA
Petroleum Hydrocarbons (TPHC), mg/L	Monthly	10.0 Avg. 15.0 Max	0	12	12	100%	NA
pH, S. U.	Monthly	>6.0; <9.0	0	12	12	100%	NA
Phosphorus, total mg/L (2)	Monthly	-	0	12	12	100%	NA
Total Suspended Solids (TSS), mg/L	Monthly	-	0	12	12	100%	NA
Intake C1							
Total Suspended Solids (TSS), mg/L	Monthly	-	0	12	12	100%	NA

NA = Not applicable
mg/L = milligram per liter
Note: All samples reported in quality or concentration on monthly DMR

(1) *Methods for Chemical Analysis of Water and Wastes*, Environmental Monitoring and Support Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, March 1983, EPA-600 4-79-020 [EPA83].
(2) *Phosphorus Evaluation Study will be included in the Raritan Watershed Study.*
(3) *Tetrachloroethylene (PCE) found in the retention basin outfall results from ground water from the building foundation drainage system. Additional basin aeration is expected to keep the discharge concentration of PCE at or below 0.703 micrograms per liter (µg/L).*
(4) *Number* of samples taken indicates the minimum number of samples required for the current NJPDES permit. Additional samples and duplicates may be taken and reported each calendar year.

Exhibit 4-2. NJPDES Reporting Requirements 2022

Parameter	Location	Frequency/Type	Last Completed
Discharge Monitoring Report (DMR)	DSN001, DSN003	Monthly	Monthly 2022
Acute Whole Effluent Toxicity ***LC50 48hr - Ceriodaphnia dubia***	DSN003	4 – 4.5 Years per Permit	Scheduled for August 2023
Chronic Toxicity (% Effluent) **IC25 7 Day - *Ceriodaphnia dubia***	DSN001	Annual	January 2022
Waste Characterization Report (WCR) – Complete WCR	DSN001	Annual	February 2022
Waste Characterization Report (WCR) – Metals, SVOC, Chloroform	DSN001	Semi Annual	January & August 2022
Waste Characterization Report (WCR) - Metals	DSN003	Annual	January 2022
Waste Characterization Report (WCR) – Complete WCR	DSN003	4 – 4.5 Years per Permit	Scheduled for August 2023

B. Acute Toxicity Study

The last Acute Biomonitoring Report for the *Ceriodaphnia dubia* (water flea) was completed on December 5, 2017 for DSN003. Samples were collected for the 48-hour acute toxicity survival test, required to be performed once per permit cycle between 4 to 4.5 years after the effective date of the permit (Exhibit 4-2). The toxicity test with *Ceriodaphnia dubia* (water flea) resulted in an inhibition concentration (IC25) of >100 percent (statistically possible) [PPPL19i]. Acute toxicity monitoring is no longer required at discharge DSN001.

C. Chronic Whole Effluent Toxicity Study

Annual Chronic Whole Effluent Toxicity testing for DSN001 was completed on January 28, 2022 (Exhibit 4-2). In all chronic toxicity tests, *Ceriodaphnia dubia* survival rate IC25, as defined by the NJ Surface Water Quality Standards, was IC25 >100 percent no observable effect concentration (NOEC) [NJDEP19, PPPL22f].

D. Waste Characterization Report (WCR)

WCRs are required by NJPDES Permit for monitoring effluent conditions. DSN001 Semi Annual WCR were completed twice annually on January 26, 2022 and August 12, 2022. The DSN001

Annual WCR was completed on January 26, 2022 [PPPL22g]. DSN003 Annual WCR was completed on January 26, 2022 [PPPL22i]. WCR data can be seen in Appendix Table 25.

4.1.2 Lined Surface Impoundment Permit (LSI)

PPPL complies with NJDEP Ground Water General Permit No. NJ0142051 and is permitted to operate LSI Program Interest (P.I.) ID#:47029 dated February 26, 2009. The LSI Permit operates on a 5-year permit cycle, which was renewed by the NJDEP on May 1, 2019 and will expire on April 30, 2024. The LSI Permit authorizes PPPL to discharge from our lined retention basin outlet to surface water, Bee Brook in Plainsboro, NJ [NJDEP09]. PPPL measured a total of 79,283,598 gallons annually or an average 217,215 gallons per day (GPD) of water that was discharged from the retention basin in 2022 [Hug23a].

Exhibit 4-3. PPPL Retention Basin

Exhibit 4-4. Flow Sensor and Discharge Valve

LSI permit allows maintenance of liner as necessary. Inspection, repairs (if needed), and certification by a Professional Engineer (PE) are required by the permit within 18 months of a permit renewal. In 2020, the curtailment of onsite operations due to the global coronavirus pandemic impacted PPPL's planned repairs and re-certification of the detention basin liner. In 2021, PPPL retained a NJ licensed Professional Engineer to perform the necessary basin liner evaluation and oversee testing and repairs along with a construction company to make the required repairs. The general process of the repairs is cleaning and drying all surfaces and heat welding a like material over the existing breached area. The repairs failed in multiple locations because the existing liner material lacked elasticity to melt and cure for the appropriate bond to be made. The environmental engineer deemed the basin liner, which is over 25 years old, is no longer capable of being repaired using the above procedure and needs replacement. A General Plant Project to reline the basin is being developed by the Facilities & Site Services department. In the interim, the basin operating conditions are inspected weekly, and any findings are corrected promptly as outlined in PPPL's basin manual.

Water flowing through the retention basin includes site storm water, ground water from building foundation drains, non-contact cooling water, and cooling tower and boiler blow down. PPPL operates and maintains all equipment associated with the retention basin including aerators, sonic algae control, oil sensors, oil boom, sump pump, and flow meter (Exhibit 4-3). If oil is detected within the basin, an alarm signals the Site Protection communications center and automatically closes the discharge valve (Exhibit 4-4). The ultrasonic flow meter measures flow from the basin and is downloaded monthly for NJPDES DMR.

4.1.3 Ground Water

A. NJPDES Ground Water Program

No ground water monitoring is required by the LSI General Ground Water Permit.

B. Regional Ground Water Monitoring Program

PPPL's Remedial Investigation and Remedial Action Selection Report (RI & RASR) was approved by NJDEP in 2000 [PPPL99b]. The Remedial Action Work Plan (RAWP) was approved NJDEP in June 2000 [PPPL00]. The process of natural attenuation by the indigenous bacteria and other in-situ processes are slowly degrading tetrachloroethylene or perchloroethylene (PCE) to its natural products. The de-watering sumps located in the D-site Motor Generator (MG) and air shaft (formerly TFTR) basements draw ground water radially from the shallow aquifer, controlling ground water flow preventing off-site contaminant migration, and extracting contaminated ground water from the aquifer. For details, see Chapter 6, "Site Hydrology, Ground Water, and Drinking Water Protection."

In early 2018, NJDEP issued Ground Water Remedial Action Permit number RAP17001, effective for 30 years, for the ongoing remediation and monitoring programs at PPPL. PPPL modified its monitoring program to meet the conditions of the new permit [NJDEP18]. Additional ground water information can be found in Chapter 6.

4.1.4 Metered Water

A. Drinking (Potable) Water

Potable water is supplied by the public utility, New Jersey American Water Company. PPPL used approximately 1.87 million gallons in 2022 (Exhibit 4-5) [Sta23]. PPPL uses potable water as a backup resource for non-contact cooling and fire protection. Water usage greatly decreased during the PPPL curtailment of operations starting on March 13, 2019, in response to the coronavirus pandemic. In 2022, work arrangements included a greater remote and hybrid workforce than pre-pandemic years.

Exhibit 4-5. PPPL Potable Water Use from NJ American Water Co. [Sta23]

CY	In Million Gallons
2013	4.52
2014	2.74
2015	2.64
2016	3.21
2017	2.99
2018	2.66
2019	3.81
2020	1.52
2021	1.21
2022	1.87

Exhibit 4-6. PPPL Non-Potable Water Use From D&R Canal [Hug23l]

CY	In Million Gallons
2013	5.73
2014	5.14
2015	8.59
2016	10.34
2017	8.89
2018	5.61
2019	7.38
2020	7.65
2021	6.63
2022	6.72

B. Process (Non-potable) Water

Non-potable water from the D&R Canal is used for fire protection and process cooling. Non-potable water is pumped from the D&R Canal as authorized through a contract with the New Jersey Water Supply Authority that allows for the withdrawal of up to 150,000 GPD and an annual limit of 54.75 million gallons [NJWSA12]. PPPL used a total of 6.72 million gallons of non-potable water from the D&R Canal in 2022 (Exhibit 4-6) [Hug23l]. There was minimal change in D&R Canal water usage in CY 2022.

The D&R Canal pump house includes a strainer to remove solids from the non-potable water and metering pumps used for the addition of water treatment chemicals like PAA and a corrosion inhibitor. DSN003, located at the canal pump house filter-backwash, is a separate discharge point in the NJPDES surface-water permit and is monitored monthly (Appendix Table 17). No treatment chemicals are discharged through DSN003 because the chemicals are added after the canal pump and well downstream of the strainer. A sampling point upstream of DSN003 (Canal [C1]) was established to provide baseline data for surface water that is pumped from the D&R Canal for non-potable uses. Appendix Table 11 summarizes the results of water quality analysis at the water intake C1, at the D&R Canal.

C. Surface Water

Surface water is monitored for potential non-radioactive pollutants both on-site and at surface-water pathways upstream and downstream off-site. Other sampling locations - Bee Brook (B1 & B2), New Jersey American Water Company (potable water supplier - E1), D&R Canal (C1), Millstone River (M1), and Cranbury and Devil's Brooks in Plainsboro (P1 & P2) sampling points (Appendix Tables 9-15)—are not required by regulation but are a part of PPPL's environmental surveillance monitoring program.

D. Sanitary Sewage

Sanitary sewage is discharged to the Publicly-Owned Treatment Works (POTW) located in South Brunswick Township, which is operated by the Stony Brook Regional Sewerage Authority (SBRSA). SBRSA requires quarterly reporting of the total volume discharged from the Liquid Effluent Collection (LEC) tanks on D-site. PPPL continues to collect samples for tritium analysis and measurement of pH and temperature (Appendix Table 7). Detailed radiological and discharge quantities for LEC tanks can be found in Chapter 5 "Environmental Radiological Program Information".

For 2022, PPPL estimated a total annual sanitary sewage discharge of 1.86 million gallons to the South Brunswick sewerage treatment plant [Sta23].

4.2 Non-Radiological Waste Programs

4.2.1 Hazardous Waste Programs

A. Toxic Substance Control Act (TSCA)
In CY 2022, PPPL shipped 1,080 pounds of PCB waste, primarily for the disposition of excess legacy equipment and assistance. All components were recycled or incinerated in a permitted facility as TSCA Hazardous Waste [San23a].

B. Hazardous Waste
PPPL did not meet the threshold to submit a Biennial Hazardous Waste Generator Report to NJDEP for hazardous waste generated in the last period of CY 2022 [San23a]. A description of RCRA compliance is found in Exhibit 2-1 of this report.

PPPL continues to evaluate opportunities to remove hazardous materials (HAZMAT) from the workplace that have the potential to become hazardous wastes by substituting them with non-hazardous materials that have the added benefit of reducing employee exposure.

C. Recycled Hazardous/Universal Waste
The types and quantities of waste that are recycled each year changes due to the activities varying greatly from year to year, as shown in Exhibit 4-7. PPPL's waste shipments can include hazardous, universal, non-hazardous, and TSCA regulated waste. PPPL avoids landfilling environmental waste through recycling and incinerating, aligning with PPPL's commitment to sustainability. PPPL's only hazardous/TSCA waste that is landfilled is asbestos waste.

Exhibit 4-7. 2022 Waste Shipments [San23a]

Recycled Hazardous Materials	Pounds	Kilograms
Recycled	14,131	6,409.7138
Incinerated	18,331	8314.8
Landfilled	*	*
Burial	0	0
Treated	0	0
Total Waste	**32,462**	**14,724.5**

*Only volume of container is recorded

4.3 Environmental Protection Programs

4.3.1 Release Programs

A. Spill Prevention Control and Countermeasure (SPCC)

PPPL maintains a SPCC program. The last major revision to the SPCC Plan was in November 2016, and is reviewed annually . In annual review, Environmental Services updated Section 10 Summary of Past Required Action Items. The SPCC Plan is incorporated as a supplement to the PPPL Emergency Preparedness Plan. In addition to the 5-year major revision as required by the USEPA, PPPL's ESD completes a review every year to make any minor changes required to the SPCC [PPPL16a].

B. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) - Continuous Release Reporting

Under CERCLA reporting requirements for the release of listed hazardous substances in quantities equal to or greater than its reportable quantity, the National Response Center is notified, and the facility is required to report annually to EPA. Because PPPL has not released any CERCLA-regulated hazardous substances, no "Continuous Release Reports" have been filed with EPA in CY 2022 [Ger23].

C. Superfund Amendments and Reauthorization Act (SARA) Title III Reporting Requirements

NJDEP administers the SARA Title III, also known as the EPCRA, reporting for EPA Region II. The modified Tier I form includes SARA Title III and NJDEP-specific reporting requirements. PPPL submitted the SARA Title III Report to NJDEP on February 27, 2023 [Ger23]. No changes were reported in PPPL's 2022 EPCRA/SARA.

SARA Title III reports included information about eleven compounds used at PPPL as listed in Exhibits 4-8 and 4-9.

PPPL does not exceed threshold amounts for chemicals listed on the Toxic Release Inventory (TRI), PPPL completed the TRI cover page and laboratory exemptions report for 1996 and submitted these documents to DOE. Since PPPL did not exceed the threshold amounts, no TRI submittal was completed for 2022 [Ger23].

Exhibit 4-8. 2022 Summary of PPPL EPCRA Reporting Requirements

SARA	YES	NO	NOT REQUIRED
EPCRA 302-303: Planning Notification	X		
EPCRA 304: EHS Release Notification		X	
EPCRA 311-312: MSDS/Chemical Inventory	X		
EPCRA 313: TRI Report			Did not exceed threshold

EHS – Extremely hazardous substances (No EHS are on-site at PPPL)
MSDS – Material Safety Data Sheets
TRI – Toxic Release Inventory

Exhibit 4-9. 2022 Hazard Class of Chemicals at PPPL

Compound	Category	Compound	Category
Bromochlorodifluoro-methane (Halon 1211)	Sudden release of pressure & Acute health effects	**Lead**	Chronic health effects
Carbon dioxide (CO_2)	Sudden release of pressure & Reactive	**Nitrogen**	Sudden release of pressure
Diesel Fuel Oil	Fire	**Propane**	Sudden release of pressure
Gasoline	Fire & Chronic Health Hazard	**Petroleum Oil**	Fire
Helium	Sudden release of pressure	**Sulfur Hexafluoride**	Sudden release of pressure
Sulfuric acid	Acute Health Hazard & Reactive		

4.3.2 Environmental Releases

As discussed in Section 2.5, PPPL had two reportable spills including 1 gallon of B-20 biodiesel fuel and hydraulic oil [San23b]. Due to New Jersey's no *de minimis* thresholds, all oil released to unpaved surfaces must be reported. Both incidents were remediated and documented under NJDEP's Site Remediation Regulations.

4.3.3 Pollution Prevention Program

In 2022, PPPL continued to pursue waste minimization and pollution prevention opportunities through active recycling efforts and through the purchasing of recycled-content and other environmentally preferred products (EPP). In FY 2022, PPPL diverted 59.7% of the municipal solid waste (MSW) through single stream recycling program. The DOE goal of 50% recycle versus disposal rate was met and accomplished by active participation of Laboratory employees. There was a substantial decrease in MSW recycling rate because of the pandemic-related curtailment of onsite operations. The pandemic curtailment also resulted in PPPL temporarily suspending its organics and food waste composting program. PPPL's FY 2022 rate for recycling of construction materials including wood, concrete, and metal was 86.4% by weight. The increase in C&D recycling is attributed to the various construction projects [Kin23a].

4.4 Non-Radiological Emissions Monitoring Programs

Air Permits

PPPL maintains NJDEP air permits/certificates for the equipment as listed in Exhibit 4-10. PPPL is classified as a synthetic-minor facility and does not exceed the Potential to Emit (PTE) limits for any of the Criteria Air Pollutants.

PPPL tracks NJDEP Air Quality Conditions Alerts. Unhealthy conditions are noted, and all generator testing are postponed until normal air quality is reinstated. During those times, the standby (emergency) generators may be used only in an emergency (power outage) or when a voltage reduction issued by Pennsylvania, New Jersey, Maryland Interconnect (PJM – electric-power grid controllers) and posted on the PJM internet website under the "emergency procedures" menu.

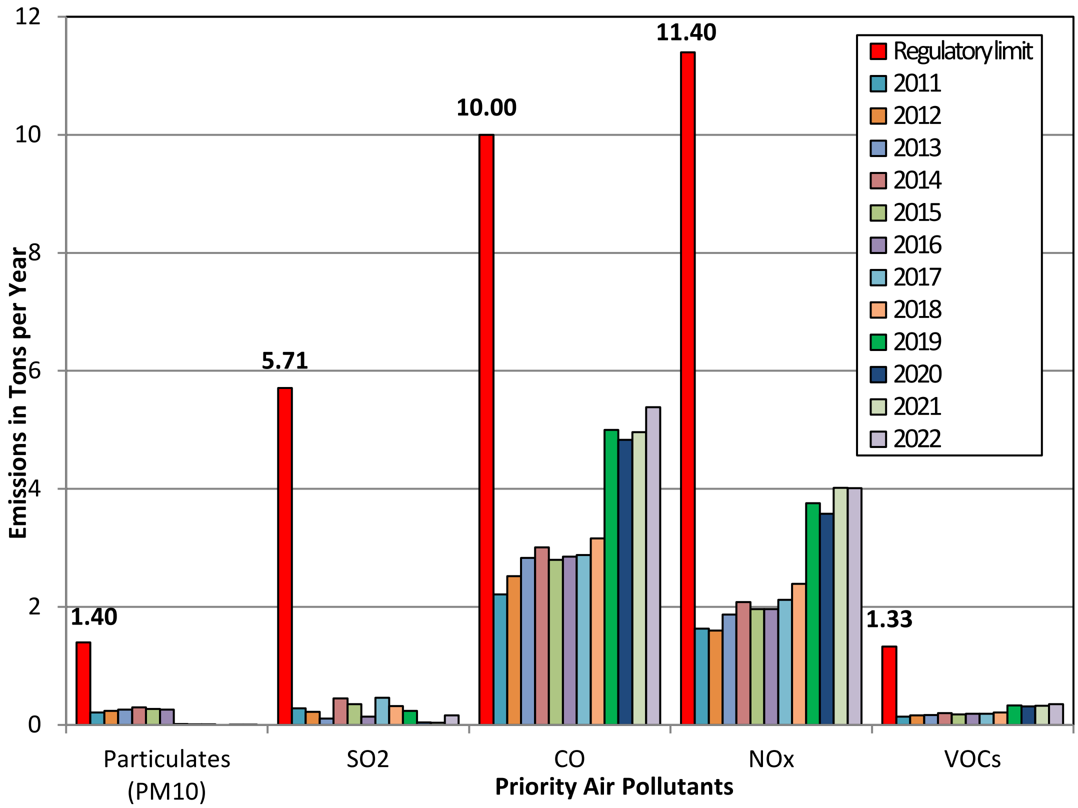
In 2008, NJDEP reduced the regulatory limits for the criteria air pollutants for operating the boilers; PPPL's emissions for these four boilers were well below those limits in 2022 (Exhibit 4-10 & Appendix Table 8). With the installation of digital controls and high-efficiency, lower nitrogen oxide (NO_x) burners, the NO_x, volatile organic compounds (VOCs), particulates, sulfur dioxide (SO_2), and carbon monoxide (CO) emissions are being further reduced [Rog23].

In late 2017, the NJDEP replaced GP-003 permits for woodworking equipment like dust collectors to GP-016A permits. The new construction permits exempted, "Single or multiple pieces of manufacturing and materials handling equipment each with a PTE less than the reporting threshold for each air contaminant." Because PPPL's dust collector PTE is less than the reporting threshold, the Lab no longer has a general permit for its dust collector. The dust collector permit was renewed on June 28, 2021 and expires on June 28, 2026.

Exhibit 4-10. PPPL's Air-Permitted Equipment

Type of Air Permit	Qty	Location	Requirements
Storage tanks vents*	2	25,000 gal. No. 2 & 4 oil 15,000 gal. No.1 oil	TANKS – EPA annual emissions based on amount of fuel through-put. *Note: Canceled per NJDEP Audit 2/2017
Diesel generators**	1 2	D-site generator C-site generator	Annual limit of 100 hours of operation per generator excluding emergencies; no testing on NJDEP Air Action Days. **Three separate permits combined to a single General Permit in 11/2019.
Utility boilers	4	Units 2,3,4, & 5 in Facilities	Annual emission testing same quarter each year; annual emission calculations based on hours of operations (Ex.4-12); rolling 12-month calendar total fuel consumed by boiler and fuel type (Table 8). Visual stack checked weekly when operating.
Fluorescent bulb crusher	1	Hazardous Materials Storage Facility	Hours of operations and number of bulbs crushed; air monitoring for mercury during filter changes.
Dust Collector	1	C-Site MG Annex (Carpenter shop)	Hours of operation. Bulb limit. Periodic filter changes. Emission limit.

Exhibit 4-11. PPPL's Boiler Emissions from 2012-2022 vs. Regulatory Limits (Hug23g)



4.5 Land Resources and Conservation

4.5.1 Wetlands Letter of Interpretation (LOI)

PPPL's ES&H Executive Board chose to allow its Wetlands Letter of Interpretation (LOI) to expire on April 1, 2018. No projects or construction within the 50-foot buffer of PPPL wetlands is planned in the foreseeable future. No construction or alterations to existing vegetation within 50 feet of wetlands can commence without state notification. PPPL's NEPA review process verifies projects do not alter vegetation within 50 feet of wetlands. The freshwater line verifications must be present on all future site development drawings [PPPL15b]. In the event PPPL identifies the need for land-disturbing activities within the wetland transition zone, a new wetland boundary delineation will be necessary to support the LOI process.

4.5.2. Soil Erosion and Landscaping

PPPL maintains SESC engineering standard for projects that have soil disturbance below the permit threshold of 5,000 square feet, above 5,000 square feet to less than an acre, and above one acre [PPPL14a]. Currently there are no projects that require SESC permit from the Freehold Soil Conservation District (FSCD). However, there are some projects in the early planning stages that may require a permit. In addition, certain planned major construction projects may require a general stormwater and soil erosion permit from NJDEP/EPA.

PPPL Stormwater Pollution Prevention Plan encourages the reduction of turf grass areas that required mowing and other maintenance by planting native meadow grasses that can grow tall where practical. Other landscaping improvements, such as rain gardens and tree planting improve the local wildlife habitat and help to minimize stormwater pollution.

4.5.3 Herbicides and Fertilizers

During 2022, PPPL's Facilities Division used herbicides, insecticide, and fertilizer on campus grounds (Exhibit 4-11). These materials are applied in accordance with state and federal FIFRA regulations and PPPL's Integrated Pest Management Plan. Chemicals are applied by New Jersey-certified applicators. PPPL does not store herbicides or fertilizers on site; therefore, no disposal of these types of regulated chemicals is required by PPPL [Kin23b].

Exhibit 4-12. 2022 Fertilizer and Herbicide Use

Type of Material	Name of Material	Registered EPA No.	Application Qty
Fertilizer and Preemergent	Lime	67619-14	13,068 lbs.
Herbicide	Q4	2217-886	960 gallons
Herbicide	Cheetah Pro	228-743366	33.6 gallons

4.5.4 Stormwater Pollution Prevention

PPPL's SWPPP was revised in 2022 to provide guidance to reduce the impact of PPPL's operations on stormwater quality [PPPL22c]. As summarized in Exhibit 8 of SWPPP, PPPL reduces stormwater quantity by utilizing best management practices, such as limiting the mowing areas with rain gardens and native grass meadows plantings.

4.6 Safety

PPPL's 2022 performance with respect to worker safety is noted in Exhibit 4-12 [Wet23].

Exhibit 4-13. 2022 PPPL's Safety Performance

Total OSHA recordable case rate[1]	Days away, restricted, transferred (DART) case rate[1]
1.07	0.76
Number of radioactive contaminations (external)	**Number of Safety report OSHA (ORPS) Occurrence confined space, chemical exposure and lock-out, tag-out (LOTO) incidents**
0	2

OSHA – Occupational Safety and Health Administration
[1] Per 200,000 hours worked

Chapter 5

The DOE Princeton Plasma Physics Laboratory's Environmental Radiological program includes information about PPPL's tritium releases to the environment and dose to employees and to the public. This annual dose is calculated using air and water measurements, and in 2022 was 1.05E-03 mrem compared to 310 mrem annual dose from natural sources.

ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

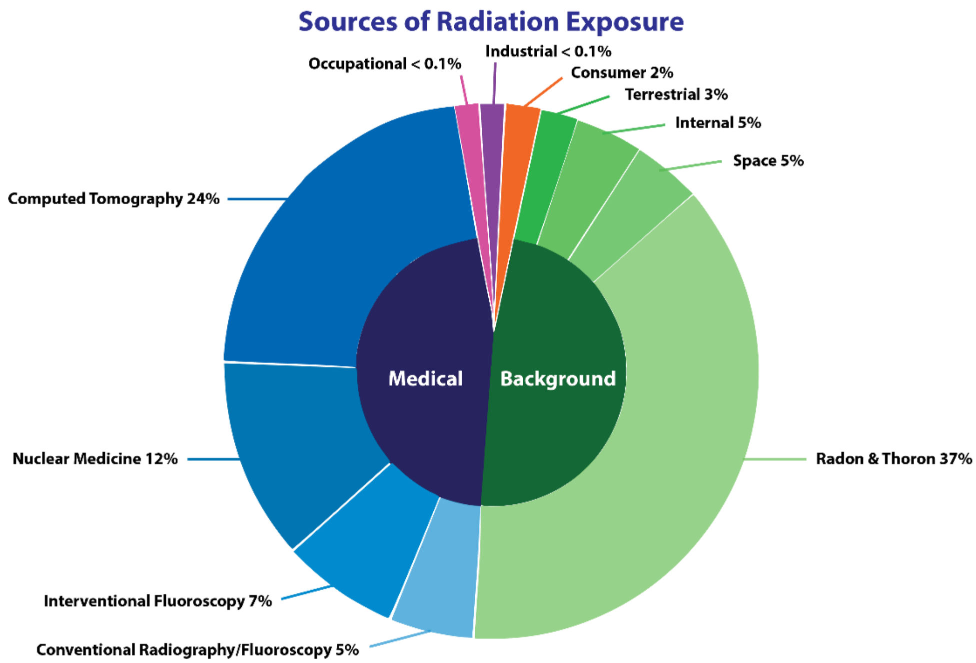
5.1 Radiological Emissions and Doses

For 2022, the releases of tritium to air and water and the dose to the MEI are summarized in Exhibit 5-1. The calculated dose to the MEI is 1.05E-05 mSv or 1.05E-03 milli-radiation equivalent man (mrem), far below the annual limit of 10 mrem per year [Hug23k]. PPPL's atmospheric releases of tritium from the D-site stack in 2022, totaled 6.09E-01 Curies (Ci) as shown in Exhibit 5-2. The Laboratory measures this data using active and passive stack monitors [Fre23a].

Laboratory policy states that when occupational exposures have the potential to exceed 1,000 mrem (1 rem) per year (10 mSv/year), the PPPL ES&H Executive Board must approve an exemption. This value (1,000 mrem per year limit) is 20% of the DOE legal limit for occupational exposure. In addition, the Laboratory applies the "ALARA" (As Low As Reasonably Achievable) policy to all its operations. This philosophy for control of occupational exposure means that environmental radiation levels for device operation are also very low. From all operational sources of radiation, the ALARA goal for maximum individual occupational exposure was less than 100 mrem per year (1.0 mSv/year) above the natural background at PPPL. The average annual dose to a member of the general population is considered to be about 620 mrem/year with 310 mrem contribution from natural sources and 310 mrem from man-made sources [NCRP Report No. 160].

- Cosmic radiation - 28 mrem/year
- Terrestrial sources /earth's crust - 28 mrem/year
- Food - 40 mrem/year
- Radon - ~200 mrem/year

- Medical sources - 310 mrem from medical diagnostics such as x-rays, CAT scans, and cancer treatments.



Average Annual Radiation Dose

Sources	Radon & Thoron	Computed Tomography	Nuclear Medicine	Interventional Fluoroscopy	Space	Conventional Radiography/ Fluoroscopy	Internal	Terrestrial	Consumer	Occupational	Industrial
Units mrem (United States) mSv (International)	228 mrem 2.28 mSv	147 mrem 1.47 mSv	77 mrem 0.77 mSv	43 mrem 0.43 mSv	33 mrem 0.33 mSv	33 mrem 0.33mSv	29 mrem 0.29 mSv	21 mrem 0.21 mSv	13 mrem 0.13 mSv	0.5 mrem 0.005 mSv	0.3 mrem 0.003 mSv

Exhibit 5-1. National Council on Radiation Protection & Measurements Report No. 160

Exhibit 5-2. Summary of 2022 Emissions and Dose from D-Site Operations

Radionuclide & Pathway	Source	Source Term Curies (Bq)	MEI mrem/year (mSv/year)	Percent of Total	Collective EDE w/in 80 km in person-rem (person-Sv)
Tritium (air)	D-site stack	HTO - 6.05E-01 (2.24E+10) HT - 4.84E-03 (1.79E+08)	4.40E-04 (4.40E-06)	41.81%	1.43E-02 (1.43E-04)
Tritium (water)	LEC tank	HTO – 2.22E-02 (8.21E+08)	4.44E-04 (4.44E-06)	42.14%	6.08E-04 (6.08E-06)
Tritium Deposition (water)	Surface/ Ground	90.1 pCi/L (B2) 90.1 pCi/L (Multiple)	1.69E-04 (1.69E-06)	16.05%	2.32E-04 (2.32E-06)
Direct/Scattered neutron & Gamma radiation	NSTX	N/A[3]	N/A	0%	N/A
Argon-41 (Air)[3]	NSTX	N/A[3]	N/A	0%	N/A
Total [Hug23k]			**1.05E-03 (1.05E-05)[1]**	100%	1.51E-02 (1.51E-04)[2]

Bq = Becquerel EDE = effective dose equivalent HT = elemental tritium pCi/L = picoCuries per liter
mSv = milliSievert mrem = milli radiation equivalent man HTO = tritium oxide NSTX = National Spherical Torus Experiment

Half-life of tritium (HTO & HT) is 12.3 years.

Note:
1. Dose to the MEI occurs at the nearest business which is 351 meters from the D-site stack. Doses assume maximum exposed individual is in continuous occupation at the nearest business; waterborne doses assume that maximum exposed individual uses the ultimate destination of liquid discharges (Millstone River) as sole source of drinking water.
2. Annual limit is 10 mrem/year; background is about 620 mrem/year (Reference NCRP Report 160, 2009).
3. NSTX was not in operation in 2022, therefore it did not generate any neutrons or argon-41.

Exhibit 5-3. Radiological Atmospheric Releases for Calendar Year 2022 (Curies)

Tritium	85Kr	Noble Gases (T1/2 <40 days)	Short-Lived Fission and Activation Products (T1/2 <3 hr)	Fission and Activation Products (T1/2 >3 hr)	Total Radio-iodine	Total Radio-strontium	Total Uranium	Plutonium	Other Actinides
6.09E-01	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

5.1.1 Penetrating Radiation

The NSTX-U experiment did not operate in 2022 and did not contribute to the dose totals. Upgrades to NSTX-U include a new center stack, fabrication of magnetic field coils and upgrades to support systems. When NSTX-U resumes experimental operations, it will result in neutron production.

5.1.2 Sanitary Sewage

Drainage from D-site sumps in radiological areas is collected in one of the three LEC tanks, each with a capacity of 15,000 gallons. Prior to release of these tanks to the sanitary sewer system and the publicly owned treatment works (SBRSA), a sample is collected and analyzed for tritium concentration and gross beta activity. All samples for 2022 showed effluent quantity and concentrations of radionuclides (tritium) to be within allowable limits established in New Jersey regulations (1 Ci/year for all radionuclides), the National Safe Drinking Water regulations (40 CFR 141.66) limit of 20,000 picoCuries per liter (pCi/L) ,and DOE Order 458.1 (1.9 E+06 pCi/liter for tritium).

As shown in Exhibits 5-3 and 5-4, the total amount of tritium released to the sanitary sewer in 2022 was 2.22E-02 Ci, far less than the allowable 1.0 Ci/year limit [Hug23j]. In Appendix A, Table 7, the tritium activity is reported; the gross beta activity ranges from 6.53E+03 to 1.51E+05 pCi/L.

Exhibit 5-4. Annual Releases to Sanitary System from Liquid Effluent Collection Tanks 2011-2022

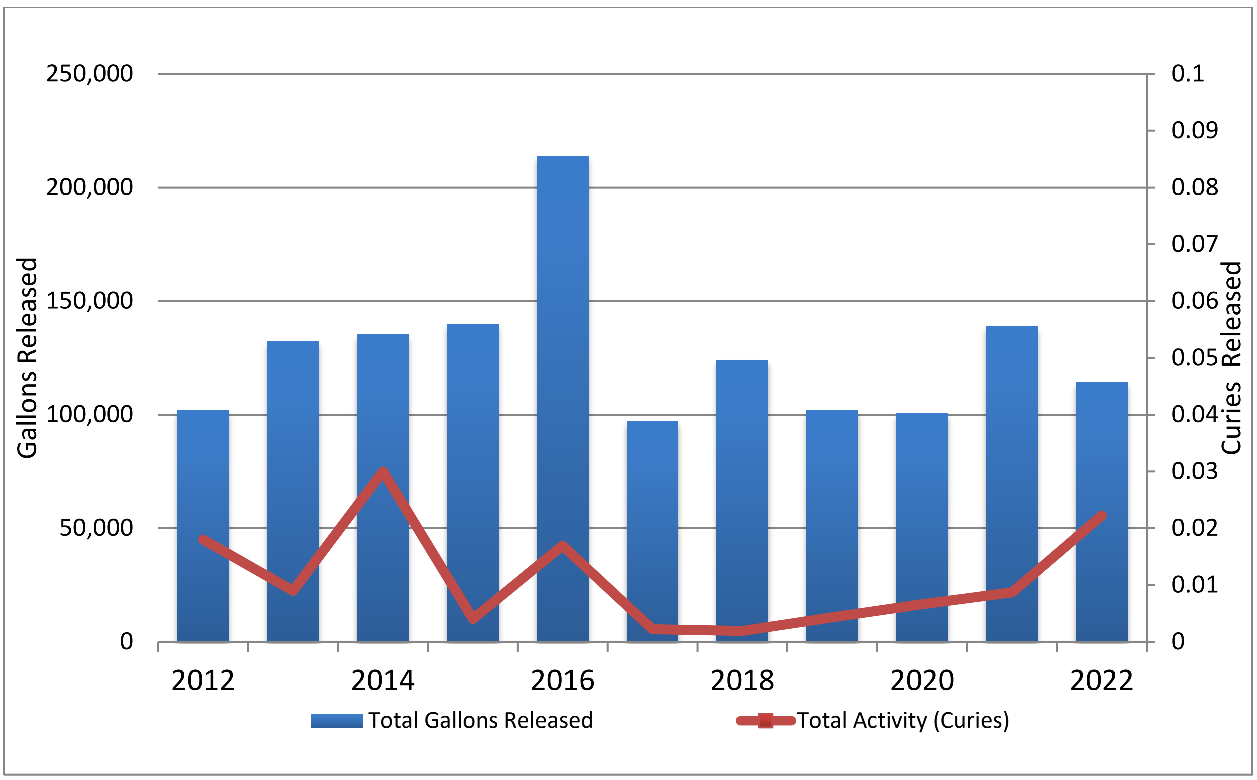


Exhibit 5-5. Total Annual Releases (LEC tanks) to Sanitary System

Calendar Year	Total Gallons Released	Total Activity (Curies)
2010	158,900	0.317
2011	134,450	0.041
2012	102,000	0.018
2013	132,250	0.009
2014	135,250	0.030
2015	139,950	0.005
2016	213,950	0.0169
2017	97,200	0.0022
2018	124,150	0.0019
2019	101,775	0.0039
2020	100,750	0.0066
2021	139,050	0.0087
2022	114,200	0.022

Exhibit 5-6. Total Low-Level Radioactive Waste

Year	Cubic meters (m^3)	Total Activity in Curies (Bq)
2010	13.3	6.30270 (2.332E+11)
2011	15.6	0.0351 (1.297E+09)
2012	No shipment	No shipment
2013	34.9	0.357 (1.32E+10)
2014	17.1	0.0082 (3.03E+08)
2015	No shipment	No shipment
2016	No shipment	No shipment
2017	17.80	12.3 (4.57E+11)
2018	0.076	0.0125 (4.63E+08)
2019	No shipment	No shipment
2020	No shipment	No shipment
2021	No shipment	No shipment
2022	13.21	1.52E-01 (5.624e9)

5.1.3 Radioactive Waste

In 2022, a small amount of low-level radioactive wastes (LLW) were stored on-site in the Radioactive Waste Handling Facility (RWHF). Limited operations in 2022 resulted in minimal LLW waste generation. PPPL had one LLW shipment for disposal in 2022. (Exhibit 5-5).

Exhibit 5-7. Truck with B-boxes and drums for shipping LLW to Energy Solutions

Most LLW are packaged for shipment and disposal in IP-1 metal containers, referred to as "B-boxes" and 55-gallon steel drums (Exhibit 5-6). PPPL maintains waste profiles for LLW that is shipped off-site for burial. PPPL ships LLW to the Energy Solutions facility in Clive, Utah. PPPL's radioactive waste program is audited periodically to ensure compliance with Department of Transportation (DOT) requirements. The audit includes employee training, waste characterization, waste packaging, quality control, and records retention.

Figure 5-8 Truck with B-box for shipping LLW to NNSS

The Tritium System Demolition & Disposal (TSDD) project generated a large volume of LLW in 2022. The project scope includes removing the contents of the Tritium Systems and two Neutral Beam Boxes (NBBs) that were used to support TFTR. Estimates of the residual activity are on the order of 19,000 Ci. As a result of the tritium inventory, the PPPL Tritium Areas were being maintained as a Hazard Category 3 (HC-3) facility as required by DOE-STD1027 Hazard Categorization of DOE Nuclear Facilities. Completing this project will subtantially reduce PPPL's risk of a tritium release and potential for employee or public exposure.

The TSDD project completed Critical Decision (CD) 1, 2, and 3 reviews in mid-2021 and solicited proposals for the work and the project was awarded to a subcontractor in 2022. D&D work started in early 2022 and is estimated to last approximately 18 to 24 months. In 2022 TSDD had 5 radioactive waste shipments totaling 78,601.97 Kg or 274.6 cubic meters (m^3). In March 2022, PPPL shipped the majority of it's tritium inventory off-site. Three Dryer Beds contained over 16,000 curies and were shipped to NNSS via exclusive use shipment (Figure 5-7). After that shipment PPPL was downgraded from a HC-3 facility to non-nuclear status.

5.1.4 Airborne Emission - Differential Atmospheric Tritium Samplers (DATS)

PPPL uses differential atmospheric tritium samplers (DATS) to measure elemental (HT) and oxide tritium (HTO) at the D-site stack. DATS are similarly used at four environmental sampling stations located on D-site facility boundary trailers (T1 to T4). All of the aforementioned monitoring is performed on a continuous basis.

Tritium (HTO and HT) was released and monitored at the D-site stack (Appendix Table 3). The projected dose equivalent to the MEI from airborne emissions of tritium was 1.05E-03 mrem/year (1.05E-05 mSv/year) in 2022.

5.2 Release of Property Containing Residual Radioactive Material

Release of property containing residual radioactivity is performed in accordance with PPPL ES&H Directives (ESHD) 5008, Section 10, Subpart L. PPPL has not released real property assets (land, structures, etc.) for public use in the past and has no plans for such releases in the future. Current property release processes focus on personal property items (equipment, materials, etc.). Property cannot be released for unrestricted use unless it is demonstrated that contamination levels on accessible surfaces are less than the values in Appendix D of ES&HD 5008, Section 10, and that prior use does not suggest that contamination levels in inaccessible surfaces exceed surface contamination values more than Appendix D. For tritium and tritiated compounds, the removable surface contamination value used for this purpose is 1,000 disintegrations per minute (dpm)/100 centimeters squared (cm^2). In addition, material is not released if radiation levels above background are detected when performing survey and activation analysis per PPPL approved procedure. During 2022, PPPL did not release any property containing radioactive material for recycle or reuse.

5.3 Protection of Biota

The highest measured concentrations of tritium in ground water in 2022 was 9.01E+01 pCi/L in the D-site MG and Airshaft sumps sample collected on several dates (Appendix Table 4) and for surface water 9.01E+01 pCi/L at sample location B2 collected on 11/7/22 (Appendix Table 5). All other sample results were below the lower limit of detection. These concentrations are small fractions of the water biota concentration guide (BCG) (for HTO) of $3x10^8$ pCi/L for aquatic system evaluations, and the water BCG (for HTO) of $2x10^8$ pCi/L for terrestrial system evaluations, per DOE Standard STD-1153-2002, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota". Because of these low concentrations and potential doses, PPPL does not conduct direct biota monitoring.

5.4 Unplanned Radiological Releases

There were no unplanned radiological releases in 2022.

5.5 Environmental Radiological Monitoring

5.5.1 Waterborne Radioactivity

A. Surface Water

Surface-water samples from nine locations; two on-site locations: DSN001 and E1; and seven off-site locations: B1, B2, C1, DSN003, M1, P1, and P2 have been analyzed for tritium (Appendix Table 5).

The highest tritium concentration in surface water measured in 2022 was 9.01E+01 pCi/L. This result was measured at several surface water and ground water sample locations both onsite and offsite. All surface water sampling results for tritium were below the lower limit of detection (see Appendix Table 5).

PPPL monitors precipitation data using the National Oceanic and Atmospheric Administration (NOAA) climate database. The monthly precipitation amounts for 2022 are shown on Appendix Table 2. Based on the average rainfall, a comparison of dry or wet years shows that 2022 was slightly below the average rainfall total at 43.87inches (111.43 cm), which is below New Jersey's expected average of 46 inches (116.8cm) (Appendix Table 6).

B. Ground Water

Ground water samples are taken from two building foundation sumps: D-site Airshaft and D-site MG sump, which are sampled monthly. The highest concentration of tritium in ground water was collected in D-site MG and the Airshaft at 9.01E+01 pCi/L (Appendix Table 4) in multiple months of 2022 [Fre23b]. This concentration is well below the state and federal Drinking Water Standard of 20,000 pCi/L.

Based on PPPL's environmental monitoring data and the available scientific literature [Jo74, Mu77, Mu82, Mu90], the most likely source of the tritium detected in the on-site ground water samples is the atmospheric releases of tritium from the D-site stack and the resulting "wash-out" during precipitation. Monitoring of ground water from building foundation sump (dewatering sump for D-site buildings) will continue as on-going atmospheric releases necessitate.

C. Drinking (Potable) Water

Potable water is supplied by the public utility, New Jersey American Water Company, formerly Elizabethtown Water Company. In April 1984, a sampling point at the input to PPPL (E1 location) was established to provide baseline data for water coming onto the site. Radiological analysis has included gamma spectroscopy and tritium-concentration determination. In 2022, tritium concentration at this location was below the lower limit of detection (Appendix Table 5).

5.5.2 Foodstuffs, Soil, and Vegetation

There were no foodstuffs, soil, or vegetation samples gathered for analysis in 2022. In 1996, the Health Physics (HP) Manager reviewed the requirement for soil/biota sampling. At that time, a decision was made to discontinue the sampling program. Tritium was not detected in almost all samples and these data were not adding to the understanding of tritium transport in the environment. Greater emphasis was placed on water sampling and monitoring, which produced more relevant results.

Chapter 6

The DOE Princeton Plasma Physics Laboratory's Site Hydrology, Ground Water, and Drinking Water Protection program includes information about PPPL's compliance with the Ground Water Remedial Action Permit issued by the New Jersey Department of Environmental Protection. This permit requires quarterly and annual ground water monitoring that includes testing for volatile organic chemicals and their natural attenuation byproducts.

SITE HYDROLOGY, GROUND WATER, AND DRINKING WATER PROTECTION

6.1 Lower Raritan River Watershed

PPPL is located within the Bee Brook Watershed. Bee Brook is a tributary to the Millstone River, which is part of the Raritan River Watershed (Exhibit 6-1). NJDEP utilizes a watershed-based management program for prospective environmental planning and has divided the State of New Jersey into twenty watershed basins.

Locally, the Bee Brook Watershed encompasses approximately 700 acres within the Princeton Forrestal Center and James Forrestal Campus tracts. It begins at College Road East (approximately 1,600 feet east of US Route 1), flows south in a wide flood plain, and then discharges into Devil's Brook at the entrance to Mill Pond [Sa80].

6.2 Geology & Topography

PPPL is situated on the eastern edge of the Piedmont Physiographic Province, approximately one-half mile from the western edge of the Atlantic Coastal Plain Province. The site is underlain largely by gently dipping and faulted sedimentary rock of the Newark Basin. The Newark Basin is one of several rift basins that were filled with sedimentary material during the Triassic Period, about 250-200 Ma (million years ago). At PPPL, bedrock is part of the Stockton Formation, which is reportedly more than 500 feet thick and consists of fractured red siltstone and sandstone [Lew87]. Regionally, the formation strikes approximately north 65 degrees east, and dips approximately 8 degrees to the northwest. The occurrence of limited amounts of clean sand near the surface indicates the presence of the Pennsauken Formation. This alluvial material was probably deposited during the Aftonian Interglacial period of the Pleistocene Epoch (approximately 2.6 million to 12,000 years ago).

Exhibit 6-1. Millstone River Watershed Basin

Within 25 miles, there are a number of documented faults; the closest of which is the Hopewell fault located about 8 miles from the site. The Flemington Fault and Ramapo Faults are located within 20 miles. None of these faults are determined to be "active" by the U.S. Geological Survey. This area of the country (eastern central US) is not generally earthquake-prone, despite the frequent occurrence of minor tremors that generally cause little or no damage.

The Millstone River and its supporting tributaries geographically dominate the region. The well-watered soils of the area have provided a wealth of natural resources including good agricultural lands from prehistoric times to the present. Land use was characterized by several small early centers of historic settlement and dispersed farmland. It has now been developed into industrial parks, housing developments, apartment complexes, and shopping centers [Gr77].

The topography of the site is relatively flat and open with elevations ranging from 110 feet in the northwestern corner to 80 feet above msl along the southern boundary. The low-lying topography of the Millstone River drainage reflects the glacial origins of the surface soils; sandy loams with varying percent of clay predominate.

Two soil series are recognized in the immediate vicinity of the site. Each reflects differences in drainage and subsurface water tables. Along the low-lying banks of stream tributaries, Bee Brook, the soils are classified Nixon-Nixon Variant and Fallsington Variant Association and Urban Land [Lew87].

This series is characterized by nearly level to gently sloping upland soils, deep, moderate to well drained, with a loamy subsoil and substratum. The yellowish-white sands contain patches of mottled coloring caused by prolonged wetness. On a regional scale, the water table fluctuates between 5 and 15 feet below the surface in wet periods and can drop below 15 feet during drier months.

In the slightly higher elevations (above 70 feet msl), the sandy loams are better drained and belong to the Sassafras series. Extensive historic farmlands and nurseries in the area indicate this soil provides a good environment for agricultural purposes, both today and in the past.

6.3 Biota

An upland forest type with dominant oak forest characterizes vegetation of the site. Associated with the various oaks are Red Maple, Hickories, Sweetgums, Beech, Scarlet Oak, and Ash. Red, White, and Black Oaks are isolated in the lower poorly drained areas. Along the damp borders of Bee Brook, a bank of Sweetgum, Hickory, Beech, and Red Maple define the watercourse. The forest throughout most of the site has been removed either for farmland during the last century or recently for the construction of new facilities. Grass has replaced much of the open areas.

The under-story of the wooded areas is partially open with isolated patches of shrubs, vines, and saplings occurring mostly in the uplands area. The poorly drained areas have a low ground cover of ferns, grasses, and leaf litter.

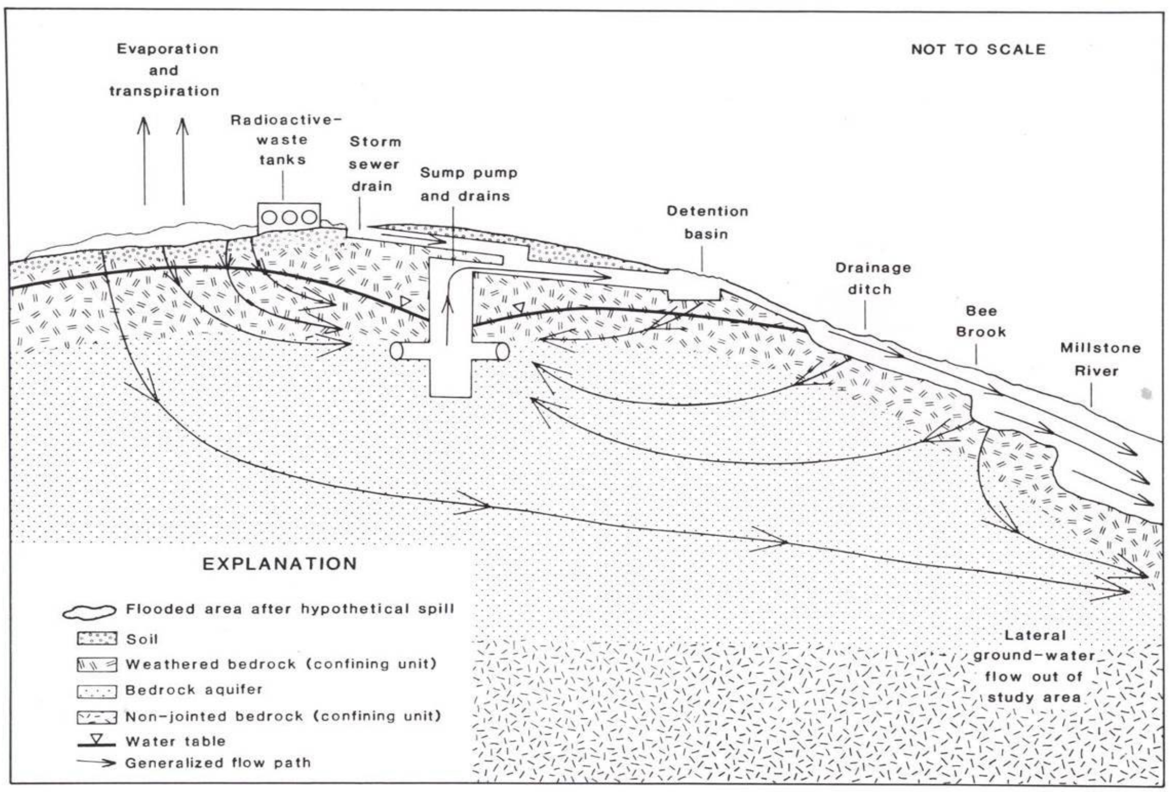
6.4 Flood Plain

All PPPL’s storm water runoff flows to Bee Brook, either directly *via* the retention basin outfall (DSN001) or along the western swale to the wetlands south of the site. Approximately 54% [Hug23f] of the site’s total area is covered by impervious surfaces – buildings, roadways and parking lots, and other structures.

PPPL’s Stormwater Management Plan minimizes impervious coverage of the Lab’s developable land consistent with an agreement between Princeton Forrestal Center and the Delaware and Raritan Canal Commission which allows for a maximum impervious coverage of 60% of the developable land. Eighteen acres of PPPL’s 88.5-acre site are wetlands, grass, and upland forest resulting in 36.7 acres of natural biota. Gravel, which is semi-impervious, covers approximately 7.97 acres, resulting in an impervious cover (buildings, roadways, sidewalks, etc.) of 28.24 acres or 54.18% [Hug23F].

Also, the 500-year flood plain elevation (85 feet above msl) delineates the storm protection corridor designated by Princeton Forrestal Center, which is vital to the flood and water quality control program for both Princeton Forrestal Center and PPPL. This "corridor" is preserved and protected from development by Princeton Forrestal Center in the Site Development Plan [PFC80].

Exhibit 6-2. Generalized Potentiometric Surface of the Bedrock Aquifer at PPPL [Lew87]



The general direction of ground-water flow on the site is from the northwest of PPPL toward the southeast in the direction of Bee and Devil's Brooks. The operation of several building foundation drainage sump pumps, especially those for the D-site experimental complex, creates a local and cone of depression drawing shallow ground water radially toward the sumps (Exhibit 6-2).

Ground water is pumped from the sumps into the retention basin, which flows into Bee Brook. Bee Brook is hydraulically connected with ground water; during flooding stages, the brook recharges ground water and during low-flow periods, ground water discharges to the brook.

6.5 Ground Water Monitoring

6.5.1 Monitoring Wells

PPPL installed a total of 46 wells to monitor ground water quality under various regulatory programs (Exhibit 6-3) during its history. Many wells have since been decommissioned, including 11 wells on C- and D-sites in December 2019. PPPL has 32 active monitoring wells for environmental monitoring and surveillance purposes. Remedial Investigation and Remedial Alternatives Analysis (RI/RAA) studies were conducted in the mid- to late-1990s to delineate shallow ground water contamination and identify a suitable remedy under the New Jersey Site Remediation Program [PPPL99a & b]. A Remedial Action Work Plan (RAWP) was approved by NJDEP in 2000. Ground water monitoring continues as part of the selected remedy [PPPL00]. PPPL completed the transition from NJDEP oversight to the Licensed Site Remediation Professional (LSRP) program in May 2012. In early 2018, NJDEP issued a revised Ground Water Remedial Action Permit number RAP17001 to replace RAP13001, effective for 30 years, for the ongoing remediation and monitoring programs at PPPL. PPPL modified its monitoring program to meet conditions of the new permit [NJDEP18].

Exhibit 6-3. Summary of Monitoring Wells at PPPL

	Remedial Action Monitoring Well (MW)	Environmental Surveillance Test Well (TW)
Active Wells Monitored On-Site	22	10
Active Wells Monitored Off-Site	0	0
Number of Wells Sampled	15	0
Sampling Rounds Completed	4	0

Exhibit 6-4. Summary of Ground Water Contamination

Historical Range of Results for Positive Detections		
	Wells	Sumps
Tritium (pCi/L)	N/A	<Bkg
PCE (µg/L)	ND – 97.4	1.3 – 32.4
TCE (µg/L)	ND – 11.4	ND – 3.1
1,4-Dioxane (µg/L)	ND – 0.69	ND - 0.173

ND = Not detected
Bkg = Background radiation naturally present

6.5.2 Sampling Events

In support of the approved ground water remedial action, PPPL monitors the ground water wells quarterly in March, June, September, and December. The type of equipment used by PPPL to sample the ground water is shown in Exhibits 6-5. Gas from a compressed gas (CO_2) cylinder is pumped down into the well via a Teflon-lined polyethylene tube into the dedicated bladder pump. The air pushes the water up through the exit tube and water flows through a chamber containing instruments to measure pH, conductivity, dissolved oxygen, temperature, and turbidity. Discharged water flows into a bucket that measures the volume discharged. A water level gauge is used to determine the rate of water recharging back into the well to ensure the sample will be representative of the ground water. Ground water monitoring parameters are listed in Exhibit 6-6.

Ground water monitoring results show that PCE, trichloroethylene (TCE), 1-4-dioxane, and their natural degradation products are present in several shallow and intermediate-depth wells on C-site (Exhibit 6-4). These VOCs are commonly contained in industrial solvents or metal degreasing agents. The source of these chemicals was identified as a former waste storage area known as the PPPL Annex Building.

PPPL's Ground Water Remedial Action Permit requires quarterly sampling for a targeted list of chlorinated VOCs and 1,4-dioxane. Ground water monitoring results are summarized in Tables 18-21 and Figure 1 in Appendix A, which show that PCE and 1,4-dioxane are present in ground water south of the Coil Assembly and Storage (CAS)/ Research Equipment Storage and Assembly Building (RESA) building. Most results have been below the NJDEP Ground Water Quality Standards. In 2022, the maximum PCE concentration detected was 66.6 micrograms per liter (µg/L) and the maximum 1,4-dioxane concentration detected was 0.264 µg/L. Typically the highest chlorinated contaminant concentrations are detected during the September sampling event. In addition to the wells sampled previously, PPPL analyzes 1,4-dioxane in monitoring wells MW-5S and MW-5I to confirm horizontal delineation to the north.

Foundation de-watering sumps located on D-site influence ground water flow across the site (Exhibits 6-8). The sumps create a significant cone of depression drawing ground water toward them. Under natural conditions, ground water flow is to the south-southeast toward Bee Brook; however, because of building foundation drains on D-site, ground water beneath the site is drawn radially toward the D-site sumps [EPA99, NJDEP18].

Exhibit 6-5. Well Monitoring Set-Up

Exhibit 6-6. Ground Water Monitoring Parameters

Frequency	Analytical Parameter	Analytical Method
Monthly	Tritium	
Quarterly	<u>Mar., Jun., Sept., Dec. 2022</u> Chlorinated Volatile Organics (VOCs)	EPA-624
	1,4-Dioxane	SW 846/8270 D
Annual (Mar.)	Nitrate & Nitrite	EPA-300.0
	Chloride	EPA-300.0
	Sulfate	EPA-300.0
	Alkalinity	SM 2320B
	Manganese	EPA-200.8 Rev. 5
	Ferrous Iron (Fe^{+2})	SM20/3500FEB
	Dissolved Methane	RSK-175
	Sulfide	SM 5310C
	Total Organic Carbon (TOC)	EPA 906.0

6.5.3 Ground Water Remedial Action

Following a site-wide RI/RAA study and remedy selection process, PPPL prepared and submitted a RAWP outlining continual operation of the ground water extraction system and a long-term monitoring program [Sh00]. The RAWP was submitted to NJDEP in May 2000 and was implemented until the Ground Water Remedial Action Permit (GWRAP) was issued in August 2013 [HLA97, HLA98, Sh 10-03]. A revised GWRAP was issued by NJDEP in January 2018.

In January 2002, an Aquifer Classification Exception Area (CEA) Designation was submitted to NJDEP. The CEA designation identifies specific areas where state-wide Ground Water Quality Standards are not met and will not be met for some time. The CEAs was granted for a specific area of an aquifer to address specific VOCs in the shallow (<60 feet deep) aquifer. The CEA request was approved by NJDEP in August 2002. The CEA was recertified in 2017, with submittal of a Biennial Remedial Action and Ground Water Classification Exception Area Recertification Report.

Long-term ground water monitoring confirms the following conditions:

- Examination of analytical data and water level measurements indicates an inverse relationship between ground water level and VOC concentration.
- Natural attenuation (anaerobic biodegradation) occurs in the wetlands adjacent to CAS/RESA.
- Contaminated ground water is captured by building sumps and is not migrating off-site.

Ground water remedial action activities in 2022 included:

- Quarterly groundwater sampling in March, June, September, and December by PPPL's environmental services subcontractor, JM Sorge/Verdantas.
- Annual sampling for chlorinated VOC + library search and monitored natural attenuation (MNA) parameters was conducted in March 2022.
- 1,4-Dioxane sampled at all wells quarterly.
- *Remedial Action Biennial Certification for Ground Water* submitted to NJDEP in September 2021; the next report is due in 2023.
- Ground water monitoring equipment and monitoring wells repaired as necessary.

6.5.4 Monitored Natural Attenuation

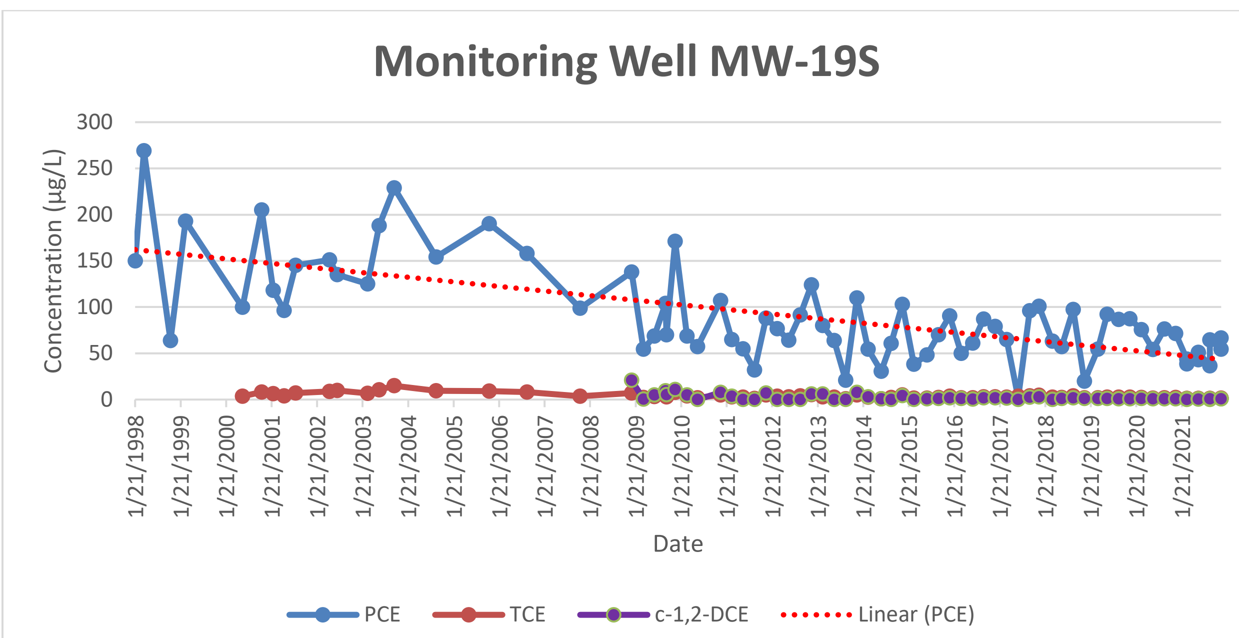
Examination of analytical data and water level measurements during the RI and the beginning of the Remedial Action indicated an inverse relationship between ground water level and VOC concentration (particularly PCE). Periods of higher water level generally corresponded with lower PCE results. Conversely, higher PCE results are generally coincident with period of lower ground water elevation (Appendix Tables 18-21).

Natural attenuation processes are active as evidenced by presence of degradation compounds in ground water down gradient of source area (Appendix Tables 18-21). PCE is sequentially degraded into TCE and cis-1,2-dichloroethlyene (c-1,2-DCE) (Exhibit 6-7). The presence of c-1,2-DCE, dissolved methane, reduced dissolved oxygen levels and negative oxidation-reduction potential (redox) values provide definitive evidence of on-going biological degradation of chlorinated ethenes [PPPL18, Sh00-13].

Exhibit 6-7. Typical PCE Degradation Pathway

Review and examination of the analytical results indicate that contaminant concentrations, particularly PCE, are generally decreasing and are below the levels documented at the beginning of the RI. Seasonal fluctuations in VOC concentrations have been seen in data collected during the RI and during subsequent remedial action monitoring. These data generally showed peak VOC concentration during the late fall/winter months (Appendix Figure 1 and 2, Exhibits 6-8). Spring and summer results are generally lower. The time-trend graph shown in Exhibit 6-8 also includes a second-order polynomial regression line fitted to PCE concentrations. This trend line shows an overall downward trend in contaminant concentration.

Exhibit 6-8. PCE Concentration vs. Time at MW-19S (1998-2022)



6.6 Drinking Water Protection

PPPL and the surrounding area do not rely on on-site or shallow supply wells for potable water. All potable water in the immediate area of the Laboratory is provided by New Jersey American Water Company. New Jersey American Water Company is supplied by a variety of sources, including surface water intakes and deep supply wells located throughout its service area. The nearest wells supplying water to New Jersey American are located approximately 2 miles south-southwest of the Laboratory near the Millstone River. As discussed above, ground water contaminated with PCE, and other organic chemicals is captured by the building foundation drains and is not migrating offsite.

Chapter 7

As required by DOE Order 450.1, Environmental Protection Program and DOE Order 414.1D, QA, PPPL has established a Quality Assurance/Quality Control (QA/QC) Program to ensure that the accuracy, precision, and reliability of environmental monitoring data are consistent.

QUALITY ASSURANCE

7.1 PEARL Lab Certification

Analyses of environmental samples for "analyze-immediately" non-radiological parameters were conducted by PPPL's on-site analytical laboratory performed the "analyze-immediately" non-radiological parameters on-site (Exhibits 7-1 & 7-2).

Exhibit 7-1. PEARL Chlorine Standard Check for Accuracy

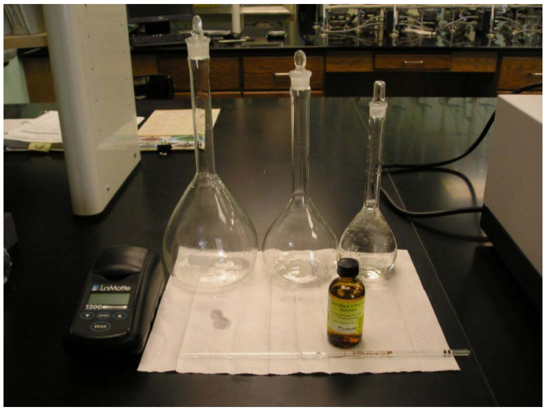


Exhibit 7-2. Distilling Samples for Tritium Analysis Performed at PEARL

The Princeton Environmental Analytical Radiological Laboratory (PEARL) procedures follow the DOE's Environmental Measurements Laboratory's *Environmental Monitoring Laboratory (EML) HASL-300 Manual* [Vo82], *EPA's Methods and Guidance for Analysis of Water* [EPA99], *and Standard Methods of Water and Wastewater Analysis* [SM22] that are nationally recognized standards.

Beginning in 1984, PPPL participated in a NJDEP certification program initially through the USEPA QA program. In March 1986, EPA/Las Vegas and NJDEP reviewed PPPL's procedures and inspected its facilities. The laboratory became certified for tritium analysis in urine (bioassays) and water. In 2001, USEPA turned the QA program over to the states; NJDEP chose a contractor laboratory, ERA, to supply the radiological PT. As of October 2013, NJDEP is no longer administrating PT Sample Contracts, requiring individual sites to obtain their own approved PT Sample Providers to obtain PT samples.

7.1.1. Radiological Parameters

Following NJDEP Office of Quality Assurance (OQA) Audit during which it was determined that PPPL's radiological analyses do not require NJDEP certification, PEARL radiological parameter certifications for tritium and gamma spectroscopy were discontinued effective August 14, 2015. As a best management practice, PPPL continues in a National Institute of Standards and Technology's (NIST) National Voluntary Laboratory Accreditation Program (NVLAP) accredited radiochemistry quality control testing program. PEARL analyzes for isotopes of cesium, cobalt and zinc using gamma spectroscopy, and for tritium using a distillation and liquid scintillation method (Exhibit 7-3, below). The results of these analyses are summarized in Appendix A, Table 24.

Exhibit 7-3. Internal Radiological Parameters

Parameter	Approved Method
Cesium 134/137*	SM 7120
Cobalt 60*	SM 7120
Zinc 65*	SM 7120
Tritium*	EPA 906.0

*Dropped NJDEP laboratory certification for parameters as of 8/14/2015

7.1.2. Non-Radiological Parameters

For non-radiological parameters, PPPL participates in NJDEP Laboratory Certification program (NJDEP ID #12471) (Exhibit 7-4). A requirement of the certification program is to analyze within the acceptance range the quality control and PT samples that are purchased from outside laboratory suppliers. These PT samples are provided as blind samples for analysis; the test results are submitted prior to the end of the study; in some cases, the PT samples are purchased as a lone study, in which PPPL can submit and receive study results immediately. Results are supplied to PPPL and NJDEP to confirm a laboratory's ability to correctly analyze those parameters being tested [PPPL22f]..

In May 2022, PPPL failed the PT for pH and total residual chlorine (CPO) due to scheduling errors. The ESD implemented a corrective action to address the error. In September 2022, PPPL failed a second proficiency test for total residual chlorine but passed for pH. It was determined there were technical flaws in the chlorine calibration process. Corrective actions were implemented to rectify these deficiencies as well. In November 2022, a settlement agreement between PPPL and the NJDEP, granted PPPL a third and final opportunity to pass a proficiency test for the year. After implementing the corrective actions of the previous two failed attempts and following manufacturer instructions and internal calibration procedures, PPPL received acceptable results for total residual chlorine. Appendix Table 24 shows the non-radiological PT results.

PPPL followed its internal procedures, EM-OP-49— "Methods for Measuring Analyze Immediately Parameters," EM-OP-31— "Surface Water Sampling Procedure," and EM-OP-38— "Ground Water Sampling Procedures." These procedures provide detailed descriptions of all NJPDES permit-required sampling and analytical methods for collection of samples, analyses of these samples, and QA/QC requirements. Chain-of-custody forms are required for all samples; holding times are closely checked to ensure that analyses are performed within established holding times and that the data is valid; trip blanks are required for all VOC analyses

Exhibit 7-4. NJDEP Non-Radiological Certified Parameters

NJDEP Laboratory Number 12471

Parameter	Approved Method
Chlorine	SM 4500-Cl G
pH	SM 4500-H B
Temperature	SM 2550 B

7.2 Subcontractor Labs

Subcontractor laboratories used by PPPL are certified by NJDEP and participate in the state's QA program; the subcontractor laboratories must also follow their own internal QA plans. SGS-Accutest Laboratories (NJDEP ID # 12129) conducts PPPL's environmental laboratory analysis. American Aquatics (NJDEP ID # PA682) is also used as a second-tier subcontractor laboratory for acute and chronic toxicity. Lower tier subcontractors are sometimes used when SGS-Accutest is not certified by the NJDEP to analyze certain parameters. When this happens SGS-Accutest confirms with PPPL that the lower tier laboratory is NJDEP certified to perform the analysis for that parameter.

PPPL's ground water monitoring and site remediation subcontractor JM Sorge, Inc. maintains NJDEP laboratory ID #18012 for certain analyze-immediately parameters. Precision Testing Laboratories, Inc. (NJDEP ID #15005) is used to analyze the majority of PPPL's waste characterization samples.

7.3 Internal QA/QC

7.3.1 Internal Audit

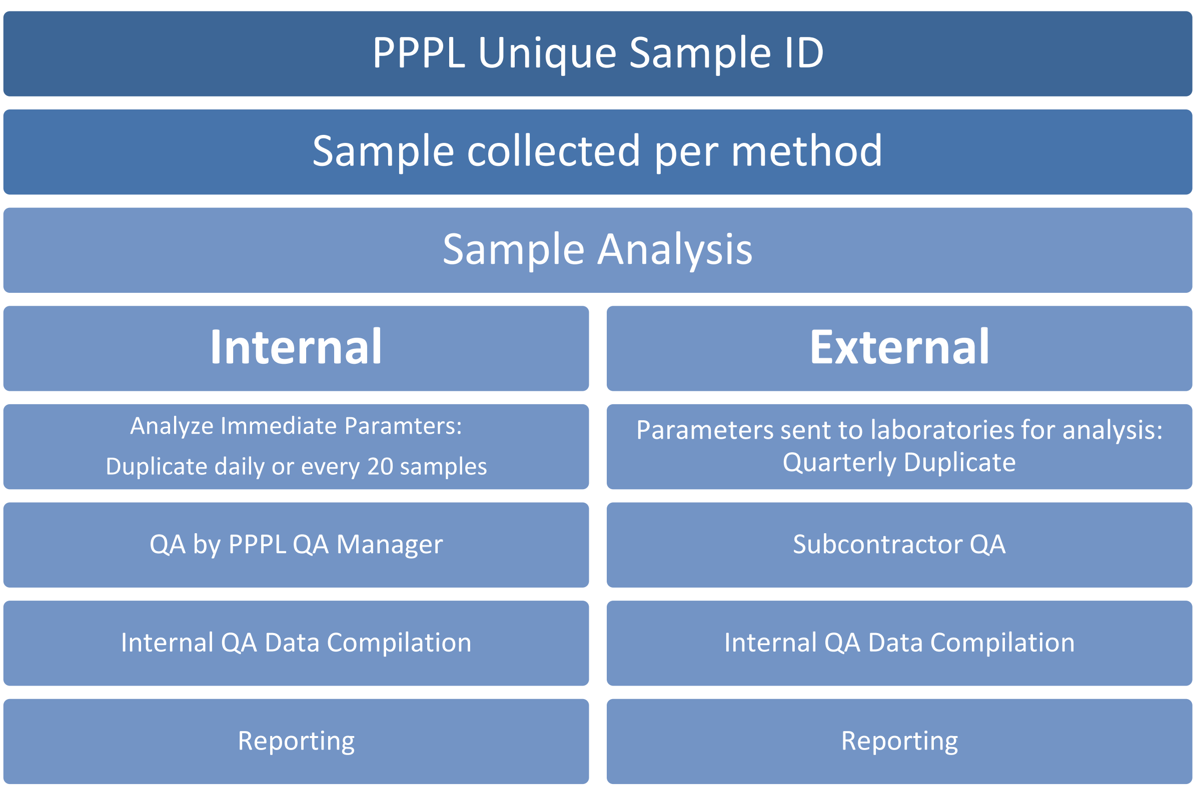
PPPL's QA program provides a variety of internal audits annually. The audits are completed with a member of QA and a subject matter expert. Due to other assessment priorities, no internal audits specific to environmental compliance programs were conducted in 2022.

7.3.2 Internal QA Check

PPPL's PEARL ensures QA/QC for its non-radiological environmental testing through procedure EM-QA-02 "Quality Assurance/Quality Control Plan for Analyze Immediately Parameters." This procedure includes the following:

- NIST thermometers are replaced with new NIST-certified long stem thermometers quarterly.
- Chlorine field meters and secondary standards are calibrated at least quarterly by chlorine standard concentrations; Quarterly chlorine calibration curves are generated.
- Duplicate samples of chlorine, pH, and temperature will be conducted daily or every 20 samples.
- Duplicate samples for NJPDES permit monitoring are submitted to the external laboratory quarterly.

PPPL's internal QA process for laboratory samples is as follows:



7.3.3. Calibrations

PPPL calibrates all equipment per equipment manual and following procedures EM-OP-49 and EM-QA-02. Calibrations are recorded in the respective lab calibration log and reported to the QA Officer for review.

PPPL's Environmental QA procedures following for calibration prior to sampling. The chlorine field meter is verified by using calibrated Secondary Standards. pH meters are calibrated with a 3-point standard calibration, and verified by checking the pH to the 7.00 standard.

7.3.4 Calibration Chemicals

Inventories are performed quarterly on calibration chemicals to ensure proper storage, expiration, and quantity. Chemical name, stock number, lot number, date received, date opened and expiration date are all checked to ensure chemical quality for calibration. Expired chemicals are removed from service and processed by PPPL's hazardous waste management group.

7.4 External QA/QC

External audits may be completed by a variety of different sources. Local, state and federal entities such as US DOE or NJDEP may request an on-site audit or inspection at any time. As discussed in Chapter 3, PPPL's EMS requires triennial registration and annual surveillance audits, which include the Measurement and Calibration elements of ISO14001. All corrective action are tracked and completed using PPPL's internal by the QA Division [Cum23]. One external audit was performed in 2022, which was a surveillance audit of PPPL's ISO-14001 EMS completed by PPPL's registrar, Orion.

Chapter 8

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Chapter 9

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Appendix A

2022 ASER TABLES & MAPS

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Table 1. PPPL NSTX-U Radiological Limits and Design Objectives

CONDITION			PUBLIC EXPOSURE[b]		OCCUPATIONAL EXPOSURE	
		P, Probability Of Occurrence In A Year	REGULATORY LIMIT (rem/year)	DESIGN OBJECTIVE (rem/year)	REGULATORY LIMIT (rem/year)	DESIGN OBJECTIVE (rem/year)
ROUTINE OPERATION Dose equivalent to an individual from routine operations (rem per year, unless otherwise indicated)	NORMAL OPERATIONS	P~1	0.1 Total, 0.01[c] Airborne, 0.004 Drinking Water	0.01 Total	5	1
	ANTICIPATED EVENTS	$(1 > P \geq 10^{-2})$	0.5 Total (including normal operation)	0.05 per event		
ACCIDENTS Dose equivalent to an individual from an accidental release (rem per event)	UNLIKELY EVENTS	$10^{-2} > P \geq 10^{-4}$	2.5	0.5	Emergency Exposure Situation: 5 to >25 depending on activity (property protection or lifesaving; see ESHD 5008, Section10.1302[PPPL13a])	
	EXTREMELY UNLIKELY EVENTS	$10^{-4} > P \geq 10^{-6}$	25	5 [d]		
	INCREDIBLE EVENTS	$10^{-6} > P$	NA	NA		

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[a] All operations must be planned to incorporate radiation safety guidelines, practices and procedures included in PPPL ESHD 5008, Section 10.
[b] Evaluated at PPPL site boundary.
[c] Compliance with this limit is to be determined by calculating the highest effective dose equivalent to any member of the public at any offsite point where there is a residence, school, business, or office
[d] For design basis accidents (DBAs), i.e., postulated accidents or natural forces and resulting conditions for which the confinement structure, systems, components, and equipment must meet their functional goals, the design objective is 0.5 rem.
[e] See PPPL ESHD-5008, Section 10, Chapter 10.1302 for emergency personnel exposure limits.

Table 2. Annual Precipitation Data for 2022

Month	Trenton-Mercer Airport KTTN (inches)
January	3.38
February	2.70
March	2.67
April	5.60
May	7.17
June	3.05
July	1.07
August	3.16
September	2.43
October	6.04
November	2.71
December	3.89
Total	**43.87**
Monthly Average	**3.65**

Table 3. D-Site Tritium Stack Releases in Curies in 2022

Week Beginning	HTO (Ci)	HT (Ci)	Weekly Total (Ci)
1/5/2022	0.0854	0.0001	0.0855
1/12/2022	0.0533	0.00003	0.0533
1/19/2022	0.0908	0.0002	0.0910
1/26/2022	0.0673	0.0001	0.0674
2/2/2022	0.0713	0.0001	0.0714
2/9/2022	0.0605	0.0001	0.0606
2/16/2022	0.0275	0.0007	0.0282
2/23/2022	0.1060	0.0008	0.1068
3/2/2022	0.0259	0.00003	0.0259
3/9/2022	0.0002	0.0012	0.0014
3/16/2022	0.0002	0.0001	0.0003
3/23/2022	0.0003	0.0003	0.0005
3/30/2022	0.0008	0.0001	0.0009
4/6/2022	0.0006	0.0002	0.0007
4/13/2022	0.0006	0.00005	0.0006
4/20/2022	0.0005	0.0002	0.0007
4/27/2022	0.0005	0.00002	0.0005
5/4/2022	0.0008	0.0001	0.0008
5/11/2022	0.0010	0.00003	0.0010
5/18/2022	0.0005	0.0001	0.0006
5/25/2022	0.0003	0.00003	0.0003
6/1/2022	0.0003	0.0001	0.0004
6/8/2022	0.0002	0.0001	0.0003
6/15/2022	0.0001	0.00001	0.0002
6/22/2022	0.0002	0.0001	0.0003
6/29/2022	0.0002	0.00001	0.0002
7/6/2022	0.0002	0.00001	0.0002
7/13/2022	0.0006	0.00001	0.0006
7/20/2022	0.0009	0.00001	0.0009
7/27/2022	0.0006	0.00001	0.0006
8/3/2022	0.0006	0.00001	0.0006
8/10/2022	0.0005	0.00001	0.0005
8/17/2022	0.0003	0.00001	0.0003
8/24/2022	0.0005	0.00001	0.0005
8/31/2022	0.0005	0.00001	0.0005
9/7/2022	0.0006	0.00001	0.0006
9/14/2022	0.0017	0.00001	0.0017
9/21/2022	0.0005	0.00001	0.0005
9/28/2022	0.0003	0.0000	0.0003
10/5/2022	0.0002	0.0000	0.0002
10/12/2022	0.0002	0.0000	0.0002
10/19/2022	0.0003	0.000002	0.0003
10/26/2022	0.0002	0.00002	0.0002
11/2/2022	0.0003	0.00001	0.0003
11/9/2022	0.0002	0.000004	0.0002
11/16/2022	0.0001	0.000003	0.0001
11/23/2022	0.0001	0.00001	0.0001
11/30/2022	0.0001	0.00001	0.0001
12/7/2022	0.0001	0.0000	0.0001
12/14/2022	0.0001	0.00002	0.0001
TOTALS	**0.6046**	**0.0048**	**0.6095**

Table 4. Ground Water Tritium Concentrations for 2022 (pCi/L)

Month	D-Site MG Sump	D-Site Airshaft Sump
January	*	*
February	*	*
March	*	*
April	*	*
May	*	*
June	*	*
July	*	*
August	*	*
September	*	*
October	*	*
November	*	*
December	*	*

Samples at sumps are collected monthly

***All sample dates not listed or shown without a number are below LLD and background.**

Table 5. Surface Water Tritium Concentrations for 2022 (pCi/L)

Month	Bee Brook (B1)	Bee Brook (B2)	Basin (DSN001)	Basin Duplicate (DSN004)	D&R Canal (C1)	D&R Canal (DSN003)	E1	M1	P1	P2
January			*		*	*				
February	*	*	*	*	*	*	*	*	*	*
March			*		*	*				
April			*		*	*				
May	*	*	*	*	*	*	*	*	*	*
June			*		*	*				
July			*		*	*				
August	*	*	*	*	*	*	*	*	*	*
September			*		*	*				
October			*		*	*				
November	*	*	*	*	*	*	*	*	*	*
December			*		*	*				

Samples at locations DSN001, DSN003, and C1 are collected monthly.

Samples at locations B1, B2, DSN004, E1, M1, P1, and P2 are collected quarterly.

*** All sample dates not listed or shown without a number were below the LLD and background.**

Table 6. Annual Range of Tritium Concentration at PPPL in Precipitation from 1985 to 2022

Year	Tritium Range pCi/L	Precipitation In Inches	Difference from Middlesex County Avg. Precipitation of 46.5 inches/year
1985	40 to 160		
1986	40 to 140		
1987	26 to 144		
1988	34 to 105		
1989	7 to 90	55.4	+8.8
1990	14 to 94	50.3	+3.8
1991	10 to 154	45.1	-1.5
1992	10 to 838	41.9	-4.6
1993	25 to 145	42.7	-3.8
1994	32 to 1,130	51.3	+4.8
1995	<19 to 2,561	35.6	-10.9
1996	<100 to 21,140	61.0	+14.5
1997	131 to 61,660	42.0	-4.5
1998	<108 to 26,450	42.9	-3.6
1999	<58 to 7,817	47.3(38.7 w/out Floyd)	+0.8(-7.8)
2000	<31 to 3,617	38.7	-7.8
2001	153 to 14,830	32.8	-13.7
2002	24 to 3,921	47.9	+1.4
2003	9 to 1,126	54.7	+8.2
2004	27 to 427	40.5	-6.0
2005	<37 to 623	48.4	+1.9
2006	9 to 3,600	48.1	+1.6
2007	<93 to 1,440	49.1	+2.6
2008	<103 to 1,212	48.2	+1.7
2009	<Bkg to 375	47.1	+1.6
2010	<105 to 469	40.8	-5.7
2011	<109 to 269	65.1	+18.6
2012	3 to 182	38.9	-7.6
2013	<Bkg to 1331	43.25	-3.25
2014	<Bkg to 216	45.06	-1.44
2015	<Bkg to 901	39.8	-6.7
2016	<Bkg to 1,396	34.82	-11.7
2017	*	41.38	-5.13
2018	*	65.01	+18.51
2019	*	58.36	+11.86
2020	*	57.08	+10.58
2021	*	57.25	+10.75
2022	*	43.87	-2.63

* PPPL stopped monitoring tritium concentration in rainwater because NSTX was not operating

Bkg = Background

Table 7. Liquid Effluent Collection Tank Release Data for 2022

Release Date	Gallons Released	Tritium Sample Activity (pCi/L)	Total Tritium Tank Activity (Ci)
5/6/2022	12,750	6.53E+03	3.15E-04
6/20/2022	12,750	1.15E+05	5.50E-03
7/6/2022	12,750	1.51E+05	7.29E-03
7/22/2022	12,750	1.96E+04	9.46E-04
8/5/2022	12,500	1.58E+04	7.48E-04
8/12/2022	12,750	1.36E+04	6.56E-04
9/2/2022	12,500	8.41E+04	3.98E-03
9/22/2022	12,750	3.29E+04	1.59E-03
11/9/2022	12,700	2.43E+04	1.17E-03
Total	**114,200**	**4.63E+05**	**2.22E-02**

Table 8. Total Fuel Consumption by Fuel Type from 2012 to 2022

Year	Natural Gas (mmcf)*	No. 2 Fuel Oil (kgals.)
2012	200.6	4.8
2013	261.5	5.0
2014	267.2	18.5
2015	209.1	12.8
2016	233.8	4.9
2017	244.0	0.1
2018	142.3	11.0
2019	147.7	0.1
2020	337.4	0.1
2021	365.3	0.5
2022	416.0	10.4
Permit Limit	**2,176.41**	**251.4**

No. 2 Fuel Oil consumption first began December 2004.
No. 4 Fuel Oil no longer burned after December 2004.
mmcf = millions of cubic feet
kgals. = thousands of gallons
*Corrected mmcf conversion factor used in previous reports

Table 9. Surface Water Analysis for Bee Brook, B1, in 2022

Location B1 = Bee Brook upstream of PPPL basin discharge

B1							
Parameters	**Units**	**Jan. 2022**	**Feb. 2022**	**March 2022**	**April 2022**	**May 2022**	**June 2022**
Chemical Oxygen Demand, COD	mg/L		< 11			< 18.2	
Phosphorus, total	mg/L	< 0.037	< 0.027	< 0.033	< 0.11	< 0.029	< 0.029
Total Suspended Solids, TSS	mg/L		< 1.7			4.5	
Field Parameters							
pH	SU		7.47			7.25	
Oxidation-Reduction Potential, ORP	mV		-31.5			-23.0	
Temperature	°C		2.8			14.3	

Blank indicates no measurement

B1							
Parameters	**Units**	**July 2022**	**Aug. 2022**	**Sept. 2022**	**Oct. 2022**	**Nov. 2022**	**Dec. 2022**
Chemical Oxygen Demand, COD	mg/L		29.70			133.0	
Phosphorus, total	mg/L	0.075	0.10	1.0	5.0	< 0.54	0.10
Total Suspended Solids, TSS	mg/L		5.7			24.2	
Field Parameters							
pH	SU		7.99			6.99	
Oxidation-Reduction Potential, ORP	mV		-64.1			-8.8	
Temperature	°C		22.2			17.4	

Blank indicates no measurement

Table 10. Surface Water Analysis for Bee Brook, B2, in 2022

Location B2 = Bee Brook downstream of PPPL basin discharge

B2							
Parameters	**Units**	**Jan. 2022**	**Feb. 2022**	**March 2022**	**April 2022**	**May 2022**	**June 2022**
Chemical Oxygen Demand, COD	mg/L		< 11			< 11	
Phosphorus, total	mg/L	< 0.041	< 0.04	< 0.046	< 0.11	0.06	< 0.029
Total Suspended Solids, TSS	mg/L		< 1.7			< 3.6	
Field Parameters							
pH	SU		7.25			6.83	
Oxidation-Reduction Potential, ORP	mV		-20.6			-0.8	
Temperature	°C		5.0			15.3	

Blank indicates no measurement

B2							
Parameters	**Units**	**July 2022**	**Aug. 2022**	**Sept. 2022**	**Oct. 2022**	**Nov. 2022**	**Dec. 2022**
Chemical Oxygen Demand, COD	mg/L		< 11			< 11	
Phosphorus, total	mg/L	0.085	0.08	0.066	5.4	< 0.027	0.12
Total Suspended Solids, TSS	mg/L		< 3.9			< 2.1	
Field Parameters							
pH	SU		6.70			6.94	
Oxidation-Reduction Potential, ORP	mV		7.9			-6.0	
Temperature	°C		22.2			18.0	

Blank indicates no measurement

Table 11. Surface Water Analysis for Delaware & Raritan Canal, C1, in 2022

Location C1 = D&R Canal State Park at Mapleton Avenue, Plainsboro midway on pedestrian bridge

C1

Parameters	Units	Jan.	Feb.	March	April	May	June
		2022	2022	2022	2022	2022	2022
Chemical Oxygen Demand, COD	mg/L	< 11	< 11	< 11	< 17.8	< 11	< 11
Phosphorus, total	mg/L	< 0.048	0.056	0.05	0.055	0.11	0.11
Total Suspended Solids, TSS	mg/L	< 1.5	< 2.7	< 2.5	9.9	5.8	4.5
Field Parameters							
pH	SU	7.64	7.69	7.59	7.57	6.50	7.08
Oxidation-Reduction Potential, ORP	mV	-39.0	-43.2	-37.1	-38.2	17.3	-9.3
Temperature	°C	0.40	2.7	7.7	10.3	14.6	22.9

Blank indicates no measurement

C1

Parameters	Units	July	August	Sept.	Oct.	Nov.	Dec.
		2022	2022	2022	2022	2022	2022
Chemical Oxygen Demand, COD	mg/L	< 11	< 11	< 11	< 18.4	< 11	21
Phosphorus, total	mg/L	0.064	0.06	0.07	< 2.80	< 0.027	0.077
Total Suspended Solids, TSS	mg/L	< 2.4	< 3.2	< 2.3	< 2.8	< 1.8	< 3.8
Field Parameters							
pH	SU	6.73	7.10	5.99	7.0	7.55	7.63
Oxidation-Reduction Potential, ORP	mV	10.0	-14.4	27.6	N/A	39.9	-36.4
Temperature	°C	25.5	27.8	26.2	15.3	16.0	7.6

Blank indicates no measurement

Table 12. Surface Water Analysis for NJ American Water, E1, in 2022

Location E1 = NJ American Water (potable) collected at Main Gate Security Booth

E1					
Parameters	**Units**	**February 2022**	**May 2022**	**August 2022**	**Nov. 2022**
Chemical Oxygen Demand, COD	mg/L	< 11	< 11	< 12.8	< 11
Phosphorus, total	mg/L	0.35	< 0.027	0.38	< 0.034
Total Suspended Solids, TSS	mg/L	< 1.5	< 1.5	< 1.5	< 1.5
Field Parameters					
pH	SU	6.65	6.59	7.00	6.91
Oxidation-Reduction Potential, ORP	mV	16.0	12.3	-8.9	-4.4
Temperature	°C	13.5	16.5	23.9	20.7

Table 13. Surface Water Analysis for Millstone River, M1, in 2022

Location M1 = Millstone River at D&R Canal State Park at Mapleton Road

M1					
Parameters	**Units**	**February 2022**	**May 2022**	**August 2022**	**Nov. 2022**
Chemical Oxygen Demand, COD	mg/L	< 12.8	< 11	< 14	< 13.3
Phosphorus, total	mg/L	0.06	0.34	< 0.027	< 0.027
Total Suspended Solids, TSS	mg/L	8.0	7.3	8.0	< 3.6
Field Parameters					
pH	SU	7.49	7.47	6.80	7.26
Oxidation-Reduction Potential, ORP	mV	-33.0	-34.6	2.9	-23.6
Temperature	°C	4.4	15.2	26.8	17.8

Table 14. Surface Water Analysis for Cranbury Brook (Plainsboro), P1, in 2022

Location P1 = Cranbury Brook at George Davison Road, Plainsboro mid-span on bridge southbound

P1					
Parameters	**Units**	**February**	**May**	**August**	**Nov.**
		2022	**2022**	**2022**	**2022**
Chemical Oxygen Demand, COD	mg/L	23.1	< 11	< 14	< 13.3
Phosphorus, total	mg/L	0.34	0.07	0.052	< 0.027
Total Suspended Solids, TSS	mg/L	96	9.5	4.4	10
Field Parameters					
pH	SU	7.50	6.20	7.01	6.83
Oxidation-Reduction Potential, ORP	mV	-33.6	33.0	-9.0	-0.3
Temperature	°C	4.5	15.6	26.3	17.7

Table 15. Surface Water Analysis for Devil's Brook (Plainsboro), P2, in 2022

Location P2 = Devil's Brook at Schalks Crossing Road overpass, adjacent to Amtrak railroad tracks

P2					
Parameters	**Units**	**February**	**May**	**August**	**Nov.**
		2022	**2022**	**2022**	**2022**
Chemical Oxygen Demand, COD	mg/L	20.5	26.0	< 11	< 13.3
Phosphorus, total	mg/L	0.052	0.055	< 0.027	< 0.027
Total Suspended Solids, TSS	mg/L	< 2.7	4.0	< 2.4	6.3
Field Parameters					
pH	SU	7.64	7.47	7.05	6.79
Oxidation-Reduction Potential, ORP	mV	-40.7	-34.9	-11.4	2.1
Temperature	°C	5.1	13.7	22.9	17.4

Table 16. Retention Basin Outfall Surface Water Analysis, DSN001 (NJPDES NJ0023922) in 2022

DSN001								
Parameters	**Units**	**Permit Limit**	**Jan. 2022**	**Feb. 2022**	**March 2022**	**April 2022**	**May 2022**	**June 2022**
Chemical Oxygen Demand, COD	mg/L	50.0	< 11	< 11	< 11	< 11	< 11	< 11
Phosphorus, total	mg/L		0.058	0.05	0.094	0.060	0.12	0.099
Tetrachloroethylene, PCE	µg/L	0.703	< 0.54	< 0.41	< 0.41	< 0.59	< 0.41	< 0.41
Total Petroleum Hydrocarbon, TPHC	mg/L	15 Max 10 Avg	< 0.83	< 0.87	< 0.83	< 0.83	< 0.84	< 0.83
Total Suspended Solids, TSS	mg/L	50.0	< 1.6	< 1.5	5.4	8.4	< 2.9	5.3
Field Parameters								
Chlorine Produced Oxidants, CPO (Max) (Avg)	mg/L	0.100	0.030 0.050	0.04 0.04	N/A	N/A	N/A	N/A
Peracetic Acid (Duplicate)	mg/L		N/A N/A	N/A N/A	0.0856 0.0428	0.0321 0.0428	0.0428 0.0642	0.0749 0.1177
pH (Max) (Min)	SU	>6; <9	6.61 6.38	6.33 6.28	6.31 6.27	6.46 6.39	6.43 6.34	6.25 6.24
Oxidation-Reduction Potential, ORP (Duplicate)	mV		13.5 25.2	27.9 30.2	29.6 31.9	20.1 23.9	21.1 25.7	36.2 35.9
Temperature (Duplicate)	ºC	30	4.2 3.9	9.7 8.5	10.7 10.6	10.8 10.8	16.0 15.9	23.1 23.2

DSN001								
Parameters	**Units**	**Permit Limit**	**July 2022**	**August 2022**	**Sept. 2022**	**Oct. 2022**	**Nov. 2022**	**Dec. 2022**
Chemical Oxygen Demand, COD	mg/L	50.0	< 11	< 11	< 11	< 11	< 11	< 11
Phosphorus, total	mg/L		0.12	0.09	0.097	7.900	< 0.027	0.15
Tetrachloroethylene, PCE	µg/L	0.703	< 0.41	< 0.41	< 0.41	< 0.41	< 0.41	< 0.41
Total Petroleum Hydrocarbon, TPHC	mg/L	15 Max 10 Avg	< 0.83	< 0.84	< 0.86	< 0.85	< 0.96	< 0.83
Total Suspended Solids, TSS	mg/L	50.0	30.3	6.0	5.3	< 3.7	4.9	6.3
Field Parameters								
Chlorine Produced Oxidants, CPO (Max) (Avg)	mg/L	0.100	N/A	N/A	N/A	N/A	N/A	N/A
Peracetic Acid (Duplicate)	mg/L		0.1712 0.0963	0.0642 0.0642	0.0535 0.0535	0.1391 0.0749	0.1284 0.2354	0.075 0.043
pH (Max) (Min)	SU	>6; <9	6.44 6.34	6.54 6.50	6.60 6.48	7.6 7.6	6.54 6.41	7.07 6.93
Oxidation-Reduction Potential, ORP (Duplicate)	mV		25.2 30.9	17.1 19.6	6.3 13.2	N/A N/A	20.9 23.0	-7.0 0.5
Temperature (Duplicate)	ºC	30	21.7 21.7	22.9 22.9	20.8 20.7	17.0 17.0	18.1 18.0	12.7 12.4

NA = Not Analyzed
Blank indicates no measurement

Table 17. D&R Canal Pump House, DSN003

Monthly Surface Water Analysis (NJPDES NJ0023922) in 2022

DSN003														
Parameters	**Units**	**Permit Limit**		**Jan. 2022**		**Feb. 2022**		**March 2022**		**April 2022**		**May 2022**		**June 2022**
Chemical Oxygen Demand, COD	mg/L	50	<	11	<	15.4	<	11	<	11	<	11	<	11
Phosphorus, total	mg/L			0.052		0.088		0.052		0.053		0.086	<	0.033
Total Petroleum Hydrocarbon, TPHC	mg/L	15 Max 10 Avg	<	0.95	<	0.87	<	0.82	<	0.83	<	0.83	<	0.83
Total Suspended Solids, TSS	mg/L		<	3.6		10.7	<	3.1		6.4		4.8	<	2.8
Field Parameters														
pH	SU	>6;<9		7.07		7.02		6.71		7.57		6.85		6.73
Oxidation-Reduction Potential, ORP	mV			-10.1		-8.6		8.8		-38.1		-1.7		9.8
Temperature	°C	30 Max		10.1		10.4		9.8		13.7		16.1		25.9

DSN003														
Parameters	**Units**	**Permit Limit**		**July 2022**		**August 2022**		**Sept. 2022**		**Oct. 2022**		**Nov. 2022**		**Dec. 2022**
Chemical Oxygen Demand, COD	mg/L	50	<	11	<	11	<	11	<	11	<	11		21
Phosphorus, total	mg/L			0.079	<	0.027		0.074		0.17	<	0.027		0.083
Total Petroleum Hydrocarbon, TPHC	mg/L	15 Max 10 Avg	<	0.83	<	0.83	<	0.86	<	0.85	<	1.30	<	0.83
Total Suspended Solids, TSS	mg/L		<	2.4	<	3.1	<	1.6		4.0	<	2.6	<	3.0
Field Parameters														
pH	SU	>6;<9		6.75		7.50		6.08		6.7		7.08		7.58
Oxidation-Reduction Potential, ORP	mV			9.0		-37.5		22.9		N/A		-13.9		-34.0
Temperature	°C	30 Max		28.3		28.3		27.1		16.5		16.2		11.4

Blank indicates no measurement

Table 18. Summary of Ground Water Sampling Results – March 2022

Target Chlorinated Volatile Organic Compounds (VOC), Monitored Natural Attenuation (MNA)

Well ID	NJ Ground Water Quality Standards-Class IIA (2020)	Units	MW-3S	MW-5I	MW-5S	MW-9S	MW-12S	MW-13I	MW-13S	MW-17	MW-18	MW-19I	MW-19S
PPPL Sample ID			MW-3S 22-164	MW-5I 22-165	MW-5S 22-166	MW-9S	MW-12S 22-168	MW-13I 22-169	MW-13S 22-170	MW-17 22-171	MW-18 22-172	MW-19I 22-173	MW-19S 22-174
Lab Sample ID			JD41883-2	JD41730-3	JD41730-2	JD41806-7	JD41883-3	JD41730-6	JD41730-4	JD41806-3	JD41806-2	JD41998-1	JD41998-2
Target Volatile Organic Compounds													
Tetrachloroethene	1	ug/L	<0.9	<0.9	0.9 J	4.6	<0.9	11.5	11.1	7.7	<0.9	ND	38.4
Trichloroethene	1	ug/L	<0.53	1.1	<0.53	3	<0.53	<0.53	1.6	1.1	<0.53	ND	1.1
cis-1,2-Dichloroethene	70	ug/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,1,1-Trichloroethane	30	ug/L	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54
1,1-Dichloroethane	50	ug/L	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57
Vinyl chloride	1	ug/L	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79
Target Semi-Volatile Organic Compounds													
1,4-Dioxane	0.4	ug/L	<0.2	<0.19	<0.19	<0.2	<0.2	0.2 J	0.222 J	<0.19	<0.2	<0.2	0.216 J
Natural Attenuation Indicators													
Chloride	250000	ug/L	19300	219000	185000	15700	129000	17800	171000	19700	48200	259000	4700
Manganese	50	ug/L	1690	437	1.9	26.7	<1.4	29.3	5020	72.6	448	5.7	29.1
Alkalinity	–	ug/l	169000	130000	13000	73000	53000	102000	20000	57500	9500	8000	<3600
Nitrate as N	10000	ug/L	<93	<93	1700	<93	3100	130	<93	<93	<93	1400	380
Nitrite	1000	ug/L	15	39	<3	<3	13	<3	<3	24	<3	<3	<3
Sulfate	250000	ug/L	16600	17600	9200	12600	25700	15600	14500	12100	23900	8100	38400
Sulfide	–	mg/L	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48
Total Organic Carbon	–	ug/L	12700	1200	840	2900	1300	1300	2300	920	1900	880	1900
Ferrous Iron	–	ug/L	<29	<29	<29	<29	<29	<29	<29	<29	<29	<29	<29
Dissolved Methane	–	ug/L	326	5.24	<0.08	0.53	0.11	<0.08	30.4	<0.08	0.14	<0.08	0.19
Dissolved Oxygen	–	mg/L	0.0	0.69	NA	0.0	1.97	1.67	7.53	0.0	4.43	3.16	0.0
pH	6.5 - 8.5	Std. Units	6.13	7.17	NA	5.63	6.3	6.46	5.93	6.21	4.48	5.43	4.22
Redox Potential	–	mVe	12	-35	NA	262	242	250	67	84	230	291	356

NOTES:

B - Analyte is found in the associated method blank

J - Estimated, concentration listed greater than the MDL but lower than the lowest standard.

NA - Not Analyzed

Ground water quality standards as published in N.J.A.C. 7:9-6.9

— - Compound-specific Ground Water Quality Standard not published

* MW-26S is duplicate sample from well MW-13S

Table 18 cont. Summary of Ground Water Sampling Results – March 2022

Target Chlorinated Volatile Organic Compounds (VOC), Monitored Natural Attenuation (MNA)

Well ID	NJ Ground Water Quality Standards- Class IIA (2020)	Units	MW-22S	MW-23S	MW-24S	MW-25S	MW-26S*	D-site Air Shaft	D-site MG Basement	TRIP BLANK 122-183	TRIP BLANK2 22-183	TRIP BLANK3 22-183	TRIP BLANK4 22-183
PPPL Sample ID			MW-22S 22-175	MW-23S 22-176	MW-24S 22-177	MW-25S 22-178	MW-26S 22-179	AIRSHAFT 22-181	D-SITE MG 22-180	TRIP BLANK 122-183	TRIP BLANK2 22-183	TRIP BLANK3 22-183	TRIP BLANK4 22-183
Lab Sample ID			JD41883-5	JD41998-3	JD41883-4	JD41806-4	JD41730-5	JD41806-5	JD41806-6	JD41730-1	JD41806-1	JD41883-1	JD41998-4
Target Volatile Organic Compounds													
Tetrachloroethene	1	ug/L	<0.9	<0.9	<0.9	<0.9	10.7	2	15.4	<0.9	<0.9	<0.9	<0.9
Trichloroethene	1	ug/L	<0.53	<0.53	<0.53	<0.53	1.7	<0.53	1.6	<0.53	<0.53	<0.53	<0.53
cis-1,2-Dichloroethene	70	ug/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,1,1-Trichloroethane	30	ug/L	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54
1,1-Dichloroethane	50	ug/L	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57
Vinyl chloride	1	ug/L	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79
Target Semi-Volatile Organic Compounds													
1,4-Dioxane	0.4	ug/L	<0.2	<0.2	<0.19	<0.2	0.264 J	<0.2	<0.2	NA	NA	NA	NA
Natural Attenuation Indicators													
Chloride	250000	ug/L	100000	5300	7600	68600	172000	123000	157000	NA	NA	NA	NA
Manganese	50	ug/L	32	63.7	9.4	3940	5210	111	2110	NA	NA	NA	NA
Alkalinity	–	ug/l	6000	<3600	6500	90500	17000	108000	93500	NA	NA	NA	NA
Nitrate as N	10000	ug/L	640	<93	130	<93	<93	1300	870	NA	NA	NA	NA
Nitrite	1000	ug/L	14	<3	20	<3	<3	<3	30	NA	NA	NA	NA
Sulfate	250000	ug/L	21500	57600	14300	24200	14800	14700	14200	NA	NA	NA	NA
Sulfide	–	mg/L	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48	NA	NA	NA	NA
Total Organic Carbon	–	ug/L	2000	1700	940	1700	2400	1100	1600	NA	NA	NA	NA
Ferrous Iron	–	ug/L	<29	<29	<29	<29	37	<29	37	NA	NA	NA	NA
Dissolved Methane	–	ug/L	<0.08	<0.08	<0.08	5.12	30.2	<0.08	4.4	NA	NA	NA	NA
Dissolved Oxygen	–	mg/L	5.65	5.09	4.6	0.0	7.53	NA	NA	NA	NA	NA	NA
pH	6.5 - 8.5	Std. Units	5.44	4.63	4.99	6.35	5.93	NA	NA	NA	NA	NA	NA
Redox Potential	–	mVe	320	369	372	12	67	NA	NA	NA	NA	NA	NA

NOTES:

B - Analyte is found in the associated method blank

J - Estimated, concentration listed greater than the MDL but lower than the lowest standard.

NA - Not Analyzed

Ground water quality standards as published in N.J.A.C. 7:9-6.9

— - Compound-specific Ground Water Quality Standard not published

Table 19. Summary of Ground Water Sampling Results – June 2022

Target Chlorinated Volatile Organic Compounds (VOC), Monitored Natural Attenuation (MNA)

Well ID	NJ Ground Water Quality Standards-Class IIA (2020)	Units	MW-3S	MW-5I	MW-5S	MW-9S	MW-12S	MW-13S	MW-17	MW-18
PPPL Sample ID			MW-3S 22-238	MW-5I 22-239	MW-5S 22-240	MW-9S 22-241	MW-12S 22-242	MW-13S 22-243	MW-17 22-244	MW-18 22-245
Lab Sample ID			JD46596-4	JD46596-1	JD46596-2	JD46804-4	JD46596-3	JD46596-5	JD46804-2	JD46706-4
Target Volatile Organic Compounds										
Tetrachloroethene	1	ug/L	<0.9	<0.9	<0.9	19.1	<0.9	12.1	5.1	<0.9
Trichloroethene	1	ug/L	<0.53	0.96 J	<0.53	3.2	<0.53	1.8	0.88 J	<0.53
cis-1,2-Dichloroethene	70	ug/L	<0.51	6.1	<0.51	<0.51	<0.51	12.1	<0.51	<0.51
1,1,1-Trichloroethane	30	ug/L	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54
1,1-Dichloroethene	1	ug/L	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59
Vinyl chloride	1	ug/L	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79
Target Semi-Volatile Organic Compounds										
1,4-Dioxane	0.4	ug/L	<0.3	<0.3	<0.3	0.162 J	<0.3	<0.3	<0.25	<0.3
Natural Attenuation Indicators										
Dissolved Oxygen	–	mg/L	0.0	0.0	NA	0.0	1.38	7.38	0.0	0.0
pH	6.5 - 8.5	Std. Units	5.98	7.15	NA	5.24	6.7	5.84	6.24	4.71
Redox Potential	–	mVe	4	-69	NA	254	129	40	118	136

NOTES:

B - Analyte is found in the associated method blank

J - Estimated, concentration listed greater than the MDL but lower than the lowest standard.

NA - Not Analyzed

Ground water quality standards as published in N.J.A.C. 7:9-6.9

— - Compound-specific Ground Water Quality Standard not published

Table 19 cont. Summary of Ground Water Sampling Results – June 2022

Target Chlorinated Volatile Organic Compounds (VOC), Monitored Natural Attenuation (MNA)

Well ID	NJ Ground Water Quality Standards-Class IIA (2020)	Units	MW-19S	MW-25S	MW-26S*	D-site MG Basement	TRIP BLANK	TRIP BLANK	TRIP BLANK
PPPL Sample ID			MW-19S 22-246	MW-25S 22-247	MW-26S 22-248	D-SITE MG 22-250	TRIP BLANK 22-251	TRIP BLANK 3 22-251	TRIP BLANK2 22-251
Lab Sample ID			JD46804-5	JD46706-3	JD46804-3	JD46706-2	JD46596-6	JD46804-1	JD46706-1
Target Volatile Organic Compounds									
Tetrachloroethene	1	ug/L	51	<0.9	10	22.7	<0.9	<0.9	<0.9
Trichloroethene	1	ug/L	1.3	0.69 J	1.7	2.6	<0.53	<0.53	<0.53
cis-1,2-Dichloroethene	70	ug/L	0.6 J	1.9	12.2	1.4	<0.51	<0.51	<0.51
1,1,1-Trichloroethane	30	ug/L	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54
1,1-Dichloroethene	1	ug/L	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59
Vinyl chloride	1	ug/L	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79
Target Semi-Volatile Organic Compounds									
1,4-Dioxane	0.4	ug/L	<0.23	<0.31	<0.23	<0.29	NA	NA	NA
Natural Attenuation Indicators									
Dissolved Oxygen	–	mg/L	7.97	0.0	8.17	NA	NA	NA	NA
pH	6.5 - 8.5	Std. Units	4.23	6.53	5.67	NA	NA	NA	NA
Redox Potential	–	mVe	287	31	61	NA	NA	NA	NA

NOTES:

B - Analyte is found in the associated method blank

J - Estimated, concentration listed greater than the MDL but lower than the lowest standard.

NA - Not Analyzed

Ground water quality standards as published in N.J.A.C. 7:9-6.9

— - Compound-specific Ground Water Quality Standard not published

* MW-26S is duplicate sample from well MW-13S

Table 20. Summary of Ground Water Sampling Results –September 2022

Target Chlorinated Volatile Organic Compounds (VOC), Monitored Natural Attenuation (MNA)

Well ID	NJ Ground Water Quality Standards-Class IIA (2020)	Units	MW-13S	MW-17	MW-18	MW-19S	MW-25S	MW-3S	MW-5I
PPPL Sample ID			MW-13S 22-553	MW-17 22-554	MW-18 22-555	MW-19S 22-556	MW-25S 22-557	MW-3S 22-548	MW-5I 22-550
Lab Sample ID			JD51912-3	JD51912-5	JD51998-2	JD51998-3	JD51998-1	JD51876-3	JD51876-2
Target Volatile Organic Compounds									
Tetrachloroethene	1	ug/l	8.5	19.8	<0.56	64.6	<0.56	<0.9	<0.9
Trichloroethene	1	ug/l	1.7	2.7	<0.53	1.3	0.67 J	<0.53	0.63 J
cis-1,2-Dichloroethene	70	ug/l	10.6	<0.51	<0.51	0.69 J	2.5	2.5	2.9
1,1,1-Trichloroethane	30	ug/l	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54
1,1-Dichloroethene	1	ug/l	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59
Vinyl chloride	1	ug/l	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79
Target Semi-Volatile Organic Compounds									
1,4-Dioxane	0.4	ug/l	<0.19	<0.17	<0.2	<0.19	<0.2	<0.2	<0.17
Natural Attenuation Indicators									
Dissolved Oxygen	–	mg/L	8.74	0.0	0.0	0.0	0.0	0.0	0.0
pH	6.5 - 8.5	Std. Units	5.03	5.46	5.39	4.56	6.35	6.24	7.4
Redox Potential	–	mVe	74	120	147	258	5	1	-30

NOTES:

B - Analyte is found in the associated method blank

J - Estimated, concentration listed greater than the MDL but lower than the lowest standard.

NA - Not Analyzed

Ground water quality standards as published in N.J.A.C. 7:9-6.9

— - Compound-specific Ground Water Quality Standard not published

* MW-26S is duplicate sample from well MW-13S

Table 20 cont. Summary of Ground Water Sampling Results –September 2022

Target Chlorinated Volatile Organic Compounds (VOC), Monitored Natural Attenuation (MNA)

Well ID	NJ Ground Water Quality Standards- Class IIA (2020)	Units	MW-5S	MW-9S	MW-26S*	D-site MG Basement	TRIP BLANK	TRIP BLANK	TRIP BLANK
PPPL Sample ID			MW-5S 22-544	MW-9S 22-551	MW-26S 22-558	D-SITE MG 22-560	TB 22-561	TB 3 22-561	TB2 22-561
Lab Sample ID			JD51876-1	JD51912-2	JD51912-4	JD51912-1	JD51876-4	JD51998-4	JD51912-6
Target Volatile Organic Compounds									
Tetrachloroethene	1	ug/l	<0.9	11.2	8.7	26.9	<0.9	<0.56	<0.56
Trichloroethene	1	ug/l	<0.53	9.8	1.7	3.2	<0.53	<0.53	<0.53
cis-1,2-Dichloroethene	70	ug/l	<0.51	7.6	10.5	2	<0.51	<0.51	<0.51
1,1,1-Trichloroethane	30	ug/l	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54
1,1-Dichloroethene	1	ug/l	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59
Vinyl chloride	1	ug/l	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79
Target Semi-Volatile Organic Compounds									
1,4-Dioxane	0.4	ug/l	<0.18	0.204 J	<0.18	<0.17	NA	NA	NA
Natural Attenuation Indicators									
Dissolved Oxygen	–	mg/L	NA	0.0	8.74	NA	NA	NA	NA
pH	6.5 - 8.5	Std. Units	NA	6.05	5.03	NA	NA	NA	NA
Redox Potential	–	mVe	NA	87	74	NA	NA	NA	NA

NOTES:

B - Analyte is found in the associated method blank

J - Estimated, concentration listed greater than the MDL but lower than the lowest standard.

NA - Not Analyzed

Ground water quality standards as published in N.J.A.C. 7:9-6.9

— - Compound-specific Ground Water Quality Standard not published

* MW-26S is duplicate sample from well MW-13S

Table 21. Summary of Ground Water Sampling Results – December 2022

Target Chlorinated Volatile Organic Compounds (VOC), Monitored Natural Attenuation (MNA)

Well ID	NJ Ground Water Quality Standards-Class IIA (2020)	Units	MW-3S	MW-5I	MW-5S	MW-9S	MW-13S	MW-17	MW-18
PPPL Sample ID			MW-3S 23-61	MW-5I 23-62	MW-5S 23-63	MW-9S 23-64	MW-13S 23-66	MW-17 23-67	MW-18 23-68
Lab Sample ID			JD57517-4	JD57517-3	JD57517-2	JD57686-3	JD57686-1	JD57584-1	JD57584-2
Target Volatile Organic Compounds									
Tetrachloroethene	1	ug/L	<0.56	<0.56	0.92 J	1.8	10.1	18.8	<0.56
Trichloroethene	1	ug/L	<0.53	0.98 J	<0.53	<0.53	2.2	2.8	<0.53
cis-1,2-Dichloroethene	70	ug/L	<0.51	5.4	<0.51	<0.51	12	<0.51	<0.51
1,1,1-Trichloroethane	30	ug/L	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54
1,1-Dichloroethene	1	ug/L	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59
Vinyl chloride	1	ug/L	<0.52	<0.52	<0.52	<0.52	<0.52	<0.52	<0.52
Target Semi-Volatile Organic Compounds									
1,4-Dioxane	0.4	ug/L	<0.17	<0.2	<0.2	<0.2	<0.21	<0.21	<0.21
Natural Attenuation Indicators									
Dissolved Oxygen	–	mg/L	0.135	0.13	NA	0.51	9.63	0.0	0.19
pH	6.5 - 8.5	Std. Units	5.93	6.97	NA	5.37	5.9	5.44	5.21
Redox Potential	–	mVe	155	-27	NA	142	64	127	129

NOTES:

B - Analyte is found in the associated method blank

J - Estimated, concentration listed greater than the MDL but lower than the lowest standard.

NA - Not Analyzed

Ground water quality standards as published in N.J.A.C. 7:9-6.9

— - Compound-specific Ground Water Quality Standard not published

* MW-26S is duplicate sample from well MW-13S

Table 21 cont. Summary of Ground Water Sampling Results – December 2022

Target Chlorinated Volatile Organic Compounds (VOC), Monitored Natural Attenuation (MNA)

Well ID	NJ Ground Water Quality Standards-Class IIA (2020)	Units	MW-19S	MW-25S	MW-26S*	D-site MG Basement	TRIP BLANK	TRIP BLANK	TRIP BLANK
PPPL Sample ID			MW-19S 23-69	MW-25S 23-70	MW-26S 23-71	D-SITE MG 23-73	TRIP BLANK 3 23-74	TRIP BLANK1 23-74	TRIP BLANK2 23-74
Lab Sample ID			JD57686-4	JD57584-3	JD57686-2	JD57517-1	JD57686-5	JD57517-5	JD57584-4
Target Volatile Organic Compounds									
Tetrachloroethene	1	ug/L	66.6	<0.56	10.3	17	<0.56	<0.56	<0.56
Trichloroethene	1	ug/L	1.5	<0.53	2.4	2	<0.53	<0.53	<0.53
cis-1,2-Dichloroethene	70	ug/L	0.69 J	<0.51	12.7	1.2	<0.51	<0.51	<0.51
1,1,1-Trichloroethane	30	ug/L	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54
1,1-Dichloroethene	1	ug/L	<0.59	<0.59	<0.59	0.62 J	<0.59	<0.59	<0.59
Vinyl chloride	1	ug/L	<0.52	<0.52	<0.52	<0.52	<0.52	<0.52	<0.52
Target Semi-Volatile Organic Compounds									
1,4-Dioxane	0.4	ug/L	0.242 J	<0.21	<0.21	<0.17	NA	NA	NA
Natural Attenuation Indicators									
Dissolved Oxygen	–	mg/L	10.31	0.058	9.63	NA	NA	NA	NA
pH	6.5 - 8.5	Std. Units	4.61	6.38	5.9	NA	NA	NA	NA
Redox Potential	–	mVe	202	42	64	NA	NA	NA	NA

NOTES:

B - Analyte is found in the associated method blank

J - Estimated, concentration listed greater than the MDL but lower than the lowest standard.

NA - Not Analyzed.

Ground water quality standards as published in N.J.A.C. 7:9-6.9

— - Compound-specific Ground Water Quality Standard not published

Table 22. Summary of Ground Water Sampling Results – D-Site MG Sump, 2022

D-Site Airshaft													
Parameters	**Units**	**Jan. 2022**	**Feb. 2022**	**March 2022**	**April 2022**	**May 2022**	**June 2022**	**July 2022**	**August 2022**	**Sept. 2022**	**Oct. 2022**	**Nov. 2022**	**Dec. 2022**
Chemical Oxygen Demand, COD	mg/L		< 11			< 11			27			< 11	
Phosphorus, total	mg/L	0.69	2.8	0.10	4.6	1.1	0.11	0.70	0.98	0.62	2.1	8.5	58.8
Total Suspended Solids, TSS	mg/L		472			400			183			454	

Blank indicates no measurement

Table 23. Summary of Ground Water Sampling Results – D-Site Airshaft Sump, 2022

D-Site Airshaft													
Parameters	**Units**	**Jan. 2022**	**Feb. 2022**	**March 2022**	**April 2022**	**May 2022**	**June 2022**	**July 2022**	**August 2022**	**Sept. 2022**	**Oct. 2022**	**Nov. 2022**	**Dec. 2022**
Chemical Oxygen Demand, COD	mg/L		< 11			< 11			< 11			< 11	
Phosphorus, total	mg/L	0.12	< 0.027	0.10	0.11	0.092	0.10	0.062	< 0.027	0.44	0.68	< 0.27	0.06
Total Suspended Solids, TSS	mg/L		< 1.5			10.4			< 2.7			35.7	

Blank indicates no measurement

Table 24. Quality Assurance Data for Radiological and Non-Radiological Samples for 2022

Laboratory, Program and Parameter	Units	Reported Value	Actual Value	Acceptance Range	Acceptable Not Acceptable
ERA Co. May 2022 RAD-129, P678101 Proficiency Test					
Tritium	pCi/L	18,145.95	18,100	15,800 –19,900	Acceptable
ERA Co. November 2022 RAD-131, Proficiency Test					
Tritium	pCi/L	14,522.52	15,100	13,2000 – 16,600	Acceptable
Phenova March 2022					
pH	S.U.	NA	NA	NA	Not Acceptable
Residual Chlorine	mg/L	NA	NA	NA	Not Acceptable
Phenova September 2022 R34038					
pH	S.U.	1.85	3.025	1.37 – 2.18	Not Acceptable
Residual Chlorine	mg/L	5.79	5.82	5.59 – 5.99	Acceptable
Phenova November 2022 R34617					
Residual Chlorine	mg/L	1.13	1.01	0.843 – 1.36	Acceptable

Table 25. Waste Characterization Report (WCR) Surface Water Sampling 2022

No limits exceeded, only parameters listed above non-detect without blank interference.

Laboratory Parameter	Reported Value (mg/L)	
DSN001 Semi Annual	January 2022	August 2022
Copper	25.3	
Manganese	66.7	86.1
Zinc	29.2	50.8
DSN001 Annual	January 2022	
Barium	181	
DSN003 Annual	January 2022	
Zinc	21.6	

Figure 1. 1,4-Dioxane, PCE, TCE Distribution for Ground Water Wells 2022

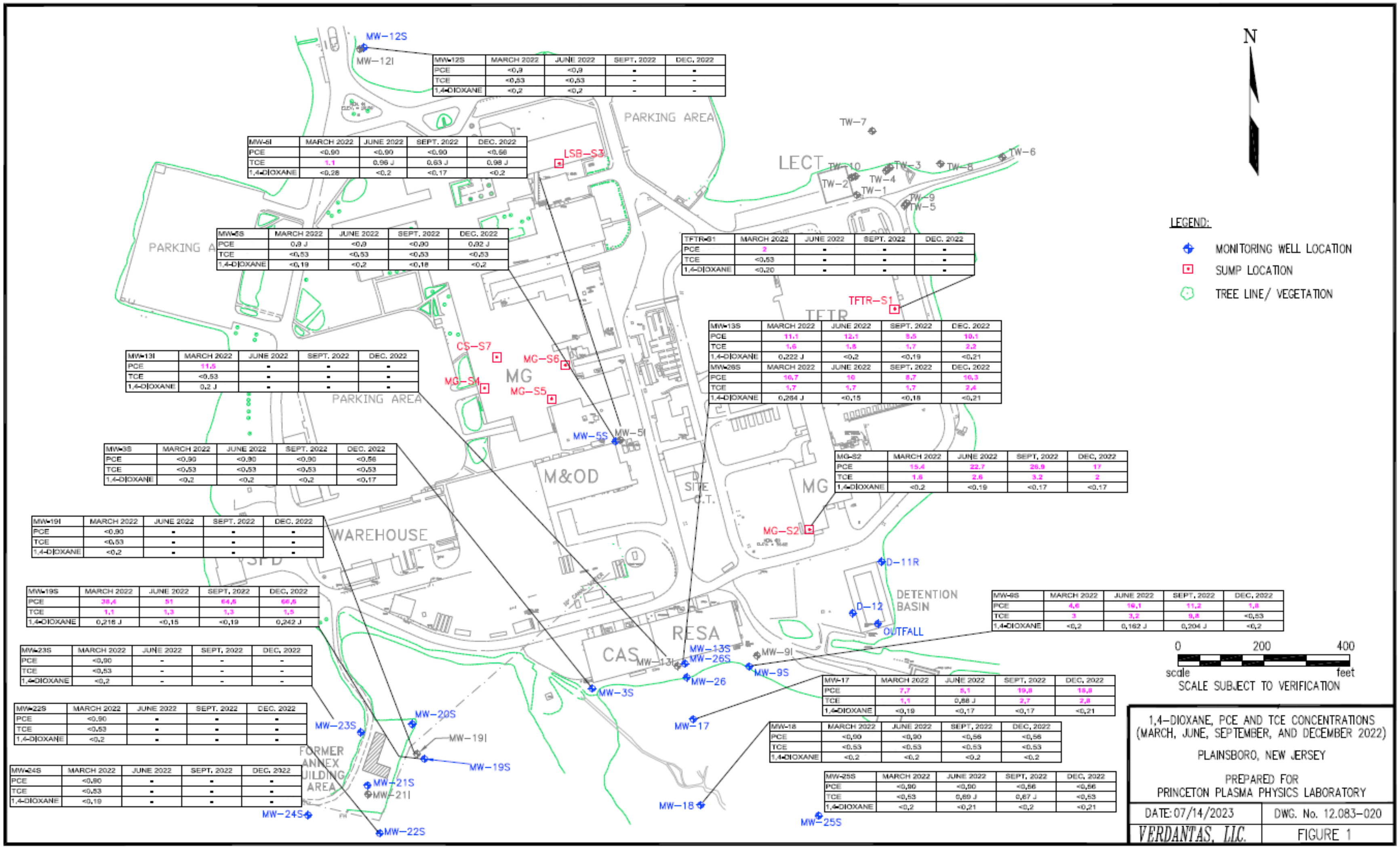


Figure 2. Potentiometric Surface Contours Shallow Ground Water Wells – September 2022

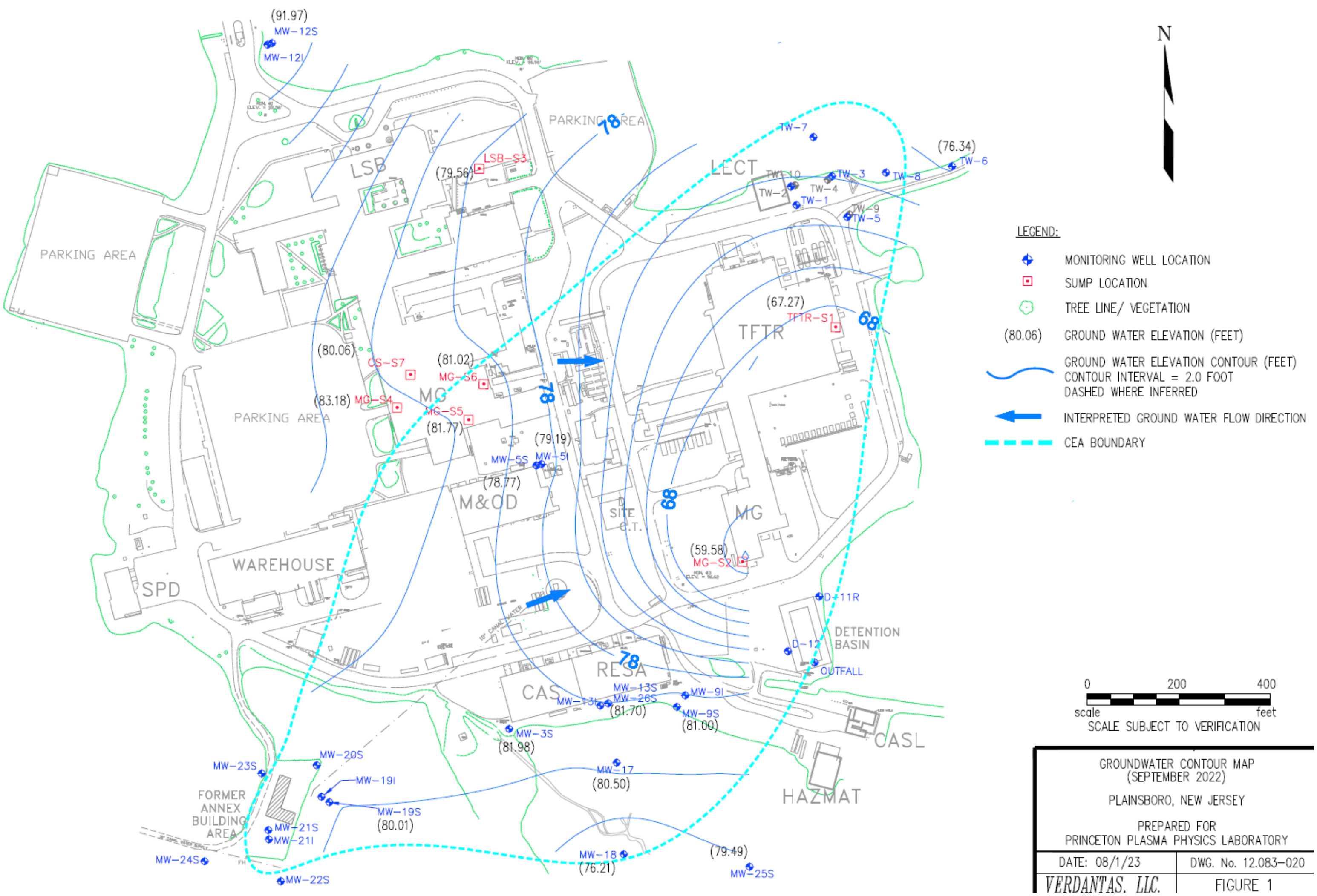


Figure 3. PPPL On-site Sampling Location Map

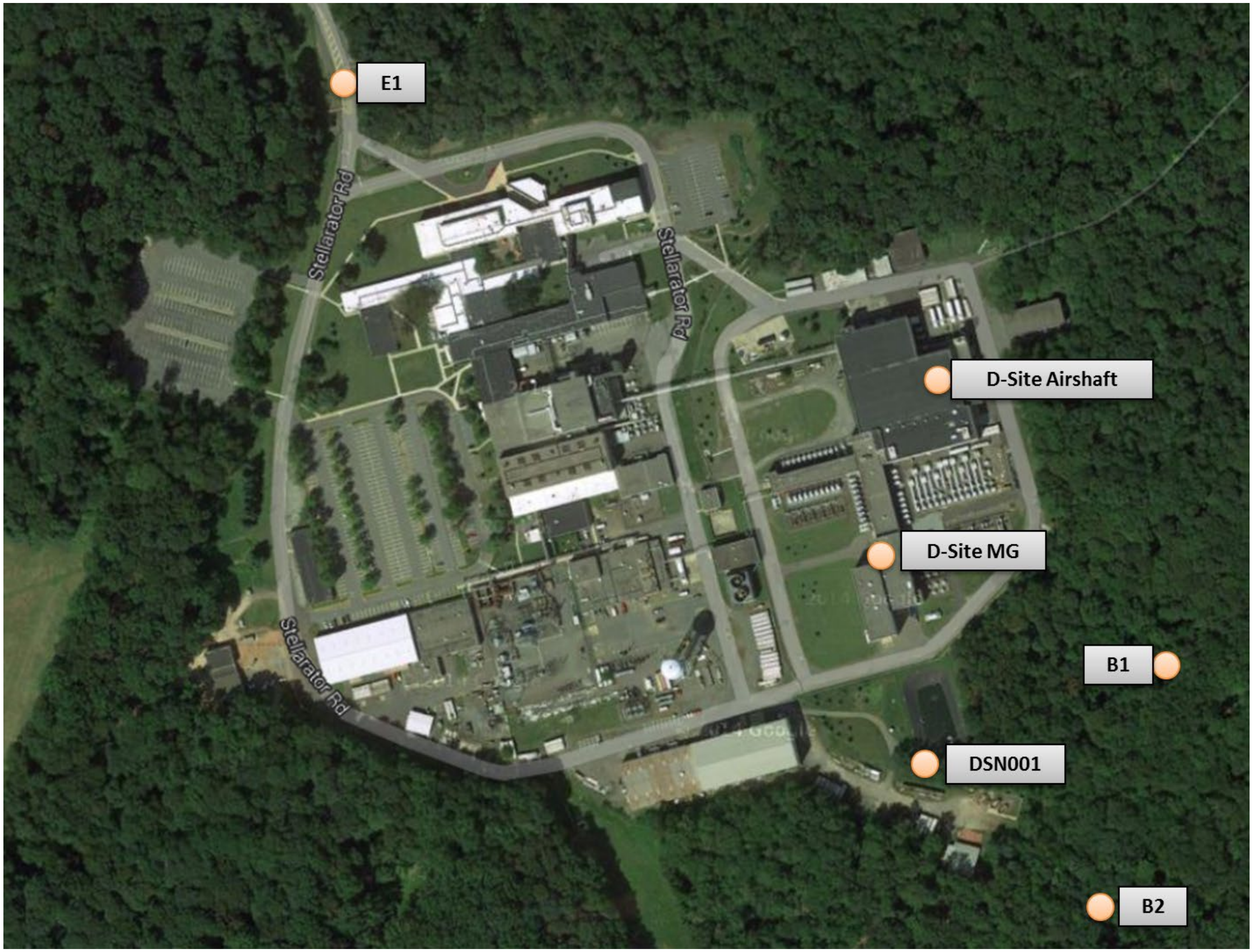


Figure 4. PPPL Off-site Sampling Location Map

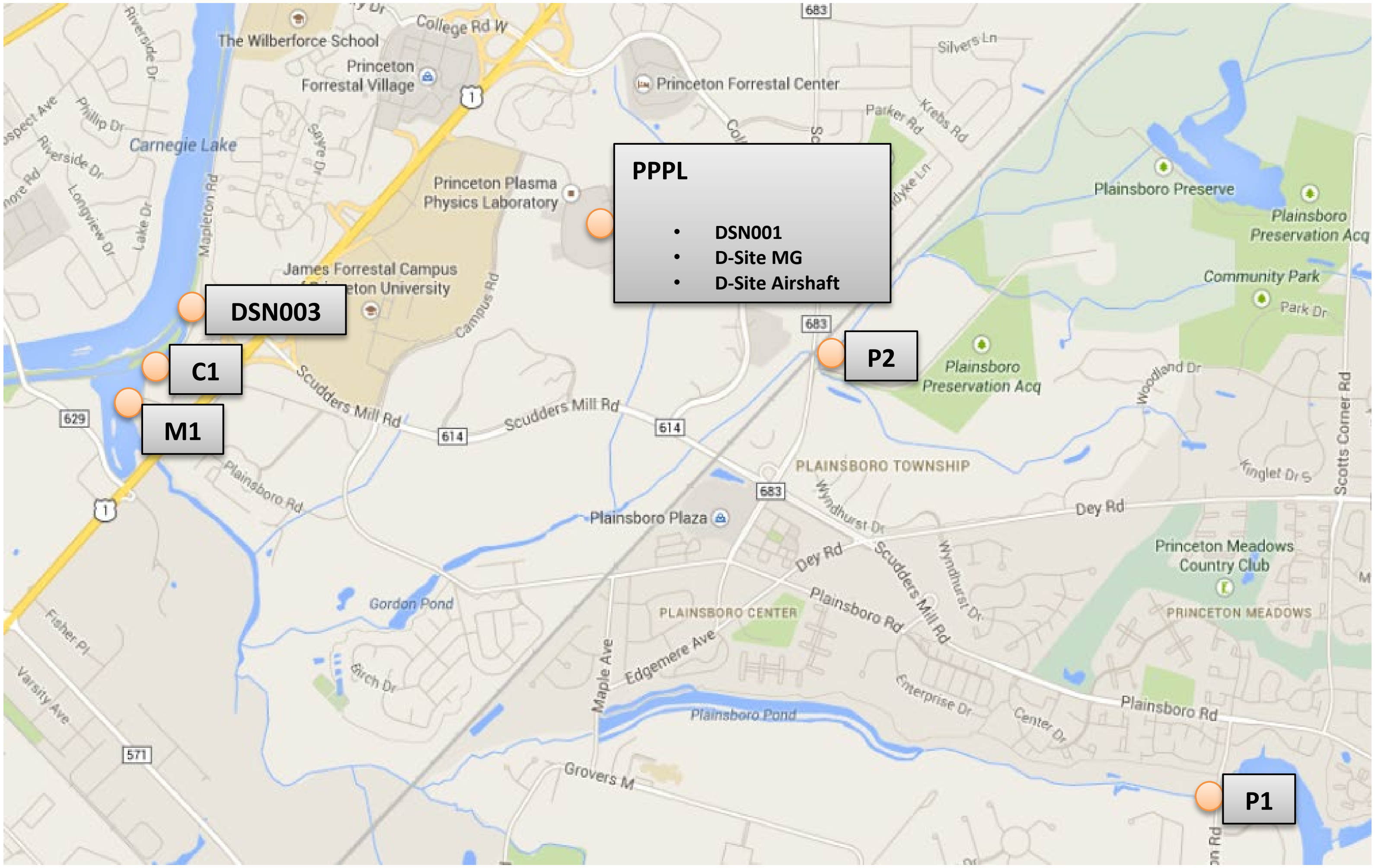
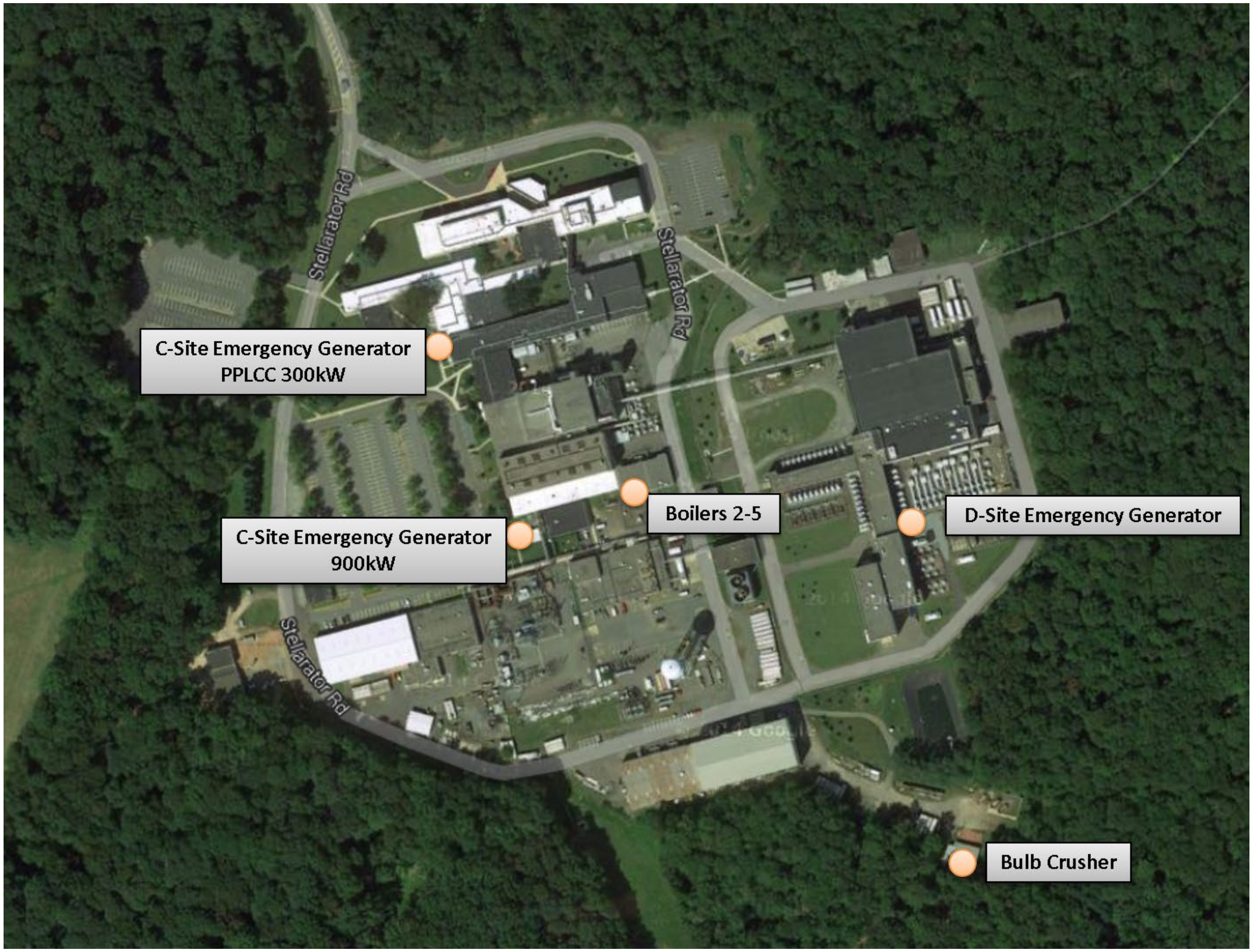


Figure 5. PPPL Air Permitted Equipment Location Map



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