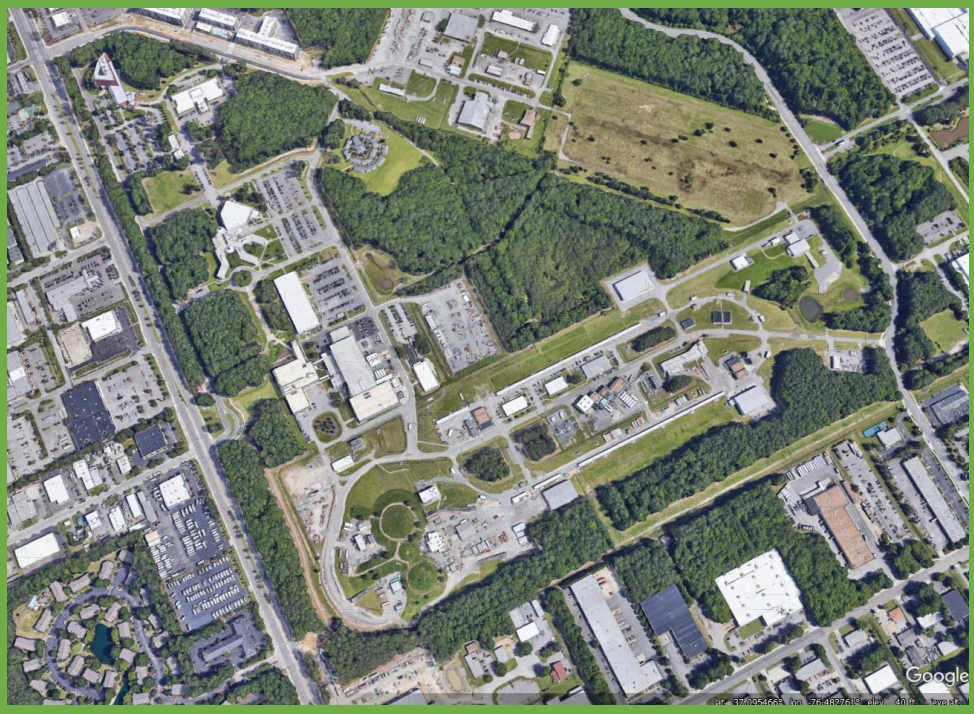
Jefferson Lab
Thomas Jefferson National Accelerator Facility

2024 Annual Site Environmental Report for Thomas Jefferson National Accelerator Facility



Prepared for:
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Thomas Jefferson Site Office
Thomas Jefferson National Accelerator Facility
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EXECUTIVE SUMMARY

This Annual Site Environmental Report documents the U.S. Department of Energy's (DOE) Thomas Jefferson National Accelerator Facility's (TJNAF, also known as Jefferson Lab) environmental protection program and its performance in 2024. This report presents results from environmental compliance and monitoring programs that are within the scope of TJNAF's existing environmental permits, applicable regulations, and the Environmental Management System (EMS). This report also provides the DOE and the public with information regarding the impact of radioactive and non-radioactive pollutants, if any, resulting from TJNAF operations.

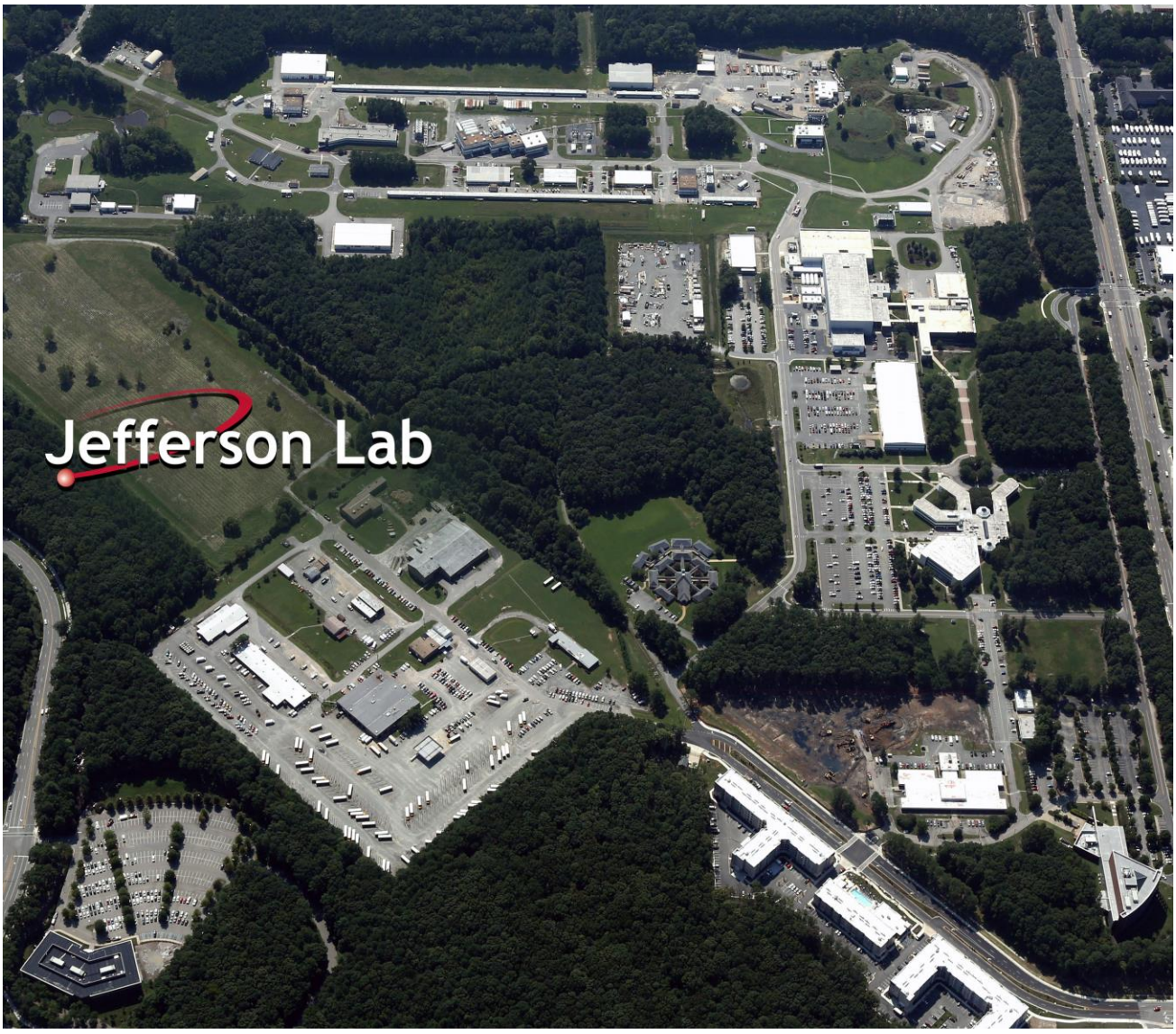
Jefferson Science Associates, LLC (JSA), is the managing and operating contractor of TJNAF. JSA is a Southeastern Universities Research Association (SURA) owned limited liability company committed to achieving DOE science goals through a disciplined approach to laboratory operations and business management.

Jefferson Lab, a forefront U.S. DOE Nuclear Physics research facility, provides world-class, unique research capabilities and innovative technologies to serve an international scientific user community. Specifically, the facility's mission is to:

- Deliver discovery-caliber research by exploring the atomic nucleus and its fundamental constituents, including precise tests of their interactions.
- Apply advanced particle accelerator and detector technologies to address challenges of modern society.
- Advance knowledge of science and technology through education and public outreach.
- Provide responsible and effective stewardship of resources.

At the Continuous Electron Beam Accelerator Facility (CEBAF), the electron beam begins its first pass at the injector and proceeds through the underground racetrack-shaped accelerator tunnel at nearly the speed of light. The accelerator uses superconducting radiofrequency (SRF) technology to drive electrons to increasingly higher energies. The accelerator's electron beam is capable of simultaneous use by four experimental halls, three of which are circular, partially buried domed chambers. A fourth experimental hall transitions from a below-grade to an above-grade facility. The special equipment in each hall records the interactions between incoming electrons and the target materials. A continuous electron beam is necessary to accumulate data at an efficient rate yet ensures that each interaction is separate for precise measurements.

In 2024, planning and design activities continued for the CEBAF Center Renovation and Expansion project. Preliminary planning continued for the Jefferson Lab Data Center project and environmental compliance requirements associated with the Virginia Department of Environmental Quality's (DEQ) General Virginia Pollutant Discharge Elimination System (VPDES) Permit for Stormwater from Construction Activities issued for the Laydown Yard Expansion project. General requirements included routine inspections and maintenance of on-site stormwater Best Management Practices (BMP).



An aerial view of TJNAF, facing south. The racetrack outline of the CEBAF loop is visible at top, and the experimental halls are located to the right and left of the accelerator loop.

LOW ENERGY RECIRCULATOR FACILITY (LERF)

TJNAF's Low Energy Recirculator Facility was developed using the lab's expertise in SRF accelerators. As a free electron laser, the facility provided a high-power tunable infrared laser while also providing ultraviolet laser light, including vacuum ultraviolet light, and terahertz light. Now known as the LERF, the facility will be home to future missions with potentially broader scope. The LERF hosted a DarkLight Experiment in 2016. Radioisotope production research and development experiments occurred in 2020-2021. The facility is also used for SRF component testing.

RESEARCH AREAS

Staff and visiting scientists continued using the Center for Advanced Studies of Accelerators (CASA), the Institute for SRF Science and Technology, and the Lattice Quantum Chromodynamics Computing Project to perform research and development programs. This research provides technology and associated experience for the construction of new accelerators for DOE Office of Science research projects at other facilities in nuclear physics, basic energy sciences, and high-energy physics.

INTEGRATED SAFETY MANAGEMENT (ISM) SYSTEM

Through ISM, TJNAF incorporates Environment, Safety, and Health (ES&H) requirements into all work procedures. The primary objective of ISM is to ensure that safety, health and environmental protection are always included in the planning and execution of routine work and projects.

ENVIRONMENTAL MANAGEMENT SYSTEM

TJNAF's EMS is established and maintained to conform to the ISO 14001 Standard for Environmental Management Systems and DOE Order requirements. Its principles continually improve the practices of environmental stewardship at the lab. The EMS is integrated within the ISM system.

REQUIREMENTS IDENTIFICATION PROCESS

Requirements are based on the laws, regulations, and standards necessary and sufficient to ensure worker and public health and safety and protect the environment. TJNAF continually identifies new and changing requirements for inclusion in its programs. Subject matter experts follow the development of new requirements, evaluating their applicability to existing facility operations.

IMPLEMENTATION OF THE NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)

Construction activities, all accelerator upgrades, and large/unique experiments are subject to review under NEPA. The initial construction of the CEBAF, two upgrades, and new buildings were all screened for compliance with NEPA regulations through the preparation of four Environmental Assessments (EAs). Site-specific NEPA categorical exclusions cover routine activities and special projects that have no individual or cumulative significant environmental impacts and do not require the preparation of an EA or Environmental Impact Statement. All approved NEPA reviews and associated documentation are available through DOE's Public Reading Room.

RADIOLOGICAL AND NON-RADIOLOGICAL RELEASES TO THE PUBLIC FROM SITE OPERATIONS

In 2024, no unplanned radiological or non-radiological releases to the environment occurred due to accelerator operations. Releases from normal operations were within permit and regulatory limits and had negligible impact to the public and no health or safety implications.

ENVIRONMENTAL PERFORMANCE MEASURES

TJNAF measures its environmental performance in several ways. In 2024, the DOE gave JSA a C+ (resulting from electrical safety issues not directly related to environmental protection performance) for its ability to "Sustain Excellence and Enhance Effectiveness of Integrated Safety, Health, and Environmental Protection." Additionally, TJNAF reports annually to the Office of the

Federal Environmental Executive and tracks numerous internal environmental performance metrics, all of which indicated success in 2024.

INSPECTION

TJNAF's inspection programs demonstrate its commitment to protect the environment, public health, and safety. To ensure operations and activities are performed effectively, staff and external agencies, including the DOE Site Office, State of Virginia, and the local sanitation district, conduct periodic inspections. This report includes independent inspection results, including detailed comments on TJNAF's record of compliance with applicable laws and regulations. TJNAF also conducts routine self-inspections for on-site stormwater management, Resource Conservation and Recovery Act (RCRA) hazardous waste compliance inspections, TJNAF hurricane warden inspections, and safety observations.

GENERAL COMPLIANCE

TJNAF's ES&H Manual facilitates integration of general environmental compliance initiatives into site operations. This report presents TJNAF's environmental compliance activity performance in 2024 and focuses on water resources and public health. No significant environmental compliance issues arose during 2024.

AWARDS AND RECOGNITIONS

In 2024, TJNAF was awarded with a Hampton Roads Sanitation District (HRSD) Gold Award for perfect compliance with industrial wastewater discharges to sanitary sewer during 2023. Qualifying for this award requires maintaining a perfect compliance record for at least one year and demonstrating a commitment to environmental excellence. Other criteria for receiving this award include meeting all HRSD permit compliance requirements, with no non-compliances or civil penalties. TJNAF also maintained a perfect record throughout 2024 and anticipates receiving another HRSD Gold Award next year.

In 2024, TJNAF was also recognized by the Virginia DEQ as an Exemplary Environmental Enterprise (E3) facility within the Virginia Environmental Excellence Program (VEEP). The program consists of three levels: E2, Environmental Enterprise; E3, Exemplary Environmental Enterprise; and E4, Extraordinary Environmental Enterprise. The E3 level is for facilities with fully implemented environmental management systems, pollution prevention programs, and demonstrated environmental performance.

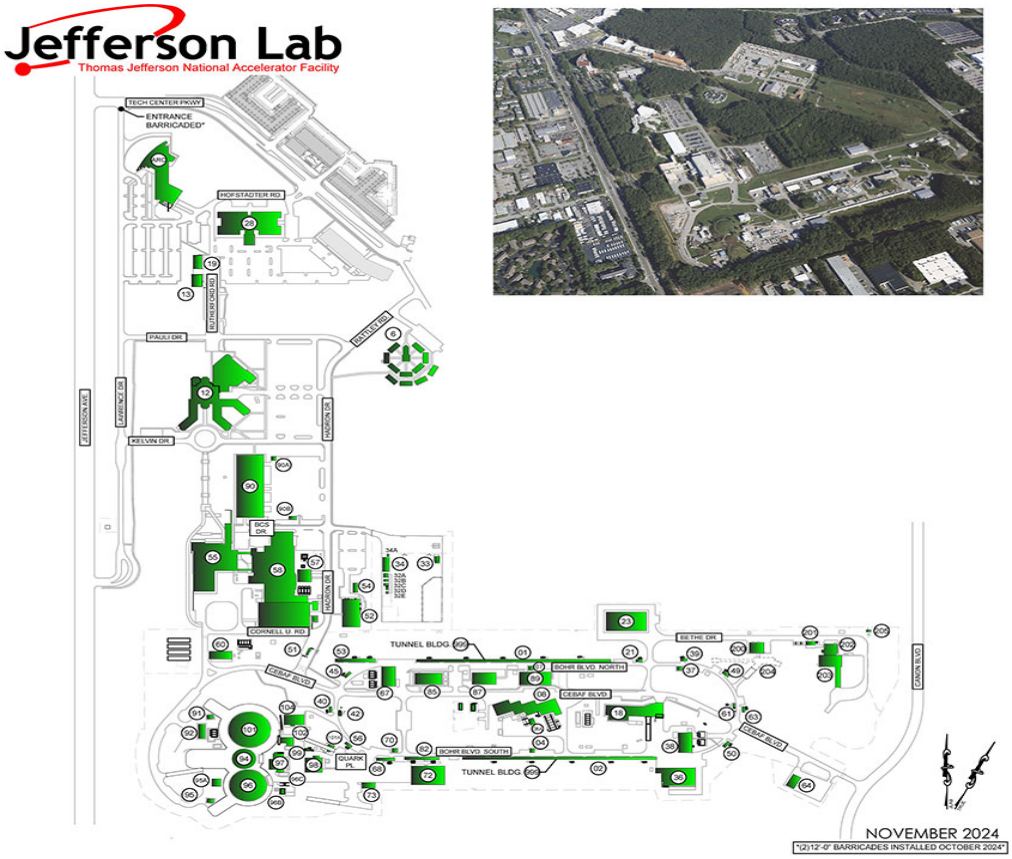
At left, a pileated woodpecker (Dryocopus pileatus) in the north central portion of the facility. At right, young bucks from the lab's white-tailed deer (Odocoileus virginianus) population in the Hall D area.

1 INTRODUCTION

1.1 Site Location

The Thomas Jefferson National Accelerator Facility (TJNAF), also known as Jefferson Lab, is located in the Oyster Point Business Park within the city of Newport News, Virginia. Figure 1 – Site Map of TJNAF – depicts the facility's location and buildings.

Figure 1 – Site Map of TJNAF

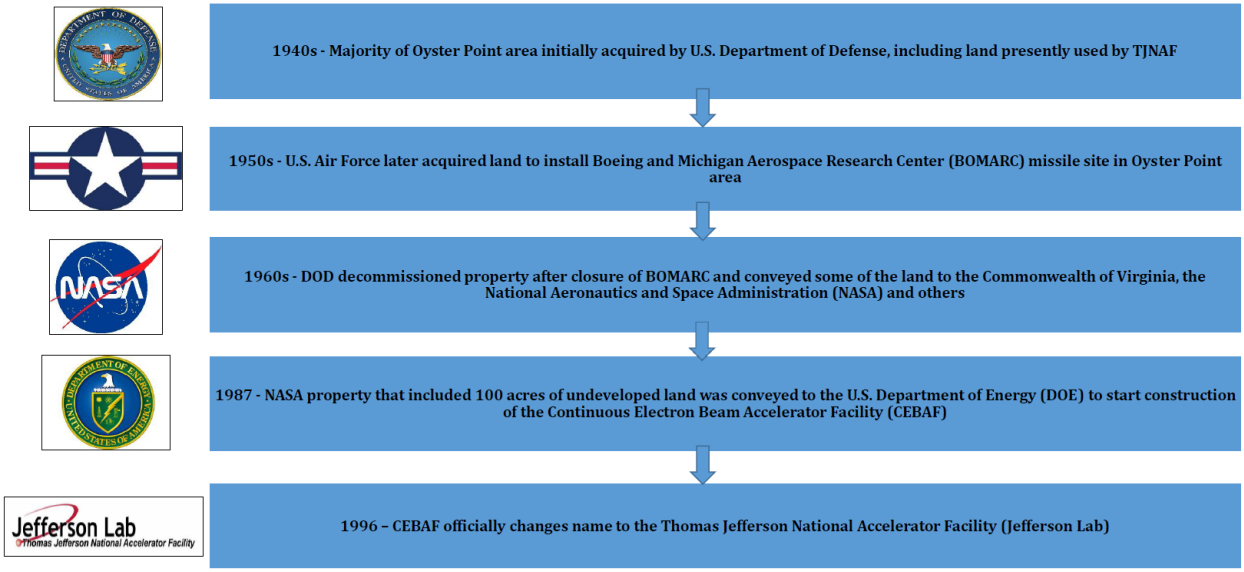


LIST OF BUILDINGS — Buildings are indicated on the above map by a circle & number: Example (01) ; number corresponds below

01	North LINAC - 01 Bohr Blvd. North	40	West Arc Service (W4) - 40 Bohr Blvd. South	90	Experimental Equipment Lab (EEL) - 90 Hadron Dr.
02	South LINAC - 02 Bohr Blvd. South	42	Exit Stair 6 - 42 BOHR Blvd. South	90A	Hall A Storage Shed - 90A Hadron Dr.
04	Exit Stair #4 - 04 Bohr Blvd. South	45	West Arc Service (W5) - 45 Bohr Blvd North	90B	Hall C Storage Shed - 90B Hadron Dr.
06	SURA Residence Facility - 12006 Rattley Rd.	49	East Arc Service (E3) - 49 Bohr Blvd. North	91	Hall A Beam Dump Cooling - 91 CEBAF Blvd.
07	Exit Stair #1 - 07 Bohr Blvd. North	50	East Arc Service (E5) - 50 Bohr Blvd. South	92	Service Bldg. - 92 CEBAF Blvd.
08	Central Helium Liquefier (CHL) - 08 CEBAF Blvd.	51	Guard House - 51 Hadron Dr.	94	Experimental Hall B - 94 Quark Pl.
08A	K50 Bldg. - 08A Bohr Blvd.	52	ES&H Bldg. - 111 Hadron Dr.	95	Hall C Beam Dump Cooling - 91 CEBAF Blvd.
12	CEBAF Center - 12000 Jefferson Ave.	53	Injector Service - 53 Bohr Blvd. North	95A	Lead Storage - 95A CEBAF Blvd.
13	FM Storage Shed - 13 Rutherford Rd.	54	Radcon Calibration - 54 Hadron Dr.	96	Experimental Hall C - 96 Quark Pl.
18	Low Energy Recirculator Facility (LERF) - 18 CEBAF Blvd.	55	Technology & Engineering Dev. Bldg. - 600 Kelvin Dr.	96B	Hall B Gas Shed - 96B Quark Pl.
19	Facilities Maintenance Shop - 19 Rutherford Rd.	56	West Arc Service (W3) - 56 Bohr Blvd. South	96C	Hall C Gas Shed - 96C Quark Pl.
21	North Extractor Service (E1) - 21 Bohr Blvd. North	57	Cryogenics Test Facility (CTF) - 57 Hadron Dr.	97	Counting House - 97 Quark Pl.
23	Experimental Staging - 23 Bethe Dr.	58	Test Lab - 600 Kelvin Dr.	98	Physics Fabrication - 98 Quark Pl.
28	Support Service Center (SSC) - 628 Hofstadter Rd.	60	Central Utility Plant (CUP) - 60 CEBAF Blvd.	99	Exit Stairwell - 99 Quark Pl.
32A	Spill Response Storage - 32A BCS Rd.	61	Exit Stair 3 - 61 Bohr Blvd. North	101	Experimental Hall A - 101 Quark Pl.
32B	Flammable Storage - 32B BCS Rd.	63	East Arc Service (E4) - 63 Bohr Blvd.	101A	Hall A Gas Shed - 101A Quark Pl.
32C	Corrosive Storage - 32C BCS Rd.	64	Fabric Storage 1 - 64 CEBAF Blvd.	102	End Station Refrigeration (ESR) - 102 Quark Pl.
32D	Chemical Storage - 32D BCS Rd.	67	North Access - 67 Bohr Blvd. North	104	End Station Refrigeration 2 (ESR 2) - 104 Bohr Blvd. South
32E	Waste Oil Storage - 323 BCS Rd.	68	West Arc Service (W2) - 68 Bohr Blvd. South	200	Service Bldg. - 200 Bethe Dr.
33	CMSA Shed - 33 BCS Rd.	70	Exit Stair 5 - 70 Bohr Blvd. South	201	Cryo Plant - 201 Bethe Dr.
34	Material Handling Equipment Storage - 34 BCS Rd.	72	Physics Storage - 72 Quark Pl.	202	Counting House - 202 Bethe Dr.
34A	CMSA Office -34A BCS Dr.	73	Material Handling Equipment Storage - 73 Quark Pl.	203	Experimental Hall D - 203 Bethe Dr.
36	General Purpose Building - 36 Bohr Blvd. South	82	South Extractor Service (W1) - 82 Bohr Blvd. South	204	Tagger Area - 204 Bohr Blvd. North
37	Exit Stair 2 - 37 Bohr Blvd. North	85	Machine Control Center (MCC) - 85 CEBAF Blvd.	205	Canon Communications Hut - 205 Bethe Dr.
38	South Access - 38 Bohr Blvd. South	87	Accel. Maintenance Support (AMS) - 87 CEBAF Blvd.	999	Accelerator Tunnel - 999 Quark Pl.
39	East Arc Service (E2) - 39 Bohr Blvd. North	89	Cryogenics Engineering Office - 89 CEBAF Blvd.	ARC	Applied Research Center (ARC) - 12050 Jefferson Ave.

1.2 Site History

Prior to the construction of TJNAF, several federal agencies used this general area of Newport News. The U.S. Department of Defense (DOD) acquired most of the Oyster Point area, including the land presently used by TJNAF. The U.S. Air Force later acquired the land and installed a Boeing and Michigan Aerospace Research Center (BOMARC) missile site on a portion of the property. After closure of BOMARC, the DOD decommissioned the property and conveyed some land to the Commonwealth of Virginia, the National Aeronautics and Space Administration (NASA), and others. Ownership of the NASA property, including 100 acres of undeveloped land, was conveyed to the DOE in 1987. An additional 52 acres of land was transferred to the DOE from other sources. The total DOE-owned parcel upon which TJNAF now stands is 179 acres.



1.3 Environmental Setting

The most comprehensive reviews that bound the site's environmental constraints are the four Environmental Assessments (EAs) completed under NEPA. Each evaluated the potential impact of the site (or proposed changes to the site) on cultural resources, air quality, water quality, noise, wetlands, endangered and threatened species, and a host of other subjects.

EAs conducted at TJNAF include:

- A 1987 EA that yielded a "Finding of No Significant Impact (FONSI)" associated with initial CEBAF construction.
- A 1997 EA for the CEBAF upgrade (FONSI).
- A 2002 EA for the LERF (formerly known as the FEL, or free electron laser) upgrade and five building construction projects (FONSI).
- A 2007 EA for the 12GeV upgrade project (FONSI)

As a result, proposed projects have been completed with the assurance that no harm would come to the environment and therefore Environmental Impact Statements were not needed.

An Eastern coyote (Canis latrans) in the northeastern part of campus.

1.4 Site Mission

TJNAF, a DOE nuclear physics research facility, provides world-class, unique research capabilities and innovative technologies to serve an international scientific user community.

Specifically, its mission is to:

- Deliver discovery-caliber research by exploring the atomic nucleus and its fundamental constituents, including precise tests of their interactions

- Apply advanced particle accelerator, detector, and other technologies to develop new basic research capabilities and address the challenges of modern society
- Advance knowledge of science and technology through education and public outreach.
- Provide responsible and effective stewardship of resources.

1.4.1 Primary Operations and Activities at the Site: CEBAF

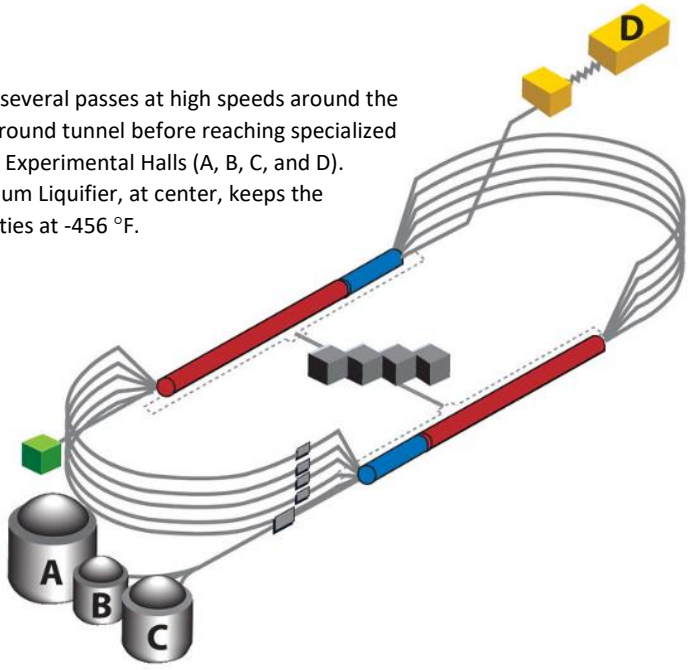
- The CEBAF accelerator provides continuous wave electron beams with energies of 0.5 to 12 GeV. During 2024, experiments were conducted in all four of CEBAF's experimental end stations at up to full beam energy.

1.4.2 End Stations

The Experimental Hall End Stations house complementary experimental equipment to support their primary functions.

- Hall A has a pair of superconducting, high-resolution magnetic spectrometers optimized for precision electron-scattering, coincidence experiments.
- Hall B houses the CEBAF Large Acceptance Spectrometer for the 12 GeV Upgrade (CLAS12). CLAS12 supports studies of electron- and photon-induced reactions with forward-focused reaction products at increased luminosities.
- Hall C contains two spectrometers: the High Momentum Spectrometer and the Super High Momentum Spectrometer, which enable measurements of particles scattered at up to full beam momentum.
- Hall D supports studies of photon-induced reactions using a solenoidal-based detector with high acceptance for charged particles and photons.

Electrons make several passes at high speeds around the CEBAF's underground tunnel before reaching specialized detectors in the Experimental Halls (A, B, C, and D). The Central Helium Liquifier, at center, keeps the accelerator cavities at -456 °F.



1.4.3 Institute for Superconducting Radiofrequency Science and Technology

TJNAF's primary research and development facility provides continuous improvement efforts for the CEBAF and the LERF. Work there includes:

- Support of the operation, improvement, and upgrade of the CEBAF.
- Exploration of techniques for producing improved-performance SRF systems.

The SRF Institute is the lab's main research and development facility.

1.4.4 Center for Advanced Studies of Accelerators

CASA supports the site accelerators and evaluates future opportunities. Its primary mission is to generate, investigate, and distribute knowledge about advanced accelerator and beam physics, facilitating and improving the results generated through the work performed at TJNAF. A secondary goal for the organization is to archive information generated by TJNAF's activities and make it available to guide future projects.

1.4.5 Low-Energy Recirculator Facility (LERF)

Designed and built with TJNAF's expertise in SRF accelerator technology, the LERF (formerly known as the FEL) facility was the world's highest-power tunable infrared laser and also provided ultraviolet laser light, including vacuum ultraviolet light and terahertz light. The LERF accelerator is not routinely operated and ran for only a short period. However, the LERF's SRF infrastructure has been routinely used to support testing of superconducting cryomodules built by TJNAF for the LCLS-II accelerator at the SLAC National Accelerator Facility.

1.4.6 Upgraded Injector Test Facility (UITF)

The UITF is a small-scale electron beam accelerator designed to support physics experiments and improve on the design of the CEBAF electron beam injector. Commissioning and operation of this accelerator began in 2020.

1.4.7 Relevant Demographic Information

TJNAF is a world-class research facility. It attracts both resident and visiting physicists, as well as other scientists from around the world. In 2024, approximately 769 full-time physicists, engineers, technicians, and support staff worked at TJNAF and more than 1,500 academic and industrial researchers, from the United States and approximately 30 other countries and 230 institutions, participated in scientific collaborations.

Each year, research conducted at TJNAF produces more than one-third of all nuclear physics doctoral degrees awarded in the United States.

Above, an osprey (Pandion haliaetus) observed in the central portion of the CEBAF. At right, An Eastern coyote (Canis latrans).

2 COMPLIANCE SUMMARY

The following sections summarize TJNAF's 2024 compliance status related to local, state, federal, and DOE requirements.

2.1 Compliance Status

2.1.1 National Environmental Policy Act

NEPA requires that Federal agencies evaluate projects for the potential to have significant environmental impacts. All projects occurring at TJNAF are evaluated through the preparation of EAs or managed according to Categorical Exclusions, and no Environmental Impact Statement was necessary. During 2024, an updated NEPA compliance checklist was completed for the CEBAF Renovation & Expansion/Applied Research Center Renovation Project and an updated Categorical Exclusion was approved for the project (DOE approval in December 2024).

2.1.2 Air Quality and Protection

TJNAF currently has no processes or associated air emissions that exceed the threshold for required air permitting in Virginia. Internal calculations are routinely conducted to confirm this status. All non-radiological emissions remained well below reportable levels in 2024, and radiological emissions were far below the applicable limits. The city of Newport News has met Environmental Protection Agency (EPA) and Virginia DEQ designated pollutant limits for National Ambient Air Quality Standards (NAAQS) since 2008.

2.1.3 Stratospheric Ozone-Depleting Substances (ODS)

TJNAF minimizes the use of ODSs by using safe, cost-effective, environmentally preferable alternatives where possible.

To reduce the potential for emissions of ODSs and comply with Section 608 of the Clean Air Act's Refrigerant Recycling Rule, TJNAF uses EPA-certified subcontractors and staff to perform all work involving ODS-containing refrigeration and air conditioning equipment on-site. There is one ODS recovery machine on-site. The one remaining chlorofluorocarbon-based chiller receives preventive and corrective maintenance by a qualified mechanical subcontractor to ensure optimal performance with minimal loss. An inventory of ODS-containing equipment and annual usage on-site is submitted annually to the DOE.

2.1.4 Greenhouse Gas Emissions

During 2024, TJNAF and DOE continued to assess greenhouse gas emissions. Efforts to understand these various emissions allowed for the development of ways to minimize them.

2.1.5 Water Quality and Protection

TJNAF complies with all water quality protection requirements and performs monitoring in compliance with applicable state water quality permits. Combinations of engineering and administrative controls are used to maintain groundwater quality during operations. Discharges to surface water are permitted under TJNAF's DEQ VPDES Permit No. VA0089320. Outfall 001 consists of groundwater extracted from beneath Halls A, B and C; Outfall 002 consists of discharges from one of the site's cooling towers. Discharged wastewater flows to permit-authorized outfalls included in TJNAF's environmental monitoring program. Groundwater monitoring wells are sampled routinely under VPDES Permit VA0089320 to ensure site operations do not degrade groundwater quality. All stormwater discharges are managed through structural and non-structural BMPs in compliance with TJNAF's Municipal Separate Storm Sewer System (MS4) permit and Virginia Stormwater Management Program (VSMP) regulations. Operational control measures include proper storage and minimizing the use of products that could pollute ground and surface water. Applicable site personnel have received training from the Virginia DEQ in the areas of Stormwater Management and Erosion & Sediment Control to conduct plan reviews and site inspections of all regulated land disturbances.

TJNAF received initial approval from the DEQ in 2015 for the preparation of a Chesapeake Bay Total Maximum Daily Load (TMDL) Action Plan as part of Permit No. VAR040079 to meet the newly established requirements of the VSMP set forth on July 1, 2014. In 2018, TJNAF received approval for a 2nd Phase update to the Chesapeake Bay TMDL Action Plan.

In 2023, TJNAF prepared and submitted to DEQ the Chesapeake Bay TMDL Action Plan Update that contained the required and suggested elements necessary to comply with the General Permit and the Chesapeake Bay TMDL Special Condition Guidance issued by DEQ on July 19, 2023 (VPDES General Permit for Discharges of Stormwater from Small Municipal Separate Storm Sewer Systems (MS4s) Amendments to 9VAC25-890 and Reissuance of the General Permit). The updated plan verified that Jefferson Lab met the requirements of the Special Condition for the Chesapeake Bay for the first and second permit cycle and will meet the requirements for the L2 reductions by the end of the third permit cycle. TJNAF held four active water permits in 2024 (see Figure 2). No regulatory limits were exceeded, and all water quality programs were in compliance.

Figure 2 – Active TJNAF Water Permits

Permit Type	Outfalls	Parameter	Permit Exceedances	Samples Taken	Compliant Samples	Compliance
Industrial Wastewater Discharge to Surface and Groundwater Quality (VPDES Permit VA0089320)	2 Outfalls (001 & 002) 16 wells*	**Outfall 001** (pH, Flow, Temperature, Tritium, Sodium 22, Beryllium 7, Manganese 54, Gross Beta Activity) **Outfall 002** (pH, Flow, Temperature, Ammonia, Chlorine, Copper, Zinc, Phosphorus, Hardness) **A-ring/B-ring wells** (Groundwater Elevation, pH, Conductivity, Total Dissolved Solids, Tritium, Sodium 22, Beryllium 7, Manganese 54, Manmade Radioactivity) **GW-15a background well/C-ring wells** (Groundwater Elevation, pH, Conductivity, Total Dissolved Solids, Tritium, Sodium 22, Beryllium 7, Manganese 54) **Hall D wells** (Groundwater Elevation, pH, Conductivity, Total Dissolved Solids, Tritium, Sodium 22, Beryllium 7, Manganese 54)	0	Outfall 001 (1) Outfall 002 (4) A-ring wells (8) B-ring wells (10) C-ring wells (3) GW-15a (1) Hall D wells (6)	Outfalls (5) Wells (28)	100% 100%
***Municipal Separate Storm Sewer System Permit (VAR-0400790)	3	NA	0	**NA	NA	100%
Industrial Wastewater Discharge to Sewer (****HRSD Permit 0117)	4	Radionuclides, pH, Flow, Temperature	0	24	24	100%
Groundwater Withdrawal (Virginia DEQ GW0047201)	1	Volume of Dewatering	0	12	12	100%

*TJNAF's VPDES permit includes two outfalls and the collection and reporting of radionuclide monitoring data from 16 groundwater monitoring wells throughout the site. TJNAF applied for renewal of VPDES Permit #VA089320 with the DEQ in 2021. In 2022, TJNAF received authorization and reissuance of VA0089320 from DEQ for an additional 5 years.
**The MS4 program requires TJNAF to implement a variety of BMPs to prevent contamination from entering the stormwater system or leaving the site. No sampling, analysis, and reporting of chemical constituents are currently required.
***TJNAF applied for renewal of the existing MS4 permit and received a new permit authorized by DEQ effective November 1, 2023.
****TJNAF applied for renewal of the existing HRSD permit #0117 in 2021. In 2022, TJNAF received authorization and reissuance of the permit for an additional 5 years.

Virginia white-tailed deer (Odocoileus virginianus) are a frequent sight around the lab campus

2.1.6 Conformance with Energy Independence and Security Act (EISA) Section 438

During 2015, TJNAF conducted a conformance assessment of its stormwater management program as related to EISA Section 438 requirements. Applicable projects were reviewed to determine conformance status, and strategies were developed for future projects.

Projects are screened through an environmental compliance checklist that includes the requirement for conformance with EISA Section 438. During 2024, projects that were screened included the CEBAF Renovation & Expansion/Applied Research Center Renovation Project.

2.1.7 Future Strategies for EISA Section 438 Conformance

In December of 2009, the EPA released "Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act." According to this guidance, conformance for future development or redevelopment projects of >5,000 sq. ft. will be satisfied by implementing planning, design, construction, and maintenance strategies that achieve Option 1 – Retain the 95th percentile rainfall event to the maximum extent technically feasible (METF) from a sitewide perspective. This is accomplished through review of project design criteria to ensure the following strategies have been considered:

- Apply "runoff reduction" as the central stormwater management tool during planning stages of future development by incorporating the use of low-impact development (LID)/green infrastructure (GI) for stormwater management to the METF as mentioned above.
- Reduce clearing by preserving remaining natural areas as much as possible.
- Reduce regrading by preserving natural drainage patterns on development sites where feasible.
- Minimize amount of imperviousness for planned development where feasible.
- Promote runoff across natural features to reduce runoff volumes and pollutant loads.

During the conformance assessment conducted by TJNAF in 2015, it was determined that applicable projects occurring at TJNAF can conform to the technical requirements by:

- Calculating stormwater treatment requirements on a facility-wide basis, as opposed to a project/site-specific level.
- The two stormwater retention ponds at the facility have treatment storage capacity available to accommodate conformance with requirements for the remaining projects that qualify.
- Conformance for future projects may require the intentional routing of stormwater flows into the existing retention ponds for treatment.

2.1.8 Other Environmental Statutes and Executive Orders

OIL POLLUTION CONTROL

A five-year review of TJNAF's Spill Prevention, Control, and Countermeasure (SPCC) Plan occurred during 2021. The plan was deemed compliant with the requirements of 40 CFR Part 112 for Oil Pollution Prevention, and no technical amendments were required. The SPCC Plan describes methods to prevent, control, and/or mitigate releases of oil and other petroleum substances to the environment. The plan also describes the proper handling, use, and transport of petroleum products on-site along with proper spill containment, clean-up, and disposal of any spilled material. To ensure proper handling and spill response, all staff working with oil receive annual SPCC training. On-site oil inventory comprises numerous oil-containing transformers, generators, compressors, above-ground storage tanks, and mechanical equipment. TJNAF's estimated volume of oil is approximately 56,211 gallons; this includes utility-owned electrical equipment. TJNAF implements an SPCC inventory spreadsheet to allow for management of real-time inventory when new oil-containing equipment is brought on-site. Adherence to the SPCC plan continued in 2021, and administrative changes were incorporated into the plan in 2022. TJNAF ES&H-Environmental Group initiated efforts to begin the next review and update the existing SPCC Plan in 2024; additional updates will be provided in next year's report.

PFAS AND ADDITIONAL EMERGING CONTAMINANTS

Emerging contaminants include chemical products that are perceived as threats to health and environment but may not be addressed by existing health standards. Emerging contaminants continue to be detected in surface waters across the United States, with growing concern for potential impacts on aquatic species and humans.

At the forefront of these emerging contaminants are per-and polyfluoroalkyl substances (PFAS). PFAS substances have been generated since the 1940s through manufacturing and other industries, including clothing production, cookware/food packaging, and fire-fighting foams. Growing evidence shows that PFAS exposure can have adverse effects on human and environmental health.

Due to growing concerns, a focus on preventing and mitigating impacts from PFAS contamination has increased. In September 2021, DOE released information on the potential impacts of PFAS to DOE facilities. Included in this guidance was the requirement for DOE facilities to conduct surveys of their respective sites for the presence of PFAS contaminants, along with the requirement to report any releases of PFAS-containing Aqueous Film Forming Foams (AFFF) used during fire-fighting operations. In response to this, TJNAF initiated a gap analysis to identify any potential vulnerabilities on-site and document proposed program improvements. The gap analysis was completed in 2022 and is summarized in Figure 3.

Figure 3 – Summary of PFAS Gap Analysis

Requirement	TJNAF Program Status	Proposed Program Improvements
DOE reporting of spills and releases of PFAS-containing AFFF	TJNAF has no AFFF on-site; off-site fire response is provided through a memorandum of understanding (MOU) with the Newport News Fire Department (NNFD)	Existing MOU with NNFD revised to incorporate reporting requirements for any use or spills of AFFF at the facility
Any site manufacturing, waste management, industrial, and/or chemical process that may generate the release of PFAS to the environment	PFAS-containing products on-site include: 1) R134a refrigerant containing 1,1,1,2-tetrafluoroethane; 2) R410a refrigerant that contains pentafluoroethane; 3) EnsolvNext degreaser that contains perfluoroisobutyl methyl ether; 4) HFE-7100 engineered fluid that contains perfluorobutyl methyl ether and perfluoroisobutyl methyl ether	JSA Environmental and Facilities Management & Logistics (FML) collaboration during future purchases of substitute refrigerant blends not containing PFAS; Environmental will also continue collaboration with Cryo/Engineering to minimize use of EnsolvNext and HFE-7100 as feasible through use of alternative products
Does site provide drinking water from an on-site source such as a river, stream, lake, reservoir, or well? If so, do you sample and test for PFAS?	TJNAF does not provide a drinking water source; this is provided from an off-site reservoir through Newport News Water Works (NNWW); NNWW is working with Virginia DEQ and Department of Health (VDH) to assess drinking water sources	2022 NNWW PFAS Factsheet issued in June 2022 with the following strategies: - Determine PFAS levels in drinking water source - Understand treatment options - Develop strategies to reduce PFAS levels - Participate in statewide screenings and assessment programs with VDH, DEQ, and U.S. Geological Survey (USGS)

Figure 4 – Departmental Pillars for Managing PFAS

In August 2022, DOE issued the PFAS Strategic Roadmap: DOE Commitments to Action 2022-2025, which outlines the DOE's goals, objectives, and planned actions for managing PFAS at DOE facilities. The PFAS Roadmap describes four Departmental Pillars and Goals for managing PFAS, shown in Figure 4, above: Understand, Manage & Protect, Advance Solutions, and Communicate & Collaborate.

In October 2022, DOE released the Initial Assessment on Per- and Polyfluoroalkyl Substances (PFAS) at DOE sites that summarized known uses and releases of PFAS.

In December 2022, TJNAF prepared the PFAS Implementation Plan that describes strategies for implementing the 4 Departmental Pillars and Goals for managing PFAS at Jefferson Lab.

During 2023, TJNAF continued to provide feedback on DOE reporting requirements for PFAS. This included review/feedback on draft DOE PFAS Environmental Sampling Guidance and review/feedback on DOE R&D Workshop information.

During 2024, TJNAF continued to provide support and feedback to DOE on PFAS reporting requirements and other data requests. This included providing review/response for the 2024 Annual Site PFAS Status Update Survey and review/concurrence on consistencies of the DOE Initial PFAS Assessment versus the Updated PFAS Assessment Report.

2.1.9 Reductions in the Generation and/or Toxicity of Hazardous Waste Through Pollution Prevention

In 2024, TJNAF continued to incorporate waste minimization and pollution prevention evaluations to site activities during early planning phases. Opportunities to reduce waste generation were identified and implemented. Notable activities included:

- Donating materials and supplies to local schools.
- Recycling over 549 tons of scrap metals.
- Re-use of on-site concrete construction debris.
- Re-using excessed equipment from completed projects.

The lab's recycling program diverted 94.5% of the overall waste generated on-site from landfills.

2.1.10 Reduction or Elimination of Acquisition of Toxic and Hazardous Chemicals and Materials

Purchase requests for hazardous materials are approved by TJNAF's ES&H staff to ensure the most environmentally preferable products are acquired and used.

2.1.13 Electronic Stewardship

TJNAF uses the EPA's EPEAT when selecting energy-efficient desktop/laptop computers and computer monitors, photocopies, televisions, printers, fax machines, tablets, and scanners. The facility tracks the purchase of this type of equipment. Energy savings, based on the rated efficiencies of the equipment, can then be calculated and reported. The EPEAT Purchase Awards program honors organizations showing leadership in the procurement of sustainable products. During 2024, TJNAF was awarded its eighth consecutive award for purchase of eligible products that were compliant with EPEAT bronze, silver, or gold registration requirements. A central power management system is used for desktop computers, laptops, and monitors that can hibernate without impacting facility operations. Printers are managed with default settings for printing duplex copies in black and white. Power management settings on printers and copiers are set to sleep mode when idle for set amounts of time.

2.1.14 Recycling Practices

Recycling is standard practice at TJNAF. Recycling containers are featured in every office, conference, and break room. TJNAF staff, users, and subcontractors also use facility-wide

office product recycling centers. These collect aluminum cans, small batteries, cardboard, printer cartridges, paper waste, telephone books, and plastic and glass bottles.

In 2024, with construction debris, scrap metal, and automatic data processing equipment included, approximately 1,310.3 tons of material were diverted from landfill disposal. The lab's extensive recycling program also resulted in the diversion of 94.5% of the overall waste generated on-site (1,387.0 tons of material).

2.1.15 Resource Conservation & Recovery Act

RCRA promotes the protection of health, the environment, and conservation of valuable material and energy resources. As a small quantity generator (SQG), TJNAF generates less than 1,000 kilograms (kg) of hazardous waste per month (but more than 100 kg). In 2024, approximately 3,415.10 kg of RCRA hazardous waste were generated. TJNAF does not store (outside of SQG allowed quantities/time limits), treat, transport, or dispose of RCRA-regulated waste on-site. All RCRA waste is disposed of through licensed waste-handling transport and disposal facilities.

The two largest volume hazardous wastes generated in 2024 were flammable liquid lab packs and acid mixtures, used for cavity and component processing.

2.1.16 Emergency Planning and Community Right-to-Know Act (EPCRA)

Under EPCRA, as aligned with the Superfund Amendments and Reauthorization Act (SARA), TJNAF provides hazardous material data (characteristics, quantities, and storage locations) to local entities so they can plan to provide adequate chemical and other emergency response services.

TJNAF meets applicable reporting requirements, such as toxic chemical usage and environmental releases, as required. See Figure 6.

Figure 5 – Status of EPCRA Reporting in 2024

EPCRA Section	Description of Reporting	Status
EPCRA § 302-303	Planning Notification	Completed
EPCRA § 304	EHS Release Notification	Not Required (No releases occurred)
EPCRA § 311-312	Safety Data Sheets/ Chemical Inventory	Completed
EPCRA § 313	Toxic Release Inventory Reporting	Not Required (No reporting thresholds exceeded)

2.1.17 Environmental Restoration and Waste Management

Waste streams at TJNAF include RCRA hazardous waste, non-hazardous solid waste, universal waste, used oil, non-RCRA low-level radioactive waste (LLW), mixed RCRA-LLW (MLLW), and medical waste. In 2024, TJNAF conducted waste management activities in accordance with applicable standards and requirements. No environmental restoration

activities were required under the Comprehensive Environmental Response, Compensation, and Liability Act.

2.1.18 Other Waste

TJNAF generates other waste, including wastewater discharges to sanitary sewer and non-hazardous solid waste from construction/maintenance activities and office waste bins. Most of this waste is non-hazardous solid, consisting of routine office trash and construction debris. As noted in section 2.1.14, the TJNAF recycling program repurposed or diverted 94.5% of the overall waste generated on-site in 2024.

LLW is generated and managed in accordance with DOE Order 435.1 – Radioactive Waste Management. Radioactive waste is disposed of at a licensed commercial facility (generally shipped to the facility in 25-cubic-yard containers). One LLW shipment took place in 2024.

Only a minor amount of medical waste was generated by TJNAF's on-site clinic in 2024. Its disposal was in accordance with all applicable regulations.

2.1.19 Relevant Demographic Information

TJNAF is a world-class research facility. It attracts resident and visiting physicists, as well as other scientists from around the world. In 2024, approximately 769 full-time physicists, engineers, technicians, and support staff worked at TJNAF. More than 1,500 academic and industrial researchers, from across the United States and approximately 30 other countries and 230 institutions, participated in scientific collaborations.

Each year, research conducted at TJNAF produces more than one-third of all nuclear physics doctoral degrees awarded in the United States.

2.1.20 Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

FIFRA applies to the storage and use of herbicides and pesticides. Use of these substances has environmental implications, especially where water quality is concerned. Consequently, only subcontractors who have completed the certification program administered by the Commonwealth of Virginia perform the application of herbicides and pesticides at TJNAF.

To minimize the chances of herbicides and pesticides washing into local stormwater channels, TJNAF requires that there be no outdoor application of these compounds when rain is expected. No industrial-strength herbicides or pesticides are stored or disposed of on TJNAF property, and only small amounts are allowed to be mixed on-site.

2.1.21 Unplanned Releases

During 2024, TJNAF ES&H staff continued to provide environmental guidance on spill prevention strategies to incorporate during activities occurring at the facility. Environmental guidance was provided to project managers during the initial planning phases of projects to identify potential contaminant sources along with providing strategies for pollution prevention during activities. Oil worker training and chemical safety training were also provided to applicable staff as a knowledge update of spill

prevention and the control of releases that may occur on-site. TJNAF ES&H continued to document all spills and releases on-site to identify any potential trends that could lead to potential improvements in spill prevention measures.

The following list summarizes the unplanned releases that occurred on-site during 2024:

February 2, 2024

JSA ES&H staff responded to a small hydraulic fuel leak from a 55-gallon drum in the southeastern portion of the Central Material Storage Area in the east-central portion of the facility. JSA staff immediately responded to the leak by removing contaminated soil adjacent to the drum and applying absorbent materials. The drums and contaminated soils were analyzed for eventual off-site disposal. All materials discharged from the release were contained to the immediate area and did not migrate off-site.

February 11, 2024

JSA ES&H staff responded to a small hydraulic fuel leak from a refuse dumpster adjacent to Building 36 (General Purpose Building) in the eastern portion of the accelerator site. JSA staff immediately responded to the leak by removing contaminated soil located immediately downgradient of the dumpster and placing absorbent materials on paved surfaces and open ground in the dumpster area. The dumpster was immediately removed and replaced by the vendor. All materials discharged from the release were contained to the immediate area and did not migrate off-site.

April 24, 2024

JSA ESH staff responded to a mineral oil leak from a transformer temporarily stored in Central Material Storage Area (CMSA). JSA staff immediately responded to the leak by placing absorbent materials around the transformer to prevent further migration of leaked materials. The transformer was prepared for eventual offsite repairs. All materials discharged from the release were contained to the immediate area and did not migrate offsite.

May 28, 2024

JSA ESH staff responded to a small hydraulic fuel leak from a manlift being temporarily used adjacent to the Hall D truck ramp in the eastern portion of the accelerator site. JSA staff immediately responded to the leak by placing absorbent materials around the transformer to prevent further migration of leaked materials. The manlift was prepared for eventual offsite repairs and a spill tray was inserted under the manlift prior to transport. All materials discharged from the release were contained to the immediate area and did not migrate offsite.

August 27, 2024

JSA ESH staff responded to a hydraulic fuel leak from a subcontractor vehicle onsite. JSA staff immediately responded to the leak by placing absorbent materials around the area of the release to prevent further migration of leaked materials. The vehicle was moved for

eventual offsite repairs. All materials discharged from the release were contained to the immediate area and did not migrate offsite.

September 30, 2024

JSA ESH staff responded to a diesel fuel leak from the generator located adjacent to the southern side of the TED building in the central portion of the campus area. JSA staff immediately responded to the leak by placing absorbent pads and triwall box around the area of the release to prevent further migration of leaked materials. The generator was repaired to prevent future releases, and contaminated soils were excavated and properly disposed of offsite. All materials discharged from the release were contained to the immediate area and did not migrate offsite.

2.1.22 Summary of Permits

TJNAF held four active environmental permits in 2024, listed in Figure 7.

Figure 6 – Environmental Permits in 2024

Permit Number	Permit Type
GW0047201	Groundwater Withdrawal
VA0089320	Industrial Wastewater to Surface – Groundwater Quality
VAR040079	Municipal Separate Storm-Sewer System (MS4)
HRSD 0117	Industrial Wastewater to Sanitary Sewer

During 2023, TJNAF received a five-year extension of the existing MS4 permit (VAR040079). There were no major changes to the permit, apart from new BMPs implemented within the Minimum Control Measures sections of the permit. During May 2022, TJNAF received a five-year extension of the existing VPDES permit (VA0089320). During March 2022, TJNAF received a five-year extension of HRSD permit 0117.

A great blue heron (Ardea Herodias), observed in the West Pond.

2.1.23 Radiation Protection

All TJNAF activities in 2024 were in full compliance with applicable limits for occupational and environmental radiation protection. See Section 4.0 – Environmental Radiological Protection Program and Dose Assessment.

2.1.24 Environmental Oversight

TJNAF's exemplary environmental performance is due to constant attention from all parties involved in facility operations. The DOE Site Office, JSA, subcontractors, and various Commonwealth and local authorities provide continuous oversight of the facility's environmental program. This includes routine inspections of construction projects, the MS4 system through IDDE inspections (12 monthly inspections in 2024), routine observations of effluent discharge locations for the sanitary sewer system (12 inspections and monitoring in 2024), waste storage inspections (50 RCRA CAA inspections; 12 RCRA SAA inspections), MS4 high-priority areas (12 monthly inspections in 2024), and review of other potential contaminant sources. Self-assessments, inspections, and work observations are used to measure program effectiveness.

3 ENVIRONMENTAL MANAGEMENT SYSTEM

3.1 Environmental Operating Experience

TJNAF's EMS is designed to:

- Identify facility activities with the potential for environmental impacts.
- Mitigate and otherwise manage the impacts of these activities.
- Maintain compliance with applicable environmental protection requirements.
- Promote the long-term stewardship of the facility's and our neighbors' natural resources.
- Encourage understanding and promote dialogue with interested parties.
- Assess performance, implement corrective actions where needed, and ensure continual improvement.

TJNAF has invested in a multidimensional process to ensure that its staff and contractors understand the potential impacts (both positive and negative) of their work on the environment and have the tools and training necessary to minimize the negative ones and maximize the positive ones. As our compliance history and awards demonstrate, that on-going process has been successful.

Because EMS is about continuous improvement, a cross-cutting team of engineers and other professionals was assembled to form the TJNAF EMS Green Team, which meets routinely to review progress, identify issues, and brainstorm possible solutions to improve the system. The EMS Green Team reviews the previous year's EMS performance, discusses changes to facility operations and how these would affect the environment, and determines where the facility should focus improvement activities. This analysis is reviewed by organizational leadership and identifies major focus areas (i.e., objectives) as well as specific projects to support each focus area (i.e., success metrics). Figure 8 summarizes the 2024 objectives.

Snapping turtles, great blue herons, and white-tailed deer are among the wildlife on the lab campus.

The TJNAF EMS Green Team gathered for Earth Day 2024 site-wide cleanup.

Figure 7 – 2024 EMS Objectives

EMS Objective	Success Metric(s)	Status
Energy Usage and Emissions	Develop list of ECMs to be used at TJNAF	**Completed**: ECMs list developed in FY24 2nd Quarter
Water Usage and Discharge/Temperature Controls	Use "turtle diagram" to prepare FY24 desktop audit of HRSD permit compliance/sanitary sewer system and conduct follow-up field audit	**Completed:** Audit of HRSD permit compliance/field audit of sanitary sewer system in FY24 4th quarter
Hazardous/Toxic Materials Management	Additional training for ES&H personnel in TJNAF waste management process: waste characterization; CAA weekly inspection; SAA monthly inspections; waste transfers; waste shipment preparation	**Completed:** ES&H personnel received additional training during FY24 1st and 3rd quarters
Ionizing Radiation Production Management	ESH/Radcon collaboration to prepare VPDES Annual Report for 2024 as required for new VPDES Permit VA0089320	**Completed:** ESH/Radcon successfully prepared VPDES Permit Annual Report to DEQ
Land Disturbance and Development	JSA Facilities Management personnel to develop Stormwater Pollution Prevention Plan (SWPPP) for Laydown Yard Expansion Project	**Completed:** Project SWPPP for Laydown Yard Expansion Project completed and approved in FY24 1st quarter
Purchase and Fabrication of Equipment	Purchase of parts and services that comply with FAR Sustainable Acquisition Clauses (FAR 52.223)	**Completed:** Purchase of sustainable products accomplished during FY24
Public Education and Outreach	Earth Day planning activities coordinated through ESH, FML, and Communication personnel; TJNAF EMS Green Team to develop subcommittee to install storm drain medallions on-site	**Completed:** ESH-Environmental and FML-Sustainability participated in volunteer and outreach activities for the 2024 TJNAF Open House; ESH-Environmental developed subcommittee and initiated install of storm drain medallions

*Excerpts taken from the CY2024 Environmental Management System Objectives Implementation Summary

3.2 Accomplishments, Awards, and Recognition

In 2024, TJNAF earned an HRSD Gold Award for perfect compliance with industrial wastewater discharges to sanitary sewer during 2023. Qualifying for this award requires maintaining a perfect compliance record for at least one year and demonstrating a commitment to environmental excellence. Other criteria for receiving this award include the requirement for an organization to meet HRSD permit compliance requirements and have no non-compliances or civil penalties. TJNAF maintained perfect compliance with industrial wastewater discharges throughout 2024 and anticipates receiving another HRSD Gold Award next year.

In 2024, TJNAF was also recognized by the DEQ as an Exemplary Environmental Enterprise (E3) facility within the Virginia Environmental Excellence Program (VEEP). The program consists of three levels: E2 – Environmental Enterprise; E3 – Exemplary Environmental Enterprise; and E4 – Extraordinary Environmental Enterprise. The E3 level is for facilities with fully implemented environmental management systems, pollution prevention programs, and demonstrated environmental performance.

3.3 Environmental Performance Measurement

An existing program on www.FedCenter.gov allows Federal agencies to measure EMS performance using metrics developed to gauge the maturity and health of environmental programs, based on the requirements of the ISO 14001 standard. In 2024, TJNAF's EMS received the highest score.

A great blue heron fishes in one of the lab's ponds.

4 ENVIRONMENTAL RADIOLOGICAL PROTECTION PROGRAM AND DOSE ASSESSMENT

4.1 Radiological Discharges and Doses

4.1.1 Radiation in the Environment

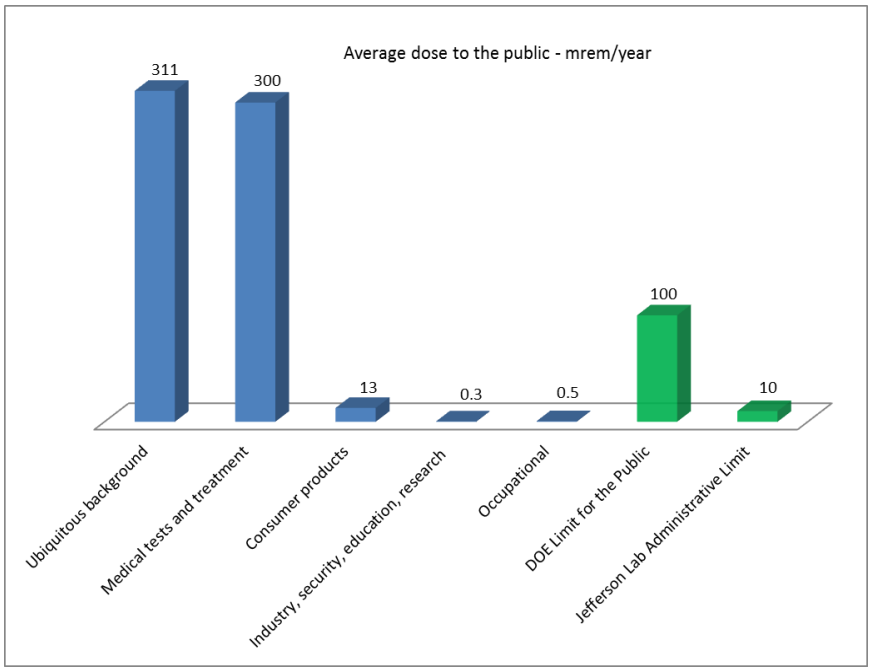
People are exposed to radiation constantly:

- Cosmic radiation from extraterrestrial sources
- Terrestrial radiation from naturally occurring elements in the earth's crust
- Manmade sources of radiation, notably from medical procedures.

Radiation exposure or "dose" is quantified in units of rem (roentgen equivalent man) and may be expressed as an individual dose or average amounts among groups or populations. Usually the millirem (mrem) is used to express the small doses associated with occupational and environmental exposure (1 mrem is 1/1000 of a rem). The SI unit in which dose is expressed is the sievert or millisievert (mSv). A sievert is equal to 100 rems, so 1 mSv is equal to 100 mrem.

Figure 9, Comparison of Sources of Radiation Exposure, shows the relative significance of various sources of radiation exposure to the average member of the public. According to the National Council on Radiation Protection and Measurements, as of 2006, the average individual radiation exposure in the U.S. from all sources now totals about 620 mrem per year, up from an estimated 360 mrem in the early 1980s. The increase can be attributed to medical uses of radiation.

Figure 8 – Comparison of Radiation Exposure Sources



The DOE limits the potential dose to the public that is attributable to DOE facility operations to 100 mrem per year. TJNAF has established an Alert Level of 10 mrem, either measured or estimated, for protection of the general public.

4.1.2 Radiation Exposure Pathways at TJNAF

Two broadly defined sources of potential radiation exposure exist at the facility: direct, or "prompt," radiation and induced radioactivity. Both types are produced during accelerator operations, but direct radiation has a potential impact only within proximity to an operating accelerator on-site. Accelerator operation (i.e., running an electron beam) produces significant levels of direct radiation within the accelerator enclosure. This radiation is produced within the beam enclosure, and its production stops when an accelerator is turned off. Almost all direct radiation is absorbed by extensive shielding, which is an integral part of accelerator design. Any possible exposure to this radiation decreases rapidly with distance from the accelerators and is extremely small at the site boundary.

TJNAF has an extensive radiation monitoring network in and around the accelerator. Approximately 50 active, real-time radiation monitors and a series of passive integrating detectors are deployed around the accelerator site. Among these, eight monitors collected direct radiation data around the site boundary in 2024. These monitoring stations are equipped with specialized detection devices, optimized for measuring radiation at close to background levels.

In addition to prompt radiation, the interaction of the accelerator beam with matter can cause the formation of radioactive materials through activation of matter (i.e., induced radioactivity). The beam lines, magnets, beam line components, targets, detectors, other experimental area equipment, and the energy dissipating devices (beam dumps) used to contain the beam's energy may become activated. Cooling water, lubricants, and air in the beam enclosure may also become activated. Strict controls limit possible radiation exposure from these activated items and materials.

All materials with potential for transferable contamination or volumetric induced radioactivity are monitored for radioactivity prior to being released from local control. TJNAF adheres to DOE approved limits for surface contamination and induced volumetric radioactivity.

Controls are in place to minimize exposure from direct and induced radiation to facility personnel, the environment, and the public. Access to the accelerator site and to areas containing radioactive material is strictly limited. Fencing, safety interlocks, signs, training, and other engineered and administrative controls prevent inadvertent or unnecessary exposures to direct radiation and induced radioactivity.

The largest potential source of environmental impact of a radiological nature at TJNAF is the operation of the CEBAF accelerator. A reasonable proxy for the overall environmental radiological impacts of operating the accelerator is the beam power delivered to the experimental halls. Halls A and C receive by far the greatest fraction of beam power. Figure 10 summarizes the approximate total beam power delivered to these two halls

since 2017. The impact of this beam delivery is reflected in the historical data presented in the following sections.

Figure 9 – Beam Power Delivered to Halls A and C

Calendar Year	Beam Power (MW-hr)
2017	16
2018	1025
2019	481
2020	586
2021	577
2022	964
2023	808
2024	167.4

4.1.3 Monitoring of Potentially Activated Wastewater

Water that could potentially become activated is sampled, analyzed, and discharged under HRSD Permit No. 0117 and VPDES Permit No. VA0089320. These wastewaters can include:

- CEBAF accelerator enclosure and experimental hall floor drainage.
- Beam dump and target cooling water.
- Environmental samples once analyzed.
- Groundwater extracted from beneath Halls A, B, and C.

Hall A Beam Line to Beam Dump.

The potential radiological constituents of TJNAF's wastewater discharge to HRSD in 2024 (see Figures 11 and 12) totaled 0.131 curies (Ci) of tritium (versus a limit of 5 Ci) and 0.00738 Ci of total gamma-emitters (limit = 1 Ci). These values represent over-estimates, since sample data yielding a zero or negative result (statistically expected for some samples with no radioactivity) are replaced with the minimum detectable activity value for the analysis.

Figure 10 – Radioactive Discharges to HRSD, 2024

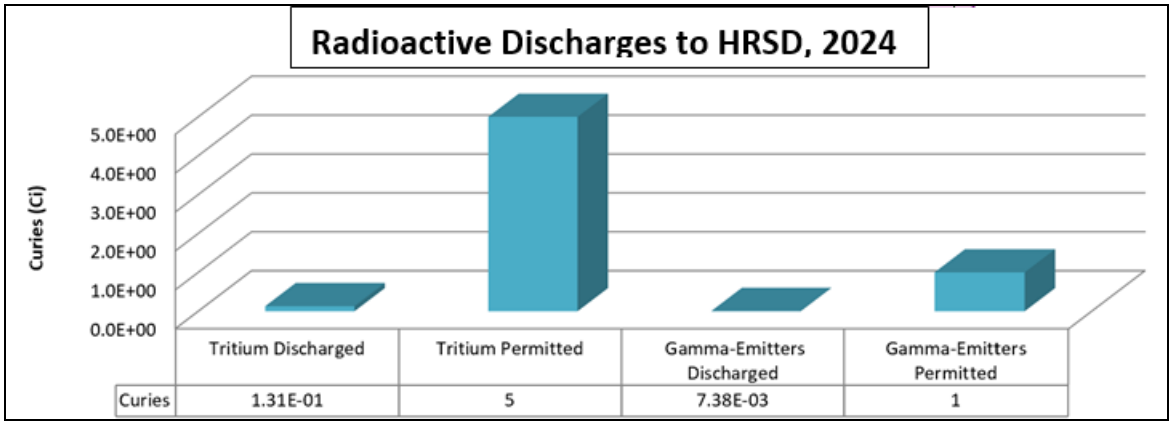


Figure 11 – Five-Year Summary of Radioactive Discharges to HRSD

Five Year Summary of Radioactive Discharges to HRSD					
Year	Unit	Tritium Discharged	Tritium Permitted	Gamma-Emitters Discharged	Gamma-Emitters Permitted
2024	Ci	1.31E-01	5	7.38E-03	1
2023	Ci	1.68E-01	5	1.17E-04	1
2022	Ci	7.20E-03	5	6.84E-04	1
2021	Ci	8.59E-2	5	8.99E-5	1
2020	Ci	2.62E-03	5	8.78E-07	1

DOE regulates radiological wastewater effluents under DOE Order 458.1. The order requires wastewater treatment to reduce radioactivity content using the best available technology (BAT) at specified concentration thresholds, in keeping with the ALARA (As Low as Reasonably Achievable) principle. Average discharge concentrations in 2024 remained a small fraction of the BAT treatment threshold.

4.1.4 Airborne Radionuclides

Essentially all airborne radionuclide emissions from the facility are the result of the release of air from accelerator enclosure vaults containing activation products resulting from beam interactions with the air. The interaction of the beam with air produces short-lived radionuclides such as Oxygen-15, Nitrogen-13, and Carbon-11, and smaller amounts of the longer-lived Hydrogen-3 (tritium). Measurable quantities of airborne radionuclide production (and emission) occur almost exclusively in the CEBAF accelerator at experimental Halls A and C and the beam switchyard portion of the accelerator. Other areas of CEBAF and the LERF contribute only a very small amount to the total emissions. See Figure 13 for a summary of estimated atmospheric releases from TJNAF in 2024.

Figure 12 – Atmospheric Discharges of Radionuclides, 2024

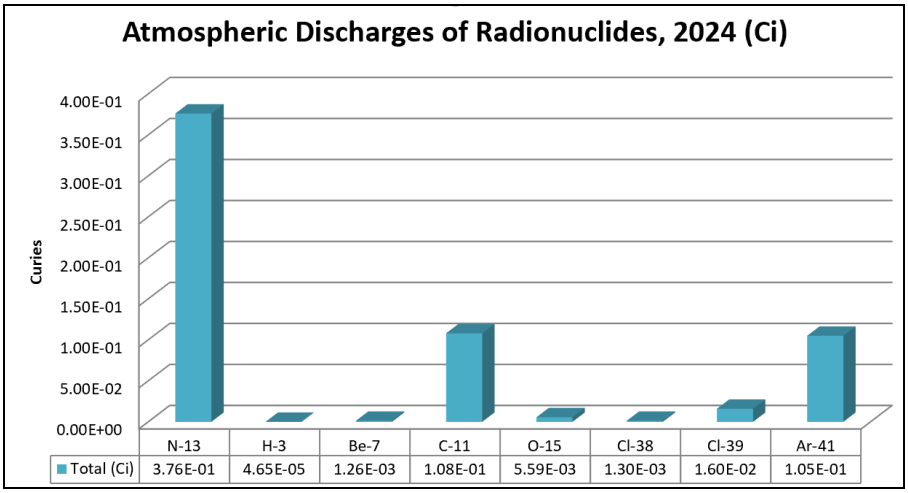


Figure 13 – Five Year Summary of Atmospheric Discharges of Radionuclides

Five Year Summary of Atmospheric Discharges of Radionuclides									
Year	**Unit**	**N-13**	**H-3**	**Be-7**	**C-11**	**O-15**	**Cl-38**	**Cl-39**	**Ar-41**
2024	Curies	3.76E-01	4.65E-05	1.26E-03	1.08E-01	5.59E-03	1.30E-03	1.60E-02	1.05E-01
2023	Curies	2.32E+00	3.00E-01	6.32E-03	5.88E-01	2.96E-01	9.20E-03	1.13E-01	5.06E-01
2022	Curies	3.40E+00	2.92E-04	7.76E-03	7.85E-01	6.87E-01	1.45E-02	1.77E-01	6.04E-01
2021	Curies	1.63E+00	1.69E-04	4.53E-03	4.25E-01	2.12E-01	6.58E-03	8.08E-02	3.67E-01
2020	Curies	3.16E+00	2.08E-04	5.34E-03	6.26E-01	9.92E-01	1.50E-02	1.84E-01	3.71E-01

Compliance with EPA regulations (40 CFR Part 61) requires TJNAF to determine the potential for maximum exposure to this radioactivity by a member of the public. Annual calculations using an EPA-approved computer model (CAP-88 PC, Ver. 4), show that TJNAF's operational emissions remain several orders of magnitude lower than the EPA's 10 mrem/year dose limit for a member of the general public. The calculated 2024 dose to the maximum exposed individual (MEI) among members of the public was 0.0062mrem/year due to airborne releases. The location of the MEI was approximately 150 meters south of the CEBAF accelerator, in the nearby Lidl supermarket parking lot. This MEI dose represents a conservative estimate, as the population in the Lidl parking lot would be expected to occupy their location for no more than 40 hours/week. CAP88-PC does not distinguish between commercial or residential (up to 24 hours/day) presence.

4.1.5 Direct Radiation Monitoring

Active (real-time) radiation measurement devices installed along the accelerator site boundary continued to be used to measure dose from direct radiation attributable to facility operations. Figure 17 shows the approximate locations of the radiation boundary monitors (RBMs) that measure and log radiological information, along with the groundwater monitoring well network.

Figures 15 and 16 display the radiation doses in mrem at the detectors that saw the largest dose from accelerator operations in 2024 (RBM-3). This dose represents direct

radiation exposure that would be experienced at the actual on-site boundary monitor location during accelerator operations. Note that the boundary dose shown is the total cumulative dose for the year. This does not, however, represent an estimate of the potential dose to a member of the public; under 4.1.6 any credible scenario, that dose would be a small fraction of this amount.

Figure 14 – Direct Radiation Dose at Site Boundary, 2024

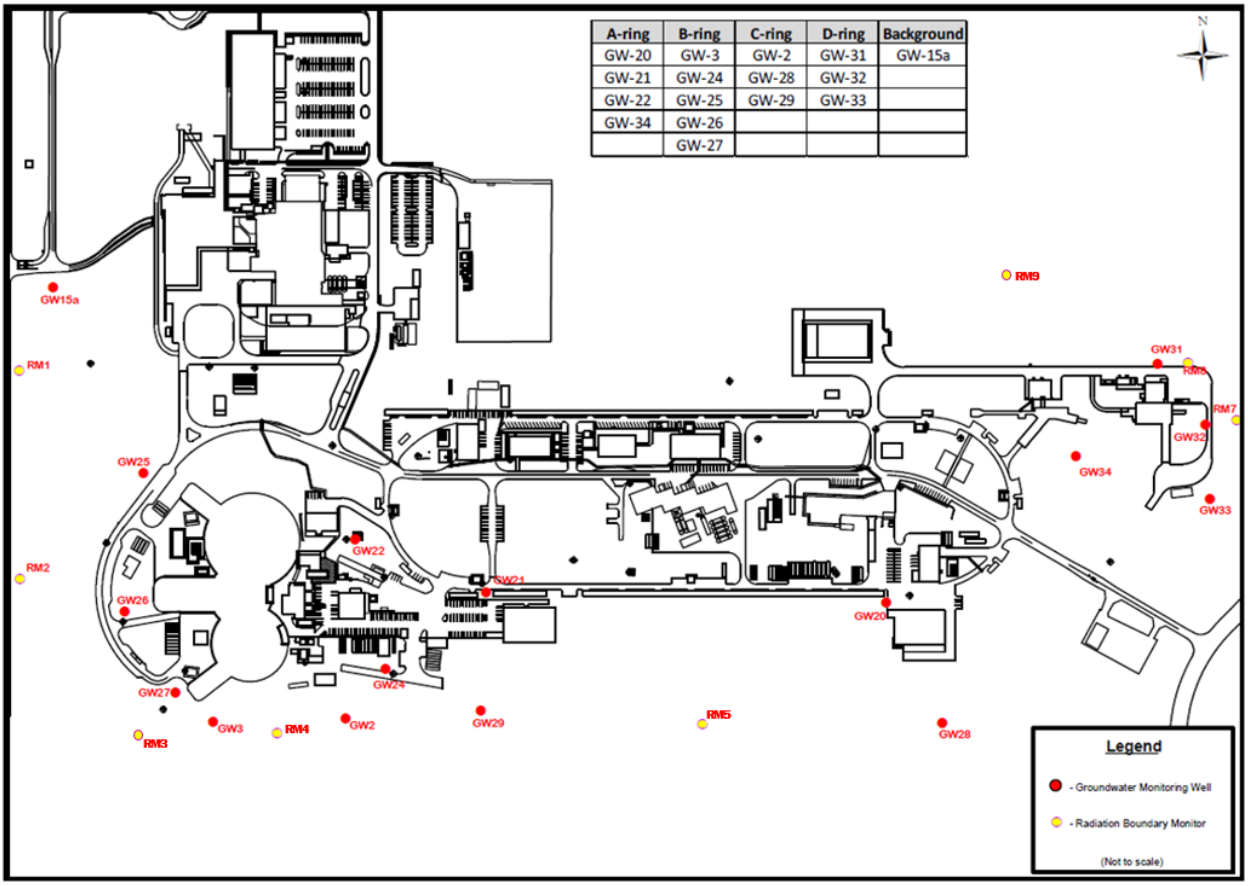
Direct Radiation Dose at Site Boundary, 2024			
Period	**Neutron (mrem)**	**Gamma (mrem)**	**Total (mrem)**
CY2024	0.395	0.196	0.59
CY2023	1.07	0.64	1.71
CY2022	2.41	1.22	3.63

Figure 15 – Five Year Summary of Direct Radiation Dose at Site Boundary

Five Year Summary of Direct Radiation Dose at Site Boundary			
Period	**Neutron (mrem)**	**Gamma (mrem)**	**Total (mrem)**
2024	0.395	0.196	0.59
2023	1.07	0.64	1.71
2022	2.41	1.22	3.63
2021	1.07	0.29	1.36
2020	1.30	0.25	1.55

The measured dose in 2024 is approximately 5.9% of the facility's design goal of 10 mrem/year (one-tenth of the DOE dose limit). See Section 4.1.9, Potential Dose to the Public and to Biota, for estimates of potential doses to the public.

Figure 16 – RBMs and Groundwater Monitoring Wells



4.1.6 Groundwater Monitoring

Geologically, the underground CEBAF and associated experimental end stations lie in the Yorktown Formation. Groundwater occurs sitewide at a depth of approximately 3 to 25 feet below ground surface.

Under VPDES Permit No.VA0089320, TJNAF monitors groundwater that is pumped from around the experimental halls and discharged through Outfall 001 to the surface. Most of the surface water leaving the site flows to the Big Bethel Reservoir via Brick Kiln Creek, with a smaller amount going to the lower James River.

In 2024, 16 wells (see Figure 17 – Radiation Boundary Monitors and Groundwater Monitoring Wells) were routinely monitored for radioactivity, using EPA or other approved sampling and analysis protocols. Wells are designated as A-ring, B-ring, C-ring, Hall D, or background. A-ring wells, closest to the accelerator, are most likely to show the effects of soil and groundwater activation. B-ring wells are farther from potential sources of activation. Both A-ring and B-ring wells are sampled semiannually. C-ring wells, positioned to represent conditions near the property boundaries, are sampled annually, along with the background well. Monitoring of Hall D wells was conducted on a semiannual basis.

Groundwater samples are analyzed for H-3 (tritium), Be-7 (Beryllium 7), Mn-54 (Manganese 54), and Na-22 (Sodium 22). The VPDES permit specifies limits for radioactivity in the wells based on their location with respect to the accelerators. No accelerator-related radionuclides were detected in the groundwater, and no permit exceedances occurred in 2024.

4.1.7 Other Environmental Surveillance

TJNAF routinely collects environmental samples not required by any regulation or permit. Sediments from storm drainage channels and soils in areas that could potentially be affected (by contaminated runoff or storage and handling of radioactive materials) are sampled at a variety of locations on a location-specific frequency. Results of sampling continue to show that no significant radioactivity is being released to the environment through these pathways.

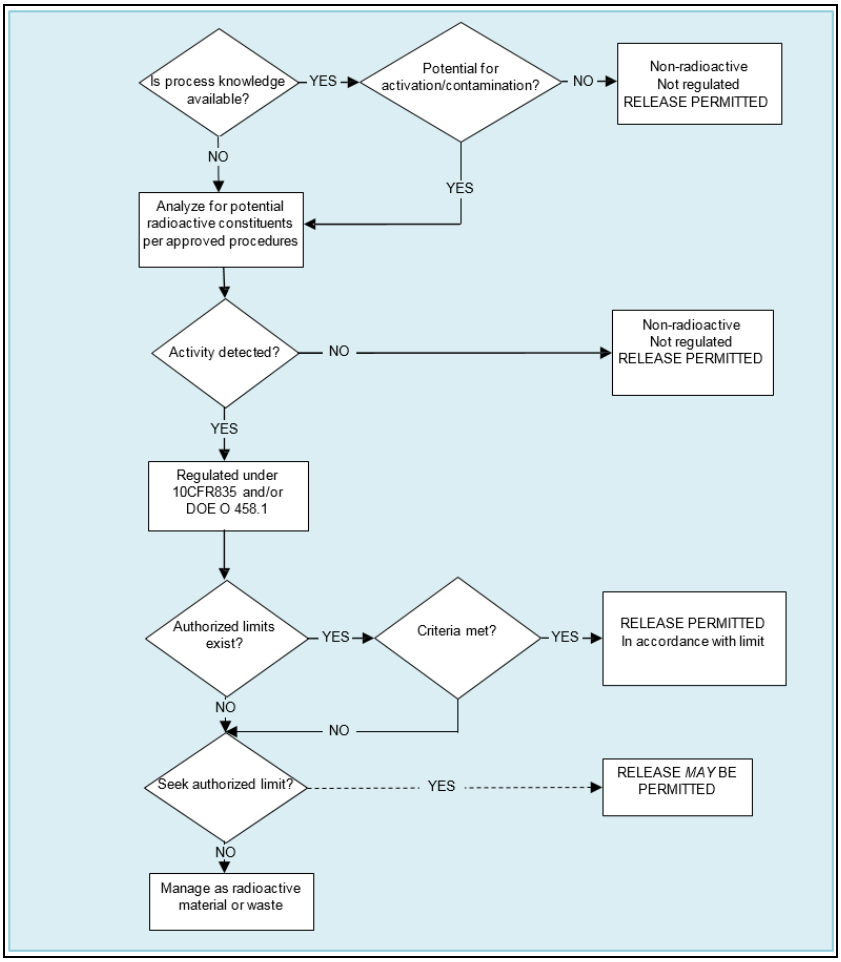
4.1.8 Clearance of Property Containing Residual Radioactive Material

TJNAF does not release to the public any residual radioactive material, such as contaminated concrete or soil, so there are no resulting dose impacts to the public. The facility has developed a process to determine if potentially radioactive materials are to be managed as material containing residual radioactivity or as non-radioactive. All potentially activated or contaminated material and equipment is monitored prior to release from control. The program involves many hundreds of radiological surveys annually.

TJNAF adheres to DOE limits for radioactive surface contamination (although little material with surface contamination is generated here). DOE Order 458.1 does not prescribe a specific limit for the release of volumetrically activated materials; therefore, the facility has adopted methods and procedures to ensure equipment and materials being released contain no volumetric radioactivity distinguishable from background. Materials with potential for internal contamination or volumetric radioactivity that cannot be reliably assessed are treated as radioactive materials and not released to the public.

Figure 17 – General Process for Materials Classification – summarizes TJNAF's process. This process is consistent with the approach recommended by a multi-agency task group regarding defining impacted areas and classifications of material.

Figure 17 – General Process for Materials Classification



The application of process knowledge comprises the first step in the characterization of materials for possible release. The approach at TJNAF has historically been a conservative one: If materials were in the accelerator enclosure during beam operations, it is assumed that they may be activated and are subject to further analysis. Surveys, sampling and analysis are conducted by trained technicians using formal written procedures. Results of the surveys or other analyses are documented appropriately.

In 2024, the estimated volume of materials released through the process described above was about 8.6 tons of solid waste and an estimated 6.8 tons of scrap metals for recycling.

Potential doses to the public from undetected radioactivity in released materials have been assessed and documented as prescribed in various national and international standards. These standards and DOE requirements apply a dose constraint of 1 mrem/ year for determining the significance of potential dose to the public. The measurement sensitivity of the facility's procedures was evaluated against this benchmark as part of its technical basis, confirming that potential dose to a member of the public through this pathway is insignificant.

An independent review of TJNAF's process for releasing materials from radiological control is conducted periodically by DOE or a designated third party.

TJNAF sought no authorized limits for the release of material containing residual radioactivity in 2024. All materials exhibiting radiation above background levels were managed as radioactive material, and either saved for beneficial reuse or classified as waste. Almost all radioactive waste generated at TJNAF is LLW, with an occasional small additional amount of MLLW. This waste is transferred for off-site disposal at an authorized disposal facility. One waste transfer occurred in 2024 through Energy Solutions, a licensed disposal facility.

4.1.9 Potential Dose to the Public

Controls are in place to minimize exposure from both direct radiation and radiation from activated materials to facility personnel, the environment, and the public. Access to the accelerator site and to areas housing radioactive material is strictly limited. Fencing, safety interlocks, signage, training, and other engineered and administrative controls prevent inadvertent exposures to direct and induced radiation.

The direct dose and air emissions discussed above are the only sources for which any contributions to public dose can be directly measured or calculated. Other sources involve only hypothetical doses. In Figure 18 – TJNAF Radiological Dose Summary for 2024 – the maximum possible dose to the public assumes a 24-hours-a-day, 365-days-a-year exposure to the highest levels measured at the site boundary. However, it is not credible under any plausible conditions for a member of the public to actually receive this dose. The southern and western boundaries of the site, where the monitors are located, are heavily wooded and mostly undeveloped or adjacent to a major roadway. All site boundaries are also posted with "U.S. Government – No Trespassing" signs.

Figure 18 - TJNAF Radiological Dose Summary for 2024

2024 Radiological Dose Summary			
Pathway	**Dose to Maximally Exposed Individual, mrem**	**% of 100 mrem/yr DOE Limit**	**Estimated Population Dose, person-rem**
Air*	0.0062	0.000062	0.0015
Water**	~0	~0	<0.1[ʃ]
Release of materials**	~0	~0	<0.1[ʃ]
Direct radiation***	0.59	0.0059	<0.1[ʃ]
Plausible scenario [†]	0.00034	0.0000034	-

*From 2024 atmospheric modeling results for National Emission Standards for Hazardous Air Pollutants reporting
** See text below
*** From Boundary Radiation Monitors, before applying realistic exposure scenario (see text)
[ʃ] Estimated upper bound for population doses from these pathways
[†] Total effective dose using a conservative, reasonable exposure scenario (see text)

Using the measured dose from continuous monitoring and calculated dose from CAP88-PC modeling, one can construct an exposure scenario in which a more realistic estimate of the maximum potential dose to a member of the public is obtained. A reasonably conservative scenario might involve exposure at the boundary in which an individual

spent two hours per day walking along the site boundary or waiting for a Jefferson Avenue bus and did so for 250 days of the year. Under this scenario, we can assign the average dose rate from monitoring to the individual for the entire occupancy duration. This hypothetical case represents a conservative scenario for the MEI for this source. Given these conditions, the MEI for this exposure path would have received 0.0015 mrem in 2024 from direct radiation, 0.000015% of the DOE limit of 100 mrem. The potential dose from air releases is also modeled using a 100% exposure time assumption. A reasonable modification would be to adjust this value for a typical occupational duration (2,000 hours) at the location of concern. This results in a dose of 0.00034 mrem.

Doses from these two sources represent the only reasonably quantifiable exposure pathways to the public from facility operations. If we combine the dose from these two scenarios, the maximum postulated dose from all pathways to a member of the public from TJNAF operations in 2024 is approximately 0.59 mrem.

There is no public or private use of the shallow aquifer in the vicinity of TJNAF; thus there is no exposure to the public via contact with or ingestion of groundwater. No accelerator-produced radioactivity was detected in any of the samples from the End Station Sump or in surface water. Considering the extremely small quantities of radioactivity that are potentially present in this effluent, the potential dose to a member of the public or biota from this pathway is insignificant. A 2013 residual radiation (RESRAD)-based evaluation found that the total dose from pathways such as ingestion of plants, fish, meat, and milk, as well as all pathways related to surface water, was in the range of 10-8 mrem/year. The upper bound on the estimate of the total population dose from all liquid effluent pathways is less than 0.1 rem/y.

As described earlier, DOE requirements apply a dose constraint of 1 mrem/year for the release of property to the public. The primary exposure pathway for potential dose from this source is through metal recycling. Given the modest volume of metal released to this pathway, and the conservative protocols in place for material release, potential dose to an individual from this exposure path is considered negligibly small. Estimates of the population dose from this pathway, assuming all released material containing the upper limit of radioactivity are in the range of 0.5 rem/y. More realistic assumptions result in a population dose well below 0.1 rem/y.

4.2 Addressing Radiation Protection for Biota in ASER

4.2.1 Dose Rate Limits for Protection of Biota and Compliance Methods

TJNAF can only estimate absorbed dose to local biota (aquatic or terrestrial). The DOE has provided guidance on evaluating dose that may be received by biota. DOE-STD-1153-2019 provides screening values for both terrestrial and aquatic organisms. The internationally recommended dose limit for terrestrial biota, 0.1 rad/day, is the lowest limit for any biota. The rad is a dose unit similar to the rem, but it does not contain any of the risk factors associated with exposure to humans. Therefore, all criteria are met if doses do not exceed 0.1 rad/day.

The best indicators of dose to biota are the passive dosimeters placed around the property. These are the same types of dosimeters used to monitor worker exposure. In 2024, monitored doses from 23 locations were used to estimate environmental dose.

Earthen domes over Halls A, B, and C

During 2024, the site provided habitats for deer, coyotes, foxes, raccoons, squirrels, groundhogs and other small mammals; reptiles; aquatic macroinvertebrates; and a wide variety of birds. The birds and some of the mammals roam the site, but others (e.g., the groundhogs) live in established burrows. The biota expected to receive the maximum dose would be ground-dwelling animals living in the earthen berms over the experimental halls.

Figures 19 shows the frequency distribution of annual (2024) doses from the network of dosimeters, while Figure 20 provides a 5-year summary. The maximum recorded dose was 105 mrad, measured at the northwest side of the Hall A earthen dome. Dividing this value by 365 days yields an average dose of 0.00023 rad/day, far below the most stringent criteria. Figure 22 – Environmental Radiation vs. Limit – illustrates these data.

Figure 19 –Distribution of 2024 Dose Reflected by Environmental Dosimeters

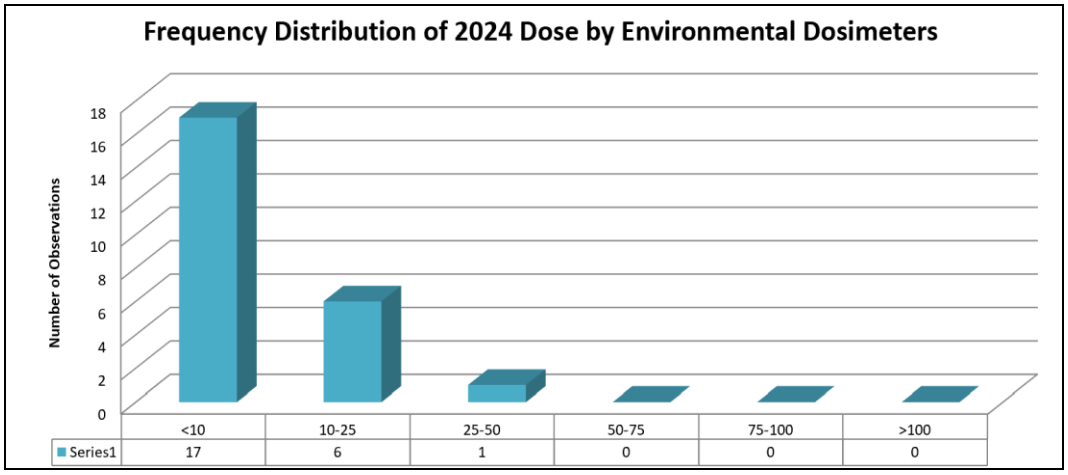


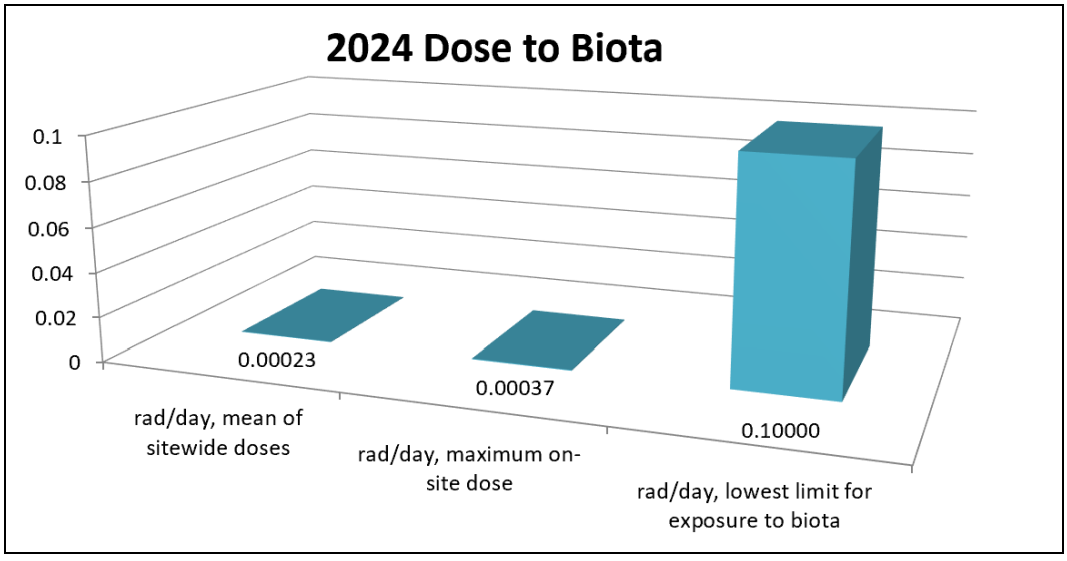
Figure 20 – Five-Year Summary of Distribution of Dose in Millirad/Year

Five-Year Summary of Distribution of Dose in millirad/year, Reflected by Environmental Dosimeters							
Year	**<10**	**>10-25**	**>25-50**	**>50**	**>50-75**	**>75-100**	**>100**
2024 Count	17	6	1	0	0	0	0
2023 Count	21	2	0	0	0	0	0
2022 Count	14	20	5	9	3	3	3
2021 Count	22	15	2	-	-	-	-
2020 Count	28	7	3	-	-	-	-

Figure 21 – Five-Year Summary of Dose to Biota

Five-Year Summary of Dose to Biota			
Year	**Rad/day, mean of site-wide doses**	**Rad/day, maximum on-site dose**	**Rad/day, lowest limit for exposure to biota**
2024	0.000231	0.00037	0.1
2023	0.000132	0.00060	0.1
2022	0.000104	0.00088	0.1
2021	0.000037	0.00009	0.1
2020	0.000013	0.000082	0.1

Figure 22 – Environmental Radiation Dose vs. Limit



4.2.2 Unplanned Radiological Releases

TJNAF had no unplanned radiological releases in 2024.

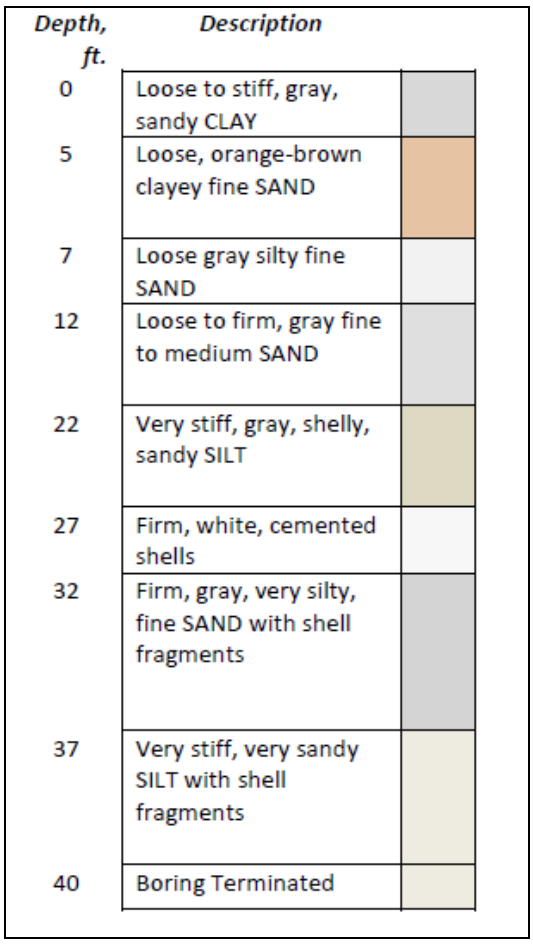
4.2.3 Environmental Radiological Monitoring

Ionizing radiation and a variety of radioactive materials are byproducts of research activities at TJNAF. Any potential impacts have been significantly reduced by adhering to the ALARA philosophy in dealing with potential sources of radiation. The potential dose to members of the public from various pathways, such as inhalation, ingestion, and skin absorption, is evaluated by the ES&H Division to demonstrate compliance with regulatory limits (as required by DOE Order 458.1, "Radiation Protection of the Public and the Environment").

5 GROUNDWATER PROTECTION PROGRAM

Figure 24 – Typical Cross Section of Boring at TJNAF Site, compiled from several on-site boring logs, depicts a typical cross-section of soil at the facility. The CEBAF tunnel and experimental end stations are located underground within the Yorktown Formation. Activation of groundwater and soil are a potential source of groundwater contamination. Groundwater occurs site-wide at a depth of approximately 3 to 25 feet below grade. Groundwater quality in the soil surrounding the accelerator complex is the Commonwealth's greatest concern with site operations.

Figure 23 – Typical Cross Section of Boring at TJNAF Site



The monitoring of VPDES-permitted wells for groundwater quality continued in 2024 and provided much of the basis for the Groundwater Protection Program. Through a combination of engineered controls (e.g., shielding) designed into the CEBAF and LERF facilities, and adherence to operational limits, no measurable groundwater activation was produced on or off-site.

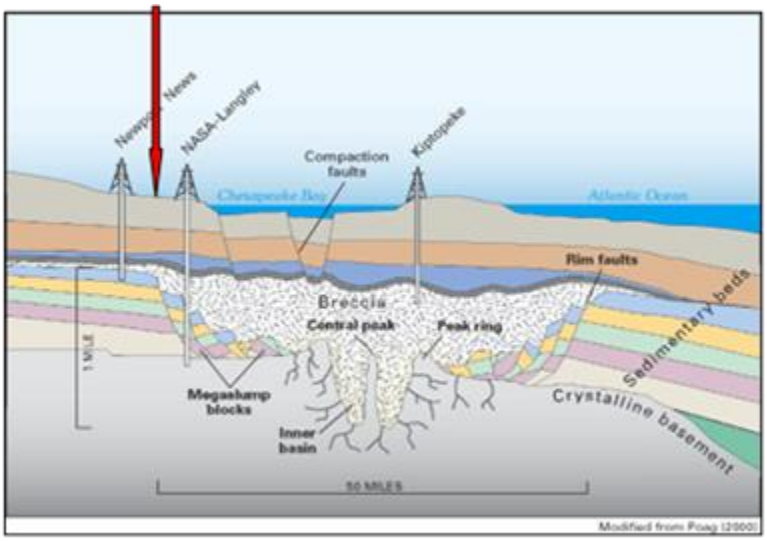
Many other programs at TJNAF contribute to groundwater protection: spill prevention and control, pollution prevention and waste minimization, materials storage, and waste management are a few.

Relatively recent information places TJNAF in a unique geologic position. Approximately 35 million years ago, a giant bolide blasted a huge crater into the continental shelf. A bolide of this magnitude creates a complex crater with inner and outer rims.

As Figure 25 – Delineation of Inner and Outer Craters, indicates, the outer rim of the crater lies across Newport News. The inner and outer rims have complex, characteristic stratigraphic features, as shown in Figure 26 – Location *of TJNAF Relative to the Outer Rim of the Chesapeake Bay Bolide Crater*.

Figure 24 – Delineation of Inner and Outer Craters

Figure 25 – Location of TJNAF Relative to the Outer Rim of the Chesapeake Bay Bolide Crater



The red arrow in Figure 26 indicates the approximate location of TJNAF relative to the Chesapeake Bay bolide crater. Site geology could be more complex than once thought. Notably, in this area, the Yorktown-Eastover aquifer is greatly diminished. Extensive studies of the groundwater

characteristics within the outer rim show that even deeper aquifers were affected by the bolide, which evaporated water more than a mile deep. That water was replaced by saline water, which remains present to this day in the Potomac aquifer and other, deeper groundwater sources.

TJNAF activities to date have involved only the Yorktown-Eastover aquifer; that aquifer is the focus of our Groundwater Protection Program. The Yorktown-Eastover aquifer is represented in Figure 26 by the blue layer between the orange-tan (Yorktown) and dark gray (Eastover) formations.

Semiannual monitoring of wells installed around the Hall D complex was initiated in Fall 2016 because of the reissuance of VPDES Permit VAR0089320. Groundwater data from wells around Hall D for 2024 was consistent in quality with the remainder of the TJNAF site.

6 QUALITY ASSURANCE

Extensive quality assurance (QA) activities ensure that TJNAF's environmental monitoring program continually performs in accordance with the principles of the QA Program (DOE Order 414.1D) and the requirements of DOE Order 458.1. The QA Program includes:

- Qualifications of the laboratories that provide analytical services.
- Verification of certification to perform analytical work.
- Review of performance test results.
- Assessment of the adequacy of each subcontractor's internal quality control (QC) practices, recordkeeping, chain of custody, etc.

In addition to the internal QA performed by TJNAF's ES&H Division, independent assessments are performed by Performance Assurance, the DOE Site Office, regulatory agencies such as the EPA and Virginia DEQ, and oversight groups within DOE. No QA concerns regarding environmental sampling protocols or results were noted in 2024.

An independent laboratory (James R. Reed & Associates) collected most of 2024's VPDES and HRSD permit-required water samples. Other samples, which involve radionuclide analysis, including some required by the HRSD permit, are collected by the ES&H Division and analyzed in TJNAF's radiological analysis facility. Composites of these samples are then produced and delivered to the independent lab. Eberline Services performed all subcontracted radiological analyses. James R. Reed is a Virginia Environmental Laboratory Accreditation Program certified facility as administered by the Virginia Division of Consolidated Laboratory Services (DCLS). The DCLS administers the certification/accreditation program and conducts inspections of environmental laboratories to ensure consistency with the National Environmental Facility Laboratory Accreditation Program.

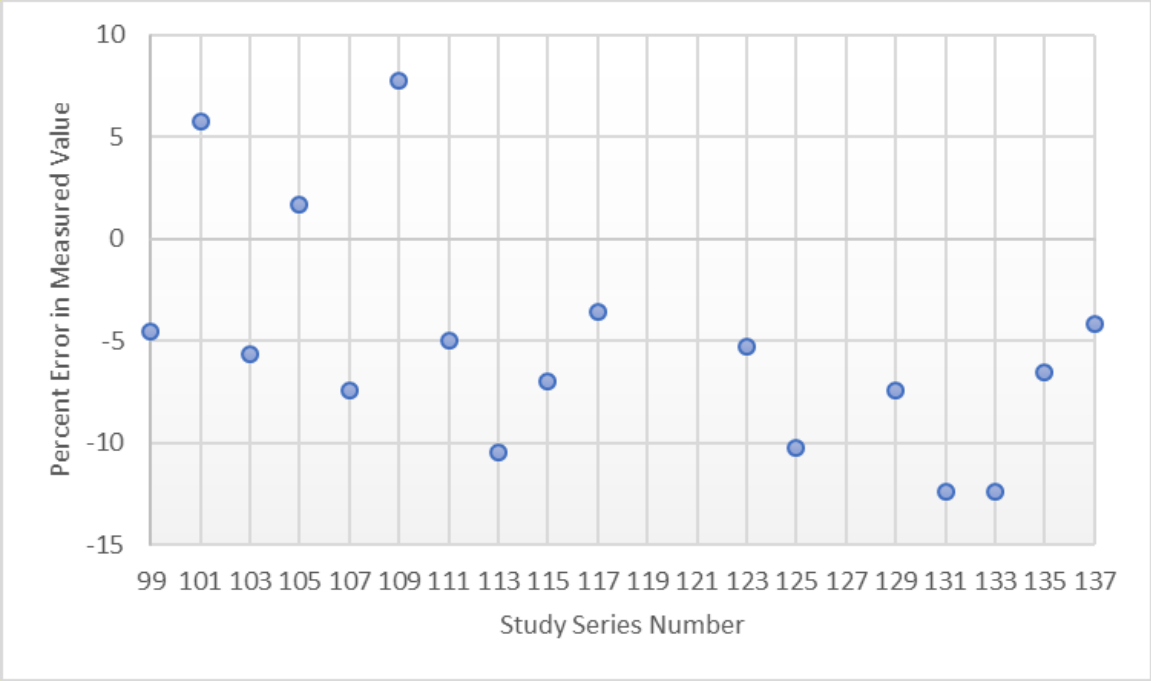
Samples collected by external analytical laboratories are analyzed for radiological (and non-radiological) attributes using standard EPA-approved analytical procedures. Both external facilities and TJNAF have a continuing program of analytical laboratory QC. Participation in inter-laboratory crosschecks, analysis of various blanks, and replicate sampling and analysis verify data quality. ES&H Division staff and other responsible TJNAF personnel review all analytical data for the samples analyzed under their subcontracts. The analytical results are reviewed relative to the accompanying QA/QC results and compared with regulatory limits for acceptability. These reviews include inspection of chains of custody, sample stewardship, sample handling and transport, and sampling protocols. When applicable to the analysis requested, analytical labs must be appropriately certified.

Ongoing precision and accuracy are monitored by analysis of the following with each batch of samples taken under Permit VA0089320 (laboratory standards, duplicate determinations, matrix spikes, and matrix spike duplicates). These data are used to calculate the relative standard deviation on all applicable parameters. The quality of the data is then evaluated and compared to regulatory limits to determine acceptability. Satisfactory results from the vendors enable TJNAF to validate compliance with the QA requirements in the permit.

TJNAF and Eberline Services participate in the Mixed Analyte Performance Evaluation Program (MAPEP) conducted by DOE's Radiological and Environmental Services Laboratory, which is available to all DOE subcontractors. This program tests the quality of environmental radiological and non-radiological measurements and provides DOE with complex-wide comparability of measurement performance. In the two rounds of MAPEP QA testing in 2024, overall performance by both TJNAF and Eberline was acceptable, with only minor potential quality concerns associated with incorrectly converted units or results for constituents that are not of concern at TJNAF. Results of the MAPEP testing can be found at: http://www.id.energy.gov/resl/mapep/mapepreports.html.

TJNAF also participates in an additional annual quality test for analysis of tritium. Figure 27 – Environmental Resource Association (ERA) Quality Control Program for Tritium Analysis – demonstrates the agreement between the control samples and the values reported by our radioanalytical laboratory over time (note: two rounds of testing – late 2019 and early 2020 – were not conducted due to the COVID pandemic). A persistent negative bias indicated in the results since 2017 was addressed by procurement of new calibration standards and full recalibration of TJNAF's liquid scintillation counting system.

Figure 26 – ERA Quality Control Program for Tritium Analysis



7 ACRONYMS & ABBREVIATIONS

ALARA	As Low as Reasonably Achievable
BAT	Best Available Technology
Be-7	Beryllium-7
BMP	Best Management Practices
BOMARC	Boeing and Michigan Aerospace Research Center
BTU	British Thermal Unit
CASA	Center for Advanced Studies of Accelerators
CEBAF	Continuous Electron Beam Accelerator Facility
CFR	Code of Federal Regulations
Ci	Curie
CLAS12	CEBAF Large Acceptance Spectrometer for 12 GeV Upgrade
DCLS	Virginia Division of Consolidated Laboratory Services
DEAR	Department of Energy Acquisition Regulation
DEQ	Virginia Department of Environmental Quality
DOD	Department of Defense
DOE	Department of Energy
ECM	Energy Conservation Measures
EISA	Energy Independence and Security Act
EMS	Environmental Management System
EO	Executive Order
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act of 1986
EPEAT	Electronic Product Environmental Assessment Tool
ERA	Environmental Resource Association
ES&H	Environment, Safety, and Health
FAR	Federal Acquisition Regulation
FEL	Free Electron Laser
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FML	Facilities Management & Logistics
FONSI	Finding of No Significant Impact

FY	Fiscal Year
GeV	Billion (Giga)-Electron Volts
H-3	Tritium
HRSD	Hampton Roads Sanitation District
ISM	Integrated Safety Management
ISO	International Organization for Standardization
JSA	Jefferson Science Associates, LLC
kg	Kilogram
LERF	Low Energy Recirculator Facility
LLW	Low-Level Radioactive Waste
Mn-54	Manganese-54
MAPEP	Mixed Analytic Performance Evaluation Program
MBTU	One Million British Thermal Units
MDA	Minimum Detectable Activity
MEI	Maximum Exposed Individual
METF	Maximum Extent Technically Feasible
MLLW	Mixed RCRA-LLW
mrem	Millirem
mSv	Millisievert
MS4	Municipal Separate Storm Sewer System
Na-22	Sodium-22
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
ODS	Ozone-Depleting Substance
QA	Quality Assurance
QC	Quality Control
Radcon	Radiation Control
RBM	Radiation Boundary Monitor
RCRA	Resource Conservation and Recovery Act
REC	Renewable Energy Credit
REM	Roentgen equivalent man

RESRAD	Residual Radiation
SARA	Superfund Amendments and Reauthorization Act
SPCC	Spill Prevention, Control, and Countermeasure
sq ft	Square Feet
SQG	Small Quantity Generator
SRF	Superconducting Radiofrequency
TJNAF	Thomas Jefferson National Accelerator Facility
TMDL	Total Maximum Daily Load
UITF	Upgrade Injector Test Facility
VPDES	Virginia Pollutant Discharge Elimination System
VSMP	Virginia Stormwater Management Program
W	Watt

8 FIGURES