Jefferson Lab
Thomas Jefferson National Accelerator Facility

2018 Annual Site Environmental Report For Thomas Jefferson National Accelerator Facility

Prepared for:
United States Department of Energy
Thomas Jefferson Site Office
Thomas Jefferson National Accelerator Facility
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Jefferson Lab

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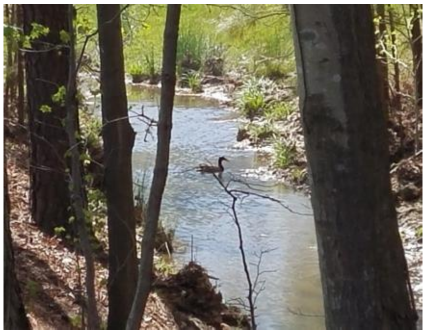










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1.0 EXECUTIVE SUMMARY

This Annual Site Environmental Report documents the U.S. Department of Energy's (DOE) Thomas Jefferson National Accelerator Facility's (Jefferson Lab) environmental protection program and its performance in 2018. This report presents results from environmental compliance and monitoring programs that are within the scope of Jefferson Lab'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 Jefferson Lab operations.

Jefferson Science Associates, LLC (JSA), has managed and operated Jefferson Lab for the U.S. Department of Energy since 2006. JSA is a Southeastern Universities Research Association /Pacific Architects and Engineers Limited Liability Company which brings the science and technology focus of more than 60 universities in the Southeast together with the corporate management focus that has successfully managed the infrastructure and business operations at three DOE sites.

"Jefferson Lab, a forefront U.S. Department of Energy Nuclear Physics research facility, provides world-class, unique research capabilities and innovative technologies to serve an international scientific user community. Specifically, the laboratory'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, and;*
- *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 radio-frequency (SRF) technology to drive electrons to higher and higher energies. The accelerator's electron beam can be split for 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 experimental 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 enough for precise measurements.

In 2018, work was completed for the Utility Infrastructure Modernization (UIM) project, which has included the replacement and upgrade of electrical distribution feeders for the CEBAF, replacement of cooling towers serving CEBAF operations, providing additional cooling and uninterruptable power for the computer center, upgrading the Cryogenics Test Facility (CTF) to support cryomodule development, and improving site communications infrastructure.

View from flyover of Jefferson Lab, facing towards the north. The racetrack outline of the Lab's accelerator facility is located in the southern portion, while the experimental halls are located at the eastern and western ends of the accelerator loop.

Low Energy Recirculator Facility (LERF)

Jefferson Lab's Low Energy Recirculator Facility, formerly known as the Free-Electron Laser (FEL), was developed using the lab's expertise in superconducting radiofrequency (SRF) accelerators. As an FEL, the facility provided a high-power tunable infrared laser and also provided ultraviolet laser light, including vacuum ultraviolet light, and Terahertz light. Currently, the lab is using the term Low Energy Recirculator Facility, or LERF, to refer to this facility, as future missions with potentially broader scope are under development. The LERF conducted a DarkLight Experiment in 2016. Planning for conducting a radioisotope production and development experiment began in 2018.

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 laboratories in nuclear physics, basic energy sciences, and high-energy physics.

Integrated Safety Management (ISM) System

Through ISM, Jefferson Lab 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 a part of routine work that is always included in the planning and execution of routine work and projects.

Environmental Management System (EMS)

Jefferson Lab'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 facility. The EMS is integrated into the ISM System.

Requirements Identification Process

Requirements are comprised of the laws, regulations, and standards necessary and sufficient to ensure worker and public health and safety, and to protect the environment. Jefferson Lab continually identifies new and changing requirements for inclusion into its programs. Subject matter experts follow the development of new requirements, evaluating the applicability to existing laboratory operations.

Implementation of the National Environmental Policy Act (NEPA)

Construction activities and all accelerator upgrades are subject to review under the NEPA. The initial construction, two upgrades to CEBAF, and new buildings have been 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 which do not have 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 posted on DOE's Public Reading Room.

Radiological and non-radiological releases to the public from site operations

In 2018, there were no unplanned radiological or non-radiological releases to the environment 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

Jefferson Lab measures its environmental performance in several ways. In 2018, the DOE gave JSA an A- for its ability to "Sustain Excellence and Enhance Effectiveness of Integrated Safety, Health, and Environmental Protection." Additionally, Jefferson Lab reports annually to the Office of the

Federal Environmental Executive and tracks numerous internal environmental performance metrics – all of which indicated success in 2018.

Inspection

Jefferson Lab'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 inspections. This report includes independent inspection results, including detailed comments on Jefferson Lab's record of compliance with applicable laws and regulations.

General Compliance

Jefferson Lab's ES&H Manual facilitates integration of general environmental compliance initiatives into site operations. This report presents Jefferson Lab's environmental compliance activity performance in 2018 and focuses on those dealing with water resources and public health. No significant environmental compliance issues arose during 2018.

Awards and Recognitions

In 2018, Jefferson Lab was awarded a DOE Gold GreenBuy Award from the Department of Energy's Office of Sustainable Environmental Stewardship for meeting leadership goals for 9 products in 6 different categories.

In 2018, Jefferson Lab was awarded with a Hampton Roads Sanitation District (HRSD) Gold Award for perfect compliance with industrial wastewater discharges to sanitary sewer during 2016. 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 includes the requirement for an organization to meet HRSD compliance requirements and have no non-compliance or civil penalties.

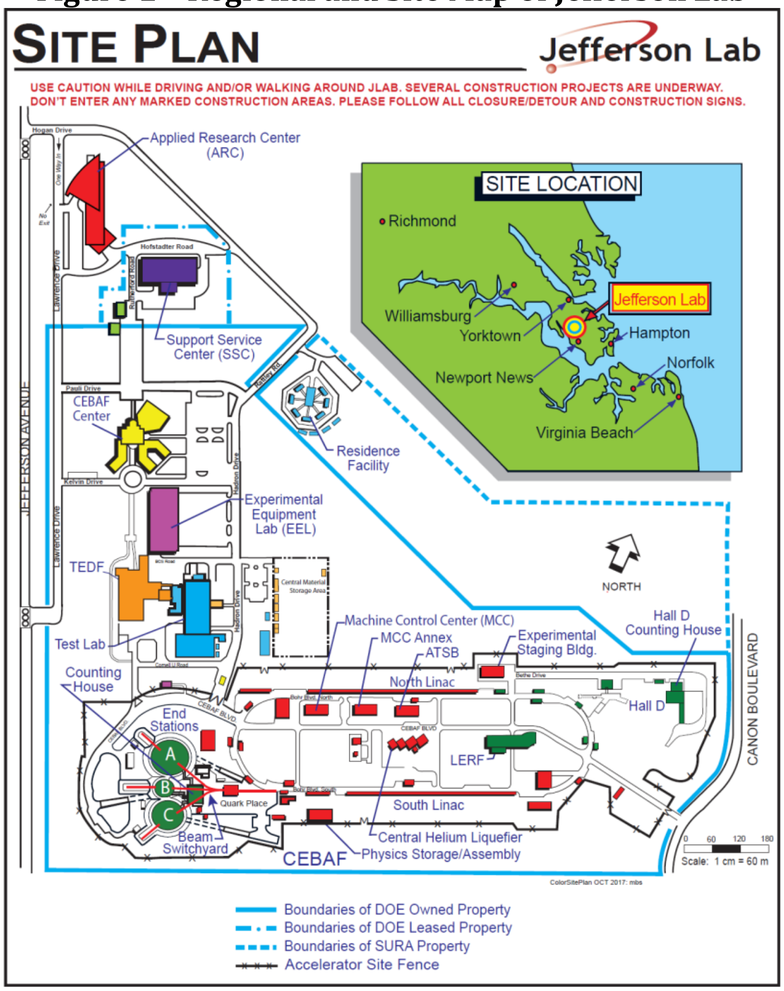
In 2018, Jefferson Lab was also recognized by the Virginia Department of Environmental Quality (DEQ) as an Exemplary Environmental Enterprise (E3) facility within the Virginia Environmental Excellence Program (VEEP). The VEEP consists of three levels: E2 – Environmental Enterprise; E3 – Exemplary Environmental Enterprise; and E4 – Extraordinary Environmental Enterprise. The E3 level is for facilities with fully-implemented Environmental Management Systems (EMS), pollution prevention programs and demonstrated environmental performance.

2.0 INTRODUCTION

2.1 SITE LOCATION

Jefferson Lab is located in the Oyster Point Business Park within the City of Newport News, Virginia. *Figure 1 – Regional and Site Map of Jefferson Lab*, depicts the facility's location and buildings.

Figure 1 – Regional and Site Map of Jefferson Lab



2.2 SITE HISTORY

Prior to the construction of Jefferson Lab, there were several users of 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 Jefferson Lab. 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 also transferred to the DOE from other sources. The total DOE-owned parcel, upon which Jefferson Lab is built, is 169 acres.

2.3 ENVIRONMENTAL SETTING

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

Environmental Assessments (EAs) conducted at Jefferson Lab include:

- 1987 EA that yielded a "Finding of No Significant Impact (FONSI)" associated with the initial construction of the CEBAF;
- 1997 EA for the CEBAF upgrade (FONSI);
- 2002 EA for the LERF (formerly known as the FEL, or Free Electron Laser) upgrade/five building construction projects (FONSI), and
- 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 there was no need to prepare Environmental Impact Statements.

2.4 SITE MISSION

Jefferson Lab, U.S. Department of Energy nuclear physics research facility, provides world-class, unique research capabilities and innovative technologies to serve an international scientific user community.

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

2.4.1 PRIMARY OPERATIONS AND ACTIVITIES AT THE SITE:

Continuous Electron Beam Accelerator Facility (CEBAF)

- The CEBAF accelerator provides continuous wave electron beams with energies of 0.5 to 12 GeV. Throughout 2018, the machine conducted beam operations up to 12 GeV power.

End Stations

- The Experimental Hall End Stations have 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 both electron- and photon-induced reactions with forward-focused reaction products at increased luminosities.
  - **Hall C** contains two spectrometers, the High Momentum Spectrometer, the Super High Momentum Spectrometer, which enables 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.

Institute for Superconducting Radio Frequency (SRF) Science and Technology

- Jefferson Lab's primary research and development facility provides continuous improvement efforts for the CEBAF and the LERF. Work includes:
  - Support of the operation, improvement and upgrade of the CEBAF.
  - Exploration of techniques for producing improved-performance SRF systems.

Center for Advanced Studies of Accelerators (CASA)

- 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, to facilitate and improve the results generated through the work performed at Jefferson Lab. A secondary goal for the organization is to archive information generated by Jefferson Lab's activities and make it available to guide future projects.

Low Energy Recirculator Facility (LERF)

- Designed and built with Jefferson Lab'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. Currently, the lab is using the term Low Energy Recirculator Facility, or LERF, to refer to this facility. The LERF generates energy from electrons and then recovers the energy using a superconducting energy-recovering linac (ERL). Within the ERL, an electron beam is recycled back through the accelerator out of phase with the accelerating field, allowing the beam energy generated in its first trip through the accelerator is returned to the SRF cavities.

Upgraded Injector Test Facility (UITF)

- The UITF is a small scale electron beam accelerator which is designed to support physics experiments and improve on the design of the CEBAF electron beam injector. Planning for commissioning and operation of this accelerator is planned for 2020.

2.4.2 RELEVANT DEMOGRAPHIC INFORMATION

Jefferson Lab is a world-class research institution. It attracts both resident and visiting physicists, and other scientists from around the world. In 2018, approximately 689 full-time physicists, engineers, technicians, and support staff worked at Jefferson Lab and more than 1,630 academic and industrial researchers, from across the United States

and approximately 39 countries and 278 institutions, participated in scientific collaborations.

Each year, research conducted at Jefferson Lab produces more than one-third of all Nuclear Physics PhDs awarded in the United States. Research at Jefferson Lab in 2018 produced seven patents.

3.0 COMPLIANCE SUMMARY

The following sections summarize Jefferson Lab's 2018 compliance status related to local, state, Federal, and DOE requirements.

3.1 ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT

Waste streams at Jefferson Lab include Resource Conservation and Recovery Act (RCRA) hazardous waste, non-hazardous solid waste, universal waste, used oil, non-RCRA low-level radioactive waste (LLW), and medical wastes. In 2018, Jefferson Lab 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.

3.1.1 EMERGENCY PLANNING & COMMUNITY RIGHT TO KNOW ACT (EPCRA)

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

Jefferson Lab meets applicable reporting requirements, such as toxic chemical usage and environmental releases, as required. See *Figure 2 – Status of EPCRA Reporting in 2018*.

Figure 2 – Status of EPCRA Reporting in 2018

EPCRA Section	Description of Reporting	Status
EPCRA § 302-303	Planning Notification	Completed
EPCRA § 304	EHS Release Notification	Not Required
EPCRA § 311-312	Material Safety Data Sheets/Chemical Inventory	Completed
EPCRA § 313	Toxic Release Inventory Reporting	Not Required

3.1.2 RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

RCRA promotes the protection of health, the environment, and conservation of valuable material and energy resources. As a "Small Quantity Generator (SQG)," Jefferson Lab generates less than 1000 kilograms (kg) of hazardous waste per month (but more than 100 kg). In 2018, approximately 3,311.73 kg of RCRA hazardous waste was generated. Jefferson Lab does not store (outside of SQG allowed quantities/time limits), treat, transport, or dispose of RCRA-regulated waste on site. All RCRA wastes are disposed through licensed waste-handling transport and disposal facilities.

The two largest-volume hazardous wastes generated in 2018 were acid mixtures, used for cavity and component processing; and liquid scale dissolver, used for the cleaning of copper surfaces.

3.1.3 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 Jefferson Lab.

In order to minimize the chances of herbicides and pesticides washing into local stormwater channels, Jefferson Lab 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 Jefferson Lab property; and only small amounts are allowed to be mixed on site.

3.1.4 NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)

NEPA requires that Federal agencies evaluate projects for the potential to have significant environmental impacts. All projects occurring at Jefferson Lab are evaluated through the preparation of Environmental Assessments (EAs) or managed according to Categorical Exclusions, and no Environmental Impact Statement was necessary. No activities requiring new NEPA evaluations took place in 2018.

3.1.5 OTHER WASTES

Other wastes generated at Jefferson Lab include wastewater discharges to sanitary sewer, non-hazardous solid waste, radioactive waste, and medical waste. The vast majority of this waste is non-hazardous solid, consisting of routine office trash and construction debris. Jefferson Lab has an extensive recycling program that resulted in the recycling of 75% of the solid waste generated on site (339.1 tons of material) in 2018. Jefferson Lab also recycled close to 100% of its used oil and excessed computer equipment.

LLW is generated and managed in accordance with DOE Order 435.1 – Radioactive Waste Management. In 2018, approximately 15.7 tons (33 yd^3) of LLW was shipped offsite for disposal. Most of this waste was consolidated into a single intermodal container (25 yd^3). A very small amount (approximately 35 pounds) of mixed LLW, in the form of lead-acid batteries, was also transferred for treatment and disposal.

Only a minor amount of medical waste was generated by Jefferson Lab's on-site clinic in 2018. Its disposal was in accordance with all applicable regulations.

3.2 RADIATION PROTECTION

All Jefferson Lab activities in 2018 were in full compliance with applicable limits for radiation protection. See Section 5.0 – Environmental Radiological Protection Program and Dose Assessment below.

3.3 AIR QUALITY AND PROTECTION

Jefferson Lab currently has no process, or associated air emissions that exceed the threshold levels that require air permitting in the State of Virginia. Internal calculations are routinely conducted to confirm this status. All emissions remained well below reportable thresholds in 2018. The City of Newport News also remained within Environmental Protection Agency (EPA) and state designated pollutant limits since 2008.

3.3.1 STRATOSPHERIC OZONE-DEPLETING SUBSTANCES (ODS)

Jefferson Lab 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, Jefferson Lab utilizes 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 onsite is submitted annually to the DOE (beginning in 2018).

3.3.2 GREENHOUSE GAS (GHG) EMISSIONS

During 2018, Jefferson Lab and DOE continued to assess GHG emissions. Efforts to understand these various emissions allowed for the development of ways to minimize them. See "Department of Energy Executive Orders" section below.

3.4 WATER QUALITY AND PROTECTION

Jefferson Lab 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 utilized to maintain groundwater quality during operations. Discharges to surface water are permitted under Jefferson Lab's Department of Environmental Quality (DEQ) Virginia Pollutant Discharge Elimination System (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 Jefferson Lab's environmental monitoring program.

Groundwater monitoring wells are sampled routinely under VPDES Permit VA0089320 to ensure that site operations do not degrade groundwater quality.

All stormwater discharges are managed through structural and non-structural Best Management Practices (BMPs) in compliance with Jefferson Lab's Municipal Separate Storm Sewer System (MS4) permit and the 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 Department of Environmental Quality in the areas of Stormwater Management and Erosion & Sediment Control in order to properly conduct plan reviews (Stormwater Pollution Prevention Plans and Erosion & Sediment Control Plans) and site inspections of all regulated land disturbances. During 2015, Jefferson Lab received initial approval from the DEQ 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 Virginia Stormwater Management Program (VSMP) set forth on July 1, 2014.

Jefferson Lab held four active water permits in 2018 (see *Figure 3 – Jefferson Lab's Active Water Permits*). No regulatory limits were exceeded and all water quality programs were in compliance.

Figure 3 – Jefferson Lab's Active Water Permits

PERMIT TYPE	# OF OUTFALLS	PARAMETER	# OF PERMIT EXCEEDANCES	# OF SAMPLES TAKEN	# OF COMPLIANT SAMPLES	PERCENT COMPLIANCE
Industrial Wastewater Discharge to Surface and Groundwater Quality (VPDES Permit VA0089320)	2 Outfalls (001 and 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 GW0047200)	1	Volume of dewatering	0	12	12	100

*Jefferson Lab's VPDES permit includes two outfalls and the collection and reporting of radionuclide monitoring data from 16 groundwater monitoring wells located throughout the site.
**The MS4 program requires Jefferson Lab to implement a wide variety of BMPs to prevent contamination from entering the stormwater system and leaving the site. No sampling, analysis, and reporting of chemical constituents are currently required.
***Jefferson Lab applied for renewal of the existing MS4 permit during 2018.

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

During 2015, Jefferson Lab conducted a conformance assessment of the current 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.

3.4.2 FUTURE STRATEGIES FOR EISA SECTION 438 CONFORMANCE

In December of 2009, the EPA released the "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 SqFt, is 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 assure 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 a development site, 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 Jefferson Lab in 2015, it was determined that applicable projects occurring at Jefferson Lab 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 located on 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.

3.5 DEPARTMENT OF ENERGY EXECUTIVE ORDERS

3.5.1 DOE ORDER 436.1 DEPARTMENTAL SUSTAINABILITY

The purpose of DOE Order 436.1 is to "….Provide requirements and responsibilities for managing sustainability within the DOE to 1) ensure the [DOE] carries out its missions in a sustainable manner that addresses national energy security and global environmental challenges, and advances sustainable, efficient and reliable energy for the future, 2) institute wholesale cultural change to factor sustainability and GHG reductions into all DOE corporate management decisions, and 3) ensure DOE achieves the sustainability goals established in its Strategic Sustainability Performance Plan pursuant to applicable laws, regulations and Executive Orders, related performance scorecards, and sustainability initiatives."

Jefferson Lab satisfies this Order's requirements through the implementation of its EMS (see Section 4 – Environmental Management System below) and Site Sustainability Plan, summarized in *Figure 4 – Jefferson Lab's Sustainability Goal Performance*.

In 2018, Jefferson Lab updated its Site Sustainability Plan. This plan addressed each specific goal in the DOE O 436.1, assessed performance status, and established planned actions and schedules for meeting them. *Figure 4 – Jefferson Lab's Sustainability Goal Performance* summarizes major 2018 activities associated with the plan.

Figure 4 – Jefferson Lab's Sustainability Goal Performance

SSPP Goal #	DOE Goal	Performance Status	Plans and Projected Performance
GOAL 1: Greenhouse Gas Inventory			
1.1	50% Scope 1 and 2 (Green House Gas (GHG) emissions reductions by FY 2025 from a FY 2008 baseline.	Scope 1 & 2 GHG levels decreased (41.1 %) compared to the FY '08 baseline as new HEMSF (High Energy Mission Specific Facility) accelerator and related operations continued to increase in FY '18.	Scope 1 maintain successful fugitive emission reduction practices Scope 2 requires multiple lower GHG content electric supply strategies, and increase of Renewable Energy Credit (REC) purchases to maintain interim goals.
1.2	25% Scope 3 GHG emissions reduction by FY 2025 from a FY 2008 baseline.	Scope 3 GHG decrease (25%) vs. FY '08 primarily from reduced T & D (Transmission & Distribution) losses and increased REC purchases.	Implement commuting emissions reduction program (alternative work schedule) to reduce controllable Scope 3 GHG emissions.
GOAL 2: Facilities			
2.1	25% energy intensity (Btu per gross square foot) reduction in goal-subject buildings by FY 2025 from a FY 2015 baseline.	FY '18 energy intensity decreased 19% vs Interim Target (FY 2018) of -7.5%.	Further reductions in BTUs/SF will occur as identified energy conservation measure (ECM) projects and building renovations are implemented which will enable Jefferson Lab to achieve the 25% EUI reduction goal by FY25. Project include: interior/exterior LED lighting upgrades; advanced lighting controls; and chilled water distribution efficiency improvements.
2.2	"Renewable Electric Energy" requires that renewable electric energy account for not less than 30% of a total agency electric consumption by FY 2025 and each year thereafter.	FY '18 renewable electricity current performance of 21% vs Interim Target (FY 2018) of 15%.	Jefferson Lab has achieved interim goals in this category and plans to continue similar strategies.

SSPP Goal #	DOE Goal	Performance Status	Plans and Projected Performance
2.3	"Clean Energy" requires that the percentage of an agency's total electric and thermal energy accounted for by renewable and alternative energy shall be not less than 25% by FY 2025 and each year thereafter.	FY '18 Clean Energy current performance of 15% vs Interim Target (FY 2018) of 13%.	Jefferson Lab has achieved interim goals in this category and plans to continue similar practices to achieve results that meet or exceed requirements of this goal category.
2.4	36% potable water intensity (gal per gross square foot) reduction by FY 2025 from a FY2007 baseline.	Approximately 58 million gallons of potable water (83% of Jefferson Lab's total potable water consumption in FY 18) was required for evaporative cooling of High Energy Mission Specific Facilities (HEMSF). FY 18 potable water intensity increased by approximately 16% from the FY07 baseline, due primarily to increased overall accelerator operations. Multiple water reduction and alternative water source strategies (including rainwater harvesting) have been evaluated during the past several years. Unfortunately, the majority of identified strategies which would result in a significant water intensity reduction are not yet economically feasible. Consequently, achievement of the water intensity goal remains the most significant challenge for Jefferson Lab.	One identified water reduction strategy has been designed and is expected to be awarded and completed in FY 19. The project uses Ultra-Pure Water (UPW) which is currently discharged from the Test Lab facility to sanitary sewer and diverts this to a nearby cooling tower for use as a make-up water supply source. Estimated annual potable water reduction from this project is approximately 5 million gallons of annual consumption. As potable water consumption from evaporative cooling is anticipated to increase significantly in future years as the scientific mission increases, additional sources of alternative water supply will be required to achieve a 36% reduction in water intensity compared to the FY07 baseline level. A potential source of alternative (non-potable) water involves a rainwater harvesting project in the City of Newport News, VA (estimated to provide 40+ million gallons which would achieve FY25 goal).

SSPP Goal #	DOE Goal	Performance Status	Plans and Projected Performance
2.5	30% water consumption (Gal) reduction of industrial, landscaping, and agricultural (ILA) water by FY 2025 from a FY 2010 baseline.	FY '18 water consumption reduction current performance of -12.7% vs Interim Target (FY 2018) of -16%.	Continue strategies from previous years to minimize consumption of ILA water.
2.6	Ensure 17% (by building count or gross square feet) of existing buildings greater than 5K (GSF) to be compliant with the *revised* Guiding Principles for HPSB by FY 2025, with progress to 100% thereafter.	Current HPSB compliance with HPSB principles (24.9% of GSF) exceeds the HPSB 2025 compliance goal (17% of GSF).	Future new construction projects (Test Lab High Bay Annex) and major renovation/addition projects (Building 89, CEBAF Center, and Experimental Equipment Lab) will be designed to achieve compliance with HPSB Guiding Principles.
GOAL 3: Fleet Management			
3.1	30% reduction in fleet-wide per-mile GHG emissions reduction by FY 2025 from a FY 2014 baseline.	FY '18 Fleet Greenhouse Gas Emission/Mile current performance of 13% vs Interim Target (FY 2018) of -16%.	Continue strategies implemented for previous several years to minimize petroleum consumption and increase low GHG emission alternative fuel vehicle use.
3.2	20% reduction in fleet petroleum use by FY 2015 and thereafter relative to FY 2005 baseline; Interim target (FY 2017): 20% reduction.	Fleet petroleum use reduction current performance of -57% vs Interim Target (FY 2018) of -20%.	Continue strategies from previous several years to minimize petroleum consumption and increase low GHG emissions alternative fuel vehicle use.
3.3	10% increase in annual alternative fuel consumption by FY 2015 relative to a FY 2005 baseline; 2017 target: 10%.	Fleet annual alternative fuel consumption increased to 1,576 gallons in FY '18, approximately ***<u>47%</u>*** above the FY 2005 baseline.	Jefferson Lab has exceeded the FY 2015 goal, and will maintain a 10% annual target increase.

SSPP Goal #	DOE Goal	Performance Status	Plans and Projected Performance
GOAL 4: Waste Management			
4.1	Divert at least 50% of non-hazardous solid waste (excluding construction and demolition debris); Interim target (FY 2018): 50%.	Annual non-hazardous solid waste diverted from landfill / recycled = ***58%***.	Continue current best practices that contribute to exceeding the 50% goal.
4.2	Divert at least 50% of construction and demolition materials and debris; Interim target (FY 2018): 50%.	Annual construction materials diverted from landfill / recycled = ***91%***.	Continue current best practices that contribute to exceeding the 50% goal.
GOAL 5: Electronic Stewardship			
5.1	100% of eligible electronics procurements must be environmentally sustainable (EPEAT). Interim target (FY 2018): 95%.	***91%*** of eligible products purchased in FY '18 were compliant with EPEAT (bronze, silver or gold) registration.	Continue EPEAT product registered procurement at levels exceeding the 95% target.
5.2	Dispose of 100% of electronics through government programs and certified recyclers. Interim target (FY 2018): 100%.	Current performance: 100%.	Continue environmentally sound disposal/recycle practices for ***100%*** of used electronics systems.
5.3	Implement and actively use Power management features on 100% of eligible computers (PCs & laptops) and monitors. Interim Target (FY 2018): 100%.	93% of power management Eligible IT devices were power management enabled.	Continue efforts to reach 100 of power management for all eligible equipment.
5.4	Implement and actively use duplex printing features of 100% of eligible printers. Interim target (FY 2018): 100%.	Automatic duplexing (double sided printing) is set on 97% of computers by default.	Maintain automatic duplexing policy and continue efforts to reach 100%.
GOAL 6: Sustainable Acquisition			
6.1	Ensure 95% of new contract actions for products and services meet sustainable acquisition requirements. Interim target (FY 2018): 95%.	The performance of the site for this category is consistent with prior year.	Jefferson Lab has achieved interim goals in this category and plans to continue similar practices to achieve results that meet or exceed requirements of this goal category.
GOAL 7: Measures, Funding, & Training			
7.1	Annual targets for performance contracting to be implemented in FY 2017 and annually thereafter as part of the planning of section 14 of E.O. 13693.	The performance of the site for this category is consistent with prior year.	Jefferson Lab has achieved interim goals in this category and plans to continue similar practices to achieve results that meet or exceed requirements of this goal category.

SSPP Goal #	DOE Goal	Performance Status	Plans and Projected Performance
GOAL 8: Organizational Resilience			
8.1	Discuss overall integration of climate resilience in emergency response, workforce, and operations procedures and protocols.	The performance of the site for this category is consistent with prior year.	Jefferson Lab has achieved interim goals in this category and plans to continue similar practices to achieve results that meet or exceed requirements of this goal category.

3.5.2 REDUCTIONS IN THE GENERATION AND/OR TOXICITY OF HAZARDOUS WASTE THROUGH POLLUTION PREVENTION

In 2018 Jefferson Lab completed significant upgrades to utility infrastructure through the Utility Infrastructure Modernization (UIM) project. The planning of these activities incorporated waste minimization and pollution prevention evaluations. Opportunities to reduce waste generation were identified and implemented across the lab, notable activities include:

- Donating materials and supplies to local schools.
- Recycling over 167 tons of scrap metals.
- Re-use of on-site concrete construction debris.
- Re-utilizing equipment that was excessed from completed projects.

3.5.3 REDUCTION OR ELIMINATION OF ACQUISITION OF TOXIC AND HAZARDOUS CHEMICALS AND MATERIALS

Purchase requests for hazardous materials are approved by Jefferson Lab's ESH&Q staff to ensure that the most environmentally preferable products are acquired and used.

3.5.4 ENVIRONMENTALLY PREFERABLE PURCHASING

Jefferson Lab promotes the purchasing of DOE-Priority Products through the Greenbuy Program and provides ready access to recycled content/remanufactured products. Facilities Management and Logistics explores opportunities to find vendors that recycle items no longer needed for operations.

3.5.5 ELECTRONIC STEWARDSHIP

Jefferson Lab utilizes the EPA's Electronic Product Environmental Assessment Tool (EPEAT) when selecting energy efficient desktop/laptop computers and computer monitors, photocopies, televisions, printers, fax machines, tablets and scanners. The laboratory 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. Each star is awarded to an organization for each category in which eligibility requirements are met. During 2018, Jefferson Lab was a Four-Star Award Winner for the following categories:

- Personal computers and displays;
- Imaging equipment;
- Televisions;
- Mobile Phones.

3.5.6 RECYCLING PRACTICES

Recycling is standard practice for Jefferson Lab. Recycling containers are featured in every office, conference, and break room. Jefferson Lab staff, users, and subcontractors also utilize lab-wide office product recycling centers. These collect: aluminum cans, small batteries, cardboard, printer cartridges, paper wastes, telephone books, and plastic and glass bottles.

In 2018, with construction debris, scrap metal, and automatic data processing equipment included, approximately 255.9 tons of material was recycled. The overall percentage of material diverted from landfills in 2018 was 75%.

3.6 OTHER ENVIRONMENTAL STATUTES

3.6.1 OIL POLLUTION CONTROL

A five year review of Jefferson Lab's Spill Prevention, Control, and Countermeasure (SPCC) Plan occurred during 2016. 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 the spilled material. To ensure proper handling and spill response, all staff, working with oil, receives annual SPCC training. On-site oil inventory comprises numerous oil-containing transformers, generators, compressors, above-ground storage tanks, and mechanical equipment. Jefferson Lab's estimated volume of oil is approximately 51,000 gallons; this includes utility-owned electrical equipment. During 2016, Jefferson Lab implemented an SPCC inventory spreadsheet to allow for management of 'real-time' inventory when new oil-containing equipment is brought onsite. Adherence to the SPCC plan continued in 2018.

3.7 UNPLANNED RELEASES

During 2018, Jefferson Lab 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 in order to identify potential contaminant sources along with providing strategies for pollution prevention during activities. Oil worker training and chemical safety training was also provided to applicable staff in order to update knowledge of spill prevention and the control of releases that may occur onsite. Jefferson Lab ES&H continued to document all spills and releases onsite in the effort to identify any potential trends that could lead to potential improvements in spill prevention measures.

The following list summarizes the unplanned releases that occurred onsite during 2018:

January 7, 2018

JSA staff responded to a hydraulic fluid release being discharged from a subcontracting vendor delivery truck located adjacent to the southwestern side of the Central Helium Liquifier (CHL) building, in the south-central portion of the facility. JSA staff immediately responded to the spill by utilizing materials from a spill kit stored on the delivery truck. All materials discharged from the release were contained to the immediate area and did not migrate offsite.

February 24, 2018

JSA staff responded to a second hydraulic fluid release discharged from a subcontracting vendor delivery truck located adjacent to the southwestern side of the CHL building. JSA staff and delivery truck driver teamed up to immediately respond to the spill by utilizing absorbent materials from the truck driver's spill response kit located on the delivery truck. All materials released were contained to the immediate areas adjacent to the point of release and did not migrate offsite.

March 30, 2018

JSA staff responded to small leak from drum temporarily placed adjacent to the Building 92 cooling tower basin. The material was refrigerant oil being stored within a 55-gallon drum that was placed onto a spill pallet. Although the drum was placed on secondary containment, it was directly exposed to stormwater and the bung cap was not securely tightened, allowing for a small release of oil to the pallet and ground surface (spill pallet had filled up with rainwater and therefore, overflowing to the adjacent ground surface). Absorbent pads were placed on the area of the spill that migrated to the ground surface. The materials within the drum were transferred to another container and moved to the Central Material Storage Area (CMSA) for proper storage until scheduled disposal shipment. All materials discharged from the release were contained to the immediate area and did not migrate offsite.

April 16, 2018

JSA staff responded to a small fire to a golf cart that was caused by an over-heated battery located on the paved road located adjacent to the southwest corner of the Test Lab building. The fire was put out immediately with a small fire extinguisher and the foaming agent discharged by the fire extinguisher was contained to the immediate area and did not migrate offsite.

July 31, 2018

JSA staff responded to observations of a small fuel leak on the paved road surface along the central portion of Lawrence Drive (near area of CEBAF Center). Further observations indicated that the fuel leak had been from a vehicle located onsite that had just left the facility. Absorbent materials were placed on the areas of the spill and JSA staff contacted the suspected vehicle owner to alert them of the spill, with directions to have the vehicle repaired prior to returning to the site. All of the materials were contained to paved surfaces in the immediate area of the spill and did not migrate offsite.

September 7, 2018

JSA staff responded to a small hydraulic fluid leak that appeared to be discharged from a vendor delivery truck that had entered the facility. Absorbent materials were placed on the areas of the spill and all discharged fluid was contained to paved surfaces. JSA contacted the delivery driver to inform them of the release and to have the truck repaired prior to bringing it back to the facility. All materials discharged from the release were contained to the immediate area and did not migrate offsite.

Environmental education and outreach on illicit discharges to sanitary sewer and stormwater conveyances appeared to be effective in 2018 due to increased spill response efficiency, increases in preventive measures, decrease in the amount of spills that occurred onsite and overall improvements in awareness of the consequences of illicit discharges that could occur at Jefferson Lab.

3.8 SUMMARY OF PERMITS

Jefferson Lab held four active environmental permits in 2018:

Figure 5 – Environmental Permits in 2018

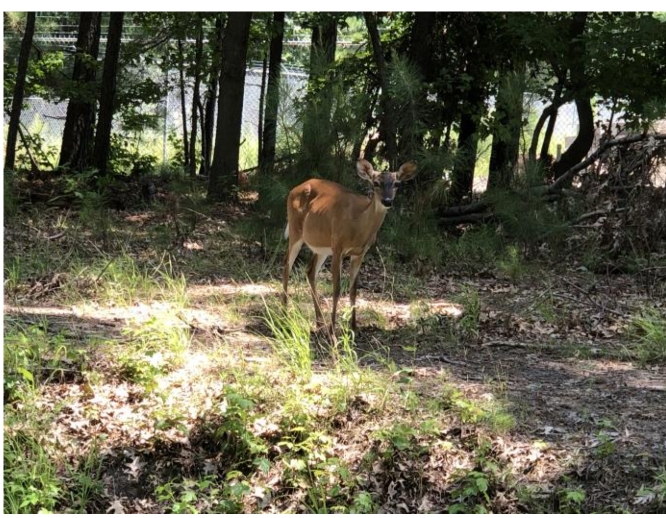
Permit Number	Permit Type
GW0047201	Groundwater withdrawal
VA0089320	Industrial Wastewater to Surface – Groundwater Quality
VAR040079	Municipal Separate Storm-Sewer System (MS4)
HRSD 0117	Industrial Wastewater to Sanitary Sewer

During 2018, Jefferson Lab received a five year extension of the existing MS4 Permit (VAR040079). There were no major changes to the permit, with the exception of new Best Management Practices implemented within the Minimum Control Measures section of the Permit.

3.9 ENVIRONMENTAL OVERSIGHT

Jefferson Lab's exemplary environmental performance is due to the constant attention it receives from all parties involved in laboratory operations. The DOE Site Office, JSA, subcontractors, and various Commonwealth and local authorities provide continuous oversight of the Lab's environmental program. This includes routine inspections of construction projects, the MS4 System, effluent discharge locations for the sanitary sewer system, and waste storage.

Self-assessments, inspections, and work observations are used to measure program effectiveness.



4.0 ENVIRONMENTAL MANAGEMENT SYSTEM

Jefferson Lab's Environmental Management System (EMS) is designed to:

- Identify lab 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 Lab'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.

Jefferson Lab has invested in a multi-dimensional process to assure 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 are assembled, at least annually, to review progress, identify issues, and brainstorm possible solutions to better the system. This group reviews the previous year's EMS performance, discusses changes to lab operations, how these would affect the environment, and determines where the lab should focus its improvement activities. This analysis, reviewed by (among others) the Laboratory Director, identifies major focus areas (Objectives) as well as specific projects to support each focus area (Success Metrics).

**Figure 6 – 2018 EMS Objectives Summary below summarizes the Objectives for 2018.*

***Figure 6 – 2018 EMS Objectives Summary**

EMS Objective	Success Metric(s)	Status
OBJECTIVE 1 REMEDIATION OF ZINC CONTAMINATION IN COUNTING HOUSE SUMP TO PREVENT UNAUTHORIZED DISCHARGE TO HRSD	Contamination media within sump is successfully extracted; follow-up sampling results in contaminant levels below regulatory threshold	Complete
OBJECTIVE 2 TRACKING (THROUGH MAXIMO INTERNAL SYSTEM) OF STORMWATER MANAGEMENT (SWM) AND EROSION & SEDIMENT CONTROL (ESC) ISSUES IDENTIFIED ONSITE THAT REQUIRE MAINTENANCE OR REPAIR	Tracking system is developed in Maximo; SWM/ESC issues are repaired	Complete
OBJECTIVE 3 REPAIR OF ACID CHILLED WATER SYSTEM IN TEST LAB TO REDUCE OCCURRENCE OF GLYCOL RELEASE/DISPOSAL	New piping for acid chilled water system in Test Lab is installed and operating properly	Complete
OBJECTIVE 4 TRAINING OF ADDITIONAL STAFF MEMBERS IN SWM AND ESC TO SUPPORT JLAB PROGRAM	Additional staff members attend DEQ training courses for SWM and/or ESC	Complete

*Excerpts taken from the CY2018 Environmental Management System Objective Implementation Plan.

4.1 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 2018, Jefferson Lab's EMS received the highest score.

5.0 ENVIRONMENTAL RADIOLOGICAL PROTECTION PROGRAM AND DOSE ASSESSMENT

5.1 ENVIRONMENTAL RADIOLOGICAL MONITORING

Ionizing radiation and a variety of radioactive materials are by-products of research activities at Jefferson Lab. Any potential impacts have been significantly reduced by adhering to the philosophy of "as low as reasonably achievable" (ALARA) 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 ESH&Q Division to demonstrate compliance with regulatory limits (as required by DOE Order 458.1, "Radiation Protection of the Public and the Environment").

5.1.1 RADIATION IN THE ENVIRONMENT

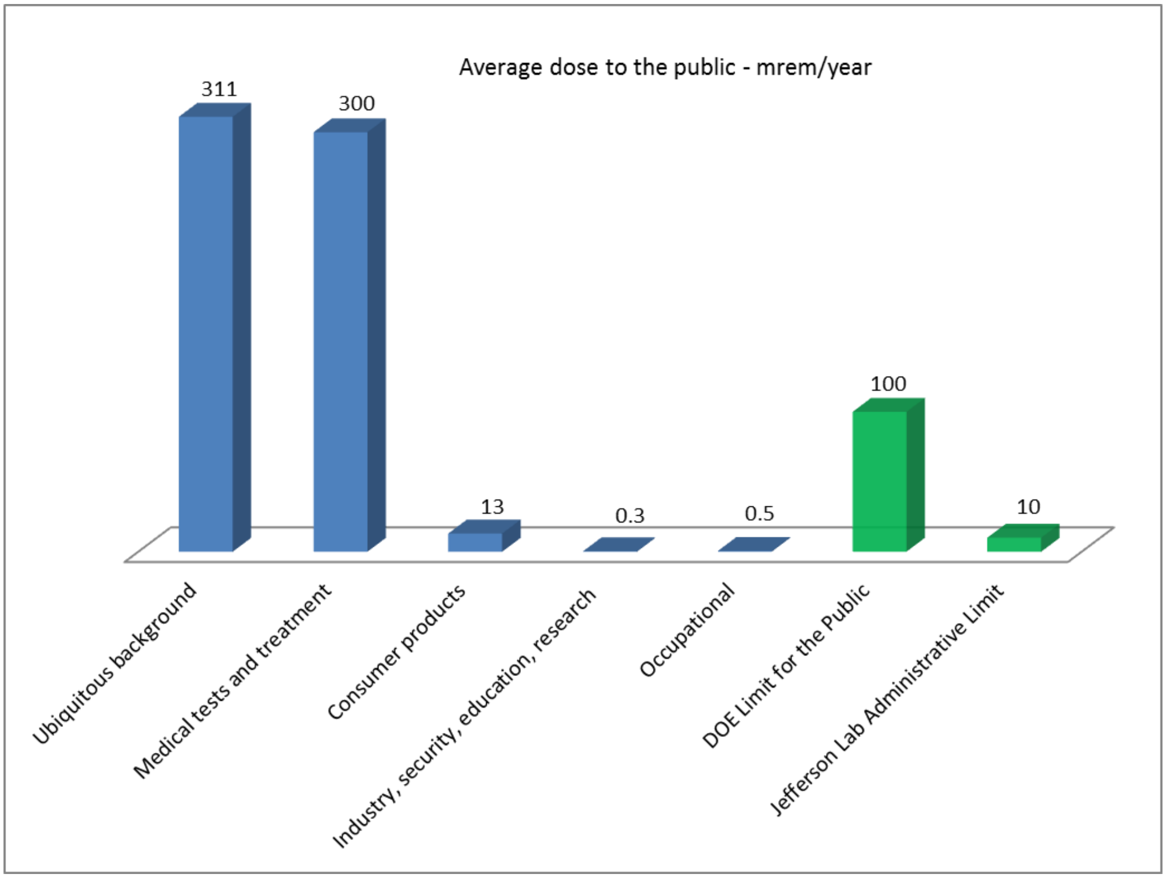
People are exposed to radiation constantly:

- Cosmic radiation from extraterrestrial sources;
- Terrestrial radiation from naturally-occurring elements in the earth's crust; and
- Man-made 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 7 – 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 1980's. The increase can be attributed to medical uses of radiation.

Figure 7 – Comparison of Sources of Radiation Exposure



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

5.1.2 RADIATION EXPOSURE PATHWAYS AT JEFFERSON LAB

Two broadly-defined sources of potential radiation exposure exist at the Lab: *direct (or "prompt") radiation* and *induced radioactivity*. Both types are produced during accelerator operations, but direct radiation has a potential impact only within close proximity to an operating accelerator on the 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.

Jefferson Lab has an extensive radiation monitoring network in and around the accelerator. There are approximately 50 active, real-time radiation monitors and a series of passive integrating detectors deployed around the accelerator site. Among these, eight monitors collected direct radiation data around the site boundary in 2018. 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 (*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 exposed to the beam or to potential sources of transferable contamination are monitored for radioactivity prior to being released from local control. Jefferson Lab adheres to the DOE release limits for surface contamination, and follows DOE guidance for ensuring that materials being released contain no detectable induced radioactivity.

Controls are in place to minimize exposure from both direct and induced radiation to lab 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 Jefferson Lab is the operation of the CEBAF accelerator. CEBAF has been increasing its operating schedule since the completion of the 12 GeV upgrade in 2014. Little or no high power operations occurred in 2014. A reasonable proxy for the overall environmental radiological impact of operating the CEBAF accelerator is the beam power delivered to experimental halls. Halls A and C receive by far the greatest fraction of beam power. The table below depicts the approximate total beam power delivered to these two halls since 2015. The impact of this beam delivery is reflected in the historical data presented in the following sections.

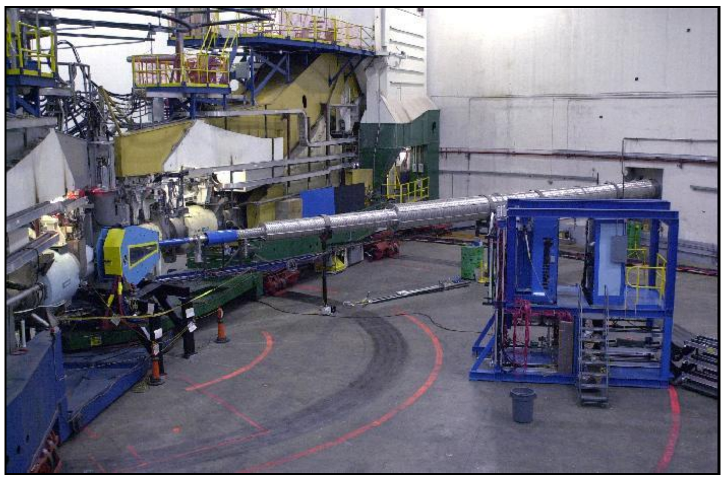
Beam Power Delivered to Halls A and C

Calendar Year	Beam Power (MW-hr)
2015	12
2016	184
2017	16
2018	1025

5.1.3 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[1]
- Beam dump and target cooling water
- Environmental samples, once analyzed
- Groundwater extracted from beneath Halls A, B, and C

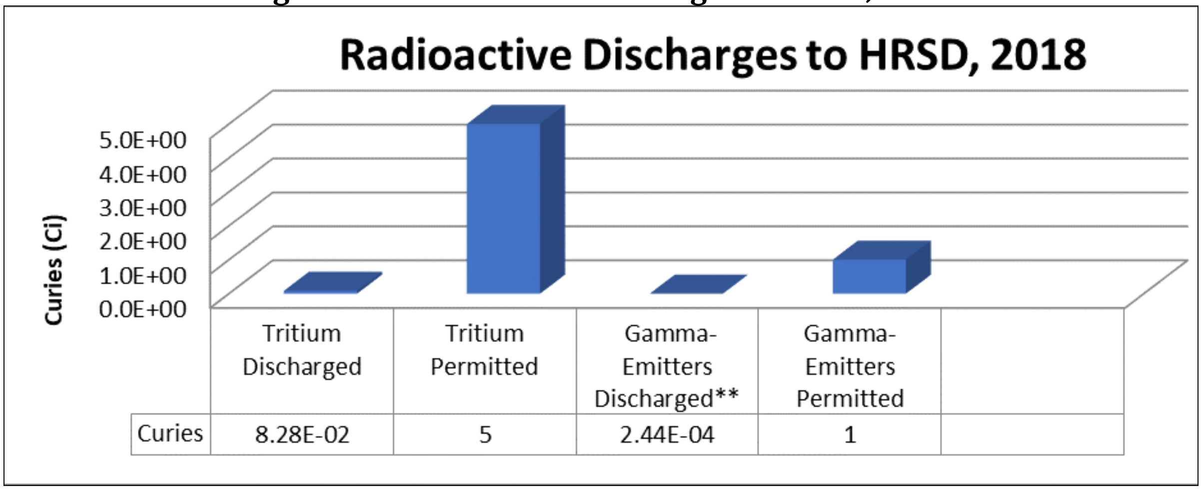


Hall A Beam Line to Beam Dump toward Right

The potential radiological constituents of Jefferson Lab's wastewater discharge to HRSD in 2018 (*see Figure 8 – Radioactive Discharges to HRSD, 2018*) totaled 0.0828 curies (Ci) of tritium (versus a limit of 5 Ci) and 0.000244 Ci of total gamma-emitters (limit = 1 Ci). These potential releases are conservative in that they are overestimates, as they use both measured levels of activity and Minimum Detectable Activity (MDA) values (e.g., detection limits) where activity cannot be measured.

[1] The floor drain system accumulates water from A/C condensate drains, spills and leaks from cooling water systems, cleaning activities, and minor in-leakage from surface/ground water.

Figure 8 – Radioactive Discharges to HRSD, 2018



**All gamma emitter activity calculated from average MDA values. Measured gamma emitter discharge was approximately 1/1000 the reported value.

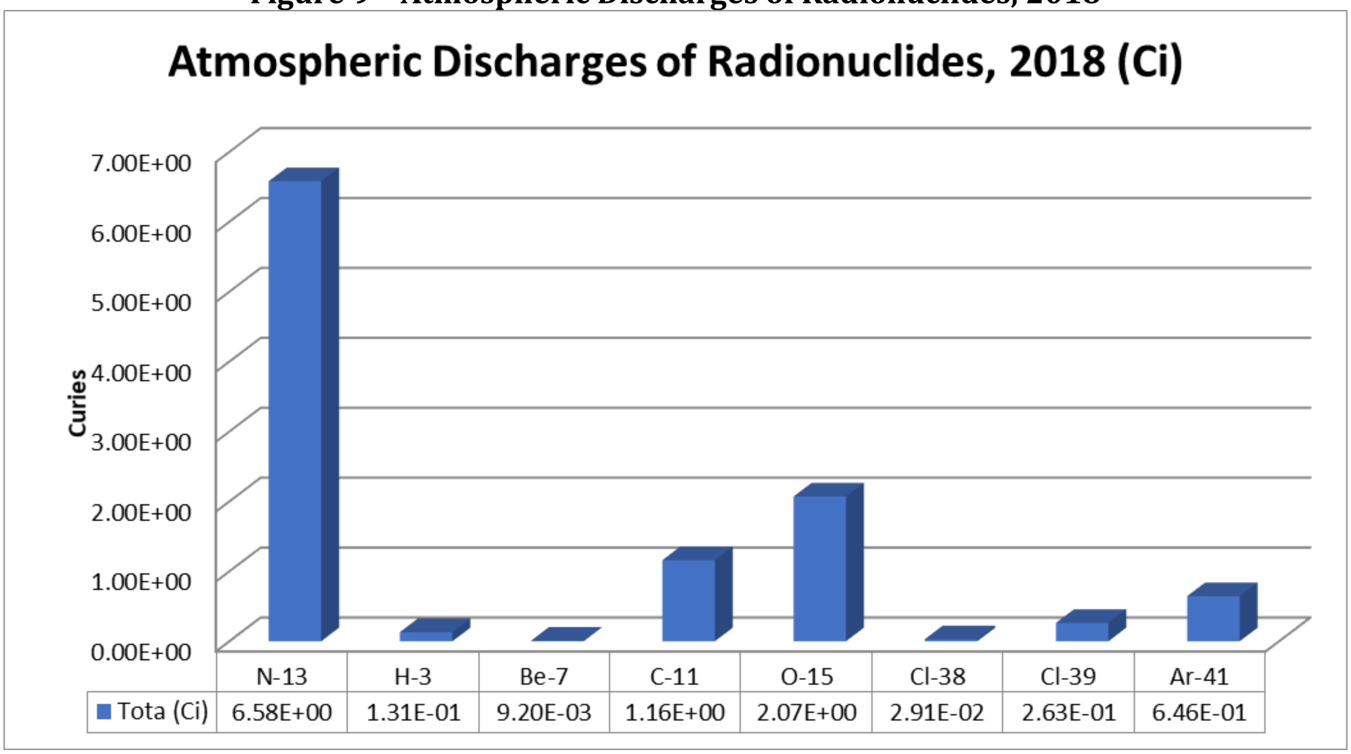
Five Year Summary of Radioactive Discharges to HRSD					
Year	Unit	Tritium Discharged	Tritium Permitted	Gamma-Emitters Discharged	Gamma-Emitters Permitted
2018	Curies	8.28E-02	5	2.44E-04	1
2017	Curies	3.27E-03	5	2.42E-04	1
2016	Curies	7.28E-04	5	1.43E-04	1
2015	Curies	5.33E-03	5	4.97E-04	1
2014	Curies	1.35E-03	5	1.57E-01	1

DOE regulates 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 principle. Average discharge concentrations in 2018 remained a small fraction of the BAT treatment threshold.

5.1.4 AIRBORNE RADIONUCLIDES

Essentially all airborne radionuclide emissions from the Lab 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 9 – Atmospheric Discharges of Radionuclides, 2018 below for a summary of estimated atmospheric releases from Jefferson Lab in 2018.

Figure 9 – Atmospheric Discharges of Radionuclides, 2018



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**
2018	Curies	6.58E+00	1.31E-01	9.20E-03	1.16E+00	2.07E-00	2.91E-02	2.63E-01	6.46E-01
2017	Curies	2.49E-01	7.51E-03	1.45E-04	3.65E-02	1.20E-01	1.24E-03	1.46E-02	8.24E-03
2016	Curies	8.51E-01	1.56E-03	1.89E-03	1.93E-01	1.87E-01	3.64E-03	4.41E-02	1.44E-01
2015	Curies	1.07E+00	1.07E-02	3.81E-04	1.39E-01	5.76E-01	5.35E-03	6.17E-02	7.88E-03
2014	Curies	1.74E+00	2.76E-03	2.21E-03	3.08E-01	6.72E-01	8.09E-03	9.53E-02	1.50E-01

Compliance with EPA regulations (40CFR61) requires Jefferson Lab to determine the potential for the 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 Jefferson Lab'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 2018 dose to the Maximum Exposed Individual (MEI) among members of the public was 0.0389 mrem/year due to airborne releases. The location of the MEI was approximately 200 meters south of the accelerator, in the Oyster Point office park. This MEI dose represents a very conservative estimate, as the population in the office park would be expected to occupy their location for only 40 hours/week. CAP-88 does not distinguish between commercial or residential (up to 24 hour/day) presence.

5.1.5 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 lab operations. Figure 11 shows the approximate locations of the Radiation Boundary Monitors (RBMs) that measure and log radiological information, along with the groundwater monitoring well network.

Figure 10 – Direct Radiation Dose at Site Boundary, 2018 displays the radiation doses in mrem at the detectors that saw the largest dose from accelerator operations in 2018. 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 any credible scenario, that dose would be a small fraction of this amount.

Figure 10 – Direct Radiation Dose at Site Boundary, 2018

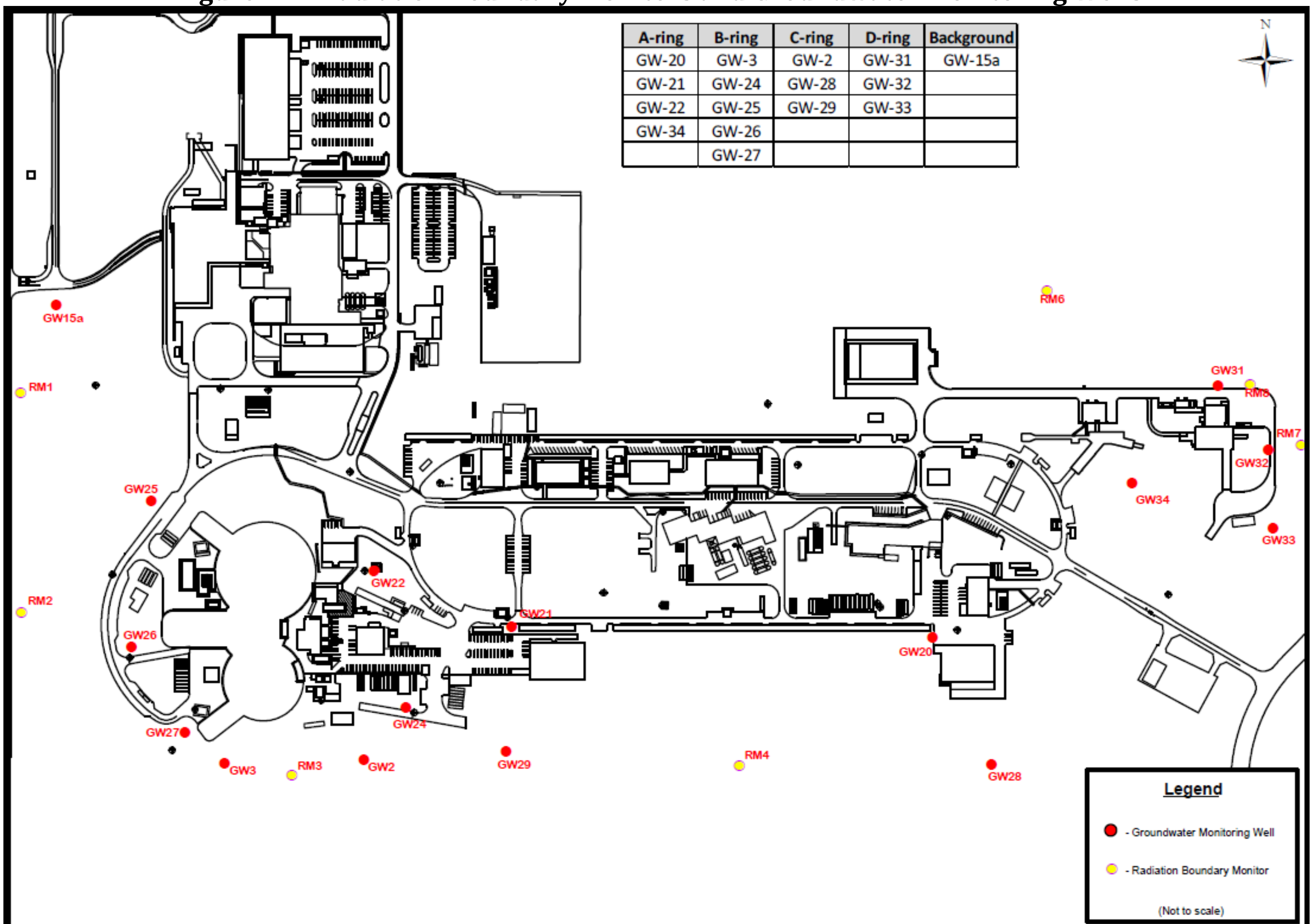
Period	Neutron (mrem)	Gamma (mrem)	Total (mrem)
Jan-June (RBM-4)	0.60	0.15	0.75
July-Dec (RBM-4)	0.50	0.13	0.63
TOTAL	1.10	0.28	1.38

Five Year Summary of Direct Radiation Dose at Site Boundary			
Period	**Neutron (mrem)**	**Gamma (mrem)**	**Total (mrem)**
Jan-June 2018 (RBM-4)	0.60	0.15	0.75
July-Dec 2018 (RBM-4)	0.50	0.13	0.63
TOTAL	1.10	0.28	1.38

Jan-June 2017 (RBM-4)	0.063	0.016	0.08
July-Dec 2017 (RBM-4)	0.008	0.002	0.01
TOTAL	0.071	0.018	0.09
Jan-June 2016 (RBM-1)	0.016	0.04	0.20
July-Dec 2016 (RBM-1)	0.34	0.07	0.41
TOTAL	0.50	0.11	0.61
Jan-June 2015 (RBM-2)	0.038	0.0095	0.0475
July-Dec 2015 (RBM-3)	0.003	0.00075	0.00375
TOTAL	0.041	0.01	0.051
Jan-June 2014 (RBM-1)	0.003	0.0008	0.004
July-Dec 2014 (RBM-2)	0.017	0.004	0.021
TOTAL	0.02	0.005	0.025

The 2018 dose is approximately 7 times less than the Lab's design goal of 10 mrem/year (one-tenth of the DOE dose limit). See Potential Dose to the Public and to Biota for estimates of potential doses to the public.

Figure 11 – Radiation Boundary Monitors and Groundwater Monitoring Wells



A-ring	B-ring	C-ring	D-ring	Background
GW-20	GW-3	GW-2	GW-31	GW-15a
GW-21	GW-24	GW-28	GW-32	
GW-22	GW-25	GW-29	GW-33	
GW-34	GW-26			
	GW-27			

5.1.6 GROUNDWATER MONITORING

The underground CEBAF and associated experimental end stations lie in the Yorktown Formation. Groundwater occurs site-wide at a depth of approximately 3 to 25 feet below ground surface.

Under VPDES Permit No.VA0089320, Jefferson Lab monitors groundwater that is pumped from around the experimental halls and is discharged through Outfall 001 to the surface. The vast majority 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 2018, sixteen of the site's 34 wells (*See Figure 11 – 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, located closest to the accelerator, are most likely to show the effects of soil and groundwater activation. B-ring wells are located further from potential sources of activation. Both A-ring and B-ring wells are sampled semi-annually. C-ring wells, positioned to represent conditions near the property boundaries, are sampled annually, along with the background well. Monitoring of Hall D wells were conducted on a semiannual basis. Hall D wells (GW31, GW-32, GW-33) were incorporated into the revision of Jefferson Lab's VPDES Permit that occurred in 2017.

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 in 2018.

5.1.7 OTHER ENVIRONMENTAL SURVEILLANCE

Jefferson Lab 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.

5.2 POTENTIAL DOSE TO THE PUBLIC

Controls are in place to minimize exposure from both direct radiation and radiation from activated materials to lab 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 are the only sources for which any plausible contribution to public dose exists. In *Figure 12 – Jefferson Lab Radiological Dose Summary for 2018* - the maximum possible dose to the public assumes a 24-hour 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 12 - Jefferson Lab Radiological Dose Summary for 2018

Pathway	Dose to Maximally Exposed Individual, mrem	% of 100 mrem/yr DOE Limit	Estimated Population Dose, person-rem
Air*	0.0389	0.0389	0.00089
Water**	~0	~0	~0
Release of materials**	≤1	≤1	~0
Direct radiation***	1.38	1.38	~0
Total, all pathways	≤2.42	≤2.42	~0
Plausible scenario †	0.0054	0.054	0.0054

*From 2018 atmospheric modeling results for National Emission Standards for Hazardous Air Pollutants (NESHAP) reporting
** See text below and in section 5.2.1
*** From Boundary Radiation Monitors, before applying realistic exposure scenario (see text)
† Total effective dose using a conservative, reasonable exposure scenario (see text)

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 reasonably conservative scenario for the MEI for this source. Given these conditions, the MEI for this exposure path would have received 0.078 mrem in 2018 from direct radiation, 0.078% 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 (2000 hours) at the location of concern. This results in a dose of 0.0089 mrem. Doses from these two sources represent the only reasonably quantifiable exposure pathways to the public from Lab operations. If we combine the dose from these two scenarios, the maximum postulated dose from

all pathways to a member of the public from Jefferson Lab operations in 2018 is approximately 0.087 mrem.

There is no public or private use of the shallow aquifer in the vicinity of Jefferson Lab; 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 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 total "potentially exposed population" reported herein is defined by DOE as those living within 80 km (50 miles) of the site. Population data from the 2010 Census uses an outer radius of 70 km. Population dose estimates in this report are based entirely on the NESHAP dose calculation. Dose beyond the site's boundary is so low it cannot be reliably measured.

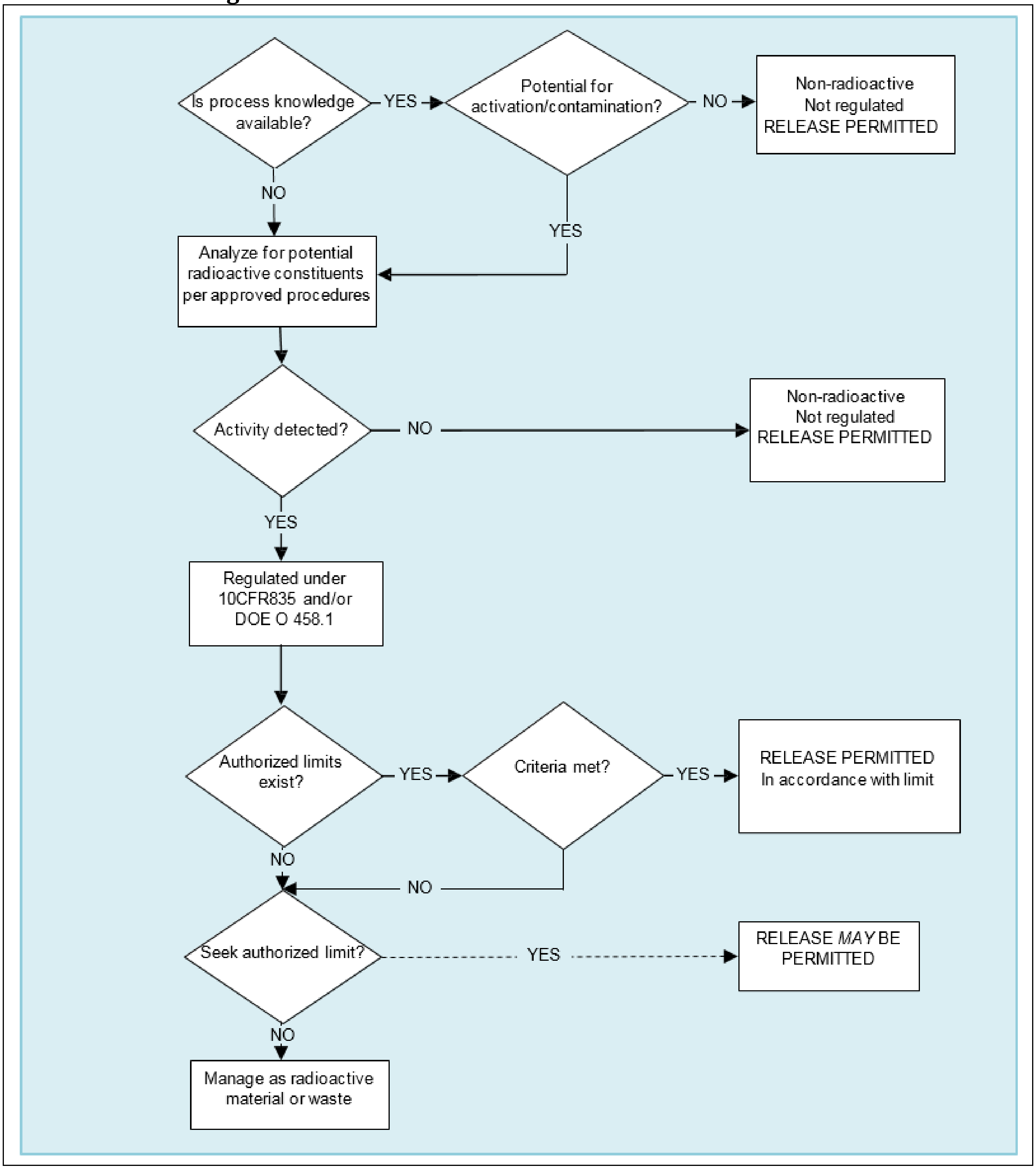
5.2.1 DOSE VIA UNRESTRICTED RELEASE OF MATERIALS AND EQUIPMENT

Jefferson Lab does not release any residual radioactive material, such as contaminated concrete or soil, so there are no resulting dose impacts to the public. The Lab 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.

Jefferson Lab 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 release of volumetrically-activated materials; therefore, the Lab has adopted methods and procedures that ensure equipment and materials being released contain no radioactivity distinguishable from background. Materials with potential for internal contamination or volumetric radioactivity that cannot be reliably assessed are treated as radioactive materials and are not released to the public.

Figure 13 – General Process for Materials Classification - summarizes Jefferson Lab's process. This process is consistent with the approach recommended upon by a multi-agency task group regarding defining impacted areas and classifications of material.

Figure 13 – 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 Jefferson Lab 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 they are subject to further analysis. Surveys and sampling and analysis are conducted by trained technicians using written procedures. Results of the surveys or other analyses are documented appropriately.

In 2018, the estimated volume of materials released through the process described above was about 8.5 tons of solid waste and an estimated 16.7 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 guidance apply a benchmark value of 1 mrem/year for determining the significance of potential dose to the public. The measurement sensitivity of the Lab'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.

Independent review of Jefferson Lab's process for releasing materials from radiological control is conducted by DOE or a designated third party. These reviews are scheduled annually; the 2018 review found no deficiencies in Jefferson Lab's program for clearance of material.

Jefferson Lab sought no Authorized Limits for the release of material containing residual radioactivity in 2018. All materials that exhibit radiation above background levels were managed as radioactive material, and either saved for beneficial reuse, or disposed. Almost all radioactive waste generated at Jefferson Lab is low-level waste (LLW). In 2018 approximately 31,400 pounds of LLW was transferred for offsite disposal. This represented the completion of radioactive waste disposal activities resulting from the CEBAF 12 GeV upgrade project, which generated significant LLW volume due to the decommissioning and removal of large components and significant quantities of concrete. There were no high level wastes or any that would be categorized as special nuclear materials. About 35 pounds of mixed LLW was transferred for disposal.

5.2.2 DOSE TO LOCAL BIOTA

Jefferson Lab 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-Standard-1153-2002 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 at various locations around the property. These are the same types of dosimeters used to monitor worker exposure. In 2018, 38 locations were monitored by this method.

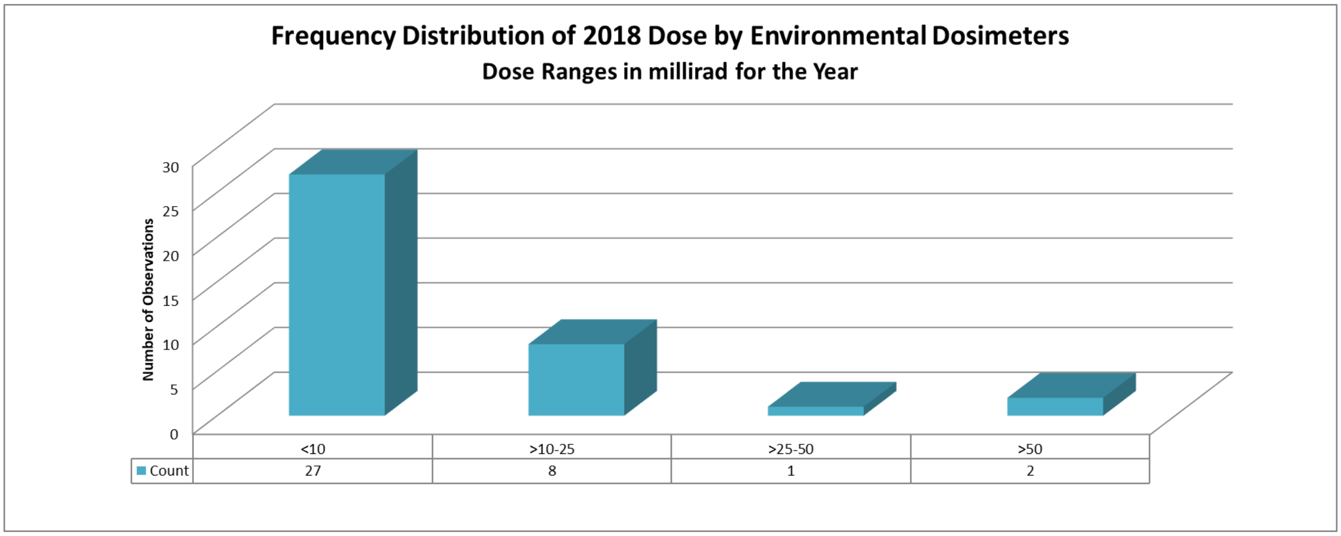
Earthen domes over Halls A, B, and C

During 2018, the site provided habitat for deer, 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 (like the groundhogs) live in an established burrow. The biota expected to receive the maximum dose would be ground-dwelling animals living in the earthen domes over the experimental halls.

Figure 14 – Distribution of 2018 Dose Reflected by Environmental Dosimeters - shows the frequency distribution of annual (2018) doses from the network of dosimeters. The maximum recorded dose was 213 mrad, measured at the southwest side of the Hall C dome. Dividing this value by 365 days yields a daily dose of 0.00058 rad/day, far below

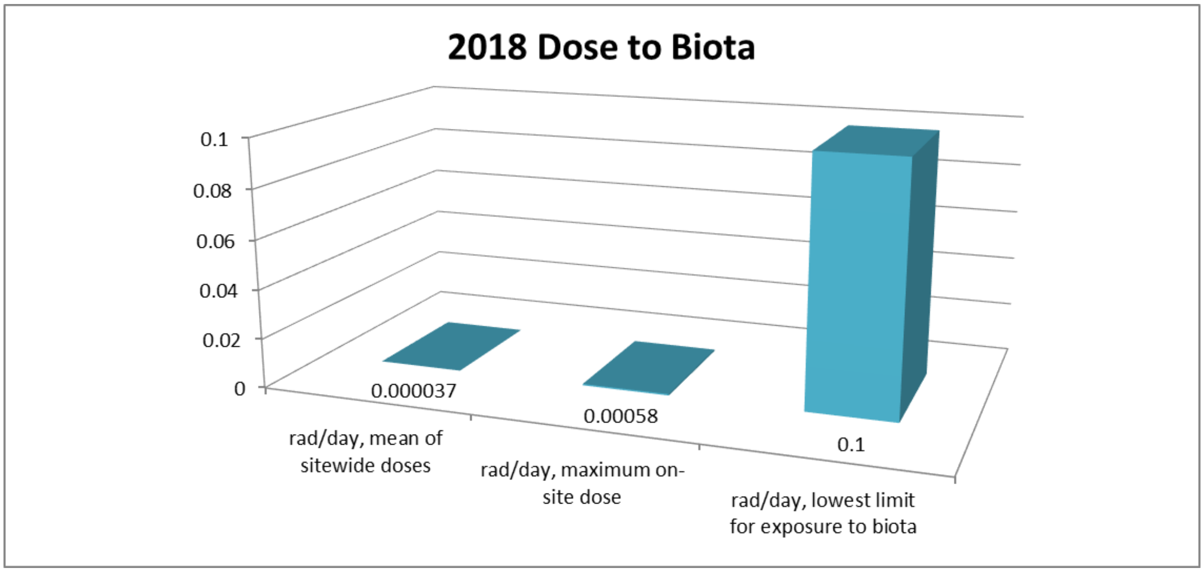
the most stringent criteria. *Figure 15 – Environmental Radiation vs. Limit* - illustrates these data.

Figure 14 –Distribution of 2018 Dose Reflected by Environmental Dosimeters



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**
2018 Count	27	8	1	2	-	-	2
2017 Count	28	8	1	1	-	-	-
2016 Count	28	8	1	1	-	-	-
2015 Count	24	6	5	1	-	-	-
2014 Count	30	13	7	-	2	0	2

Figure 15 – Environmental Radiation Dose vs. Limit



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**
2018	0.000037	0.00058	0.1
2017	0.000017	0.00019	0.1
2016	0.000065	0.002	0.1
2015	0.0000275	0.00014	0.1
2014	0.0000426	0.0004	0.1

5.3 UNPLANNED RADIOLOGICAL RELEASES

Jefferson Lab had no unplanned radiological releases in 2018.

6.0 GROUNDWATER PROTECTION PROGRAM

Figure 16 – Typical Cross Section of Boring at Jefferson Lab Site, compiled from several on-site boring logs, depicts a typical cross section. The CEBAF tunnel and experimental end stations are located underground within the Yorktown Formation. Activation of the groundwater and soil are 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 16 – Typical Cross Section of Boring at Jefferson Lab Site

Depth, ft.	*Description*
0	Loose to stiff, gray, sandy CLAY
5	Loose, orange-brown clayey fine SAND
7	Loose gray silty fine SAND
12	Loose to firm, gray fine to medium SAND
22	Very stiff, gray, shelly, sandy SILT
27	Firm, white, cemented shells
32	Firm, gray, very silty, fine SAND with shell fragments
37	Very stiff, very sandy SILT with shell fragments
40	Boring Terminated

The monitoring of VPDES-permitted wells for groundwater quality continued in 2018, 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 offsite.

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

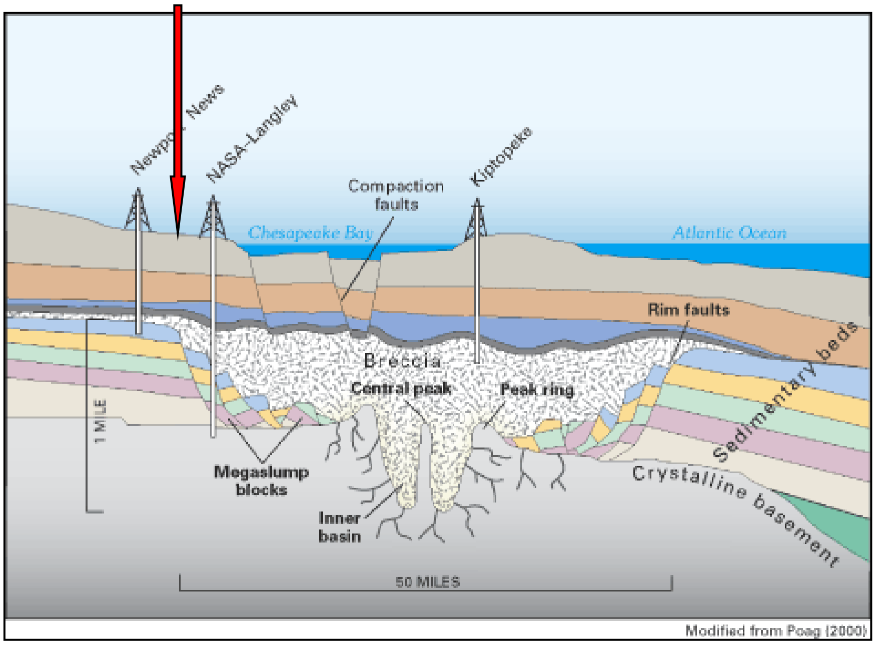
Relatively recent information places Jefferson Lab in a unique geologic position. Approximately 35 million years ago, a giant bolide[2] blasted a huge crater into the continental shelf. A bolide of this magnitude creates a complex crater with inner and outer rims.

As *Figure 17 – 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 18 – Location of Jefferson Lab Relative to the Outer Rim of the Chesapeake Bay Bolide Crater*.

Figure 17 – Delineation of Inner and Outer Craters

[2] There is no consensus on the definition of a bolide. It is used here to mean an extraterrestrial body in the 1-10-km size range, which impacts the earth at velocities of literally faster than a speeding bullet (20-70 km/sec = Mach 75), explodes upon impact, and creates a large crater. "*Bolide*" is a generic term, used to imply that we do not know the precise nature of the impacting body . . . whether it is a rocky or metallic asteroid, or an icy comet, for example.

Figure 18 – Location of Jefferson Lab Relative to the Outer Rim of the Chesapeake Bay Bolide Crater



The red arrow (*Figure 18 – Location of Jefferson Lab Relative to the Outer Rim of the Chesapeake Bay Bolide Crater*) indicates the approximate location of Jefferson Lab 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.

Jefferson Lab 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 the above figure 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 the Fall of 2016, as a result of the reissuance of VPDES Permit VAR0089320. Groundwater data from wells around Hall D for 2018 is consistent in quality with the remainder of the Jefferson Lab site.

7.0 QUALITY ASSURANCE (QA)

Extensive QA activities ensure that Jefferson Lab'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:

- Qualification 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 Jefferson Lab's Radiation Control Department, independent assessments are performed by the Quality Assurance & Continuous Improvement Department, the DOE Site Office, regulatory agencies such as the EPA and Virginia Department of Environmental Quality, and oversight groups within DOE. No QA concerns regarding environmental sampling protocols or results were noted in 2018.

An independent laboratory (James R. Reed & Associates) collected most of 2018's VPDES and HRSD permit-required water samples. Other samples that involve radionuclide analysis, including some required by the HRSD permit, are collected by the ESH&Q Division and analyzed in Jefferson Lab's radiological analysis lab (RAL). Eberline Services performed all subcontracted radiological analyses. James R. Reed is a Virginia Environmental Laboratory Accreditation Program (VELAP) 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 Laboratory Accreditation Program (NELAP).

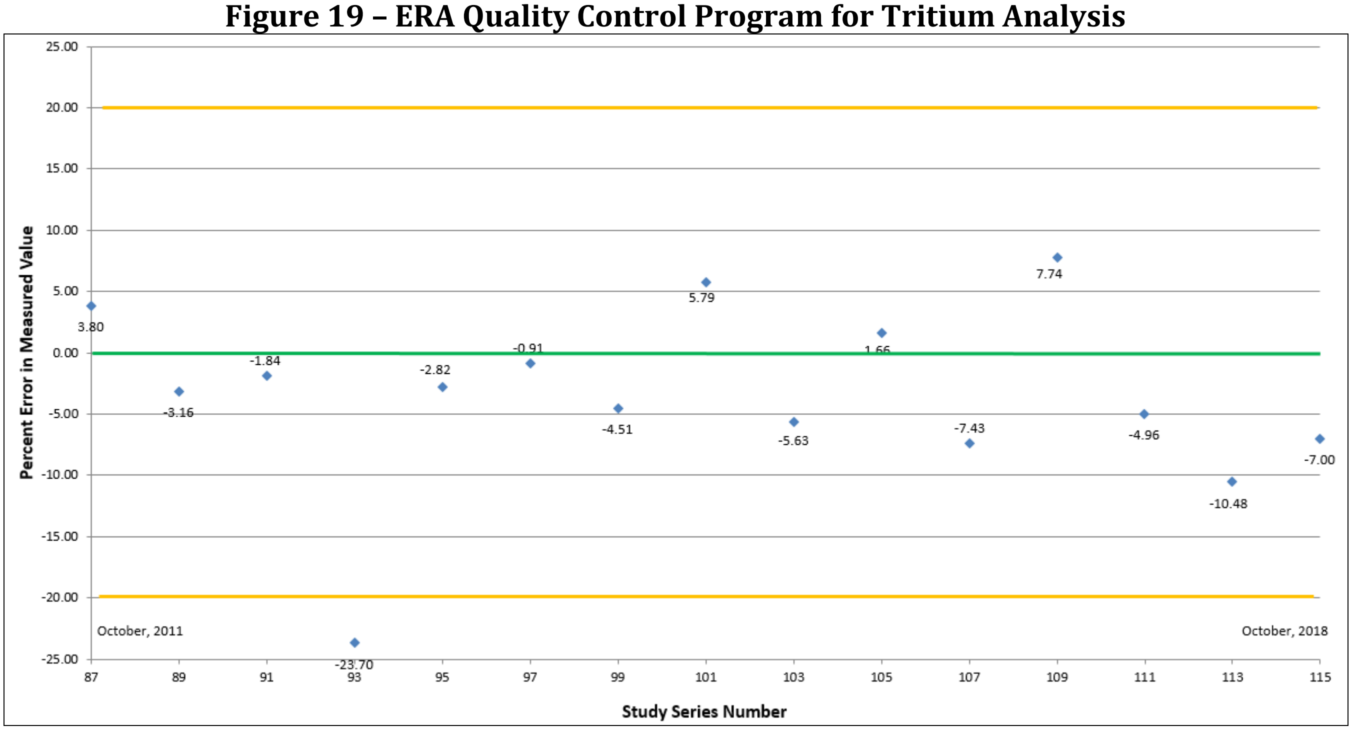
Samples collected by external analytical laboratories are analyzed for radiological (and non-radiological) attributes using standard EPA-approved analytical procedures. Both external facilities and Jefferson Lab have a continuing program of analytical laboratory QC. Participation in inter-laboratory crosschecks, analysis of various blanks, and replicate sampling and analysis verify data quality. ESH&Q Division staff and other responsible Jefferson Lab 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 chain-of-custodies, sample stewardship, sample handling and transport, and sampling protocols. When applicable to the analysis requested, analytical labs must be appropriately certified.

On-going 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 Jefferson Lab to validate compliance with the QA requirements in the permit.

Jefferson Lab 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 2018, overall performance by both Jefferson Lab and Eberline was acceptable, with only minor potential quality concerns associated with false positive results or results for constituents that are not of concern at Jefferson Lab. Results of the MAPEP testing can be found at:
http://www.id.energy.gov/resl/mapep/mapepreports.html.

Jefferson Lab also participates in an annual quality test for analysis of tritium. *Figure 19 – 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.

Figure 19 – ERA Quality Control Program for Tritium Analysis



8.0 ACRONYM LIST

ALARA	As Low As Reasonably Achievable
AFV	Alternative Fuel Vehicles
ASHRAE	American Society of Heating, Refrigerating, and Air-conditioning Engineers
BAT	Best Available Technology
BDX	Beam Dump Experiment
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
CD	Critical Decision
CEBAF	Continuous Electron Beam Accelerator Facility
CFR	Code of Federal Regulations
CHL	Central Helium Liquifier
Ci	Curie
CLAS12	CEBAF Large Acceptance Spectrometer for 12 GeV Upgrade
CMSA	Central Material Storage Area
CRAD/LOI	Criteria Review and Approach Document/Lines of Inquiry
CTF	Chiller Treatment Facility
DCLS	Virginia Division of Consolidated Laboratory Services
DEQ	Virginia Department of Environmental Quality
DOD	Department of Defense
DOE	Department of Energy
EA	Environmental Assessment
ECM	Energy Conservation Measures
EEL	Experimental Equipment Lab
EISA	Energy Independence and Security Act
EIU	Energy Intensity Utilization
EMS	Environmental Management System
E.O.	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
ESH&Q	Environment, Safety, Health and Quality

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
GHG	Greenhouse gas
GP	Guiding Principles
GSF	Gross Square Foot
H-3	Tritium
HEMSF	High Energy Mission Specific Facility
HPSB	High Performance and Sustainable Building
HRSD	Hampton Roads Sanitation District
ILA	Industrial, Landscaping, and Agricultural
ISM	Integrated Safety Management
ISO	International Organization for Standardization
Jefferson Lab	Thomas Jefferson National Accelerator Facility
JSA	Jefferson Science Associates, LLC
kg	Kilogram
kW	Kilowatt
LED	Light-Emitting Diode
LEEDS	Leadership in Energy and Environmental Design
LERF	Low Energy Recirculator Facility
LQG	Large Quantity Generator
LID/GI	Low Impact Development/Green Infrastructure
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
mrem	millirem
mSv	millisievert
MS4	Municipal Separate Storm Sewer Systems
Na-22	Sodium-22
NASA	National Aeronautics and Space Administration
NELAP	National Environmental Laboratory Accreditation Program

NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NOV	Notice of Violation
ODS	Ozone-Depleting Substance
QA	Quality Assurance
QC	Quality Control
PC	Personal Computer
PUE	Power Utilization Effectiveness
PV	Photo Voltaic
Radcon	Radiation Control
RAL	Radiological Analysis Laboratory
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
SqFt	Square Feet
SQG	Small Quantity Generator
SRF	Superconducting Radiofrequency
SARA	Superfund Amendments and Reauthorization Act
TEDF	Technology Engineering and Development Facility
TJSO	Thomas Jefferson Site Office
TMDL	Total Maximum Daily Load
UESC	Utility Energy Service Contract
UIM	Utility Infrastructure Modernization
UITF	Upgrade Injector Test Facility
VELAP	Virginia Environmental Laboratory Accreditation Program
VPDES	Virginia Pollutant Discharge Elimination System
VSMP	Virginia Stormwater Management Program
W	Watt

9.0 FIGURES