FY 2021 ANNUAL LABORATORY PLAN

Thomas Jefferson National Accelerator Facility

Prepared for the U.S. Department of Energy Office of Science
Stuart Henderson, Laboratory Director

July 2021

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I. Mission/Overview

Thomas Jefferson National Accelerator Facility (TJNAF) is a world-leading research institution for exploring the nature of matter in depth, providing unprecedented insight into the details of the particles and forces that build our visible universe inside the nucleus of the atom. TJNAF was established in 1984 in Newport News, Virginia, and is operated by Jefferson Science Associates, LLC, for the Department of Energy's Office of Science.

Research at TJNAF reveals the fine details of the constituents of matter, from the familiar protons, neutrons, and electrons in the atom, to the lesser-known quarks and gluons inside the atom's nucleus. These studies are revealing how fundamental universal forces build and shape matter and are opening a window into matter's inner universe.

Enabling these studies is TJNAF's world leadership in the development and deployment of large-scale superconducting radiofrequency (SRF) technology. SRF technology powers TJNAF's flagship machine, the Continuous Electron Beam Accelerator Facility (CEBAF). The technological and research successes accomplished with CEBAF as a unique SRF particle accelerator have made possible a wide array of applications, from ever more powerful free-electron lasers for research to life-saving advances in nuclear medicine, and from impactful applications in industry to real-world solutions for protecting our nation's borders.

In support of its scientific mission, TJNAF maintains core capabilities and expertise in Nuclear Physics; Accelerator Science and Technology; and Large Scale User Facilities/Advanced Instrumentation. TJNAF is also exploring ways to capitalize on its expertise in the computational sciences to provide large-scale high-performance computing services to an array of research fields for accelerating and maximizing scientific insight in the future.

TJNAF actively partners with industry to advance critical technologies to benefit the nation. The lab is also investing in the next-generation STEM workforce. Its dedicated research facilities enable one-third of U.S. Ph.D.s in nuclear physics annually, and its outreach programs positively impact thousands of students and teachers while helping them build critical knowledge and skills for a brighter future.

II. Lab-at-a-Glance

Location: Newport News, Virginia

Type: Program-dedicated, single-purpose lab

Contract Operator: Jefferson Science Associates, LLC (JSA)

Responsible Site Office: Thomas Jefferson Site Office

Website: http://www.jlab.org

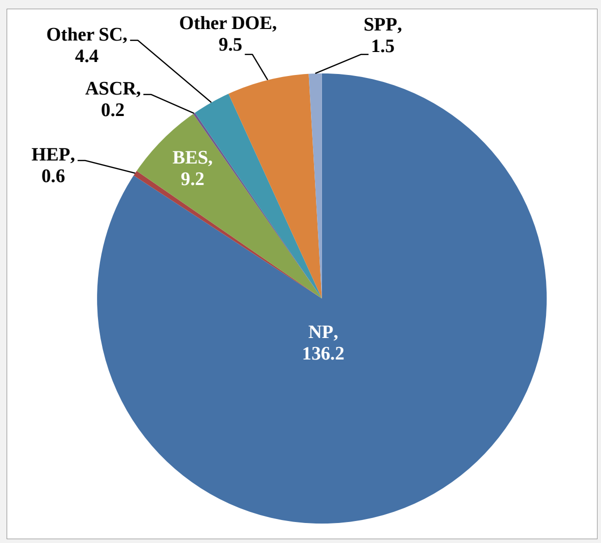
Physical Assets:

- 169 acres and 69 buildings
- 882,900 gross square feet (GSF) in buildings
- Replacement Plant Value (RPV): $509M
- 0 GSF in excess facilities
- 66,289 GSF in leased facilities

Human Capital (period ending 9/30/2020):

- 744 FTEs
- 24 joint faculty
- 36 postdoctoral researchers
- 21 undergraduate and 44 graduate students
- 1,623 facility users
- 1,488 visiting scientists

FY 2020 Costs by Funding Source:
(Cost Data in $M)



BES costs ($9.2M) reflect LCLS-II & LCLS-II HE work for SLAC

Lab Operating Costs: $161.7
DOE Costs: $160.2
SPP (Non-DOE/Non-DHS) Costs: $1.5
DHS Costs: $0.0
SPP as % Total Lab Operating Costs: 0.9%

III. Core Capabilities

Nuclear Physics

TJNAF is a unique world-leading user facility for discovery studies of the structure of nuclear and hadronic matter using continuous beams of high-energy, polarized electrons. The 2015 NSAC (Nuclear Science Advisory Committee) Long Range Plan clearly stated that its highest priority was to capitalize on this investment: “With the imminent completion of the CEBAF 12 GeV upgrade, its forefront program of using electrons to unfold the quark and gluon structure of hadrons and nuclei and to probe the Standard Model must be realized.”

The CEBAF electron beam can be simultaneously delivered to the experimental halls at different energies. With the completion of the 12 GeV Upgrade the beam energy can be up to 12 GeV, converted to 9 GeV photons for experimental Hall D, and up to 11 GeV to Halls A, B, and C. Each experimental hall is instrumented with specialized experimental equipment designed to exploit the CEBAF beam. The detector and data acquisition capabilities at TJNAF, when coupled with the high-energy electron beams, provide the highest luminosity (10^{39}/eN/cm^2/s) capability in the world. The TJNAF staff designs, constructs, and operates the complete set of equipment to enable this world-class experimental nuclear physics program, in close collaboration with a large domestic and international user community of well over 1,600 users annually.

The CEBAF science program spans a broad range of topics in modern nuclear physics. Lattice Quantum Chromodynamics (LQCD) calculations predict the existence of new exotic hybrid mesons that can be discovered with the new 12 GeV experiments, and elucidate the nature of confinement. New phenomenological tools have been developed that produce multidimensional images of hadrons with great promise to reveal the dynamics of the key underlying degrees of freedom – a new science program termed Nuclear Femtography. A surprising connection between the role of nucleon-nucleon interactions and the quark structure of many nucleon systems discovered at TJNAF earlier, needs to be understood. Development of measurements of exceptionally small parity-violating asymmetries with high precision has enabled major advances in hadronic structure, the structure of heavy nuclei (through measurement of the neutron distribution radius), and precision tests of the Standard Model of particle physics, including a measurement of the electron’s weak charge.

A comprehensive theoretical effort provides leadership across nuclear physics by pulling together state-of-the art theoretical, phenomenological, and computational approaches, including effective field theory techniques, QCD global analyses, and non-perturbative LQCD calculations. TJNAF deploys cost-optimized High Performance Computing for LQCD calculations as a national facility for the USQCD (a U.S. lattice gauge theory community) that complements DOE’s investment in leadership-class computing. Computational techniques in LQCD now promise to provide insightful and quantitative predictions that can be meaningfully confronted with and elucidated by forthcoming experimental data. Those techniques also promise to calculate the structure of hadrons that are hard, if not impossible, to do scattering experiments with.

Excellent synergy exists between the TJNAF experimental, theoretical, and computing programs. The Joint Physics Analysis Center (JPAC) develops theoretical and phenomenological understanding of production and decays of hadron resonances, which helps bridge the analyses and interpretation of experimental data from TJNAF with the results of LQCD calculations. The Jefferson Lab Angular Momentum (JAM) collaboration pulls expertise in QCD theory, phenomenology, and high performance computing to develop new and better tools to help extract the 3D tomography of hadrons from TJNAF data. TJNAF was the first to make use of Graphics Processing Units for high performance computing based on heterogeneous architectures (for LQCD calculations) and continues this innovative approach to present needs, including wide embracement of Machine Learning and Artificial Intelligence in Nuclear Physics techniques.

The 2015 NSAC LRP recommends a "high-energy high-luminosity polarized EIC as the highest priority for new facility construction following the completion of FRIB." An independent assessment of the science case for EIC was undertaken by a committee of the National Academies of Science in 2016-18. The committee made their findings public in July 2018, strongly supporting the case for a U.S.-based EIC. Following the decision to select BNL as the site of the EIC, TJNAF actively worked with BNL to provide important expertise and capability to ensure successful implementation of the EIC, including taking responsibility of scope that benefits from TJNAF's long-time intellectual investment in the EIC, TJNAF's core expertise, and its wide international user community. TJNAF played a fundamental role initiating and expanding the international EIC User Group that has now grown to 1,266 individual members from 253 institutions in 34 countries, with a large contribution of TJNAF users.

TJNAF scientists are heavily engaged in the community effort and its phenomenological studies to refine the strong science case and help develop unique detection capabilities for the future EIC, including the year-long and user-driven Yellow Report Initiative. The purpose of this Yellow Report Initiative, initiated by TJNAF scientists, was to advance the state and detail of the documented physics studies in preparation for the realization of the EIC. The effort aims to provide the basis for further development of concepts for experimental equipment best suited for science needs, including complementarity of two detectors towards future Technical Design Reports (TDRs). TJNAF has consolidated its efforts in the development of the science program by forming an Electron-Ion Collider Center (EIC^2). Seminars, visiting fellows, and workshops will be among the components of this new center.

Accelerator Science and Technology

TJNAF has world-leading capabilities in technologies required for superconducting linacs:

- Complete concept-to-delivery of superconducting linear accelerators
- State-of-the-art SRF fabrication and assembly capabilities
- Unrivaled design, commissioning, and operations experience in large cryogenic plants
- World-leading polarized electron injector capabilities
- Low-level RF and controls
- Accelerator and large-scale control systems
- Accelerator operation and design

One of the key core capabilities of TJNAF is its capability in SRF system design and production. The SRF accelerator system consists of multiple integrated technologies with expertise spread throughout multiple disciplines and departments. TJNAF maintains collaboration and communication among all associated sub-systems essential to maintaining and enhancing SRF capabilities. System integration essential to an effective SRF system includes cavity fabrication and processing, cryomodules, low-level RF controls, high-power RF, cryogenics, software and hardware controls, and monitoring systems. Ensuring that each of these sub-systems maintains state-of-the-art capabilities is critical to maintaining a world-leading program in SRF accelerator system capabilities. To accomplish the mission, the SRF Institute must maintain a comprehensive set of expertise and facilities to support SRF technologies at TJNAF and be ready to respond to current and future needs of the lab, the DOE complex, and other partners. TJNAF's SRF Facilities occupy about 60,000 SF of contiguous space all under one roof, which includes over 30,000 SF of new work centers, 25,000 SF of renovated high bay assembly and test work centers, and about 5,000 SF for parts inventory and storage. A unique feature of the SRF facility is the ~800 m2 chemroom/cleanroom suite. This state-of-the-art facility is fully engaged to support LCLS-II HE, SNS PPU, critical fundamental SRF R&D, and future projects such as EIC, PERLE, and the ILC.

The Upgraded Injector Test Facility (UITF) underwent a series of Accelerator Readiness reviews and was fully commissioned in the fall of 2020. The UITF is now certified as an accelerator facility and is operational. During the initial phase of operations, TJNAF has completed a series of experiments to characterize the HDice polarized target, conducted commissioning studies for the new SRF "booster" cryomodule, to be installed in CEBAF during the 2022 shutdown, demonstrated next-generation LLRF controls performance in support of an AIP-funded project, and supported SBIR grants to study advanced polarimetry diagnostics. A new beamline for environmental applications, supported by LDRD funds, will be installed in the spring of 2021. The first experiment will be in collaboration with the Hampton Roads Sanitation District to study the effectiveness of e-beam irradiation to break down a ubiquitous solvent 1,4-Dioxane in wastewater. The facility will then be used to conduct the first ever testing with beam of Nb3Sn coated cavities operating at 4K. This work is supported by an Early Career Award.

Electron-Ion Collider (EIC) Design

The Accelerator Division, in partnership with the Physics Division and collaborators at other national laboratories, developed a design concept for a Jefferson Lab Electron Ion Collider (JLEIC). A design report for JLEIC was published in 2012, to respond to the energy and luminosity requirements of the EIC physics white paper. The JLEIC design team, composed of TJNAF personnel and strategic national and international collaborators, developed a pre-Conceptual Design Report (pre-CDR) in FY 2018 and FY 2019. These design efforts influenced and continue to influence the EIC project that started in FY20, with TJNAF as a major partner in the overall facility design and performance objectives. In particular, the portability of some key strengths of the JLEIC design were investigated and led to a possible increase of the luminosity of the BNL-based Electron-Ion Collider by nearly a factor of two at lower Center-of-Mass Energies. The design efforts were also instrumental to study the feasibility of a possible second Interaction Region design with somewhat increased crossing angle but a stronger emphasis of forward detection, to enhance science complementarity. These design optimizations are under further study now.

Large Scale User Facilities/Advanced Instrumentation

Experimental Nuclear Physics (funded by DOE SC – Nuclear Physics)

TJNAF is the world's leading user facility for studies of the quark structure of matter using continuous beams of high-energy, polarized electrons. With well over 1,600 users annually, of which roughly two-thirds are domestic, TJNAF supports what is generally considered the largest nuclear physics user community in the world. CEBAF is housed in a seven-eighths mile racetrack and was built to deliver precise electron beams to three experimental end stations or halls. The electron beam can be converted into a precise photon beam for delivery to a fourth experimental Hall D. Accelerator instrumentation is installed to deliver beams to all four halls simultaneously.

CEBAF provides a set of unique experimental capabilities unmatched in the world, as follows:

- Highest energy electron probes of nuclear matter
- Highest average current
- Highest polarization
- Ability to deliver a range of beam energies and currents to multiple experimental halls simultaneously
- Highest-intensity tagged photon beam at 9 GeV for exotic meson searches
- Unprecedented stability and control of beam properties under helicity reversal for high-precision parity violation studies

Hall D is dedicated to the operation of a hermetic large-acceptance detector for photon-beam experiments, known as GlueX. Hall A houses two high-resolution magnetic spectrometers of some 100 feet in length and a plethora of auxiliary detector systems, including the large-acceptance Super BigBite Spectrometer. Hall B is home of the CEBAF large-acceptance spectrometer (CLAS12) with multiple detector systems and some 100,000 readout channels. Hall C boasts two roughly 80-foot-long, high-momentum magnetic spectrometers that allow for precision scattering experiments, and has housed many unique large-installation experiments. Maintenance, operations, and improvements of the accelerator beam enclosure and beam quality, and the cavernous experimental halls and the multiple devices in them, are conducted by the TJNAF staff to facilitate user experiments. Important capabilities related to the experimental program include state-of-the-art particle detection systems, high-power cryogenic targets, polarized targets, high-speed readout electronics, and advanced data acquisition technology.

CEBAF Operations (funded by DOE SC – Nuclear Physics)

CEBAF is in the midst of a long shutdown to install a new 2K cold box, perform maintenance on the in-tunnel cryogenic transfer line system, refurbish warm girder segments between cryomodules to mitigate any potential particulate contamination, complete the first phase of an upgrade to the Injector for the parity program, and conduct extensive planned maintenance on many subsystems. The Energy Reach program will also install two refurbished cryomodules and remove one more to seed the refurbishment program. In late summer TJNAF will resume its primary mission of the 4-Hall 12 GeV Physics program. The multi-year CEBAF Performance Plan and Energy Reach programs are well underway and will continue to ensure TJNAF meets reliability goals and provide operational energy margin for the Physics program. In the following year the lab will complete the second phase of the Injector upgrade. As mentioned above, plans are underway to prepare technical reports that pave the way towards an increase in the CEBAF luminosity by 50% and to double the energy using FFA technology. With the completion of the 12 GeV Upgrade, firm plans in place for maintenance and energy reach as well as a vision towards the future, TJNAF will continue to be the world's premier experimental QCD facility.

Accelerator Technology (funded by DOE SC – Nuclear Physics, Basic Energy Sciences, High Energy Physics, DOD ONR, Commonwealth of Virginia, and Industry)

The ability to use the TJNAF Low Energy Recirculator Facility (LERF) as an accelerator R&D test bed for Energy Recovery Linacs and techniques required to establish cooling of proton/ion beams, for example, provides a mutually beneficial cross-fertilization between the TJNAF LERF and Nuclear Physics. The LERF vault has recently been configured to enable higher throughput of cryomodule testing for LCLS-II HE. In addition, the LERF is supporting an R&D program to develop an accelerator-based concept to make Cu-67, a potentially useful radioisotope for medical imaging and radiotherapy.

TJNAF is applying its accelerator technology to collaborate with four other national laboratories to realize the Linac Coherent Light Source II, at the Stanford Linear Accelerator Center (LCLS-II at SLAC). TJNAF was responsible for construction of half of the superconducting cryomodules as well as the two cryogenic refrigeration plants. The lab expects to contribute to the commissioning effort for the accelerator as well as the cryogenics plants in the next year. An LCLS-II upgrade, LCLS-II-HE, is also underway to double the energy of LCLS-II from 4 to 8 GeV and extend the X-ray energy limit from 5 keV to 12.8 keV. TJNAF will build 10 cryomodules for the LCLS-II-HE project.

TJNAF has been selected to produce cryomodules for the Spallation Neutron Source Proton Power Upgrade (SNS PPU). The scope of the project is to build 7 new high beta cryomodules with 28 new SRF cavities to increase the SNS linac beam energy to 1.3 GeV. Vendor-provided cavities have started to arrive and are being qualified in our Vertical Test Area.

Cryogenics (funded by DOE SC – Nuclear Physics)

Over the last 25 years, TJNAF has developed a unique capability in large-scale cryogenic system design and operation that is a critical resource for the U.S. national laboratory complex. The TJNAF cryogenics group has been instrumental in the design of many construction projects requiring large-scale cryogenics: SLAC (LCLS-II), Michigan State University (FRIB), Oak Ridge National Lab (SNS), TJNAF (12 GeV Upgrade), and NASA (James Webb Space Telescope), as well as improving the cryogenic efficiency of existing systems (Brookhaven National Laboratory). In the process, many inventions have been patented, and one has been licensed by Linde (one of two companies that build cryogenic systems) for worldwide applications on new and existing cryogenic plants. This work has also resulted in many master's and Ph.D. theses, to ensure the continuity of this expertise in the coming decades.

The group has completed the design, specification, and procurement—and started the commissioning—of the helium refrigerators for LCLS-II. This work is based on the successful CHL2 design for the 12 GeV Upgrade and designs developed for FRIB. Significant CEBAF upgrades in progress include the installation of a replacement 2K cold box for CEBAF operations which was fabricated at TJNAF using the latest cold compressor technology. Installation and commissioning of this cold box is to be completed by July 2021. Work continues on the modification and installation of a surplus SSC refrigerator, ESR-2, to support future CEBAF end-station operations. Additionally, project work including procurement of equipment is underway to utilize funding received to upgrade the 2K capacity of the Cryogenic Test Facility that supports superconducting cavity and magnet testing at the Test Lab. The combination of ongoing operations of five refrigerators supporting the TJNAF experimental program, the upgrading of those refrigerators, and the work outside the lab has enabled the training of the next generation of cryogenic engineers in the newest technology as well as the details of plant operations supporting a dynamic experimental program.

IV. Science and Technology Strategy for the Future/Major Initiatives

The TJNAF science strategy for the future involves pursuit of four major initiatives that advance key objectives in the field of Nuclear Physics and also position the lab to more broadly contribute to the programs in the Office of Science. These initiatives position TJNAF to diversify its scientific mission by building upon our foundation in nuclear physics research to pursue new research directions and facility capabilities, particularly in advanced computing.

The first major initiative is Nuclear Physics at CEBAF. The currently planned program of experiments will require the better part of the next decade to execute. However, CEBAF will continue to provide unique capabilities to advance our understanding of hadronic matter at high luminosity far beyond what will be available at the future EIC. Advances in nuclear theory, particularly first principles calculations in Lattice Quantum Chromodynamics, provide essential support for future developments at CEBAF and EIC. TJNAF envisions a series of modest upgrades to increase luminosity, enable positron beams, and double the energy of CEBAF.

The CEBAF facility also offers unique opportunities for testing the Standard Model and searching for new physics beyond the Standard Model. An excellent example is the Heavy Photon Search experiment that was constructed in collaboration with SLAC (with DOE-HEP funding). TJNAF also has an approved program, “Electrons for Neutrinos,” that will provide important data relevant to analyzing the flagship experiment DUNE at Fermilab and the Sanford Underground Research Facility. A new proposal to search for dark matter particles emitted by the CEBAF beam dump, parasitically with the NP program, has been recommended for approval by our Program Advisory Committee. TJNAF would welcome an opportunity to discuss with DOE-HEP how to realize these important objectives and maximize the scientific impact of the CEBAF facility.

TJNAF has established itself as a major partner in the development, construction, and scientific utilization of the new Electron-Ion Collider Project, the second major initiative. This effort is both synergistic and complementary to the Nuclear Physics program at CEBAF, and exploits TJNAF’s world leading expertise in utilizing electron scattering in experimental nuclear physics as well as accelerator science and technology.

The third major initiative is Accelerator Science and Technology. TJNAF will continue to be a world-leading center for SRF technology research and production, both for fundamental scientific research and for applications to industry, medicine, and national security. Machine learning for accelerator operations and advanced photocathode development are additional elements of this initiative.

TJNAF will continue to advance the role of computation in Nuclear Physics while expanding our horizon beyond Nuclear Physics to other disciplines and research areas. TJNAF has developed a vision for an advanced computational facility to accelerate scientific discovery across DOE Office of Science programs by providing large-scale high-performance computing that brings parity between simulated, experimental, and observational data to accelerate and maximize scientific insight. This facility will provide services to Office of Science programs that enable interdisciplinary teams of scientists to attack fundamental problems in science and engineering that require nimble shared access to large data sets, often aggregated from multiple sources.

V. Infrastructure

TJNAF describes plans to maintain and improve its physical infrastructure and human capital resources while minimizing overhead cost to maximize return on science and technology investment. These plans are aligned with the FY 2021 Laboratory Agenda and its four strategic objectives. In the previous sections of this plan, the three strategic objectives that encompass the S&T mission of the laboratory were addressed. The remainder of this plan reflects the actions required to achieve the fourth and final strategic outcome related to laboratory operations that provide a strong foundation for sustained research and development excellence at TJNAF: *Provide, protect, and improve the human, physical, and information resources that enable world-class science.*

Overview of Site Facilities and Infrastructure

TJNAF is located on a 169-acre DOE-owned federal reservation within the City of Newport News in southeast Virginia. Adjacent to the federal reservation is the Virginia Associated Research Campus (VARC), a 5-acre parcel owned by the Commonwealth of Virginia and leased by SURA which sub-leases five acres to DOE for TJNAF use. Also adjacent is an 11-acre parcel owned by Newport News that contains the Applied Research Center (ARC) where JSA leases additional office and lab space. SURA owns 37 acres adjacent to TJNAF where it operates a 42-room Residence Facility at no cost to DOE.

TJNAF consists of 69 DOE-owned buildings comprising 882,990 square feet (SF) of office, shop, technical, and storage space. JSA leases additional office and lab space in the VARC (37,643 SF) and ARC (11,097 SF). JSA also leases two off-site storage warehouses (17,549 SF). Distribution of space by type is summarized in Table 4. There are currently no excess facilities and none are expected within the next 10 years. In addition to real property assets, 42 personal property shipping containers represent 12,920 SF of added storage.

Table 4: Distribution of Usable Space by Type

Type of Use	Total Usable Square Feet, Owned and Leased
Technical and Laboratory	258,768 (39%)
High Bay	150,198 (23%)
Office	101,420 (16%)
Storage	92,847 (14%)
Common	54,579 (8%)
TOTAL	657,812 (100%)

TJNAF provides office and workspace for approximately 760 JSA contractor, JSA, and federal government employees plus 1,600 transient users and visiting scientists. Facility space is well utilized with a current asset utilization index of 99.6%. The condition of TJNAF facilities is generally good as summarized in Table 5.

Table 5: TJNAF Facility Rating and Utilization Assessment

Condition		Mission-Unique Facilities		Non-Mission-Unique Facilities		Other Structures and Facilities	
		Number	SF	Number	SF	Number	SF
Rating	Adequate	36	339,976	30	353,596	35	N/A
	Substandard	0	0	7	249,069	4	N/A
	Inadequate	0	0	1	6,638	0	N/A
	TOTAL	36	339,976	38	609,303	39	N/A
Utilization	Underutilized	2	3,240	0	2,873	0	N/A
	Excess	0	0	0	0	0	N/A

TJNAF is entirely dependent on public utility service. JSA sources power from Dominion Energy at an average rate of $0.06/kWh and water from Newport News at an average rate of $3.69/HCF, and disposes of wastewater through the Hampton Roads Sanitary District at an average rate of $8.77/HCF. Utility service meets mission requirements although occasional, unplanned commercial-power outages periodically disrupt accelerator operation.

The TJNAF Land Use Plan is maintained on the TJNAF website and summarized in Enclosure 1. With the decision not to site the EIC at TJNAF, the Campus Plan and Land Use Plan have been updated to align with this decision. Additionally, a future High Performance Data Facility has been ideally located on the campus. The SURA-owned land, as well as Newport News-owned land reserved for TJNAF interests, still preserve expansion opportunities critical to the lab's strategic plan.

The SLI-funded CEBAF Renovation and Expansion (CRE) project received CD-1 in March 2020. The project includes the acquisition of the ARC, renovation of CEBAF Center, and a 22K SF building expansion—which will eliminate the VARC lease. The ARC acquisition process is anticipated to be concluded in FY 2021. An extension of the current 11,097 SF lease is in place until the acquisition is complete.

Campus Strategy

The S&T strategy described in Section 4 of this plan dictates the campus investment plan. Working with the Chief Research Officer, the facilities planning team reviews the capabilities of the current infrastructure against the S&T strategy to identify current and projected gaps. TJNAF then performs an analysis of alternatives (AOA) to select the optimum solutions to close the gaps between mission needs and infrastructure capability. The selection of solution and time phasing is driven by mission priority and constrained by the projected levels of indirect, GPP, and SLI program funding.

This plan reflects the heightened urgency to improve infrastructure reliability given the recent trend of increasingly disruptive failures impacting experimental schedules. Accelerator reliability is the product of the joint availability of all component systems (cavities, magnets, controls, infrastructure, and so forth). To meet the CEBAF 85% availability goal, the Accelerator Division has allocated to facilities infrastructure an availability requirement of >98.5%, which translates to <81 hours of total downtime over a 32-week experimental period. To accomplish this, Facilities Maintenance and Operations completed 6,162 preventative maintenance tasks and 2,001 corrective tasks in FY 2020.

The recent failure history suggests that continued substantial improvement in infrastructure reliability and high-power electronic equipment design is needed to reach this availability requirement. The impact of electrical transients to the operation of high-power electronic equipment remains the greatest cause of impact to accelerator operations and the area of major concentration. JSA continues to work with Dominion Energy to improve power quality including major maintenance of the substations feeding the lab (22, 33, and 40 MVA), removing trees near transmission lines, inspecting overhead lines, coordinating utility preventive maintenance (PM) tasks with accelerator downtimes, proactively monitoring line voltage variations within tariff limits, and meeting regularly to review power reliability. In 2020, Facilities Maintenance and Operations performed PM tasks on electrical distribution system components and multiple oil-filled transformers. Electrical safety and reliability upgrades were completed on the 40 MVA substation including a remote reset ground fault relay, upgraded controls for the automatic voltage regulators, and upgraded metering. Two transformers at the Central Helium Liquefier (CHL) were tested and de-gassed. Additionally, 33 of 55 1,000-watt high intensity discharge (HID) light fixtures in the experimental halls were replaced with 300-watt light emitting diode (LED) fixtures.

Belt-driven rack fans cooling the RF power supply racks have been in service since the original accelerator start-up and are failing at an increasing rate with parts obsolescence making it extremely difficult to maintain. An alternate design is being evaluated with plans for replacement in 2021.

A project was identified and started to increase CEBAF reliability and the cooling capacity of the linear accelerator (LINAC) service buildings as a result of increased accelerator operations during the warm summer months. The scope of the project increases chilled water capacity, improves air flow, reduces infiltration of unconditioned air, and increases air conditioning.

Replacement of accelerator fire detection and suppression systems was completed in FY 2020. This project replaced end-of-service-life components including all fire suppression, detection, and monitoring systems. A nitrogen-filled dry pipe system replaced the existing air-filled system, which will slow corrosion, improve the life of the system, and decrease maintenance costs.

Presented in Table 6 is the correlation between S&T mission requirements, required infrastructure capability, current shortfall in this capability, and optimum solution, which then becomes the basis for the infrastructure plan detailed in Enclosure 2.

Table 6: Campus Strategy Reflecting Realistic Solutions to Address Infrastructure-Capability Shortfalls to Meet TJNAF S&T Strategic Objectives

Core Capability (SC-X)	Infrastructure Requirement	Current Shortfall	Optimum Solution and Need Date
Accelerator Science and Technology (SC01)	Provide liquid helium to the Test Lab to enable the development, production, and testing of SRF components and cryomodules, both for use by TJNAF in CEBAF and projects for other labs.	The Cryogenics Test Facility (CTF) has experienced heavy utilization due to the CEBAF upgrade and BES multi-lab partnership projects. Approximately $5M of system components have reached end-of-life and others require upgrading to maintain adequate capacity for projected workload.	Complete the **CTF Upgrade.** Funding was provided in FY20 under the SLI-GPP program.
	Provide sufficient high bay, storage, and office space needed to design, produce and test SRF components and systems.	10,000 SF of high bay space in the Test Lab is unavailable for SRF needs due to occupation by Physics' large-scale assembly and testing activities. SRF office space needs in the Test Lab exceed available capacity. 10,000 SF of technical storage is leased in warehouse space remote from TJNAF. This introduces additional labor and time requirements to control and access this high-value material.	The **Thomas Jefferson Infrastructure Improvement (TJII)** project will construct a new 45,000 SF Test Lab High Bay Annex for Physics' large-scale assembly and testing activities, thus making existing Test Lab high bay space available for SRF. Physics engineering office space will be relocated to a modernized Experimental Equipment Lab (EEL) to ensure adequate space is available for SRF in the Technology and Engineering Development Facility (TEDF). A new 15-20,000 SF warehouse will relieve the demand for remote, off-site leased storage. Need date is immediate.
	Low Energy Recirculator Facility (LERF) for R&D on electron guns, dedicated cryomodule testing for DOE Projects, and R&D for production of medical isotopes.	Mechanical systems are at end-of-service-life and electrical systems are at or past capacity. Finishes are well worn and need to be renewed.	The **LERF Renovation** will ensure the facility can meet its planned operational use. Need date is FY24.

Core Capability (SC-X)	Infrastructure Requirement	Current Shortfall	Optimum Solution and Need Date
Large Scale User Facilities/R&D Facilities/Advanced Instrumentation (SC16)	Central Helium Liquefier (CHL) capable of supplying CEBAF with 9400W of 2K cooling and 22 g/s of LHe at >96% reliability.	Two plants, CHL1 and 2, must operate to meet the 2K cooling requirements, but CHL1 is unable to meet the up-time requirements due to an aging cold box.	Complete the **CHL1 2K Cold Box Replacement**. Need is immediate and project is underway as an FY 2017 SLI-GPP project scheduled for completion in FY21.
	210 tons of cooling capacity are required in each of the two linac service buildings to support CEBAF operations.	Existing cooling system is 36% undersized for current loads. Shortfall is 75 tons in each linac.	The **LINAC Additional Cooling** project increases chilled water capacity, improves air flow, reduces infiltration of unconditioned air, and increases air conditioning. Need date is immediate.
	45,000 SF of environmentally controlled high bay and technical space to support SRF production, cryogenics fabrication, and equipment assembly and staging for four experimental halls operating at 34 weeks/year.	High bay space in the EEL, Test Lab, and TED buildings is heavily over-utilized. Overcrowding increases the safety risk to staff and visiting scientists. Off-site space is currently being leased to meet the demand.	The **TJII** project will construct a new 45,000 SF Test Lab High Bay Annex for Physics' large-scale assembly and testing activities. Need date is immediate.
Nuclear Physics (SC20)	End station refrigeration capable of supplying Halls A, B, and C with 4000W of 4K cooling and 40 g/s of LHe at >85% reliability.	Current End Station Refrigerator serving Halls A, B, and C only has 1500W of 4K cooling and 11 g/s of LHe, has been operating nearly continuously for 20 years and is near end-of-life.	Complete installation of the SSC Cold Box to activate the **End Station Refrigerator 2 (ESR2)**. This will close the capability gap and provide a long-term solution to meet the experiment plan. Need date is immediate. Project funding was provided in FY20.
	Up to 210,000 SF of office and collaborative space that meets DOE high-performance, sustainable building standards to house staff, students, and visiting users.	CEBAF Center (127,000 SF) is overutilized and substandard due to aging mechanical systems that require immediate replacement. An additional 45,000 SF of office space is leased in adjacent buildings at disadvantageous rates.	The **CEBAF Center Renovation and Expansion (CRE),** including acquisition of the Applied Research Center (ARC), renovates CEBAF Center and provides an additional 144K SF of space. The project consolidates staff and vacates leased space. Need date is immediate. Initial project funding was received in FY20.

Core Capability (SC-X)	Infrastructure Requirement	Current Shortfall	Optimum Solution and Need Date
	The EEL provides 54,800 SF of technical and lab space for Physics, Engineering, and Facilities staff and is integral to our campus plan.	EEL has end-of-life mechanical systems and numerous code deficiencies. Office and technical space is insufficient, poorly distributed, and not integrated with the campus.	The **TJII** project fully renovates and modernizes the EEL facility to meet mission needs. Need date is immediate.
Support Facilities and Infrastructure (SC25)	Provide 100,000 SF of outside storage to accommodate large experimental assemblies, support structures, and equipment for future experiments and operations.	Current laydown space is scattered in multiple locations around site. Stored material in some of these sites is visible from off-site and creates an eyesore. Some 70,000 SF of existing laydown area will be lost due to future building construction.	The **Laydown Yard Expansion** roughly doubles an existing, centrally located storage area which is not visible from off-site. Consolidation will improve material management and provide an opportunity to eliminate unneeded material. Need date is immediate.
	To meet DOE sustainability goals for 2025, TJNAF must reduce potable water consumption by 36% relative to 2007 baseline.	Must reduce potable water consumption from current intensity of 63.5 gal/GSF to 41 gal/GSF.	The **Cooling Tower Water Reuse** project develops a 50M gal/year alternate water source for use in cooling towers by directing and treating water from off-site retention ponds. Need date is FY22.
	Relocate Facilities Maintenance and Operations functions	Functions are located in two substandard buildings (13 and 19) located in the administrative core of the campus. Critical spares are inefficiently scattered across the campus.	**The Integrated Maintenance and Logistics Center (IMLC) Phase 1** provides a fully integrated solution and relocates these functions to the lab's service corridor. Need date is immediate.
	Relocate logistics functions.	TJNAF logistics functions are primarily located within high bay space within the EEL building, which is already oversubscribed and needed to support research and technical operations.	The **IMLC Phase 2** provides a fully integrated solution and relocates these functions to the lab's service corridor. Need date is immediate.
	Suitable access roads and parking to meet safety and regulatory requirements.	Continued expansion of the TJNAF campus as outlined in this plan along with development of property immediately surrounding TJNAF requires expansion and alteration of campus	The **TJII** project provides site-wide road, parking, and sidewalk improvements, which rebuild existing roads and resolve impacts created by both on-site and adjacent off-site

Core Capability (SC-X)	Infrastructure Requirement	Current Shortfall	Optimum Solution and Need Date
		access and parking to support vehicle loads, and maintain compliance with safety and regulatory requirements.	construction. Need date is immediate.
	Provide 1,900 gal/hr of chilled water to cool R&D equipment in the Test Lab, EEL, CEBAF Center, and Accelerator service buildings.	Existing Test Lab chillers are approaching the end of their service life and use refrigerant that will no longer be available after FY30.	The **TJII** project includes replacing the existing chillers with a new chiller to be installed in the Central Utility Plant (CUP). Need date is FY30.
	Suitable potable water distribution to reliably meet need for 120M gal/year use.	Portions of the water system exceed 50 years and have experienced severe corrosion. The site lacks a full water loop with isolation valves to allow for normal maintenance without severely affecting operations.	The **TJII** project replaces aging sections of piping and provides for completion of the site water distribution loop with adequate isolation valves for system operations and maintenance. Need date is FY25.
	Suitable sanitary sewer system to meet the service needs of the site.	Portions of the system have insufficient slope and have experienced breaks or surface water infiltration. The capacity is marginal to meet future needs.	The **TJII** project will correct existing deficiencies and add additional capacity to meet expected growth requirements. Need date is FY25.
	Main entrance appropriate for a DOE national laboratory and adequate wayfinding signage to safely direct users and visitors.	The existing entrance does not reflect the scope and capabilities of the site or its important technology anchor role in the community.	The **Main Entrance and Site Signage** project will enhance the main entrance and provide needed wayfinding signage across the site. The site circulation plan will be impacted with the CRE project. Need date is FY25.
	Provide an isolated and secure facility to calibrate radiological instruments and house rad waste processing equipment and work in process.	Campus growth is encroaching on the existing calibration lab, creating a safety and security risk.	Construct a new **RadCon Calibration Lab and Waste Processing** work center in a more remote area adjacent to the Central Material Storage Area (CMSA). Need date is FY26.
	Relocate service entrance road to the TJNAF campus.	TJNAF service vehicle traffic flow and Facilities Maintenance and Operations functions do not support future growth of administrative, research,	Construct a new **Service Entrance Road** to directly connect the TJNAF campus to a major public road, which will facilitate the future relocation of the facility maintenance and logistics functions. Need

Core Capability (SC-X)	Infrastructure Requirement	Current Shortfall	Optimum Solution and Need Date
		and technology portions of the TJNAF campus.	date is FY29 or sooner if practical.
	Meet renewable energy goals established by DOE.	TJNAF currently relies on the purchase of renewable energy credits to meet DOE sustainability goals, which require that renewable electric energy account for not less than 7.5% of a total agency electric consumption.	The **Renewable Energy Integration** project provides a 3-4MW photovoltaic and battery storage system on-site, which will allow TJNAF to meet renewable energy goals and provide a resilient microgrid for the campus. Need date is FY30.
	Meet potable water intensity reduction goals established by DOE.	Potable water intensity is expected to dramatically increase beginning in FY26 due to campus growth and data center cooling demands.	The **Cooling Tower Water Reuse Expansion** project provides an additional 50M gal/year alternate water source for use in cooling towers. Need date is FY31.
Advanced Computer Science, Visualization, and Data (SC02) and Computer Science (SC10)	40,000 SF of data center space and administrative space for 100+ staff to grow core capabilities in computational science.	CEBAF Center's data center (6,000 SF) is at capacity, and insufficient administrative space exists in CEBAF Center to support the growth of Computational Sciences and Technology (CST).	Construct a new facility with a 40,000 SF data center and sufficient administrative space for 100-165 staff.

The gaps identified above can be closed using a combination of SLI, SLI-GPP, and NP-GPP funding of $205M. In addition to providing essential capabilities for mission performance, these investments will eliminate $5M of deferred maintenance.

The primary focus of our facilities operations and maintenance program is to increase the mean time between failure of facility systems through accelerated replacement of end-of-life systems and adding redundancy for critical systems to eliminate downtime from single-point failures. Similarly, when failures occur, TJNAF will reduce the mean time to repair by making sure sufficient stock of critical spares is on hand to immediately restore operation, rather than accept lengthy downtimes to source replacements.

The most recent TJNAF Condition Index is 0.95. However, this could drop over time if Facilities Operations and Maintenance funding continues to be limited to 1.25% of replacement value. Modernization projects and construction of new facilities through SLI and GPP funding have enabled TJNAF to maintain a modest deferred maintenance value ($7.0M in FY20). Over the next decade, no significant increase in deferred maintenance is expected as JSA implements the capital spending plan reflected in the Integrated Facilities and Infrastructure Crosscut Data table provided in Enclosure 2.

***Infrastructure Investment Table*:** The TJNAF Infrastructure Investment Table and Campus Plan is provided in Enclosure 2.

***Integrated Facilities and Infrastructure Crosscut Data Table*:** The TJNAF Integrated Facilities and Infrastructure Crosscut Data Table is also provided in Enclosure 2.

Site Sustainability Plan Summary

TJNAF remains strongly committed to achieving targets established in the DOE Strategic Sustainability Performance Plan. TJNAF received a 2018 Federal Energy and Water Management Award in the Lab and Data Center category for energy and water cost savings, optimized energy and water use, and the use of advanced and distributed energy technologies under the Computer Center Modernization project achieving a power usage effectiveness (PUE) of 1.3. For FY 2020, all but three sustainability interim target goals were met: potable water intensity, renewable energy, and sustainable buildings (by building count).

Achievement of the potable water intensity reduction goal of 36% relative to a FY 2007 baseline remains the most significant challenge due to the large amounts of water required for evaporative cooling of high energy mission-specific facilities. TJNAF has, however, identified strategies for implementation and integrated these into the Campus Plan. A project was completed in FY 2019 that reduces potable water consumption by 4M gal/yr (an annual savings of $60,000) by reusing discharge water from the Test Lab ultra-pure water system as a make-up water supply source for a nearby cooling tower. Additionally, funding has been requested to implement a storm water reuse project, which is projected to further reduce potable water consumption by up to 50 million gallons per year.

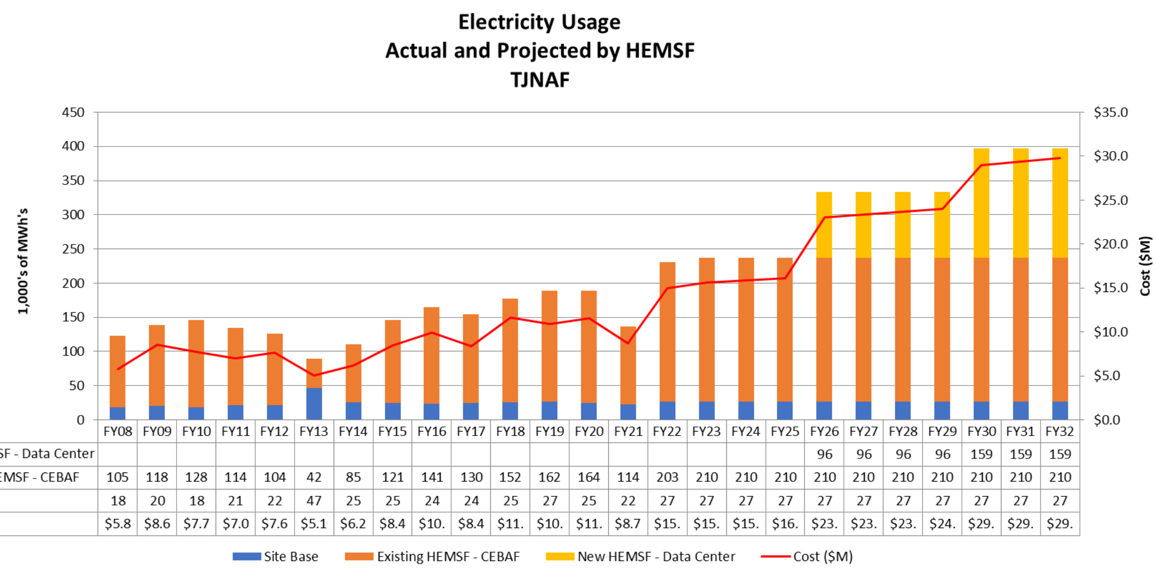
TJNAF has and continues to plan and implement clean and renewable energy technologies. Several facilities currently utilize geothermal heat pump systems that produce and consume approximately 5,306 MMBTU/yr of thermal energy. A renewable energy integration project identified in the Campus Plan is capable of providing 3 megawatts of solar energy with battery storage. Until funding is received and work is completed, however, renewable energy credits will be purchased annually to comply with interim goals in this category.

Due to operational risk, JSA decided against awarding a Utility Energy Service Contract (UESC) project totaling approximately $3.48M to address lighting, domestic water conservation, and mechanical upgrades. As an alternative, these elements are being implemented separately, either as part of operations and maintenance efforts or by incorporation into larger recapitalization projects. This approach is expected to reduce the risk while delivering the same or better outcome at a lower cost. These building-level energy and water reductions will contribute to additional facilities meeting the guiding principles for sustainable buildings.

<u>Electricity Usage and Cost Projections</u>
Figure 1 shows TJNAF's historical and projected electricity usage and costs. Projections are based on scheduled operations for FY 2021 of 6.5 weeks and, for FY 2022, 34 weeks—with some limited portions at lower energy levels. From FY 2023 onward, 34 weeks of operations at the highest achievable beam energy are projected for each year. Additional projections related to a proposed new

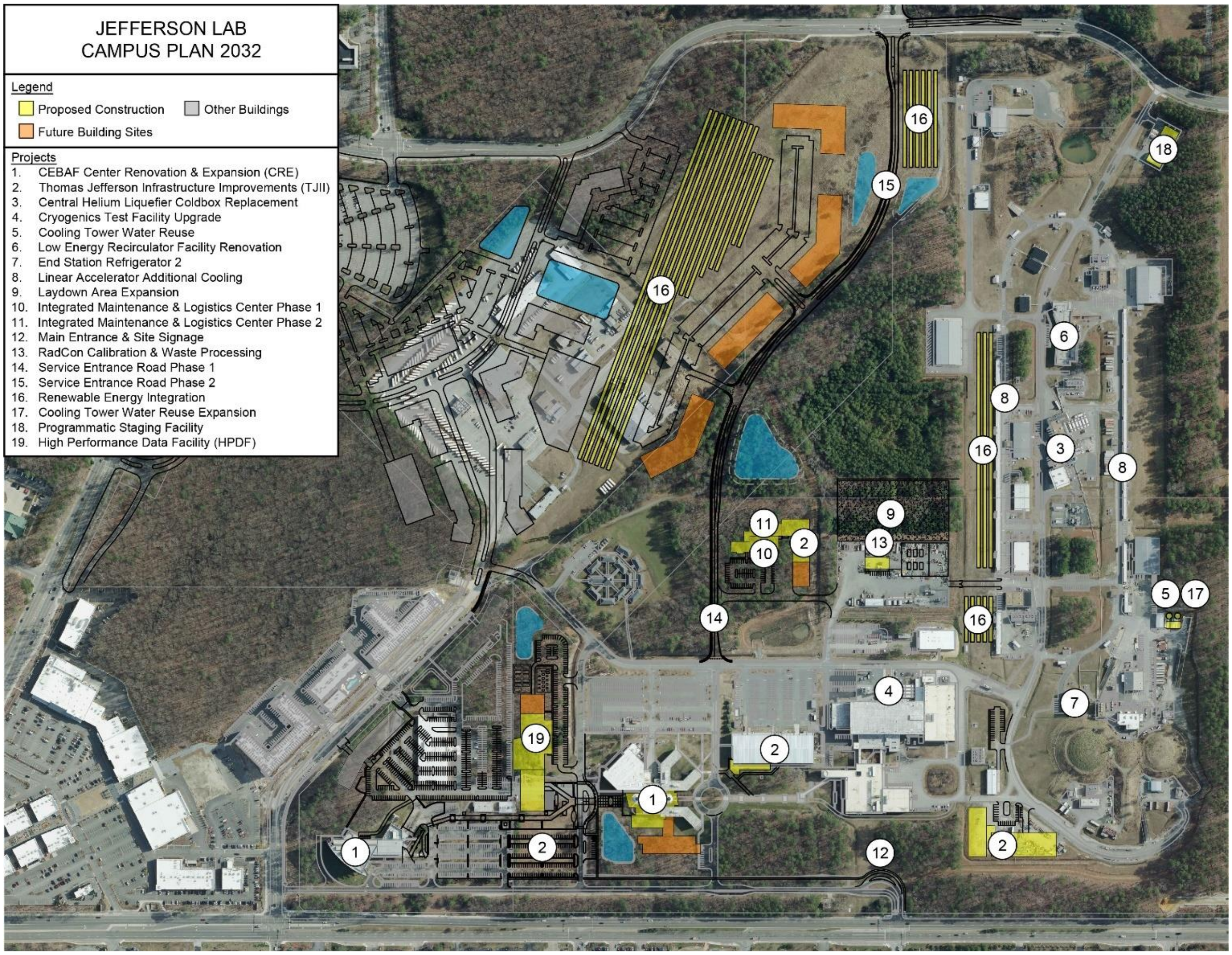
high-energy, mission-specific data center facility are also included in the projections from FY 2026 forward.

Figure 1: Electricity and Cost Projections



	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32
New HEMSF - Data Center																			96	96	96	96	159	159	159
Existing HEMSF - CEBAF	105	118	128	114	104	42	85	121	141	130	152	162	164	114	203	210	210	210	210	210	210	210	210	210	210
Site Base	18	20	18	21	22	47	25	25	24	24	25	27	25	22	27	27	27	27	27	27	27	27	27	27	27
Cost ($M)	$5.8	$8.6	$7.7	$7.0	$7.6	$5.1	$6.2	$8.4	$10.	$8.4	$11.	$10.	$11.	$8.7	$15.	$15.	$15.	$16.	$23.	$23.	$23.	$24.	$29.	$29.	$29.

Enclosure 1 – Land Use Plan



Enclosure 2 – Infrastructure Investment Table

Laboratory Name: Thomas Jefferson National Accelerator Facility

Project Title	Site Project Code *if applicable*	Total Estimated Cost ($000)	FY20 Actual ($000)	FY21 ($000)	FY22 ($000)	FY23 ($000)	FY24 ($000)	FY25 ($000)	FY26 ($000)	FY27 ($000)	FY28 ($000)	FY29 ($000)	FY30 ($000)	FY31 ($000)	FY32 ($000)	Funding Type *Select from Drop Down Menu*	Funding Program *Select from Drop Down Menu*	Project Type *Select from Drop Down Menu*	Main Project Driver *Select from Drop Down Menu*	Comment
End Station Refrigeration 2 (ESR2)		**9,500**	9,500													GPP-Prog	NP	Utility	Mission	
LINAC Additional Cooling		**1,500**	116	1,384												GPP-Prog	NP	Utility	Mission	
Laydown Yard Expansion		**1,500**		195	1,305											GPP-Prog	NP	Other	Mission Support	
Integrated Maintenance and Logistics Center (IMLC) Phase 1		**4,900**			321	2,536	2,043									GPP-Prog	NP	New Bldg	Mission Support	
Integrated Maintenance and Logistics Center (IMLC) Phase 2		**3,000**					1,113	1,887								GPP-Prog	NP	New Bldg	Mission Support	
Main Entrance and Site Signage		**1,000**						1,000								GPP-Prog	NP	Other	Other	
RadCon Calibration and Waste Processing		**3,700**						490	3,210							GPP-Prog	NP	New Bldg	ES&H	
Service Entrance Road Phase 1		**4,700**							181	3,400	1,119					GPP-Prog	NP	Other	Mission Support	
Service Entrance Road Phase 2		**3,300**									2,383	917				GPP-Prog	NP	Other	Mission Support	
Renewable Energy Integration		**5,000**										2,690	2,310			GPP-Prog	NP	Utility	Sustainability	
Cooling Tower Water Reuse Expansion		**5,000**											1,405	3,595		GPP-Prog	NP	Utility	Sustainability	
Programmatic Staging Facility		**4,000**												232	3,768	GPP-Prog	NP	New Bldg	Mission	
Central Helium Liquefier (CHL) Cold Box Replacement		**8,000**														GPP-SLI	SLI	Utility	Mission	
Cryogenics Test Facility (CTF) Upgrade		**5,200**	5,200													GPP-SLI	SLI	Utility	Mission	
Cooling Tower Water Reuse		**3,900**			3,900											GPP-SLI	SLI	Utility	Sustainability	
Low Energy Recirculator Facility (LERF) Renovation		**5,000**					5,000									GPP-SLI	SLI	Bldg Renov/N	Mission	
CEBAF Renovation and Expansion (CRE)	20-SC-73	**87,000**	2,000	2,000	37,000	46,000										LI-SLI	SLI	Bldg Renov/N	Mission	
Thomas Jefferson Infrastructure Improvements (TJII)		**95,000**			8,000	31,000	30,000	26,000								LI-SLI	SLI	New Bldg	Mission	

	FY20 Actual ($000)	FY21 ($000)	FY22 ($000)	FY23 ($000)	FY24 ($000)	FY25 ($000)	FY26 ($000)	FY27 ($000)	FY28 ($000)	FY29 ($000)	FY30 ($000)	FY31 ($000)	FY32 ($000)
GPP #'s	9,616	1,579	1,626	2,536	3,156	3,377	3,391	3,400	3,502	3,607	3,715	3,827	3,768
FY20 #'s		2,186	2,536	3,156	3,377	3,391	3,400						
ONP #'s (scenario 2)		1,579	1,626	2,536	3,156	3,377	3,391	3,400	3,502	3,607	3,715	3,827	3,942

Enclosure 2 (cont'd) – SC Integrated Facilities and Infrastructure (IFI) Crosscut Data Table

Laboratory Name: Thomas Jefferson National Accelerator Facility

Data summarized from Investment Table	($000)												
Capital Investments (summarized from Investment Table)	**FY 20 Actual**	**FY 21**	**FY 22**	**FY 23**	**FY 24**	**FY 25**	**FY 26**	**FY 27**	**FY 28**	**FY 29**	**FY 30**	**FY 31**	**FY 32**
SLI Line Items	**2,000**	**2,000**	**45,000**	**77,000**	**30,000**	**26,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
SLI GPP	**5,200**	**0**	**3,900**	**0**	**5,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
GPP - SC Research Programs	**9,616**	**1,579**	**1,626**	**2,536**	**3,156**	**3,377**	**3,391**	**3,400**	**3,502**	**3,607**	**3,715**	**3,827**	**3,768**
Total DOE Capital Investment	**16,816**	**3,579**	**50,526**	**79,536**	**38,156**	**29,377**	**3,391**	**3,400**	**3,502**	**3,607**	**3,715**	**3,827**	**3,768**
Lab Minor Construction - IGPP (see Instruction & Tab 1 for details)													
Lab Minor Construction - Other IGPP (see Instruction & Tab 1 for details)													
Total Capital Investment	**16,816**	**3,579**	**50,526**	**79,536**	**38,156**	**29,377**	**3,391**	**3,400**	**3,502**	**3,607**	**3,715**	**3,827**	**3,768**

	($000)												
Maintenance and Repair Predictive, Preventive and Corrective M&R (incl. DM Reduction) (For SC Facilities Only)*	**FY 20 Actual**	**FY 21**	**FY 22**	**FY 23**	**FY 24**	**FY 25**	**FY 26**	**FY 27**	**FY 28**	**FY 29**	**FY 30**	**FY 31**	**FY 32**
Direct Funded	98	104	107	110	117	124	131	135	139	143	148	152	157
Indirect Funded	6,652	7,051	7,263	7,481	7,929	8,405	8,909	9,177	9,452	9,736	10,028	10,328	10,638
Total Predictive, Preventive and Corrective M&R	**6,750**	**7,155**	**7,370**	**7,591**	**8,046**	**8,529**	**9,041**	**9,312**	**9,591**	**9,879**	**10,175**	**10,481**	**10,795**
Annual Required Maintenance *FY 23 Only (please describe how calculated below)* ________				9,098									

	($000)												
Operation, Surveillance & Maintenance (OS&M) of Excess Facilities	**FY 20 Actual**	**FY 21**	**FY 22**	**FY 23**	**FY 24**	**FY 25**	**FY 26**	**FY 27**	**FY 28**	**FY 29**	**FY 30**	**FY 31**	**FY 32**
Direct Funded													
Indirect Funded													
Total OS&M of Excess Facilities	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Total Maintenance and Repair & OS&M	**6,750**	**7,155**	**7,370**	**7,591**	**8,046**	**8,529**	**9,041**	**9,312**	**9,591**	**9,879**	**10,175**	**10,481**	**10,795**

	($000)												
Disposal and Demolition	**FY 20 Actual**	**FY 21**	**FY 22**	**FY 23**	**FY 24**	**FY 25**	**FY 26**	**FY 27**	**FY 28**	**FY 29**	**FY 30**	**FY 31**	**FY 32**
Direct Funded													
Indirect Funded						400		300					
Total Disposal and Demolition	**0**	**0**	**0**	**0**	**0**	**400**	**0**	**300**	**0**	**0**	**0**	**0**	**0**

	($000)												
Assessing Impacts of the Campus Strategy on Key Parameters* ***(Assumes Investment Plan fully funded)***	**FY 20 Actual**	**FY 21**	**FY 22**	**FY 23**	**FY 24**	**FY 25**	**FY 26**	**FY 27**	**FY 28**	**FY 29**	**FY 30**	**FY 31**	**FY 32**
Deferred Maintenance**	6,961	7,379	7,821	8,291	8,788	9,315	5,342	5,663	6,003	6,363	6,745	7,149	7,578
Repair Needs***	28,056	20,304	21,523	22,814	24,183	25,634	18,108	19,194	20,346	21,567	22,861	24,232	25,686
Modernization Costs***	117,130	120,644	114,650	118,090	121,632	125,281	40,503	41,718	42,969	44,259	45,586	46,954	48,362
Replacement Plant Value****	538,252	581,706	599,157	617,131	639,986	661,909	722,699	744,380	766,712	789,713	813,404	837,806	862,941
Building Area (GSF)	882,990	1,007,876	1,007,876	1,007,876	1,019,818	1,021,201	1,113,201	1,112,184	1,112,184	1,112,184	1,112,184	1,112,184	1,112,184
Increases		124,886			11,942	7,277	92,000						
Removals						5,894		1,017					
Maintenance Investment Index (M&R/RPV)	1.25%	1.23%	1.23%	1.23%	1.26%	1.29%	1.25%	1.25%	1.25%	1.25%	1.25%	1.25%	1.25%
Maintenance to Repair Needs Index (M&R/RN)	24.06%	35.24%	34.24%	33.27%	33.27%	33.27%	49.93%	48.51%	47.14%	45.81%	44.51%	43.25%	42.03%
Deferred Maintenance Investment Index (DM/RPV)	1.29%	1.27%	1.31%	1.34%	1.37%	1.41%	0.74%	0.76%	0.78%	0.81%	0.83%	0.85%	0.88%
IGPP Investment Index (IGPP/RPV) (if applicable)													
Planned FY 23 M&R/FY 23 Required Maint (%)				83.43%									