Department of Energy Laboratory Plan –TJNAF
July 19, 2019

I. Mission/Overview

The Thomas Jefferson National Accelerator Facility (TJNAF), located in Newport News, Virginia, is a laboratory operated by Jefferson Science Associates, LLC, for the Department of Energy's (DOE) Office of Science (SC). The primary mission of the laboratory is to explore the fundamental nature of confined states of quarks and gluons, including the nucleons that comprise the mass of the visible universe. TJNAF also is a world-leader in the development of the superconducting radio-frequency (SRF) technology utilized for the Continuous Electron Beam Accelerator Facility (CEBAF). This technology is the basis for an increasing array of applications at TJNAF, other DOE labs, and in the international scientific community. The expertise developed in building and operating CEBAF and its experimental equipment has facilitated an upgrade that doubled the maximum beam energy (to 12 GeV (billion electron volts)) and provided a unique facility for nuclear physics research that will ensure continued world leadership in this field for decades. TJNAF's current core capabilities are: Nuclear Physics; Accelerator Science and Technology; and Large Scale User Facilities/Advanced Instrumentation.

The lab supports an international scientific user community of 1,630 researchers whose work has resulted in scientific data from 188 full and 33 partial experiments (including 10 full and 23 partial in the 12 GeV era), 453 Physics Letters and Physical Review Letters publications and 1,550 publications in other refereed journals to-date at the end of fiscal year (FY) 2018. Collectively, there have been more than 163,000 citations for work done at TJNAF.

Research at TJNAF and CEBAF also typically contributes to thesis research material for about one-third of all U.S. Ph.D.s awarded annually in Nuclear Physics (22 in FY 2018; 630 to-date; and 212 more in progress). The lab's outstanding science education programs for K-12 students, undergraduates and teachers build critical knowledge and skills in the physical sciences that are needed to solve many of the nation's future challenges.

II. Lab-at-a-Glance

Location: Newport News, Virginia

Type: Program-dedicated, single-purpose lab

Contract Operator: Jefferson Science Associates, LLC (JSA)

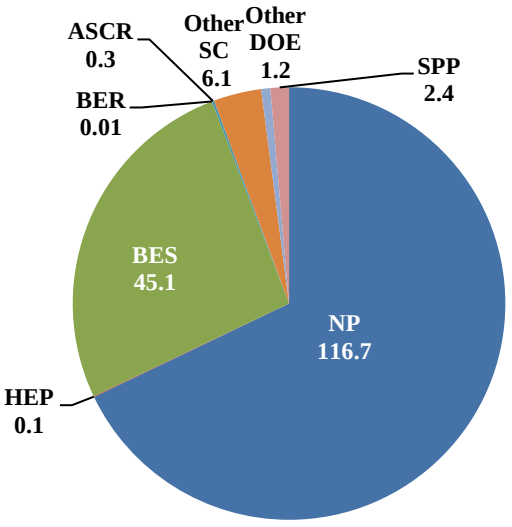
Responsible Site Office: Thomas Jefferson Site Office

Website: http://www.jlab.org

Physical Assets:
- 169 acres and 69 buildings
- 883,000 GSF in buildings
- Replacement Plant Value (RPV): $480M
- 0 GSF in Excess Facilities
- 66,289 GSF in Leased Facilities

Human Capital (period ending 9/30/18):
- 693 FTEs
- 28 Joint faculty
- 33 Postdoctoral Researchers
- 20 Undergraduate and 42 Graduate students
- 1,630 Facility Users
- 1,491 Visiting Scientists

FY18 Costs by Funding Source: *(Cost Data in $M)*



BES costs ($45.1M) reflect LCLS-II work for SLAC

Lab Operating Costs: $172.0
DOE Costs: $169.6
SPP (Non-DOE/Non-DHS) Costs: $2.4
DHS Costs: $0.0
SPP as % Total Lab Operating Costs: 1.4%

III. Core Capabilities

1. Nuclear Physics (funded by DOE SC – Nuclear Physics)

TJNAF is a unique world-leading user facility for studies of the structure of nuclear and hadronic matter using continuous beams of high-energy, polarized electrons. The completion of the 12 GeV Upgrade project enables many outstanding new scientific opportunities. 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 Continuous Electron Beam Accelerator Facility (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. With more than 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.

The CEBAF science program spans a broad range of topics in modern nuclear physics. Recent lattice QCD (Quantum Chromodynamics) 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 Lattice QCD calculations. TJNAF deploys cost-optimized High Performance Computing for Lattice QCD calculations as a national facility for the U.S. lattice gauge theory community that complements DOE's investment in leadership-class computing. Computational techniques in Lattice QCD 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 and theoretical 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 Lattice QCD calculations. TJNAF scientists are heavily engaged in the community effort and its phenomenological studies to help develop the strong science case and unique detection capabilities for a future Electron-Ion Collider (EIC). 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.

2. **Accelerator Science and Technology** (funded by DOE SC – Nuclear Physics, High Energy Physics)

TJNAF has world-leading capabilities in technologies required for superconducting linacs – notably, as follows:

- Complete concept-to-delivery of superconducting linear accelerators and associated technologies
- 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

These world-leading capabilities are evidenced by the production of more than 100 cryomodules produced and in continuous operation today. The ability to deliver large projects on time and on budget is evidenced by our involvement in major superconducting projects for SRF and cryogenics, including SNS, LCLS-II – for which TJNAF is responsible for construction of half of the superconducting cryomodules, as well as the two cryogenic refrigerators, and the FRIB helium refrigerator.

Construction of the Upgraded Injector Test Facility (UITF) at building 58 is nearly complete. The UITF provides a means to test important devices for CEBAF, like the new SRF "booster" cryomodule and the HDIce polarized target for Hall B. It is a testbed to evaluate new accelerator technologies, like Nb_3Sn-coated accelerating cavities operating at 4K, and potential accelerator applications, like wastewater treatment with electron beams. And although providing only low-energy electron beams (< 10 MeV), the UITF could be used to conduct the PAC-approved bubble chamber astrophysics experiment to study photodisintegration of oxygen.

In addition, TJNAF has pioneered Energy Recovery Linac (ERL) concepts and technologies, holds the record for recirculated beam power (1.4 MW), and has been a world leader in high-power free electron lasers based on ERL technology.
TJNAF, through its Center for Advanced Studies of Accelerators, possesses world-leading capabilities in beam dynamics' aspects of linear accelerators, energy-recovery linacs, free-electron lasers, and colliders.

<u>Electron Ion Collider (EIC) Design</u>
The Accelerator Division, in partnership with the Physics Division and collaborators at other national laboratories, has been developing 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, is developing a pre-Conceptual Design Report (pre-CDR) in FY 2018 and FY 2019, with a CDR to follow in FY 2020. Design and R&D efforts in support of the CDR phase are consistent with

the critical-decision timeline for the EIC project and with the requirements for DOE Order 413.3.

3. 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. 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)
As mentioned above, CEBAF has been recently upgraded to provide an electron beam with energy up to 12 GeV, a factor three over the original 4 GeV CEBAF design. In addition to the increase in beam energy, the maximum number of simultaneous experiments that CEBAF can support increased this year from three to four, with the completion of a four-laser injector upgrade. With the completion of the 12 GeV Upgrade, TJNAF will continue to be the world's premier experimental QCD facility.

With 418 installed SRF cavities, CEBAF operations represent a significant fraction of the worldwide SRF performance data set. Some of the CEBAF SRF cavities have been operating for more than 20 years. The CEBAF data set and operational experience is a valued resource for new or existing SRF-based accelerators. TJNAF has the ability to conceive and design large accelerator facilities, building upon 6 GeV CEBAF operations and augmented with the ongoing 12 GeV Upgrade.

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. In addition, the LERF is supporting an R&D program to develop an accelerator-based concept to make Cu-67.

As a result of the development, construction and operation of CEBAF, TJNAF has developed world-leading expertise in superconducting RF linear accelerators, high-intensity electron sources, beam dynamics and instrumentation, and other related technologies. These capabilities have been leveraged to develop new technologies relevant to other disciplines beyond nuclear physics, as well as applications to areas of national security.

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 is responsible for construction of half of the superconducting cryomodules as well as the two cryogenic refrigerators. An upgrade is already 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 seven new high beta cryomodules to increase the SNS linac beam energy.

Cryogenics (funded by DOE SC – Nuclear Physics)
Over the last two decades, 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 theses, to ensure the continuity of this expertise in the coming decades.

The group is presently responsible for designing, specifying, procuring and commissioning the two CHLs for LCLS-II, based on the successful CHL2 design for the 12 GeV Upgrade and designs developed for FRIB. The FRIB refrigerator installation is nearing completion along with TJNAF's scope of work supporting the project. Significant CEBAF upgrades in progress include design and in-house fabrication of a replacement 2K cold box for CEBAF operations using the latest cold compressor technology. Additionally, work has begun to modify and install a surplus SSC refrigerator, ESR2, to support future CEBAF end station operations.

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

The TJNAF science strategy for the future has a strong foundation based on the advancement of the U.S. nuclear physics program (as embodied in the 2015 Nuclear Science Advisory Committee (NSAC) Long Range Plan) and the support of Office of Science accelerator projects utilizing

TJNAF's expertise in Superconducting RF and cryogenics technologies. TJNAF has developed the FY 2019 Laboratory Agenda to delineate major initiatives associated with strategic objectives in Science and Technology as well as Operations. The Agenda was constructed around a set of four Strategic Outcomes that deliver on the mission of the laboratory, and three of these Strategic Outcomes are related to TJNAF's science and technology activities.

Strategic Outcome 1: Enable scientific discoveries by the Nuclear Physics User Community through our unique, world-leading facilities and capabilities.

With the completion of its 12 GeV Upgrade Project, TJNAF is now well positioned to continue its world leadership in hadronic nuclear physics. The upgraded CEBAF, along with the enhancements in experimental equipment, offers many opportunities for major advances in the understanding of the substructure of the nucleon, the fundamental theory of the strong force QCD, aspects of nuclear structure relevant to neutron star physics, and high-precision tests of the standard model of particle physics. Full exploitation of the upgraded facility will require robust CEBAF operations, as well as construction of new experimental equipment.

The 2015 NSAC Long Range Plan (LRP) strongly supports the robust operation of CEBAF necessary to deliver the long-awaited science program: "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."

Strategic Outcome 2: Plan for future facilities and capabilities to realize the long-term scientific goals in Nuclear Physics research.

The 2015 NSAC LRP recommends "increasing investment in small-scale and mid-scale projects and initiatives" and we hope this can help realize the new MIE projects at TJNAF. TJNAF has two proposed MIE projects (MOLLER and SoLID) that have received strong endorsement from the nuclear physics community.

The 2015 NSAC LRP also recommends "high-energy high-luminosity polarized EIC as the highest priority for new facility construction following the completion of FRIB." TJNAF is well positioned to provide the U.S. nuclear physics community with a highly capable option for an EIC based on the cost-effective use of CEBAF as a source of highly polarized 12 GeV electrons. TJNAF continues to develop its novel figure-eight collider ring design, known as Jefferson Lab Electron Ion Collider (JLEIC), and believes this represents an excellent opportunity for the U.S. nuclear physics community and for the long-term future of TJNAF.

The 2015 NSAC LRP also identifies a theory initiative, "new investments in computational nuclear theory that exploit the U.S. leadership in high-performance computing," that offers an opportunity to greatly advance progress in Lattice QCD calculations. TJNAF is continuing to develop expertise in advanced computer science, visualization and data management. TJNAF is a world-leading center of Lattice QCD (LQCD) computing and a partner in the Exascale Computing Project. TJNAF is extending this competency to the experimental program, which complements the lab's mission to maximize the scientific productivity of the nuclear physics community.

Strategic Outcome 3: Provide technology solutions that support the Nuclear Physics Community, the larger DOE mission and societal needs.

TJNAF also possesses key capabilities and competencies in accelerator science and in the application of modern accelerator technologies. Continued development of these capabilities is one

of the major initiatives integral to this strategic plan. In addition to providing world leading facilities and expertise to meet the identified needs of the nuclear physics research community, TJNAF has identified collaborative roles that it can play in the realization of facilities elsewhere that are associated with the Office of Science (e.g., Basic Energy Sciences and High Energy Physics) and other agencies. Most recently, this has involved the lab's contributing to the Facility for Rare Isotope Beams (FRIB) and the Linac Coherent Light Source (LCLS-II) construction projects. TJNAF is partnering with Stanford Linear Accelerator Center (SLAC) in the LCLS-II-HE Project and Oak Ridge National Laboratory (ORNL) in the Spallation Neutron Source Proton Power Upgrade (SNS-PPU) Project. TJNAF may also contribute to projects beyond SC, through future partnerships.

V. Infrastructure

TJNAF 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 2019 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.

Strategic Outcome 4: Provide, protect, and improve the human, physical, and information resources that enable world-class science.

Overview of Site Facilities and Infrastructure

Thomas Jefferson National Accelerator Facility 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 five-acre parcel owned by the Commonwealth of Virginia and leased by SURA, the managing member of the JSA joint venture, which sub-leases five acres to DOE for use by TJNAF. Also adjacent to the federal reservation is an 11-acre parcel owned by Newport News that contains the Applied Research Center (ARC), within which JSA leases additional office and lab space. SURA owns 37 acres adjacent to the TJNAF site, where it operates a 42-room Residence Facility at no cost to DOE.

The TJNAF complex consists of 68 DOE-owned buildings comprising 882,990 square feet (SF) of office, shop, technical, and storage space. JSA leases an additional 37,643 SF of office and shop space from the Commonwealth of Virginia in the VARC and 11,097 SF of office and lab space from the City of Newport News in the ARC. JSA also leases 17,549 SF of storage space in two offsite storage warehouses within 12 miles of TJNAF. These areas are gross, usable space as summarized in Table 1.

The TJNAF complex provides office and workspace for approximately 760 JSA contractor, JSA, and federal government employees along with a transient population of 1,600 users and visiting scientists. Facility space is well utilized with a current asset utilization index of 98.6%. Distribution of space by use is summarized in Table 1.

Table 1: Distribution of Usable Space by Type of Use

Type of Use	Total Square Feet, Usable Space, 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%)

The condition of TJNAF facilities is generally good (Table 2). Of the 74 DOE-owned or -leased buildings, 65 are rated adequate, eight substandard, and one inadequate. There are no longer any office trailers on site. Of the 36 other structures and facilities (including OSF 3000 series assets) assessed, 33 were rated adequate and three substandard. A total of 2,009 SF of space is currently rated as underutilized. These spaces will be fully utilized once capital funds are received and construction is complete. There are currently no excess facilities at the Lab and none are expected within the next ten years. There are 49 shipping containers representing 15,160 SF of storage space in use at TJNAF. TJNAF plans to remove four of these containers by the end of FY 2019.

Table 2: 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	29	360,697	33	N/A
	Substandard	0	0	8	259,221	3	N/A
	Inadequate	0	0	1	6,638	0	N/A
	TOTAL	36	339,976	38	626,556	36	N/A
Utilization	Underutilized	2	3,240	0	0	0	N/A
	Excess	0	0	0	0	0	N/A

TJNAF is entirely dependent on public utility service. JSA sources power from Dominion Virginia Power 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 is summarized in Enclosure 1. The only real-estate action planned for FY 2020 is an extension of the lease of 11,097 SF of office and lab space in Applied Research Center (ARC). The ARC is owned by the Newport News Economic Development Authority and sits immediately adjacent to TJNAF. JSA is currently working with Newport News to transition operations and maintenance responsibility for the entire ARC to the City before the start of FY 2020. However, the city has been reluctant to engage in definitive operations and maintenance transfer discussions due to ongoing discussions about an eventual transition of the ARC to the DOE. This is one option currently being evaluated under the CEBAF Renovation and Expansion (CRE) project which received CD0 as an SLI initiative at the end of FY 2018.

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%, which translates to <107 hours of total downtime over a 32-week experimental period.

The recent failure history suggests continued substantial improvement in infrastructure reliability is needed to reach this availability requirement. Electrical distribution issues remain the greatest cause of impact to accelerator operations and the area of major concentration. In the third quarter of 2018, Facilities Operations and Maintenance performed Preventative Maintenance (PM) on 46 15 kV transformers. The tests included oil tests and electrical tests. Of the 46 transformers serviced, 17 transformers either failed or had less than satisfactory test results. Transformers failing the test were repaired or replaced. Transformers with less than satisfactory test results are currently being monitored and tracked.

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 2020. Heat detection in the tunnel failed due to higher radiation levels during 12 GeV beam operations. A project is underway to replace the current system with a more robust heat detection wire system capable of withstanding higher radiation levels.

Presented in Table 3 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 3: 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 LHe to the Test Lab to enable the development, production and testing of SRF components and cryomodules, both for use by TJNAF in CEBAF and under WFO projects for other labs.	The Cryogenics Test Facility (CTF) has experienced heavy utilization due to the CEBAF upgrade and large WFO projects. Approximately $4M of system components have reached end-of-life and others require upgrading to maintain adequate capacity for projected workload.	Complete the **Cryogenics Test Facility (CTF) Upgrade.** Need date is FY 2021 or sooner if practical.

Core Capability (SC-X)	Infrastructure Requirement	Current Shortfall	Optimum Solution and Need Date
	Provide sufficient storage space for material and tooling needed to design, produce and test SRF components and systems.	18,000 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.	Construct a 15,000 SF **Equipment Storage Building** to relieve the demand for remote, off-site leased storage for SRF components, tooling, and work in process. Need date is FY 2022 or sooner if practical.
	Low Energy Recirculator Facility (LERF) for R&D on magnetized high-current beams, characterization of materials using low-energy positrons, and 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.	Execute a **LERF Renovation** to ensure the facility can meet its planned operational use. Need date is FY 2027 or sooner if practical.
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 >85% 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 a FY 2017 SLI-GPP project scheduled for completion in 2021.
	Provide 10,152 SF of suitable office and workspace for Cryogenics Engineering staff adjacent to CHL plant.	Current facility is substandard due to aging mechanical systems and worn finishes. Office space is over utilized due to expanding cryogenics staffing.	**Cryogenics Engineering Office Renovation (Building 89)** replaces worn systems and finishes and increases office space capacity. Project is under construction with expected completion in January 2020.
	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 32 weeks/year.	High bay space in the 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.	Build a **Large Scale Assembly & Testing (LSAT)** facility near the CEBAF experimental halls to provide an additional 45,000 SF of environmentally controlled high bay and work space. Need date is FY 2022 with desired completion by FY 2025.
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 **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.

Core Capability (SC-X)	Infrastructure Requirement	Current Shortfall	Optimum Solution and Need Date
	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 over utilized 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.	**CEBAF Center Renovation and Expansion (CRE),** possibly including the acquisition of the ARC, renovates CEBAF Center and provides an additional 82K-144K SF of space. The project consolidates staff and vacates leased space. Need date is FY 2021 with desired completion by FY 2024.
	The Experimental Equipment Lab (EEL) provides 54,800 SF of technical and lab space for physics, engineering, and facilities staff and is integral to our campus plan.	The EEL mechanical systems are at the end of their service life. Portions of the building need to be brought within code. Exterior cladding is approaching the end of its serviceable life and requires replacement within the next 8-10 years to maintain effective use of this facility.	The **LSAT** project provides a midlife renovation of the EEL facility. Completion of the proposed LSAT project also provides an opportunity to consolidate facilities operations functions from buildings 13 and 19 into the EEL. Need date is FY 2022 or sooner if practical.
Support Facilities and Infrastructure (SC25)	Provide adequate cooling water for the Test Lab, Computer Center, and CEBAF with >98% availability.	Existing Central Utility Plant (CUP) receives power from only one of three primary distribution sources at the TJNAF campus. This introduces a single-point failure that limits CUP reliability and complicates downtime planning for maintenance.	**Central Utility Plant (CUP) Power Diversity** adds a connection to the 40MVA substation to eliminate the single-point failure mode by relying on only the 22 MVA substation. Expect completion in 2019.
	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 access and parking to support vehicle loads and maintain compliance with safety and regulatory requirements.	Site-wide **Road, Parking, and Sidewalk Improvements** rebuild existing roads and resolve impacts created by both on-site and adjacent off-site construction. Need to align solution with selected option for this project. Need date is FY 2019 with desired completion by FY 2022.

Core Capability (SC-X)	Infrastructure Requirement	Current Shortfall	Optimum Solution and Need Date
	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.	**Cooling Tower Reuse Water** project develops a 40 Mgal/year alternate water source for use in cooling towers. Project would direct and treat water from off-site retention ponds for use in cooling towers. Need date is FY 2021.
	Main entrance sign appropriate for a DOE national laboratory and adequate wayfinding signage to safely direct users and visitors	Existing entrance sign was designed and built when TJNAF was first opened and no longer reflects the scope and capabilities of the site or its important technology anchor role in the community	The **Main Entrance and Site Signage** project will replace the main entrance sign and provide needed wayfinding signage across the site. The site circulation plan will be impacted with the CRE project. Need to align solution with selected option for this project. Need date is FY 2024 or sooner if practical.
	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 chilled water system uses cooling fluid that will be no longer available after FY 2030 requiring replacement prior to this date	**Test Lab Chiller Replacement** includes replacing the existing chillers with a new chiller to be installed in the Central Utility Plant (CUP). Need date is FY 2025.
	Provide 165,000 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. Another 100,000 SF of existing laydown area will be lost due to future building construction.	The **Laydown Area 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 FY 2025 or sooner if practical.
	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 and making it more susceptible to storm water flooding. Further, rad waste processing equipment and work in process are currently located in part of the Equipment Storage Building assigned to Physics Division.	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 FY 2026 or sooner if practical

Core Capability (SC-X)	Infrastructure Requirement	Current Shortfall	Optimum Solution and Need Date
	Suitable potable water distribution to reliably meet need for 120 Mgal. per 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 **Potable Water Improvements** 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 FY 2029 or sooner if practical.
	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 **Sanitary Sewer Improvements** project will correct existing deficiencies and add additional capacity to meet expected growth requirements. Need date is FY 2029 or sooner if practical.
	Suitable stormwater management infrastructure to meet 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 stormwater management structures to meet regulatory requirements and reduce flooding impacts of major rain events.	**Stormwater Improvements** will enhance existing stormwater conveyance structures and increase on-site stormwater retention to meet regulatory requirements and minimize flooding impact to our structures. Need date is FY 2030.

The gaps identified above can be closed using a combination of SLI, SLI-GPP, and NP-GPP funding of $157M. In addition to providing essential capabilities for mission performance, these investments will eliminate $5.2M 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 Asset Condition Index is 0.99. However, this could drop over time if Facilities Operations and Maintenance funding continues to be limited to 1.5% of replacement value. Recent construction of new facilities through SLI and GPP has reduced the deferred maintenance value, decreasing from $8.6M to $6.5M. Over the next few years, deferred maintenance is expected to decrease as JSA increases facility maintenance spending to 2% of RPV along with the capital spending reflected in the Integrated Facilities and Infrastructure Crosscut table provided in Enclosure 2.

Infrastructure Investment Table

The TJNAF Infrastructure Investment Table and Campus Plan is provided in Enclosure 2, at the end of this plan.

Integrated Facilities and Infrastructure Crosscut Data Table

The TJNAF Integrated Facilities and Infrastructure Crosscut Data Table is provided in Enclosure 2, at the end of this plan.

Site Sustainability Plan Summary

Table 4 shows Sustainability Project funding for planned actions to meet DOE Sustainability goals.

Table 4: Summary of Sustainability Project Funding ($k)

Category	FY 2018 Actual	FY 2019 Planned/ Request	FY 2020 Projected
Sustainability Projects	0	161,000	161,000
Sustainability Activities other than projects	0	0	0
SPO Funded Projects (SPO funding portion only)	0	43,600	0
Site Contribution to SPO Funded Project	0	195,400	0
ESPC/UESC Contract Payments	0	0	0
Renewable Energy Credits (REC) Purchase Costs	18,900	21,000	23,000
Total	18,900	421,000	184,000

The lab 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/or the use of advanced and distributed energy technologies under the Computer Center Modernization project achieving a PUE of 1.3.

JSA decided against awarding a UESC project totaling about $3.48M addressing lighting, domestic water conservation, Ultra-Pure Water Reuse, and mechanical upgrades, due to operation risk. These elements are being implemented separately by the Lab as part of operations and maintenance efforts or incorporated into planned recapitalization projects. This approach is expected to reduce the risk while delivering the same or better outcome at a lower cost. The Sustainability Program Office is partially funding the Ultra-Pure Water Reuse project scheduled for completion this year.

All but one sustainability target was met this year. The sustainability objective expected to be below the FY 2018 interim target is water intensity (interim FY 2018 target -22% relative to 2007 baseline).

Projects and strategies to achieve future interim targets goal categories have been identified and incorporated into building renovation plans. Energy intensity (BTU/GSF) should realize significant reduction through high-efficiency lighting upgrade in subject buildings. Reduction of domestic water consumption strategies are included in building renovation plans.

The building level energy and water reductions will also contribute to achievement of High Performance Sustainability Building (HBSB) compliance for several additional facilities. To date, the laboratory has exceeded the minimum 15% (by GSF) compliance requirement for HPSB's. Domestic and industrial water reduction projects will contribute to achievement of future interim

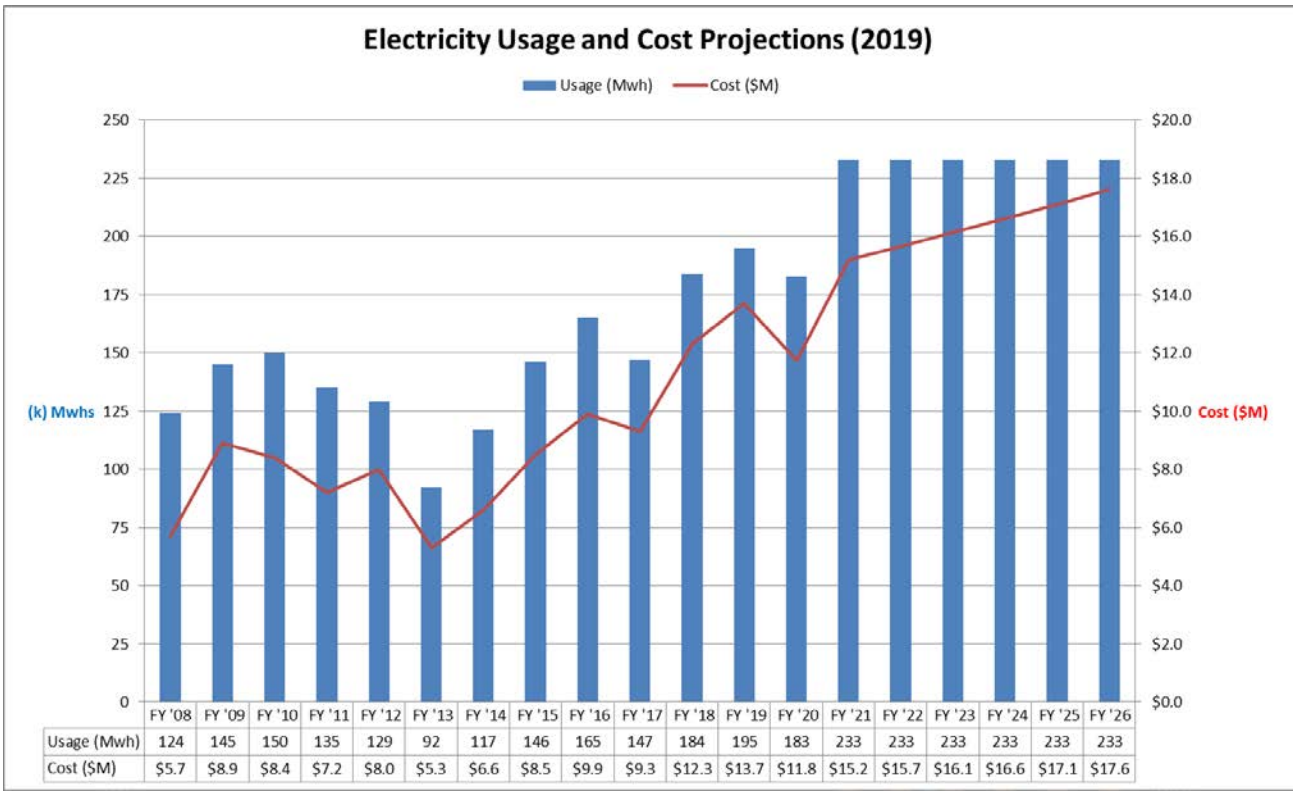
water intensity targets. Future alternative water strategies are under consideration to achieve a -36% reduction in water intensity (gallons per GSF) by FY 2025.

A previously completed climate change vulnerability assessment identified potential negative site impacts from flooding due to major storm events. Flood protection initiatives have been implemented to protect below-grade facilities from potential future flooding.

Electricity Usage and Cost Projections

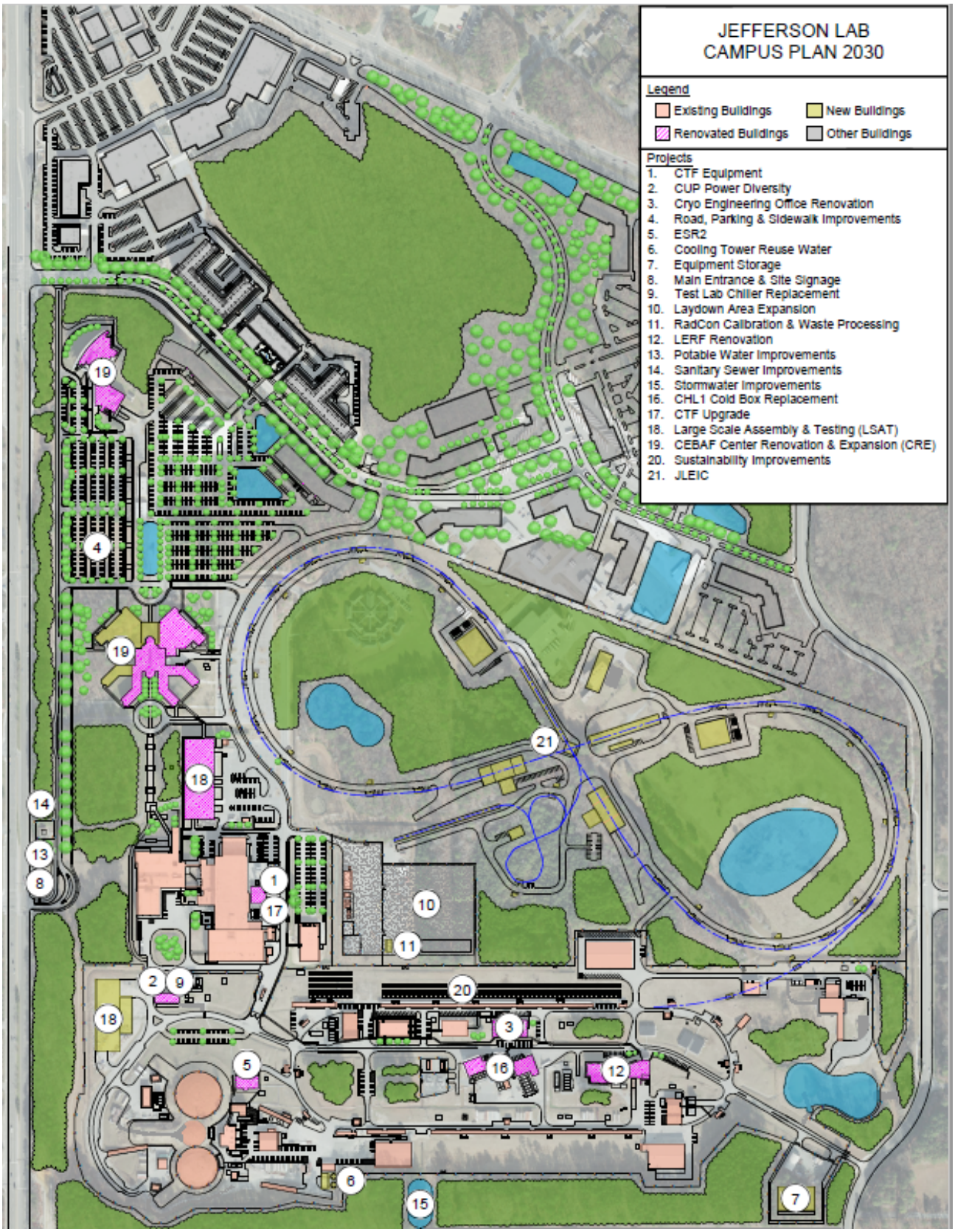
Figure 1 shows TJNAF's historical electricity usage in (k) Megawatt Hours and costs (actual year $M), and future projected electricity usage and costs. Projections are based on scheduled operations for FY 2019 of 32 weeks and FY 2020 of 26 weeks including low-energy summer runs both years. From FY 2021 forward, 34 weeks of operations are projected for each year.

Figure 1: Electricity Usage and Cost Projections



	FY '08	FY '09	FY '10	FY '11	FY '12	FY '13	FY '14	FY '15	FY '16	FY '17	FY '18	FY '19	FY '20	FY '21	FY '22	FY '23	FY '24	FY '25	FY '26
Usage (Mwh)	124	145	150	135	129	92	117	146	165	147	184	195	183	233	233	233	233	233	233
Cost ($M)	$5.7	$8.9	$8.4	$7.2	$8.0	$5.3	$6.6	$8.5	$9.9	$9.3	$12.3	$13.7	$11.8	$15.2	$15.7	$16.1	$16.6	$17.1	$17.6

Enclosure 1 – Land Use Plan



Enclosure 2 – Infrastructure Investment Table

Thomas Jefferson National Accelerator Facility

Infrastructure Objectives: *(color coded in table)*

- Objective 1 - High bay space to build and test experimental equipment, for SRF production, and for cryogenics fabrication
- Objective 2 - Adequate office and collaborative space for Laboratory staff and users
- Objective 3 - Creating reliable cryogenics capabilities for CEBAF operations and advanced R&D
- Objective 4 - Provide, protect, and improve infrastructure that enables world class science

		$000																				
Project Title	Site Project Code (if applicable)	Total	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	Funding Type	Funding Program	Primary Core Capability	Supports which SC Program(s)?	Project Category	Anticipated Reduction in Deferred Maintenance ($000)	Will change Overall Asset Condition of 1 or more assets	Will change Utilization Level of 1 or more assets from Not utilized/Under-utilized to Fully Utilized?	Comments
Cryogenics Test Facility (CTF) Equipment		**755**	500	255												GPP-Prog	NP	SC01	Multiple	Utility	0	No	No	
Central Utility Plant (CUP) Power Diversity		**700**	700													GPP-Prog	NP	SC25	NP	Utility	0	No	No	
Cryogenics Engineering Office Renovation		**1,780**	800	980												GPP-Prog	NP	SC16	NP	Bldg Renov/Modern	530	Yes-a	No	
Road, Parking & Sidewalk Improvements		**3,700**		825		1,485	1,390									GPP-Prog	NP	SC25	NP	Other	425	Yes-b	No	
End Station Refrigerator 2 (ESR2)		**9,500**			9,500											GPP-Prog	NP	SC20	NP	Utility	0	Yes-c	No	
Cooling Tower Reuse Water		**700**				700										GPP-Prog	NP	SC25	NP	Utility	0	No	No	
Equipment Storage Building		**4,700**					861	2,319	1,520							GPP-Prog	NP	SC01	NP	New Bldg	0	No	No	
Main Entrance and Site Signage		**1,000**							868	132						GPP-Prog	NP	SC25	NP	Other	0	No	No	
Test Lab Chiller Replacement		**1,800**								1,800						GPP-Prog	NP	SC25	NP	Utility	0	No	No	
Laydown Area Expansion		**1,500**								500	1,000					GPP-Prog	NP	SC25	NP	Other	0	No	No	
RadCon Calibration Lab and Waste Processing		**3,200**									1,462	1,738				GPP-Prog	NP	SC25	NP	New Bldg	0	No	No	
Potable Water Improvements		**2,100**										872	1,228			GPP-Prog	NP	SC25	NP	Utility	160	Yes-d	No	
Sanitary Sewer Improvements		**1,500**											1,200	300		GPP-Prog	NP	SC25	NP	Utility	0	No	No	
Stormwater Improvements		**2,400**											260	2,140		GPP-Prog	NP	SC25	NP	Other	0	No	No	
Sustainability Improvements		**3,180**												328	2,852	GPP-Prog	NP	SC25	NP	Utility	0	No	No	
CHL1 Cold Box Replacement		**8,000**	8,000													GPP-SLI	SLI	SC16	Multiple	Utility	0	Yes-e	No	
Cryogenics Test Facility (CTF) Upgrade		**5,000**				5,000										GPP-SLI	SLI	SC01	Multiple	Utility	0	Yes-f	No	
Low Energy Recirculator Facility (LERF) Renovation		**5,000**										5,000				GPP-SLI	Other	SC01	Multiple	Bldg Renov/Modern	0	No	No	
CEBAF Renovation & Expansion		**87,000**			10,000	40,000	37,000									LI-SLI	SLI	SC20	Multiple	Bldg Renov/Modern	3,500	Yes-h	No	
Large Scale Assembly & Testing (LSAT)		**60,000**					8,000	30,000	22,000							LI-SLI	SLI	SC16	Multiple	New Bldg	550	No	No	

Asset Condition Footnotes

Footnote	FIMS Real Property Unique ID	Current Overall Asset Condition	Anticipated Change in Condition if Funded	Antcipated DM Reduction $k
a	*130255*	*Substandard*	*Adequate*	*530*
b	*134099*	*Substandard*	*Adequate*	*435*
c	*208920*	*Inadequate*	*Adequate*	*0*
d	*134096*	*Substandard*	*Adequate*	*160*
e	*130258*	*Substandard*	*Adequate*	*0*
f	*130307*	*Substandard*	*Adequate*	*0*
g	*130259*	*Substandard*	*Adequate*	*550*
h	*129968*	*Substandard*	*Adequate*	*3,500*

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

SC Integrated Facilities and Infrastructure (IFI) Crosscut Data Table

Capital Investments (summarized from Investment Table)	FY 18 Actual	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25	FY 26	FY 27	FY 28	FY 29	FY 30
SLI Line Items			40,000	48,100									
SLI GPP	8,000			5,000			18,000			5,000			
GPP - SC Research Programs	2,000	2,060	9,500	2,185	2,251	2,319	2,388	2,460	2,534	2,610	2,688	2,768	2,852
Total DOE Capital Investment	**10,000**	**2,060**	**49,500**	**55,285**	**2,251**	**2,319**	**20,388**	**2,460**	**2,534**	**7,610**	**2,688**	**2,768**	**2,852**
Lab Minor Construction - IGPP (see Tab 1 for details)													
Lab Minor Construction - Other (see Tab 1 for details)													
Total Capital Investment	**10,000**	**2,060**	**49,500**	**55,285**	**2,251**	**2,319**	**20,388**	**2,460**	**2,534**	**7,610**	**2,688**	**2,768**	**2,852**

Maintenance and Repair Predictive, Preventive and Corrective M&R (incl. DM Reduction) (For Federally Owned Facilities)*	FY 18 Actual	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25	FY 26	FY 27	FY 28	FY 29	FY 30
Direct Funded	187	191	195	198	202	206	211	215	219	223	228	233	237
Indirect Funded	8,202	8,366	9,988	10,188	10,934	11,556	11,927	12,199	12,459	12,708	12,962	13,221	13,486
Total Predictive, Preventive and Corrective M&R	**8,389**	**8,557**	**10,182**	**10,386**	**11,137**	**11,763**	**12,137**	**12,413**	**12,678**	**12,932**	**13,190**	**13,454**	**13,723**
Annual Required Maintenance *(see FIMS Data Dictionary)*				**10,188**									

Operation, Surveillance & Maintenance (OS&M) of Excess and Unutilized Facilities	FY 18 Actual	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25	FY 26	FY 27	FY 28	FY 29	FY 30
Direct Funded	0	0	0	0	0	0	0	0	0	0	0	0	0
Indirect Funded	0	0	0	0	0	0	0	0	0	0	0	0	0
Total OS&M of Excess and Unutilized Facilities	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Total Maintenance and Repair & OS&M	**8,389**	**8,557**	**10,182**	**10,386**	**11,137**	**11,763**	**12,137**	**12,413**	**12,678**	**12,932**	**13,190**	**13,454**	**13,723**

Disposal and Demolition	FY 18 Actual	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25	FY 26	FY 27	FY 28	FY 29	FY 30
Direct Funded	0	0	0	0	0	0	0	0	0	0	0	0	0
Indirect Funded	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Disposal and Demolition	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Assessing Impacts of the Campus Strategy on Key Performance Indicators *(Assumes Investment Plan fully funded)*	FY 18 Actual	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25	FY 26	FY 27	FY 28	FY 29	FY 30
Deferred Maintenance ($000)**	6,497	7,147	7,331	8,065	8,871	9,333	10,266	7,293	6,597	6,465	6,336	6,209	6,085
Replacement Plant Value ($000)***	480,000	489,600	499,392	509,380	546,716	577,815	596,327	609,928	622,944	635,403	648,111	661,073	674,295
Building Area (GSF)	882,990	882,990	882,990	882,990	1,004,972	1,049,972	1,071,972	1,086,972	1,086,972	1,086,972	1,086,972	1,086,972	1,086,972
Increases	0	0	0	0	1	1	0	1	0	1	0	0	0
Removals	0	0	0	0	0	0	0	0	0	1	0	0	0
Buildings classified as Un-utilized /Underutilized****													
# of	0	0	0	0	0	0	0	0	0	0	0	0	0
GSF	0	0	0	0	0	0	0	0	0	0	0	0	0
Buildings Classified as "Adequate": *****													
# of	62	62	64	64	66	68	69	70	71	71	71	71	71
RPV	282,686	288,455	342,043	348,884	397,357	434,121	490,075	501,551	537,143	547,886	558,843	570,020	581,421
GSF	654,774	654,774	686,964	686,964	815,584	864,682	1,014,193	1,029,193	1,083,981	1,083,981	1,083,981	1,083,981	1,083,981
Buildings Classified as "Inadequate": *****													
# of	1	1	1	1	0	0	0	0	0	0	0	0	0
RPV	14	14	15	15	0	0	0	0	0	0	0	0	0
GSF	6,638	6,638	6,638	6,638	0	0	0	0	0	0	0	0	0

Note: Buildings are "Buildings" per FIMS "Property Type" data element. Do no include trailers. If you want to show plans for trailers, please prepare separate rows just for trailers.

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** For PNNL this would include EM facilities used by PNNL though PNNL could show SC and EM separately*

*** Projections should take into account inflation of current DM and planned projects/activities that remove DM. DM is total for all property types (Building, Trailers, and OSF's except land and OSF 3000). Use inflation factors consistent with your area.*

**** RPV is total RPV for all Property Types (Building, Trailers, and OSF's except land and OSF 3000's). Projections should take into account inflation of current RPV and planned projects that add or remove assets. Use inflation factors consistent with your area.*

***** See FIMS data element "Asset Utilization Level"*

****** See FIMS data element "Overall Asset Condition"*