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BROOKHAVEN
NATIONAL LABORATORY

Conceptual Design Report
Final Submittal

Brookhaven National Laboratory

Core Facility Revitalization (CFR)
Building 725

Upton, New York

HDR

Section 1
INTRODUCTION

1.0 Introduction

1.1 Background

The methods and techniques of scientific research at Brookhaven National Laboratory are increasingly dependent upon the ability to acquire, analyze, and store vast quantities of electronic data. The needs for data processing equipment and supporting infrastructure are anticipated to continue exponential growth, soon exceeding the capacity of existing data center resources, currently located in Building 515.

At the same time, the de-commissioning of the original National Synchrotron Light Source (NSLS-I) provides an opportunity to re-purpose an existing asset to meet this growing need in a facility with fundamentally sound basic characteristics, and in an advantageous central campus location.

The Core Facility Revitalization – (CFR) project anticipates the partial renovation and revitalization of Building 725 (NSLS-I) for use as a new computing facility with associated mechanical, electrical, fire protection and related systems.

1.2 Mission Need

This project anticipates enabling growth and providing expanded resources for a major User facility, RHIC/ATLAS, supporting expansion of the Computational Science Initiative (CSI), and potentially supporting future needs of other BNL programs. These new capabilities will support more rapid advances in particle physics, energy and material sciences, systems biology, climate science, and other programs. The Computational Science Initiative leverages simulation and software development capabilities in climate science, lattice Quantum Chromodynamics, accelerator physics, chemistry, and nano and materials science.

1.3 Program

The project provides data processing equipment space separately for RHIC/ATLAS, CSI, and potentially for other BNL occupants. Office and office support space is provided to support approximately 6 private offices and 6 shared offices in immediate proximity to the data center. Facility operations areas include mechanical and electrical equipment rooms, fire protection equipment areas, as well as loading, uncrating, assembly, and technician areas. Total project area is currently forecast at 61,980 GSF.

For a detailed tabulation of program requirements see Section 2.1.4, Project Description.

1.4 Budget

The Total Estimated Cost (TEC) is $ 67,072,000 and the estimated Total Project Cost (TPC) is $ 67,922,000.

1.5 Schedule

The preliminary overall project schedule is as follows:

Critical Decision	Fiscal Year (Oct.-Sept.)
CD-1 Approve Alternative Selection and Cost Range	September 2016
CD-2/3 Approve Performance Baseline/Site Prep	May 2018
CD-3 Approve Start of Construction	November 2018
CD-4 Approve Project Completion	July 2021

Section 2
PROJECT DESCRIPTION

2.0 Project Description

2.1 Building Use Description

2.1.1 Project Description

Computing activities at Brookhaven National Laboratory are currently housed primarily in Building 515 in the central campus. In addition to computing, the facility also supports network and communications equipment serving the entire campus. Computing and network resources have been deployed in a series of increments over time, with mechanical and electrical infrastructure typically configured and installed with capacity limited to the scale of a specific project or need. As a result, there is little consistency in system configuration or in the reliability that can be expected from systems in different portions of the building.

While some areas have electrical systems with Uninterruptable Power Supplies (UPS) and emergency generators, the true Achilles Heel of the facility is the single source of chilled water, that being from the Laboratory's Central Utility Plant. A utility outage affecting the BNL campus would result in a loss of cooling for the existing data center, likely resulting in equipment failures within a ten to fifteen minute window in the more densely utilized portions of the building.

In addition to the risk of external events, current RACF service level commitments to the ATLAS User community preclude a cumulative outage duration in excess of 3.5 days per year. With approximately 1.5 days per year anticipated for unplanned equipment failures, the remaining 2 day window does not provide sufficient duration for the execution of preventative maintenance activities required by the current infrastructure equipment profile.

The de-commissioning of the National Synchrotron Light Source (NSLS) Building 725 provides an opportunity to re-purpose a significant property asset in service of data center needs. The building is reasonably modern, large, and well located to serve the research community anticipated to increase. While much of the mechanical and electrical infrastructure dates to the building's original construction in the mid 1980's, the basic structure is robust and provides sufficient area to plan for long-term data center operations as well as related office space.

2.1.2 Research Programs

RHIC ATLAS COMPUTING FACILITY (RACF)

RACF began when the RHIC Computing Facility (RCF) was established in the 1990s to support the computing needs of the experiments (BRAHMS, PHENIX, PHOBOS and STAR) at the Relativistic Heavy Ion Collider (RHIC). The RCF was a full-service

scientific computing facility, which provided the bulk of dedicated computer processing, storage, and analysis resources for the RHIC experiments, along with general computing services for RHIC users.

In the mid 1990s, Brookhaven was selected to serve as the U.S. Tier 1 computing facility for the ATLAS experiment at the LHC (Large Hadron Collider) at CERN. The ATLAS Computing Facility (ACF) was established to support the computing needs of U.S. collaborators in the ATLAS experiment, leveraging the established infrastructure and capabilities of the RCF, and resulting in the formation of the RACF. In addition to utilizing the existing resources at the RCF, the ACF added support for newer computing services required to support the compute model planned by the ATLAS experiment.

RACF computing is challenged not only in terms of capability and scale but also in terms of operational economics. RACF is a leader in utilizing commodity off-the-shelf storage and processing hardware, and in leveraging efficient virtualization of the environment to harvest every CPU cycle.

The RACF computing environment currently leverages multiple UPS systems with non-redundant generator back-up and relies on the BNL Central Utility Plant (CUP) as a single-source of cooling resources (chilled water). The current ATLAS Tier-1 service availability requirement of 99% annual average uptime allows for 3.5 days of allowable downtime. Industry data suggests that the current infrastructure configuration is not capable of meeting these requirements when allowing for appropriate semi-annual preventative maintenance windows. A more robust data center infrastructure is required to address the ATLAS service level commitment.

COMPUTATIONAL SCIENCE INITIATIVE (CSI)

The mission of the Computational Science Initiative is to perform basic and applied research in all aspects of computational and data-intensive science, and, through collaboration and the provision of expert services and computer resources, enable and support new and existing opportunities for scientific discovery across the laboratory.

The mission of the Center for Data-Driven Discovery (C3D) is to bring under one umbrella al the data centric expertise at BNL and its collaborating institutions and to use these capabilities to analyze, simulate, and predict complex phenomena important to many areas of science.

NYCCS is a joint venture between Stony Brook University's Institute for Advanced Computational Science and Brookhaven National Laboratory's CSI. These centers have a core group of scientists and faculty who work to apply and develop high performance computing for science. They have a mission to support and expand the community of users of high performance computing for science discovery and technology development.

Data center resources are required to support anticipated computing equipment acquisitions in the next three to five years, including IBM equipment similar to Summit at Oak Ridge National Laboratory, DOE investments in commodity systems (x86, IB), and Institutional computing investments (x86, IB) supporting CFN and an HPC Code Center.

FUTURE EXPANSION – (POTENTIALLY NATIONAL SYNCHROTRON LIGHT SOURCE II COMPUTING)

With construction completed, commissioning of both the accelerator and related beamlines is proceeding, with access being provided to Users in the coming months. The seven initial beamlines will be joined by an additional twenty-one over the next three years, which are anticipated to engage a User population of over 2,000 by FY18.

The flux available at NSLS-II enables the development of immense data sets within relatively short experimental durations. Current estimates anticipate data generation on the order of 70 Terabytes per day and an annual storage requirement of over 14 Petabytes by FY18. The retention period for this data is not yet determined.

Analysis of the data thus generated constitutes a separate challenge. With the User community transitioning from “expert” users to scientists utilizing the synchrotron as a “tool”, most lack both the hardware and software resources necessary to perform analysis and related visualization of experimental data. This project can potentially offer the Light Source Directorate data center resources capable of meeting this need.

2.1.3 Project Goals

This project anticipates enabling growth and providing expanded resources for a major User facility, RHIC/ATLAS, supporting expansion of the Computational Science Initiative (CSI), and potentially supporting future needs of other BNL programs. These new capabilities will support more rapid advances in particle physics, energy and material sciences, systems biology, climate science, and other programs. The Computational Science Initiative leverages simulation and software development capabilities in climate science, lattice Quantum Chromodynamics, accelerator physics, chemistry, and nano and materials science.

As it specifically affects the data processing environment, anticipated Power Utilization Efficiency (PUE) goals will mandate certain approaches to cooling IT equipment. For air-cooled systems, such as will be prevalent in x86 dominated areas, control of the conditioning air path via aisle containment (“hot aisle”/”cold aisle”) should be anticipated. Additionally, economization technologies will be leveraged towards increased efficiency when outdoor conditions allow.

BNL and the DOE are committed to designing, locating, constructing, maintaining, and operating its facilities in an energy efficient and sustainable manner. These goals exist to enable higher standards of living, wider sharing of life's amenities, and maximum attainable reuse and recycling of resources, and do so in an economically viable manner consistent with Department and Agency missions. Where appropriate, we encourage the use of energy efficient products and designs, life cycle concepts, consensus-based standards, and performance measurement and verification methods that utilize good science, and lead to sustainable buildings.

2.1.4 Project Program

Programmatic components for the Building 725 data center are organized into three groups each having similar characteristics and infrastructure demands; Data Equipment space, Office and office support space, and Facility Operations (infrastructure) space.

Data equipment space includes separate rooms, and in some cases multiple rooms, for the three potential User groups; RHIC/ATLAS, CSC, and other potential future users. Additionally, space is designated for local network equipment (MDF/IDF) supporting data processing operations, for future expansion, and potentially for tape storage libraries.

Office support space includes six private offices and six shared offices immediately adjacent to the data halls anticipated to be utilized by technical and/or operations personnel. The building currently provides approximately 38,000 s.f. of office space on the second floor. The Computational Sciences Initiative office space is anticipated to be located there, and developed under a separate project. Seminar rooms and video conferencing facilities located on that adjacent floor are also anticipated to be shared resources for users of the data center.

Facility operations areas include electrical equipment rooms for switchgear, UPS, and emergency generators (outdoors); mechanical equipment rooms; fire protection equipment rooms; loading dock; a separate area for uncrating and initial assembly of equipment; an area for IT technicians to perform basic assembly, configuration, and commissioning of components; and an operations office adjacent to a mantrap controlling access into data processing areas.

A tabulation of space requirements is as follows:

BNL 725 Space Requirements Tabulation

USER/FUNCTION	QUANTITY	UNIT AREA (S.F.)	AREA (S.F.)
DATA EQUIPMENT SPACE			
RHIC/ATLAS			10,800
CSI			1,950
Future Expansion			3,450
Local Network Equipment	1	1,000	1,000
Tape Storage Libraries	12	400	4,800
Subtotal			**22,000**
OFFICE AND OFFICE SUPPORT			
Private Offices	6	120	720
Shared Offices	6	192	1,152
Subtotal			**1,872**
FACILITY OPERATIONS			
Electrical Equipment Rooms			
Switchgear	6	450	2700
UPS	5	300	1500
Mechanical Equipment Rooms	5	750	3750
Air Handling Equipment Rooms	4	3,000	12,000
Fire Protection Equipment Rooms	2	125	250
Loading Dock	1	320	320
Uncrate and Assembly Area	1	240	240
IT Technician Area	1	500	500
Operations Office / Mantrap	1	150	150
Pantry	1	100	100
Subtotal			**21,510**
Total Net Area			45,382
Grossing Factor 25%			11,345
TOTAL AREA			**56,727**

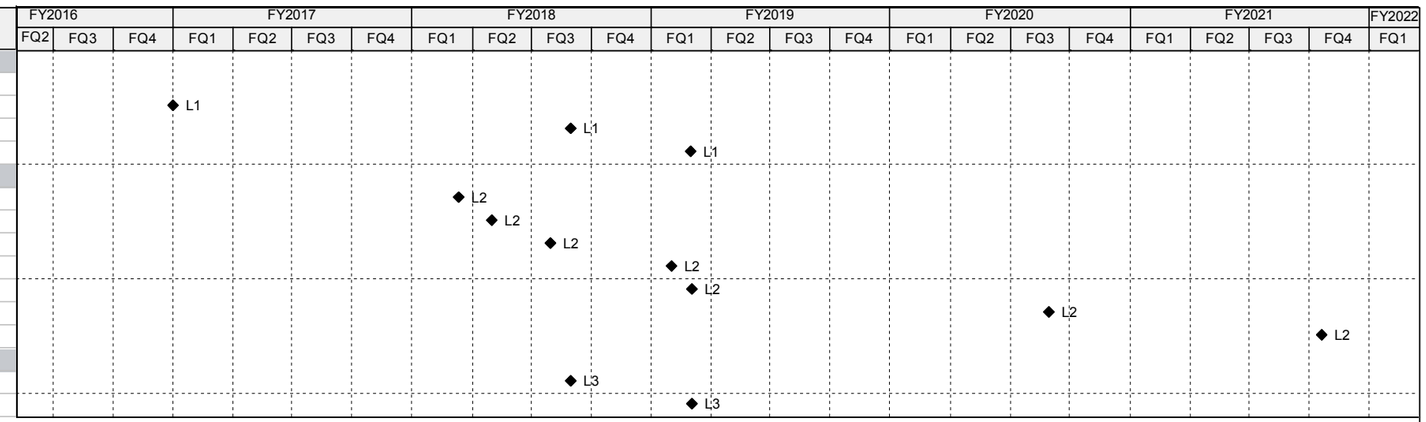
Not Included:

- Restrooms
- Lobby/Reception Areas
- Outdoor Equipment: Generators, Cooling Towers, Fuel Storage, Transformers

2.1.5 Project Milestones

Core Facility Revitalization

Activity ID	Activity Name	Start	Finish
Milestone Level: L1		01-Sep-15	30-Nov-18
MS0000	CD-0 Approve Mission Need	01-Sep-15	
MS1000	CD-1 Approve Alternative Selection & Cost Range		30-Sep-16
MS2000	CD-2/3A Approve Performance Baseline/Site		31-May-18
MS3000	Prep CD-3 Approve Start of Construction		30-Nov-18
Milestone Level: L2		11-Dec-17	21-Jul-21
MS1050	Award A/E Design Contract		11-Dec-17
MS1100	Award CM/GC Pre-Construction Services - Phase		31-Jan-18
MS1150	1 Complete Preliminary Design (30% Document)		30-Apr-18
MS2250	Complete Final Design (Bid Documents)		31-Oct-18
MS3100	Start Construction - Issue NTP	03-Dec-18	
MS3150	Construction Substantially Complete		29-May-20
MS4000	CD-4 Approve Project Completion		21-Jul-21*
Milestone Level: L3		01-Jun-18	03-Dec-18
MS2300	Start Site Preparation Activities	01-Jun-18	
MS3050	Award CM/GC Construction Services - Phase 2		03-Dec-18



◆◆ Milestone

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TASK filter: CFR Milestone.
Data Date: 01-Sep-15 Current Date: 04-Aug-16

2.2 Technical Facilities

2.2.1 Overview

Configuration, scale, and performance characteristics of the mechanical and electrical systems serving this project will be determined by both the required load (kW) and the availability requirements discussed above. Input regarding load requirements was solicited from the Users and is summarized in the table below:

BNL B-725 Hardware Forecasts - Update June 2016

User	Platform	Rack/Cabinet Quantity	Load per Rack/Cab. (kW)	Total Load (kW)
RACF				
	x86	300	10.00	3,000
Subtotal				**3,000**
CSI				
	Super Computer	15	100.00	1,500
	HPC	40	25.00	1,000
	x86	15	15.00	225
Subtotal				**2,725**
FUTURE CAPABILITY				
	Storage	1	15.00	15
	HPC	1	25.00	25
Subtotal				**40**
NETWORK				
		30	3.33	100
Subtotal				**100**
TAPE				
	Silos	9	15.00	135
Subtotal				**135**
TOTALS		**411**		**6,000**
Averages			14.60	

Determining the appropriate scale and configuration for infrastructure systems requires consideration of likely day one needs, the required capital investment, and flexibility to respond to future needs which may or may not be predictable. For this reason, the systems described herein are modular in nature, allowing for an initial capacity deployment responsive to known conditions but providing the capability to expand as equipment loads increase.

In discussions with the Users and BNL management, it was determined that an initial deployment of 2,400 kW (2 @ 1,200 kW), with a redundant (bypass) system of 1,200 kW capacity to provide for concurrent maintenance, would be an appropriate initial increment of development. Additionally, the primary service distribution systems, such as utility entrance switchgear and chilled water piping, would be sized to allow for the subsequent deployment of three additional 1,200 kW systems, for a total ultimate facility capacity of 6,000 kW. Note that these capacities refer to IT equipment loads, not total facility loads which will be larger primarily as a function of mechanical system efficiency.

2.2.2 Performance and Reliability

The need for nominally continuous operations has significant influence on the configuration and complexity of mechanical and electrical systems supporting a data center. The programming workshops focused on the subject of whether uninterrupted operations were required with each of the project's stakeholder groups in order to determine what design criteria was appropriate to their needs. The Uptime Institute's "Tier" rating system was utilized as a general point of reference in discussing mechanical and electrical system configurations as their white paper "Tier Classifications Define Site Infrastructure Performance"[1] provides comparative attributes for various prototypical systems including estimates of annual downtime based on field data.

While CSI representatives voiced concern regarding the protection of data from loss, they did not mention the need to maintain operations during a significant period of utility power loss. In the event of a utility outage, a desire was expressed to be able to execute a "soft shutdown" of processing operations in order to avoid data loss.

Alternately, RHIC/ATLAS operates as a Tier-1 service provider with an availability requirement of 99% (annual average) which translates to 3.5 days per year of scheduled and unscheduled downtime. RHIC/ATLAS representatives estimate an annual average of 1.5 days of downtime caused

[1] W. Pitt Turner IV, John H. Seader, PE, Vince Renaud, PE and Kenneth G Brill

by data equipment events, leaving a maximum of 2 days available for all necessary preventative maintenance. User representatives have indicated that this available window is insufficient to conduct required maintenance activities in the context of BNL/DOE processes and procedures.

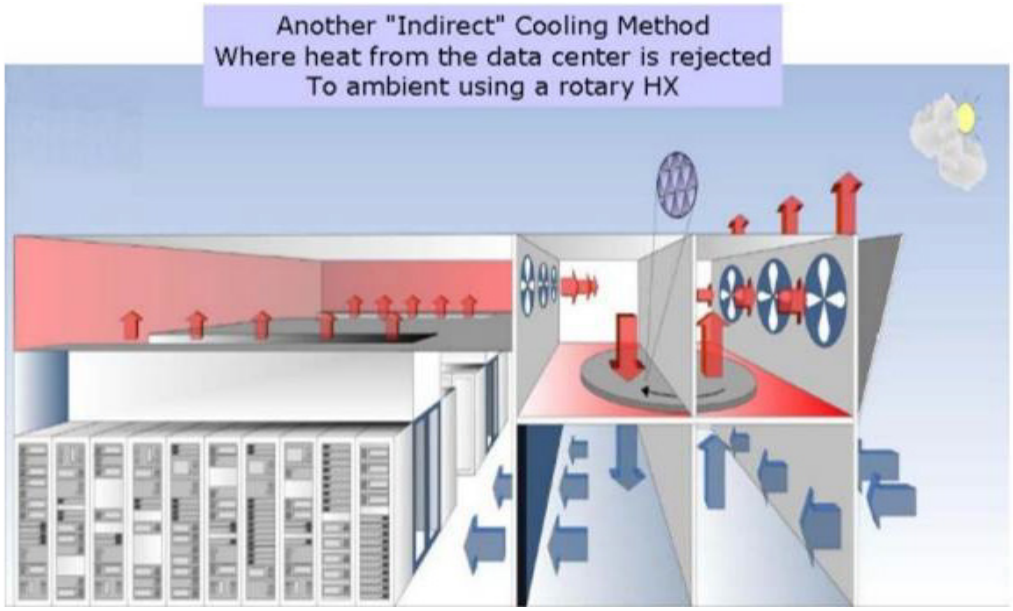
This observation is significant in that it dictates the need for system configurations capable of concurrent maintenance, which in the Tier system of the Uptime Institute would be described as Tiers III and IV. Tier III and IV systems are characterized by having redundant service and distribution components and pathways (typically "N+1") which enable the shutting down of one power source in order to perform maintenance activities without losing service to the data processing environment. This characteristic is predicated on the assumption that all data processing equipment is "dual cord" meaning that it can be connected to two power sources and automatically switches to one or the other. Alternately, rack mounted automatic transfer devices can be utilized for single cord equipment.

2.2.3 Data Center Equipment

As described above, the infrastructure equipment supporting data center operations has been configured to support deployment in increments corresponding to 1.2 MW of IT equipment load, with an ultimate capacity of 6.0 MW. These systems include service entrance switching equipment, transformers, emergency generators, switchgear, Uninterruptible Power Supplies (UPS), distribution panelboards, and raceway systems. Ultimately, five 1.2 MW systems are "primary" to the IT load; a sixth 1.2 MW system is designated "bypass" and provides the capability for concurrent maintenance by being able to assume the load from any of the primary systems.

The day-one project configuration consists of two 1.2 MW primary systems and the 1.2 MW bypass system.

Energy efficiency mandates have dictated a change in Mechanical system approach subsequent to completion of programming efforts. Executive Order 13693 requires this facility to operate at a Power Utilization Efficiency (PUE) of between 1.2 and 1.4. Achieving this level of efficiency will require primary reliance on a system capable of operating in an economizer mode for significant periods of time per year. The familiar water side economizer mode utilizing cooling towers available with a chilled water system is not capable of meeting these standards in the Long Island climate. Therefore, outside air economizer equipment will be utilized which leverages air-to-air heat exchange to provide cooling for a significant portion of the year. This air-side economizer system will be augmented by a chilled water system providing "peak shaving" when climate conditions exceed the operational capabilities of the heat exchange equipment.

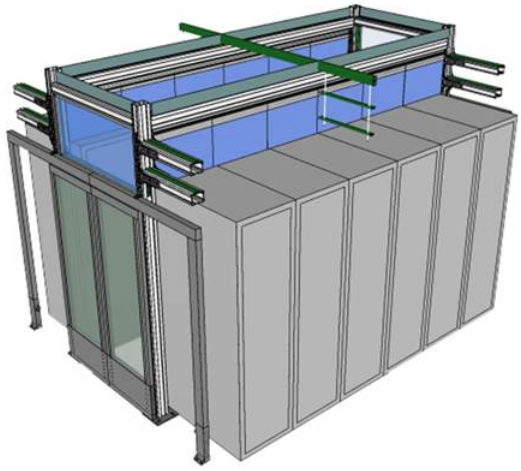


Theory behind rotary heat exchanger technology

The air side equipment will be configured to support load densities in the range of 10 to 25 kW per computing equipment cabinet. For higher power densities, chilled water will be available to utilize supplemental cooling equipment such as in-row fan-coil units, rear door heat exchangers, or water cooled computing equipment. Of significant importance to the operation of the air-side equipment will be the provision of hot aisle containment, which encloses the rear of the computing equipment cabinet rows in order to contain and direct the return air path. This containment provides for higher return air temperatures than would be possible by simply drawing mixed room air back to the air handling equipment, resulting in higher operating efficiency.

Data Center Systems

- Aisle Containment
  - Integrated provisions for air path containment, cable trays, and power raceways.
  - Required due to anticipated power density.



Double-interlock, pre-action fire sprinkler systems will be used in all data halls. These systems require the simultaneous activation of both smoke detection as well as the fusible link at a sprinkler head in order to allow the flow of water into sprinkler piping. Air–aspirating smoke detectors will be utilized as a component in this system. Gaseous suppression is not anticipated except for the Network room (and potentially in the Tape Library) where users requested this added level of protection.

An EPO (Emergency Power Off) system will be provided in each data hall and will be configured with provisions for a test mode.

Green Grid Level 3 advanced measurement mandates the monitoring of IT equipment power consumption at the point of equipment connection.

2.2.4 Data Center Information Management (DCIM)

Taking into consideration recent publications, vendor interviews, and past projects, HDR has identified several leading DCIM providers offering the following capabilities identified by BNL. This software is intended to serve both the IT and Facility management sides of the data center; however, the extent of integration of systems has yet to be determined.

IT FEATURES

- Floor Space Planning
- Rack Planning and Design
- Asset Management
- Capacity Planning
- Change Management
- Data Import & Export
- Reporting Dashboard with Key Performance Indicators
- Server Virtualization and Optimization

FACILITY FEATURES

- Power Metering (Upstream & BCM)
- Power Factor, RMS, Transient Monitoring, etc.
- Environmental (Temp, Humidity, Dew Point, Air Flow, etc.) Monitoring
- Real Time Power Utilization Efficiency (PUE) output and monitoring
- Reporting Dashboard with Key Performance Indicators

Vendors such as Emerson, Schneider Electric, iTRACS, Nlyte, Raritan and Modius were evaluated. All can meet or exceed the requirements identified by BNL. It is important to note that the cost of a DCIM solution can vary greatly ($600 to $2,500 per rack) depending on the options, overall functionality, and level of integration desired in the final configuration.

BNL should evaluate the larger, well-known providers in the industry. Smaller suppliers run the risk of being acquired by larger firms, resulting in product licensing and support challenges.

Considering the requirements listed above, including the dual functionality of monitoring both facility and IT assets, we recommend that Schneider Electric be considered as potentially the best overall value given operational objectives. With most DCIM solutions, BNL will have the option of increasing the capabilities of the solution for an additional cost per rack.

The final cost of the solution will depend on the quantity of equipment that will be included and the functionality of the system, but a Rough Order of Magnitude cost would be $1,000 per rack.

2.3 Building 725 General Scope of Work

2.3.1 Architecture

CONCEPTUAL LAYOUT

A preliminary layout of space allocation has been developed. Generally, IT equipment spaces are located in the largest and most geometrically regular area, in the Southeast quadrant of the building (formerly the VUV ring). Mechanical and Electrical infrastructure equipment is located in the Northeast quadrant in proximity to the existing loading dock area and in a new expanded portion of the Southeast quadrant. Office and office support areas are located in the second floor portion of the Southeast quadrant.

INTERIOR DEMOLITON ALLOWANCE – GENERAL

An allowance will be provided for general demolition which includes the removal and disposal, in their entireties, of partitions, ceilings, floor finishes, ductwork and equipment in areas indicated. Refer to Section 2.4. All of the NSLS-I experimental equipment has been removed.

INTERIOR DEMOLITION ALLOWANCE – MECHANICAL / ELECTRICAL ROOMS

An allowance will be provided for demolition of mechanical / electrical rooms which includes the removal and disposal, in their entireties, of air handler, chillers, pumps and associated piping and electrical distribution equipment in areas indicated. Refer to Section 2.4.

EXTERIOR ENVELOPE – WINDOW SYSTEMS REPLACEMENT

The Window System Replacement scope includes the removal of all fixed and operable aluminum windows and storefront in the facility and the installation of a 3 1/2 IN deep, Anodized Aluminum Thermally Broken Fixed Window System glazed with 1 IN Clear Low - E, Insulated Glass Units (IGU). Refer to Section 2.4.

EXTERIOR ENVELOPE – STANDARD ROOF REPLACEMENT

The Roof Replacement scope, for areas not directly over Data Halls, includes the removal of existing roofing system and insulation in its entirety and the selective abatement of asbestos base flashing at parapets. Installation of two-ply hot modified bitumen roof system including 4” polyisocyanate roof insulation. The roof system is composed of a heavy 60 mil modified base sheet with a 120 mil 70 SRI index white granular cap sheet. Refer to Section 2.4.

EXTERIOR ENVELOPE – DUAL MEMBRANE ROOF / LEAK DETECTION SYSTEM

The Dual Membrane Roof / Leak Detection System scope includes the removal of existing roofing system and insulation in its entirety and the selective abatement of asbestos base flashing at parapets. Installation of Dual Membrane Roof System which consists of fully adhered single ply 60 mil EDPM membrane including 4" polyisocyanate roof insulation over a two-ply hot modified bitumen roof system.. The computer operated leak detection system, designed to continuously detect, locate and report water intrusion and moisture accumulation within the roof assembly, shall be installed between the two-ply modified bitumen roof system and polyisocyanate insulation of EPDM roof system. The approximate areas of roof systems are indicated, refer to Section 2.4.

2.3.2 Life Safety

INTRODUCTION

This section is intended to identify minimum requirements of the proposed Data Center as mandated by the applicable codes and standards, campus guidelines and the jurisdiction having authority.

CODES, STANDARDS AND GUIDELINES

The design and construction of this facility will comply with all relevant codes and standards as defined by the jurisdictions having authority. These include but are not limited to the following:

- New York State Building Code
- American with Disabilities Act (ADA) Accessibility Guideline (ADAAG)
- FM Property Loss Prevention Data Sheets 5-32 – Data Centers
- NFPA 13 – Installation of Sprinkler Systems
- NFPA 70 – National Electrical Code with Local Amendments
- NFPA 72 – Fire Alarm and Signaling Code
- NFPA 75 – Standard for the Fire Protection of Information Technology Equipment

OCCUPANCY CLASSIFICATION

The original occupancy classification for the Building 725 included limited areas of High-Hazard Group H-3. The current and proposed occupancy classification for the repurposed NSLS Data Center will be Business Group B in accordance with the New York State Building Code.

CONSTRUCTION TYPE

The existing construction type classification for the Building 725 is Type IIB (unprotected). The allowable area for a Group B, building of Type IIB construction, equipped with an automatic sprinkler system, is only 69,000 GSF per floor; however, the facility complies with, NYSBC Section 507.5, this requirement allows a Two – Story Building of Unlimited Area. Under this section the type of construction is not restricted by area and the existing structure can remain unprotected.

FIRE AND SMOKE BARRIERS

Fire and smoke barriers exist and are being maintain at all exits and elevator enclosures and shafts.

Additional 2 hour fire and smoke barriers are being provided, at the request of BNL, at the perimeters of all Data Halls and Electrical Rooms to establish compartmentalization, provide protection of assets, and minimize damage potential from a fire event. Refer to Section 2.4 for fire and smoke barrier layouts.

ACCESSIBILITY

The majority of the existing facility is in compliance with New York State ADA with the following exceptions. Door hardware and room signage are not incompliance.

2.3.3 Fire Protection

Fire Protection Systems will be in compliance with the FM 5-32 and NFPA 13/NFPA 75 standards for all areas within the B-725 project scope.

For the Data Center halls fire sprinkler systems shall be of a double interlocked pre-action configuration with possible inputs of loss of air pressure and smoke detector activation. An early warning smoke detection system such as an air-aspirating type smoke detector shall be installed. Sprinklers and detectors will be zoned for each compartment.

Preaction sprinkler systems will be provided for the entire Data Center and will be double interlock. The inspectors test connection shall be located at the far end of the system. Sprinklers shall be pendant with U-Bend connection,

upright, listed dry type, or horizontal sidewall where the heads drain back to the main to assure no water remains in the piping. Piping and fittings for preaction system will be Schedule 40, interior and exterior galvanized, steel. Double interlock systems will be sized to deliver water to the test connection in no more than 60 seconds.

Clean Agent Systems: Alternates 12a and 12b respectively provide the Network and Tape Storage rooms with a clean agent fire suppression system in accordance with NFPA 2001 and FM LPDS 4-9. The clean agent will be FM-200 a halogenated hydrocarbon which is a halon replacement gas which is environmentally friendly. This type of system suppresses a fire by chemical reaction rather than smothering a fire by displacing oxygen.

The system consists of pressurized cylinders containing the gas which are piped to open nozzles within the space. A control panel is wired to the actuating valve at the cylinders and to smoke or heat detectors within the space. Upon actuation of a detector the system goes into alarm, with lights and horns activated. Doors to the space will automatically close. Dampers in the HVAC ducts will close to seal the space airtight to contain the gas within the space. Only upon another detector activating does the system arm and a timer starts counting down. A dead-man type abort switch is located within the space in the event of a false alarm or trapped person. This will hold the timer and prevent the release of the gas. When the timer counts out the system will discharge the gas.

The cylinders and control panel will be located in the mechanical room closest to the space. Signs will be provided inside and outside the space to alert people as to the type of suppression system within the space and to get out in the event of an alarm.

The area will also be provided with a backup double interlock pre-action system to maintain protection in the event of the activation and depletion of the clean agent.

2.3.4 Heating, Ventilating, and Air Conditioning

OWNER'S REQUIREMENTS

This document includes:

All Brookhaven National Lab (BNL) requirements identified through 10 May 2016.

Where BNL exhibited no specific criteria preference, HDR's standard HVAC design criteria or professional judgment was employed.

Criteria agreed upon with BNL:

A minimum of eight (8) hour fuel supply will be adequate for the Standby generators and will consist of each generator's belly tank. BNL has onsite source of fuel oil and will replenish each generator's fuel supply as needed in an extended power outage.

Hot aisle containment will be utilized to obtain Federal mandated Power Utilization Effectiveness (PUE) of 1.4 or lower.

The power/heat load for the Data Center shall be as follows:

Ultimate Build-out: 6,000 kW

ULTIMATE LOAD @ BUILD OUT									
User	**Platform**	**Rack/ Cabinet Quantity**	**Load per Rack/ Cab. (kW)**	**Total Load (kW)**	**% by DAE**	**% by CHW**	**DAE Load (kW)**	**Direct CHW Cooled Load (kW)**	**CHW Plant Capacity with 87% for DAE's (tons)**
RHIC/ATLAS									
	x86	300	10	3,000	100%	0%	3,000	0	742
Subtotal				3,000			3,000	0	742
CSI									
	Super Computer	15	100	1,500	0%	100%	0	1,500	426
	HPC	40	25	1,000	75%	25%	750	250	257
	x86	15	15	225	100%	0%	225	0	56
Subtotal				2,725			975	1,750	739
NETWORK									
		30	3	100	100%		100	0	
Subtotal				100			100	0	25
TAPE									
		12	15	180	100%		180	0	
Subtotal				180			180	0	45
Sub-Totals		**412**		**6,005**					
Grand Total (kW)							**4,255**	**1,750**	**6,005**
Cooling Load (tons)									**1,550**

PHASE I @ INITIAL CONSTRUCTION									
User	**Platform**	**Rack/ Cabinet Quantity**	**Load per Rack/ Cab. (kw)**	**Total Load (kw)**	**% by DAE**	**% by CHW**	**DAE Load (kw)**	**Direct CHW Cooled Load (kw)**	**Chw Plant Capacity with 87% for DAE's (tons)**
RHIC/ATLAS									
	x86	200	8.0	1,600	100%	0%	1,600	0	396
Subtotal				1,600			1,600	0	396
CSI									
	Super Computer	0	100.0	0	0%	100%	0	0	0
	HPC	20	25.0	500	75%	25%	375	125	128
	x86	10	8.0	80	100%	0%	80	0	20
Subtotal				580			455	125	148
NETWORK									
		30	3	100	100%		100	0	
Subtotal				100			100	0	25
TAPE									
		12	15	180	100%		180	0	
Subtotal				180			180	0	45
Sub-Totals		**272**		**2,460**					
Grand Total (kW)							**2,335**	**125**	**2,460**
Grand Total (tons)									**613**

In determining the allocation of power to various uses in the Phase 1 deployment, an adjustment to the cabinet/rack power density for the RACF equipment was assumed since there will be a substantial migration of existing equipment (currently consuming approximately 5 kW per cabinet). Therefore, it was assumed that x86 equipment would be provided with 8 kW per cabinet (vs. 10 kW in the ultimate projection) in Phase 1. This adjustment allows for reasonable power allocations to other users and potential users in the facility.

Phase I: 2,400 kW

User	Platform	Rack /Cabinet Qty	Load per Rack/ Cab (kW)	Total Load (kW)	% by DAE	% by CHW		DAE Load (kW)	Chilled Water Cooled Load (kW)	CHW Plant Capacity with 87% for DAE's (tons)
										87%
RHIC/ATLAS										
	x86		200	8.0	1,600	100%	0%	1,600	0	396
Subtotal					1,600			1,600	0	396
CSI										
	Super Computer	0		100.0	0	0%	100%	0	0	0
	HPC	20		25.0	500	75%	25%	375	125	128
	x86	10		8.0	80	100%	0%	80	0	20
Subtotal					580			455	125	148
NETWORK		30		3	100	100%		100	0	
Subtotal					100			100	0	25
TAPE		12		15	180	100%		180	0	0
Subtotal					180			180	0	45
Sub-Totals		**272**		**2,460**						
Grand Total (kW)								**2,335**	**125**	**2,460**
Grand Total (tons)										**613**

» Campus steam, pumped condensate and chilled water will be available for the Data Center. Chilled water shall be arranged as a backup to the new chilled water system for failure and concurrent maintenance of the system.

» Standby power will be provided for HVAC equipment and UPS for all pumps, BMS and equipment control panels to prevent rebooting of control processors in a power outage.

» HVAC equipment shall provide for concurrent maintenance for all equipment serving the Data Center loads.

CODES, REGULATIONS, AND DESIGN STANDARDS

Current editions of all Codes, Regulations and Standards shall apply unless otherwise noted.

LOCAL AND/OR STATE CODES

- International Mechanical Code
- International Energy Conservation Code
- NFPA 13 Standard for the installation of Sprinkler Systems
- NFPA 14 Standard for the installation of Standpipe and Hose Systems
- NFPA 90A Standard for the Installation of Air Conditioning and Ventilating Systems
- NFPA 90B Standard for the Installation of Warm Air Heating and Air Conditioning Systems
- NFPA 101 Life Safety Code
- NFPA 110 Standard for Emergency and Standby Power Systems
- American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
- ASHRAE Standard 15 Safety Code for Mechanical Refrigeration
- ASHRAE Standard 62 Ventilation for Acceptable Indoor Air Quality
- ASHRAE Standard 90.1 Energy Standard for Buildings Except Low-Rise Residential Buildings
- Factory Mutual System (FM)
- Air Conditioning and Refrigeration Institute (ARI)
- Air Diffusion Council (ADC)
- Air Movement and Control Association (AMCA)
- American National Standards Institute (ANSI)
- American Society for Testing and Materials (ASTM)
- American Welding Society (AWS)
- American Water Works Association (AWWA)
- Associated Air Balance Council (AABC)
- Cooling Tower Institute (CTI)
- Manufacturers Standardization Society of Valve and Fitting Industry (MSS)

- American Society of Mechanical Engineers (ASME)
- ANSI/SMACNA HVAC Duct Construction Standards
- SMACNA Seismic Restraint Manual
- DOE Data Center specific mandates (2009, 2011)
- LEED Data Center building guidelines (2013)
- Green Grid Level 3 monitoring requirements (2012)
- Executive Order 13693 – Target PUE 1.2 – 1.4

LOAD AND ANALYSIS CRITERIA

Ambient Weather Conditions

The outside ambient conditions that shall be used for design of HVAC and mechanical systems are based upon latest ASHRAE Handbook of Fundamentals 2009 Weather Data for Islip, NY being the closest weather data to Upton, NY.

Code Exempt Areas: Data Center and Support Areas, and similar areas. (Reference per ASHRAE Energy Standard)

WINTER:

- Dry Bulb: 10.6°F (99.6% of the hours during December through February, temperatures will not be below 10.6°F based on average weather data).
- Moisture Content: 0 grains per pound of dry air.

SUMMER:

- Dry Bulb: 88.4°F (0.4% of the hours during June through September, temperatures will exceed 88.4°F based on average weather data).
- Wet Bulb: 73.4°F (Coincident with design dry bulb temperature).
- Daily Range: 14°F
- BNL requested infrastructure be capable of additional cooling to ~95°F which will be handled by use of campus chiller plant for additional chilled water capacity above the design point above of 88.4°F.

Code Conformance Areas

Offices, Conference Rooms, Toilets, and similar areas. (Reference per ASHRAE Energy Standard).

WINTER:

- Dry Bulb: 15.1°F (99% of the hours during December through February, temperatures will not be below 15.1°F based on average weather data).
- Moisture Content: 4 grains per pound of dry air.

SUMMER:

- Dry Bulb: 85.6°F (1% of the hours during June through September, temperatures will exceed 85.6°F based on average weather data).
- Wet Bulb: 72.1°F (Coincident with design dry bulb temperature).
- Daily Range: 14°F
- Cooling Tower Selection at 76.7°F wet bulb, per ASHRAE.
- Prevailing Wind:
- Winter: 320 degrees at 14 mph
- Summer: 230 degrees at 13 mph

Space Temperature and Humidity

DATA CENTER AND SUPPORT AREAS, AND SIMILAR AREAS

Summer (cooling): 75°F db, target setpoint for supply air per ASHRAE Recommended values for Data Centers; allow up to 80.6°F db maximum according to ASHRAE Class A1 Allowable for Data Centers, 50% RH maximum, based on ASHRAE Recommended values.

Winter (heating): 68°F db, minimum, RH based on ASHRAE Recommended values.

Offices, Office Support Areas, Conference Rooms, and Similar Areas:

Summer (cooling): 75°F db, maximum, 50% RH.

Winter (heating): 68°F db, minimum, 35% RH ±5% (±2°F db, control tolerance in rooms with thermostats).

Offices, office support areas, conference rooms, and similar areas to have unoccupied modes for temperature setback (Cooling: 85°F, Heating: 65°F), and airflow reduction and/or system shutdown during scheduled un-occupied periods. The un-occupied mode will be on a room-by-room basis with a local over-ride at its respective temperature sensor.

MECHANICAL EQUIPMENT ROOMS AND PENTHOUSE

Summer (cooling): Ventilated 10-15 air changes per hour maximum based on gross volume (thermostatically controlled to ~95°F db).

Winter (heating): 65°F db

ELECTRICAL CLOSETS

Summer (cooling): 86°F db average, 104°F db maximum.

Winter (heating): 65°F db, minimum

Internal Load Criteria

PEOPLE

METABOLIC RATES		
Area/Degree of Activity	Sensible BTU/hr.	Latent BTU/hr.
DATA CENTER	275	475
OFFICES	250	200
SUPPORT AREAS	275	475
CONFERENCE/BREAK ROOMS	245	155
MECHANICAL AREAS	375	625
STORAGE	250	200

Note: *The above metabolic rates have been adjusted to reflect an equal percentage of male and female population.*

EQUIPMENT

Data Center: Refer to Tables at the beginning of this section for Ultimate Build-out and Phase I equipment loads.

OFFICES AND SUPPORT

HEAT GAINS		
Area	**Sensible Watts/sq.ft.**	**Latent BTU/hr./sq.ft.**
Offices	2.0	- - -
Support Areas	2.0	- - -
Conference/Break Rooms	2.0	0.50
Corridors	0.0	- - -
Storage	0.0	- - -
Copy & Vending Areas	10.0	- - -
Server Rooms	30.0	- - -
Communication / IT Closets	15.0	- - -

Note: *Final designs to be verified against manufacturer's heat rejection data.*

LIGHTING

HEAT GAINS		
Area	**Watts/sq.ft.**	
Data Center & Support	1.0	
Offices	1.0	
Support Areas	1.0	
Conference/Break Rooms	1.3	
Corridors	0.5	
Storage	0.8	
Copy & Vending Areas	1.1	

HOURS OF OPERATION

Hours of operation are HDR estimates which were used for energy simulation purposes only.

Offices	10 hrs/day, 5 days/week
Data Center	24 hrs/day, 7 days/week

Building design shall comply with applicable energy codes and Executive Order 13693 for Data Centers.

Building Envelope and Energy Conservation Criteria

- Based upon a location of Islip, NY at 40.79 latitude, 73.10 longitude, the International Energy Conservation Code (IECC), ASHRAE 90.1 requires the design of the exterior envelope of this facility to comply with the following criteria based on 5,306 annual heating degree days (base 65°F), 795 annual cooling degree days (base 65°F).
- Maximum Overall U-Value ("Uo") for Gross Exterior Wall Assemblies = 0.33 BTU/hr/sq. ft./ °F
- Maximum Overall U-Value ("Uo") for Roof/Ceiling Assemblies = 0.076 BTU/hr/sq. ft./ °F
- Maximum Overall U-Value ("Uo") for Floor/Soffit Assemblies exposed to ambient = 0.08 BTU/hr/sq. ft./ °F
- Maximum Overall Thermal Transfer Value (OTTV) for Gross Exterior Wall = 33.5 BTU/hr/sq. ft.

LEED CONSIDERATIONS

The base design targets a LEED certified Silver rating. Various enhancements might be considered for a higher rating. These items are addressed in various paragraphs above and below.

Air System Design Criteria

System Selection

HVAC equipment serving all areas will be selected with the capacity to maintain conditions of the hours of an average year as noted above.

Equipment selections will be in accordance with the IECC and have Coefficients of Performance (COP's) or Energy Efficiency Ratios (EER's) which are equal to or greater than the minimum values required by Code.

The following spare capacity will be employed in the design calculations:

- Cooling Capacity 10%
- Heating Capacity 10%
- Air Handling Supply / Return / Exhaust Capacity 10%
- Air System Leakage 3% of Total

Ventilation

Minimum design outside air ventilation rates noted below are from ASHRAE Standard 62.1-2007 and are for occupied times only. These rates meet or exceed the current requirements of the International Mechanical Code (IMC) for natural and mechanical ventilation.

MINIMUM VENTILATION RATES IN THE BREATHING ZONE

Data Center	5 cfm/person and 0.06 cfm/ft^2
Data Support	5 cfm/person and 0.06 cfm/ft^2
Corridors	0 cfm/person and 0.06 cfm/ft^2
Storage Rooms	0 cfm/person and 0.12 cfm/ft^2
Shipping/Receiving	0 cfm/person and 0.12 cfm/ft^2
Public lobby	5 cfm/person and 0.06 cfm/ft^2
Office space	5 cfm/person and 0.06 cfm/ft^2
Conference Room	5 cfm/person and 0.06 cfm/ft^2

EXHAUST AIR RATE

Janitor/trash/recycle	1.0 cfm/ft^2
Public Rest Rooms	70 cfm/water closet or urinal

RECIRCULATED AIR RATE

The actual ventilation rates supplied to each space will match the most stringent requirements of the following criteria:

- Cooling load requirements
- Heating load requirements
- Minimum ventilation requirements
- Exhaust air make-up requirements

» Office areas and support rooms shall be provided with 15% minimum outside air from air handling system during occupied hours.

PRESSURIZATION CRITERIA

Office/Support Areas: To offset air infiltration when the fan systems are on, an excess amount of supply air equal to 0.05 cfm/sq. ft. shall be allocated for all exterior offices or zones within 15'-0" from the perimeter wall as a minimum.

All other areas requiring pressurization shall have "passive pressure control" to maintain airflow direction into (negative) or out of (positive) a room. Direction of airflow shall be accomplished through air balance of supply, ducted return and purge exhaust air quantities only.

FILTRATION CRITERIA

All air serving office and occupied spaces shall be prefiltered with a double filter module consisting of MERV 8 (30% ASHRAE) and MERV 11 (65% ASHRAE) efficiency filters and final filter module downstream of the fan section with MERV 14 (85% ASHRAE) efficiency filters.

Data Center fresh air / pressurization unit shall be prefiltered with a double filter module consisting of MERV 8 (30% ASHRAE) and MERV 11 (65% ASHRAE) efficiency filters and final filter module downstream of the fan section with MERV 14 (85% ASHRAE) efficiency filters.

The recirculating Data Center Air Economizer unit shall be evaluated for no filters on the recirculation air stream. The outside air stream shall be prefiltered with a filter module consisting of MERV 8 (30% ASHRAE) and MERV 11 (65% ASHRAE) efficiency filters.

AIR DISTRIBUTION CRITERIA

General

Ductwork construction will be based on SMACNA Duct Pressure Classifications and all ductwork shall be Seal Class A regardless of pressure classification:

SMACNA Pressure Classifications			
Pressure Class	*Maximum Velocity*	*Qty/per Sensible*	*Sealing Required*
2" w.g.	2,500 fpm	Over 1" w.g. up to 2" w.g.	Transverse Joints, Longitudinal Seams & Duct Wall Penetrations
3" w.g.	4,000 fpm	Over 2" w.g. up to 3" w.g.	Transverse Joints, Longitudinal Seams & Duct Wall Penetrations
4" w.g.	4,000 fpm	Over 3" w.g.	Transverse Joints, Longitudinal Seams & Duct Wall Penetrations
6" w.g.	4,000 fpm	Over 4" w.g.	Transverse Joints, Longitudinal Seams & Duct Wall Penetrations
10" w.g.	4,000 fpm	Over 6" w.g. up to 10" w.g.	Transverse Joints, Longitudinal Seams & Duct Wall Penetrations

* Pressure ratings apply to positively and negatively pressurized ductwork

- Fire dampers shall be provided where required by Building or Mechanical Codes.
- Volume dampers shall be provided to facilitate air balancing.
- Smoke dampers and smoke detectors shall be provided in all air systems as required by code and NFPA requirements.
- Access doors shall be provided in the ductwork in the following locations:
  - At all automatic control dampers.

- On both upstream and downstream sides of each in-line fan.
- At fire dampers, smoke dampers, and smoke detectors.

SIZING CRITERIA

Louver velocities

» Fresh air intake (at roof):	650 fpm maximum through free area
» Fresh air intake (at grade):	600 fpm maximum through free area
» Relief/Exhaust:	1000-1500 fpm through free area
» Undercuts:	250 fpm

Damper Velocities

» Fresh air intake:	1000 fpm maximum
» Toilet & Janitorial exhaust air:	1000-1500 fpm

Coil Velocities

» Preheat coils:	600 fpm
» Cooling coils: 550 fpm	475 - 500 fpm for Latent coils; 450- for Sensible coils
» Reheat coils:	650-700 fpm
» Maximum rows:	6 for chilled water coils
» Maximum fins:	12 per inch for chilled water coils

Fan Velocities

» Low velocity, Low pressure:	1700-2000 fpm outlet velocity
» High velocity, Med. pressure:	2000-3500 fpm outlet velocity

Duct Friction Loss Sizing Criteria

Supply Air: 2,000 feet per minute velocity at fan outlet. Remaining ductwork will be sized based on a maximum of 0.08 inch pressure drop per 100 equivalent feet of duct or 1500 fpm, (Exception: some supply air ductwork on low pressure side of the terminal air units may be sized at a higher pressure drop without penalizing fan energy or system performance).

Miscellaneous Exhaust Air (Toilet, Mechanical Room, Electrical Closets, etc.): 0.08 inch pressure drop per 100 feet of duct run

SUPPLY SYSTEM

Insulation will be provided for all air conditioning supply ducts. Blanket wrap will be used in concealed spaces and rigid board where exposed in mechanical equipment rooms. The Dry Air Economizer supply ductwork will not require insulation.

All ductwork shall be G-90 galvanized sheet steel.

OUTSIDE AIR SYSTEMS

A minimum of 2" rigid board insulation will be provided for all outside air ductwork.

Outside air intakes shall be located as low as building conditions permit, upwind of building exhaust discharges and away from adjacent building exhaust discharges.

BALANCING AND DUCT PRESSURE TESTING

Air Balance

All air handling systems shall be balanced for specified design flow rate ±5% and system static pressure.

Air balance reports will be submitted for final review and approval.

Testing and balancing will be performed by an independent contractor contracting with BNL.

Test all ductwork greater than 1" pressure classification with air pressure not less than 125% of its duct pressure classification before external insulation is applied.

As required, test portions of system to permit finish work.

Leakage not to exceed maximum values identified by SMACNA HVAC Air Duct Leakage Test Manual (Seal Class A).

Testing procedures shall be as described by SMACNA HVAC Air Duct Leakage Test Manual.

Test low pressure ductwork to 1.25 times listed fan operating pressure with 500 Pa 2 IN WG minimum but not greater than duct construction pressure limits. Test ductwork before insulation is applied.

Duct pressure classifications shall be indicated on details on the final contract drawings. Tests will be to pressures indicated. Tests on suction side of fans to be under negative pressure test.

Special Test Requirements

Smoke testing of Data Center Hot Containment Aisles.

STEAM AND HYDRONICS SYSTEM CRITERIA

General System Criteria

Pipe guides, anchors, expansion loops, supports, expansion joints, vents, drains, controls, etc. shall be provided where required for all piping systems.

Gauges, thermometers, gauge cocks, thermo-wells, shut-off valves, control valves, and other devices will be provided for each piece of equipment for operation, maintenance, and balancing purposes.

All piping systems will be cleaned and flushed.

All piping systems shall be tested in excess of service pressure and leakage.

All hydronic systems shall be balanced for specified design flow rate and pump head. Balancing reports will be required. Balancing will be performed by an independent agency, contracting with BNL.

Hydronic Systems

The following sizing criteria apply to both open and closed piping systems; as a minimum sizing shall be in accordance with ASHRAE 90.1.

CHILLED WATER/ CONDENSER WATER/HOT WATER (<2 INCH)

- Maximum pressure drop: 4 feet head per 100 equivalent feet of pipe
- Maximum velocity: 8 feet per second

CHILLED WATER/ CONDENSER WATER/HOT WATER (>2 INCH)

- Maximum pressure drop: 8 feet head per 100 equivalent feet of pipe
- Maximum velocity (mech. room): 12 feet per second
- Maximum velocity (outside mech. room): 8 feet per second

Pipe Material

- 2” and smaller: Type L copper, soldered joints
- 2-1/2” and larger: Schedule 40 steel pipe
- Welded or seamless black steel
- Welded or grooved mechanical joints

Propylene Glycol Systems

The following water systems with have 40% propylene glycol systems:

- Hot Water Preheat System
- Each glycol system with have glycol feed tank with premixed glycol and feed pump controlled off system pressure switch

The following systems shall be provided with a Chemical Pot feeder:

- Chilled Water System
- Hot Water Preheat System
- Direct Cooling Water System

STEAM SYSTEMS

Design shall be based on a minimum of 125 psig at the building entrance. Pressure reducing stations will reduce steam pressure to 15 psig for heating and humidification systems.

Steam Piping Sizing Criteria

STEAM

Total Piping Pressure drop: 10% of operating pressure at source or pressure reducing station

Maximum velocity (mech. room): 12,000 fpm

Maximum velocity (outside mech. room): 8,000 fpm

CONDENSATE SYSTEMS

All pumped condensate is listed under Water Systems

Condensate return systems will be sized at ¼ psig pressure drop per 100 equivalent feet of pipe. All piping will have a minimum slope of 1/16” per linear foot of piping towards end of main steam trap.

Steam Trap sizing safety factor for warm-up loads is 2 to 1.

PIPING MATERIALS

Steam piping: Schedule 40 welded steel or seamless black steel pipe with welded fittings.

Condensate: Schedule 80 seamless black steel pipe with welded fittings.

CHEMICAL TREATMENT SYSTEM

Complete system consisting of chemical drums, metering pumps, blowdown/chemical controllers, piping connections and other accessories.

INSULATION

- Cold Pipe Insulation: Closed cell elastomeric foam
- Hot Pipe Insulation: Preformed commercial-grade fiberglass

Sizes

- As required by ASHRAE 90.1
- Steam vent piping within building will be insulated for safety reasons
- Aluminum jackets shall be on pipes exposed outside

CONTROL SYSTEM CRITERIA

Refer to the Controls Basis of Design section

ACOUSTIC AND VIBRATION CRITERIA

General

All noise and vibration criteria will be in accordance with general data indicated in ASHRAE Systems Handbook.

Acoustical and vibration treatment shall be provided, as required, to all system components, to maintain specified space noise criteria.

Acoustical

General: Equipment will be selected as required to meet Code, and the following room noise criteria:

AREA TYPE	CRITERIA (NC) RANGE
Private Office	35 - 40
Open Office Areas	45 - 55
Data Center Areas	55 - 65
Conference Rooms	30 - 40
Corridors and Public Areas	35 - 45

Note: *The above noise criteria does not include operating machinery and activities within the space.*

Vibration

Vibration isolators and flexible connections will be provided for all rotating equipment such as pumps, fans, etc.

Vibration isolation hangers will be provided when applicable within 50 feet of pumps.

SEISMIC CRITERIA

All elements of the mechanical system shall be installed to withstand seismic forces as required by building code. All piping, ductwork, and equipment with an Ip of 1.5 will be seismically braced.

Exceptions

Ip = 1 and Ducts or pipes are suspended by hangers less than 12 inches in length

Ip = 1 and HVAC ducts are less than 6 sq. ft. in area

Ip = 1 and Piping of highly deformable material of 2 inch in diameter or less

Site Class: D

IBC (year TBD), for Seismic Design Category: Risk Category II

Site Design Category: B

Seismic Importance Factor IE: 1.0

SPECIAL CRITERIA

The following equipment is on standby power:

- Air Handling Units serving Data Center spaces
- Heating Systems
- Exhaust Fans
- Cooling Plants Systems

All hydronic pumps and Building Automation Controls with all control panels shall be on UPS; including dedicated equipment control panels.

Expansion Capabilities

All systems capacities are based on projected future space and population requirements.

Chilled, Hot and condenser water systems will be designed with valved and capped connections to facilitate ease of future expansion.

The Direct Cooling water piping shall be extended under all of the raised floor with isolation valves on both supply and return every 10 feet to allow for future connections without disrupting service to the operating Data Center.

Pipe mains will be sized for the ultimate future capacity to be determined in Design Development Phase.

The design of utility services will provide the flexibility and accessibility necessary to accommodate program re-orientation, expansion, and modifications.

SYSTEM DESCRIPTIONS

Heating and Cooling Systems

STEAM TO HOT WATER HEAT EXCHANGERS

Four Heat Exchangers to be provided for Build-out

Capacity: 12,960 MBtuh for Ultimate Build-out; with each heat exchanger capacity at 4.320 MBtuh

HX Selection: Bell & Gossett

Phase I will include three (3) heat exchangers to allow concurrent maintenance and for failures

HOT WATER PREHEAT PUMPS

Capacity: 435 gpm, 70 ft of head, 40 HP

Pump Selection: Bell and Gossett Series 1510 3BC 4x3x9

The preheat hot water supply/return temperatures shall be 140 Deg F/120 Deg F, respectively

Hydronic hot water distribution pumps with VFD’s

COOLING SYSTEMS

The cooling plant will be comprised of water cooled centrifugal chillers, chilled water pumps, direct cooling water pumps, cooling towers, condenser water pumps, and chemical treatment. The plant is configured to provide n redundancy on local chillers with the campus chilled water system serving as n+1 redundancy for failure and to allow for concurrent maintenance on the system.

CHILLERS

Five Chillers to be provided for Build-out sized based on 1,200 kW power increments of the Data Center.

Capacity: 310 tons/each

Chiller Selection: JCI

Primary Chilled Water Pumps, include flow to Direct Cooling System

Capacity: 620 gpm, 70 ft of head, 20 HP

Pump Selection: Bell and Gossett Series 1510 6E 5x4x9.125

Phase I will include two (2) chillers and three (3) chilled water pumps; pumps providing a n+1 redundancy of local pumps while the chillers are only “n” redundancy with the campus chilled water system serving as backup for concurrent maintenance.

The chilled water supply/return temperatures shall be supply at 44º F and return at 56º F, respectively. The distribution to the Dry Air Economizers shall be arranged to allow for a mixing station to provide the 60º F supply water.

COOLING TOWERS

Five Cooling Towers to be provided for Build-out

Capacity: 310 tons/each

Selection: Marley NC; towers to comply with FM Guidelines.

Condenser Water Pumps

Capacity: 930 gpm, 80 ft of head, 25 HP

Pump Selection: Bell and Gossett Series 1510 5E 6x5x9.875

Phase I will include two (2) cooling towers and three (3) condenser water pumps providing a n+1 redundancy of local pumps. The cooling towers will be located on the existing dunnage on the roof of the building, existing cooling towers to be demolished.

The condenser water supply/return temperature shall be 85º F / 95º F, respectively.

DIRECT COOLING SYSTEM

Flat plate water to water heat exchanger will be provided to generate chilled water supplied at 55°F, returned at 65°F for the direct cooling system for Data Center equipment. The heat exchangers will be equipped with a third set of

ports to make use of water side economizer from the cooling towers. A filtration system will be provided for the condenser water prior to the inlet of the heat exchangers. Direct cooling water pumps with variable frequency drives will be provided.

Five Flat Plate Heat Exchangers to be provided for Build-out.

Capacity: 125 tons/each; 300 gpm @ 10ΔT/each

Phase I will include two (2) flat plate heat exchangers and three (3) direct cooling water pumps providing a n+1 redundancy of local pumps.

DIRECT COOLING WATER PUMPS

Capacity: 300 gpm, 70 ft of head, 10 HP

Pump Selection: Bell and Gossett Series 1510 3BC 4x3x8.625

The direct cooling water supply/return temperatures shall be 55 Deg F/65 Deg F, respectively.

HUMIDIFICATION SYSTEMS

Clean steam for humidification shall be provided from the central campus steam distribution system; which is approved for humidification and only treated with approved water treatment chemicals for humidification. The central steam shall be reduced in pressure to 15 psig steam shall be piped to jacketed dispersion type humidifiers located in each AHU.

Humidifier Selection: Armstrong 9000

DATA CENTER AIRSIDE SYSTEMS

Air conditioning for the principal data center will be provided by high efficiency Dry Air Economizers Coolers, direct equipment cooling and with local in-rack cooling solutions depending on cooling load concentrations. Note: there will not be any conventional computer room air handling units (CRAH).

DRY AIR ECONOMIZER COOLER

4,270 kW of the ultimate build out 6,000 KW technical cooling load is anticipated to be cooled by the Dry Air Economizer system with Hot-Aisle containment. The units cool primarily by rejecting the heat indirectly to outdoors. Coolers are required to support the Data Center cooling load with one redundant (n+1) unit for fault tolerance as a minimum. Normally each Dry Air Economizer Cooler will draw hot data center return air from hot aisles or rack chimneys via the return plenum above the data center with variable speed fans and pass it through a heat wheel where the heat is absorbed. The cool air will then be filtered through MERV 8 filters, pass through a backup

chilled water cooling coil and distributed to the cold aisles of the data center at low velocity. The heat absorbed in the heat wheel is then rejected to the outdoor air through variable speed ventilation fans with MERV 8 and MERV 13 filters. If the outdoor air temperatures cannot meet the cooling requirements chilled water cooling coils will supplement the outdoor heat rejection.

Dry Air Economizers: Phase I load consisting of ~2,234 kW. The Dry Air Economizer units shall be distributed among the Phase I facility in 400 kW capacity units.. Due to the compartmentalization of electrical systems and their configuration; Phase I will include seven (7) 400 kW units and four (4) 100 kW units. The Build-Out will require the addition of seven (7) more 400 kW units.

Direct Cooling Water: 1,729 kW (494 tons) of the ultimate build out 6,000 KW technical cooling load is anticipated to be cooled directly by the cooling water system through direct equipment cooling or via In-Rack cooling solutions. A medium temperature 55°F chilled water loop shall be provided under the raised access floor distributed to the equipment, sized to ultimately provide the 1,735 kW of technical cooling with 166 kW (47.4 tons) of cooling provided at Phase I.

Dry Air Economizer

These custom air handling units will have the following components:

OUTSIDE AIR TUNNEL

- Isolation fire/smoke dampers
- Angle pre-filters; MERV 8 minimum efficiency on the inlet of outside air
- Sensible Heat Recovery Wheel – Outside Air - Economizer
- Preheat coil

SUPPLY AIR TUNNEL

- Return fan sections utilizing fan array to ensure n+1 redundancy. Fans shall be equipped with airfoil blades.
- Sensible Heat Recovery Wheel – Outside Air – Economizer.
- Supply fan sections utilizing fan array to ensure n+1 redundancy. Fans shall be equipped with airfoil blades.
- Chilled Water Cooling Coil.
- Final filters: MERV 14 minimum efficiency.

» Sound attenuators.

  » Isolation fire/smoke dampers.

» Access sections.

» Double wall insulated construction.

» Estimated Dry Economizer Air Handling Unit Sizes.

- 400 kW AHU ~50,000 cfm
- 100 kW AHU ~12,500 cfm

DEDICATED OUTSIDE AIR VENTILATION AIR HANDLING EQUIPMENT (HVAC)

Ventilation, pressurization and humidity control for the data center is provided by a dedicated makeup air system. The Makeup Air Units are constructed with low leakage 4" thick double wall and roof systems and consists of an intake plenum with near bubble tight dampers, MERV 8 and MERV 14 filters, hot water [glycol] preheat coil, clean steam humidifier, chilled water cooling coil, a hot water reheat coil and an array of multiple direct drive plenum plug supply fans and a discharge plenum. The makeup air temperature and dew point will be controlled to maintain the data center humidity. The makeup air volume will be controlled to maintain date center pressure and humidity set points.

These normal service, packaged air handling units will have the following components:

» Air-side economizer.

» Angle pre-filters; MERV 8 minimum efficiency.

» Return fan sections utilizing fan array to ensure N+1 redundancy. Fans shall be equipped with airfoil blades.

» Return – Purge discharge.

» Glycol Preheat Coil.

» Humidifier Section.

» Hydronic Cooling Coils.

» Supply & Return fan sections utilizing fan array to ensure N+1 redundancy. Fans shall be equipped with airfoil blades.

» Final filters: MERV 14 minimum efficiency.

» HEPA filters: MERV 17 minimum efficiency.

» Sound attenuators.

» Isolation fire/smoke dampers on return and supply air streams.

» Access section between components to allow for complete servicing of unit.

» Double wall insulated construction.

Estimated Air Handling Unit Size

The direct ventilation AHU's shall be sized to provide positive pressurization of the building. The Phase I direct ventilation AHU shall be sized for 1,500 – 2,500 cfm.

SITE UTILITIES

Campus Utilities

» Steam: 125 psig, saturated at entrance

» Pumped Condensate: discharge pressure to be determined

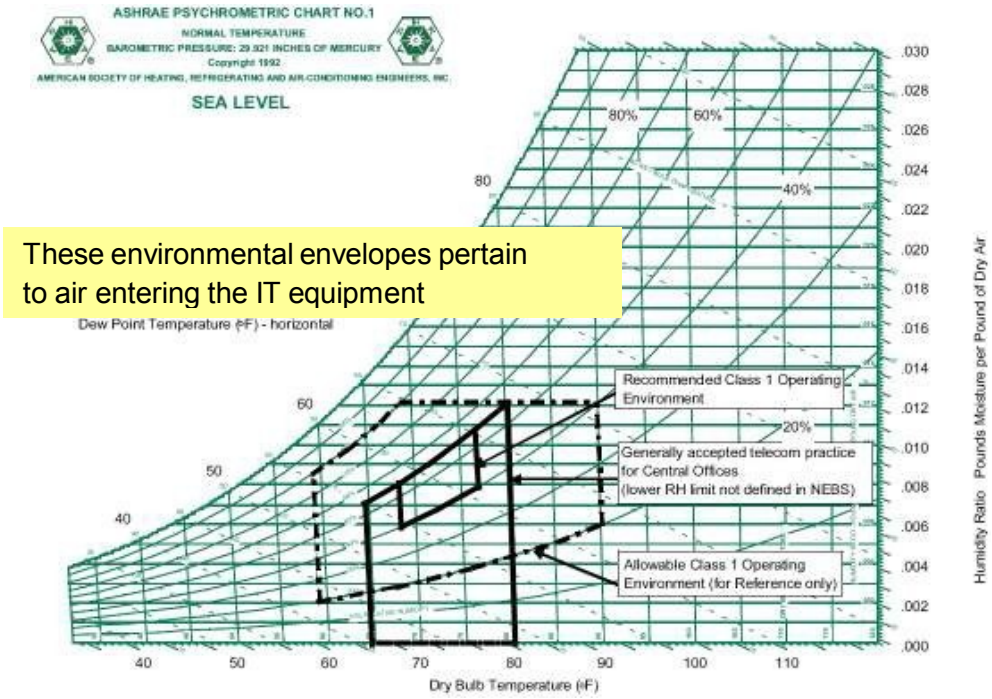
» Campus CUB chilled Water: 42^0F supply and 52^0F return

Energy & Humidity

The following will review the new ASHRAE Recommendation for Data Center Environments, especially with a focus on humidity levels within the Data Center. ASHRAE and dot.com companies came together to research environmental conditions in Data Centers to determine a larger allowable envelope of operation dependent upon varying ambient conditions in an effort to lower energy usage and cost for Data Centers.

OVERVIEW

The current recommended environmental envelope for IT Equipment is listed in Table 2.1 of the 2004 referenced ASHRAE Datacom book. These recommended conditions as well as the allowable conditions refer to the inlet air entering the datacom equipment. Specifically, it lists for data centers in ASHRAE classes 1 and 2 a recommended environment range of 20 to 25°C (68 to 77 °F) (dry bulb temperature) and a relative humidity (RH) range of 40% to 55%. (See the allowable and recommended envelopes for Class 1 in the Psychrometric chart below):



The purpose of the recommended envelope is to give guidance to data center operators on maintaining high reliability and also operating their data centers in the most energy efficient manner. The allowable envelope is where IT manufacturers test their equipment in order to verify that the equipment will function within those environmental boundaries. Typically manufacturers will perform a number of tests prior to announcement of a product to verify that their product meets all the functionality requirements within this environmental envelope.

This is not a statement of reliability but one of functionality of the IT equipment. However, the recommended envelope is a statement on reliability. For extended periods of time, the IT manufacturers recommend that data center operators maintain their environment within the recommended envelope. Exceeding the recommended limits for short periods of time should not be a problem, but running near the allowable limits for months could result in increased reliability issues. In reviewing the available data from a number of IT manufacturers the 2008 expanded recommended operating envelope is the agreed-upon envelope that is acceptable to all the IT manufacturers, and operation within this envelope will not compromise overall reliability of the IT equipment.

The previous 2004 and 2008 recommended envelope data is shown in table below:

	2004 VERSION	2008 VERSION
Low End Temperature	20°C (68 °F)	18°C (64.4 °F)
High End Temperature	25°C (77 °F)	27°C (80.6 °F)
Low End Moisture	40% RH	5.5°C DP (41.9 °F)
High End Moisture	55% RH	60% RH & 15°C DP (59°F DP)

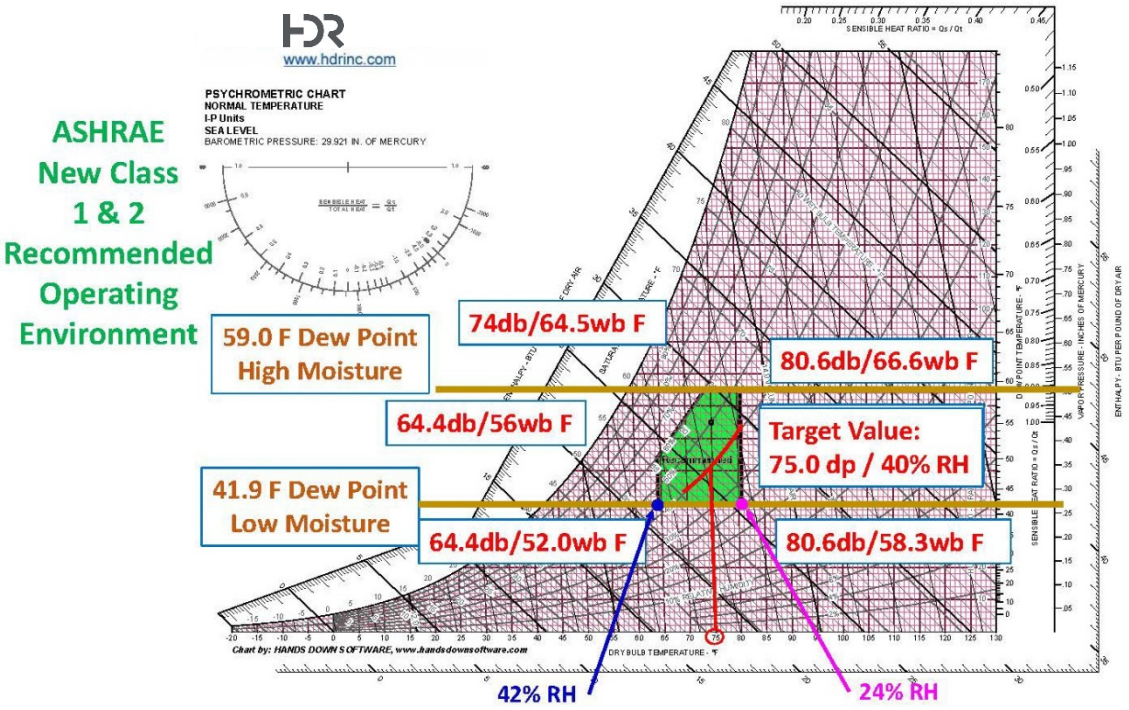
Neither the 2004 nor the 2008 recommended operating environments ensure that the data center is operating at the optimum energy efficiency. Depending on the cooling system design and outdoor environmental conditions there will be varying degrees of efficiency within the recommended zone. For instance, when the ambient temperature in the data center is raised, the thermal management algorithms within some datacom equipment will increase the speeds of the internal fans to

compensate for the higher inlet air temperatures, potentially offsetting the gains in energy efficiency due to the higher ambient temperature. It is incumbent upon each data center operator to review and determine, with appropriate engineering expertise, the ideal operating point for their system. This will include taking into account the recommended range and their site specific conditions.

The range of operation mentioned above; applies to the inlets of all equipment in the data center. Attention is needed to make sure the appropriate inlet conditions are achieved for the top portion of the equipment racks. The inlet air temperature in many data centers tends to be warmer at the top portion of racks. This warmer air also affects the relative humidity resulting in lower values at the top portion of the rack. The air temperature generally follows a horizontal line on the psychometric chart where the absolute humidity remains constant but the relative humidity decreases

TARGET VALUE

The Data Center will use a “target” value of 74^0F and 40% RH; as opposed to “setpoint” since setpoint implies one value or point on the Psychrometric chart. The sequence of operation would be to operate within the ASHRAE Recommendation envelope for Class I environments as shown as a green trapezoidal shape shown below:



LOWER MOISTURE LIMIT

The motivation for lowering the moisture limit is to allow a greater number of hours per year where humidification (and its associated energy use) is not required.

The previous recommended lower limit was 40% RH. The main concern with decreased humidity is that the intensity of static electricity discharges increases. The mechanism of the static discharge and the impact of moisture in the air are not widely understood.

The 2008 recommended range includes a dew point temperature as low as 5.5°C (41.9°F) which correlates to a range from 24% RH at 80.6°F db (pink dot and text) to 42% RH at 64.4F db (blue dot and text). Discussions with IT equipment manufacturers indicated that there have been no known reported ESD issues within the current recommended environmental limits. In addition the information on ESD mechanisms do not suggest a direct relative humidity correlation with ESD charge creation or discharge, but does demonstrate a strong correlation of dewpoint to charge creation, a lower humidity limit based upon a minimum dewpoint (rather than minimum relative humidity) is proposed. Therefore the 2008 recommended lower limit is a line from 18°C (64.4°F) dry bulb and 5.5°C (41.9°F) dew point temperature to 27°C (80.6°F) dry bulb and a 5.5°C (41.9°F) dew point temperature. Over this range of dry

bulb temperature and a 5.5°C (41.9°F) dew point the relative humidity varies from approximately 24% to 42%.

Another practical benefit of this change is that process changes in data centers and their HVAC systems, in this area of the psychrometric chart, are generally sensible only (i.e. horizontal on the psychrometric chart). Having a limit of relative humidity greatly complicates the control and operation of the cooling systems and could require added humidification operation at a cost of increased energy in order to maintain an RH when the space is already above the needed dew point temperature. To avoid these complications, the hours of economizer operation available using the 2004 guidelines were often restricted.

UPPER MOISTURE LIMIT

Based on extensive reliability testing of Printed Circuit Board (PCB) laminate materials, it has been shown that conductive anodic filament (CAF) growth is strongly related to relative humidity. As humidity increases, time to failure rapidly decreases. Extended periods of relative humidity exceeding 60% can result in failures, especially given the reduced conductor to conductor spacing's common in many designs today.

The upper moisture region is also important for disk and tape drives. In disk drives, there are head fly-ability and corrosion issues at high humidity. In tape drives, high humidity can increase frictional characteristics of tape, head wear and head corrosion. High relative humidity in combination with common atmospheric contaminants is required for atmospheric corrosion. The humidity forms monolayers of water on surfaces, thereby providing the electrolyte for the corrosion process. 60% RH is associated with adequate monolayer buildup for monolayers to start taking on fluid-like properties. Although disk drives do contain internal means to control and neutralize pollutants, maintaining humidity levels below the critical humidity levels of multiple monolayer formation retards initiation of the corrosion process. A maximum recommended dew point of 15°C (59°F) is specified to provide an adequate differential between the recommended and allowable envelopes.

The following table provides performance data for a 400 kW capacity Dry Air Economizer and effective PUE associated with it based on ambient temperature conditions:

400 kW Dry Air Economizer Performance Data																						
Outside Air		Unit					Wheel Temperatures (°F)				HX Wheel Effectiveness	Wheel rpm	Supply Fans		O/A Fans		Recirculating Mode		Component Power Consumption (kW)				
From (°F)	To (°F)	Hrs	PUE	Input kW	% HX Wheel	% CHW	RA	SA	OA	EA			tsp ("wc)	cfm	tsp ("wc)	cfm	O/A cfm	R/A cfm	Chiller	SA Fans	O/A Fans	HX Wheel	BAS
3.2	5.0	6	1.06	21.7	100%	0%	101.3	75.0	35.0	92.0	0.86	6.00	2.21	43,327	0.53	19,978	13,092	6,886	---	18.3	1.6	1.6	0.3
5.0	6.8	5	1.06	21.7	100%	0%	101.3	75.0	35.0	92.0	0.86	6.00	2.21	43,327	0.53	19,978	13,369	6,610	---	18.3	1.6	1.6	0.3
6.8	8.6	20	1.06	21.7	100%	0%	101.3	75.0	35.0	92.0	0.86	6.00	2.21	43,327	0.53	19,978	13,657	6,321	---	18.3	1.6	1.6	0.3
8.6	10.4	21	1.06	21.7	100%	0%	101.3	75.0	35.0	92.0	0.86	6.00	2.21	43,327	0.53	19,978	13,958	6,020	---	18.3	1.6	1.6	0.3
10.4	12.2	25	1.06	21.7	100%	0%	101.3	75.0	35.0	92.0	0.86	6.00	2.21	43,327	0.53	19,978	14,273	5,705	---	18.3	1.6	1.6	0.3
12.2	14.0	32	1.06	21.7	100%	0%	101.3	75.0	35.0	92.0	0.86	6.00	2.21	43,327	0.53	19,978	14,602	5,376	---	18.3	1.6	1.6	0.3
14.0	15.8	22	1.06	21.7	100%	0%	101.3	75.0	35.0	92.0	0.86	6.00	2.21	43,327	0.53	19,978	14,947	5,031	---	18.3	1.6	1.6	0.3
15.8	17.6	60	1.06	21.7	100%	0%	101.3	75.0	35.0	92.0	0.86	6.00	2.21	43,327	0.53	19,978	15,308	4,670	---	18.3	1.6	1.6	0.3
17.6	19.4	49	1.06	21.7	100%	0%	101.3	75.0	35.0	92.0	0.86	6.00	2.21	43,327	0.53	19,978	15,688	4,291	---	18.3	1.6	1.6	0.3
19.4	21.2	57	1.06	21.7	100%	0%	101.3	75.0	35.0	92.0	0.86	6.00	2.21	43,327	0.53	19,978	16,086	3,892	---	18.3	1.6	1.6	0.3
21.2	23.0	74	1.06	21.7	100%	0%	101.3	75.0	35.0	92.0	0.86	6.00	2.21	43,327	0.53	19,978	16,506	3,473	---	18.3	1.6	1.6	0.3
23.0	24.8	60	1.06	21.7	100%	0%	101.3	75.0	35.0	92.0	0.86	6.00	2.21	43,327	0.53	19,978	16,947	3,031	---	18.3	1.6	1.6	0.3
24.8	26.6	126	1.06	21.7	100%	0%	101.3	75.0	35.0	92.0	0.86	6.00	2.21	43,327	0.53	19,978	17,414	2,565	---	18.3	1.6	1.6	0.3
26.6	28.4	162	1.06	21.7	100%	0%	101.3	75.0	35.0	92.0	0.86	6.00	2.21	43,327	0.53	19,978	17,906	2,072	---	18.3	1.6	1.6	0.3
28.4	30.2	204	1.06	21.7	100%	0%	101.3	75.0	35.0	92.0	0.86	6.00	2.21	43,327	0.53	19,978	18,427	1,551	---	18.3	1.6	1.6	0.3
30.2	32.0	168	1.06	21.7	100%	0%	101.3	75.0	35.0	92.0	0.86	6.00	2.21	43,327	0.53	19,978	18,980	998	---	18.3	1.6	1.6	0.3
32.0	33.8	159	1.06	21.7	100%	0%	101.3	75.0	35.0	92.0	0.86	6.00	2.21	43,327	0.53	19,978	19,566	412	---	18.3	1.6	1.6	0.3
33.8	35.6	269	1.06	21.7	100%	0%	101.3	75.0	35.6	91.9	0.86	6.00	2.21	43,327	0.54	20,249	---	---	0.0	18.3	1.6	1.6	0.3
35.6	37.4	320	1.06	21.9	100%	0%	101.3	75.0	37.4	91.3	0.84	6.00	2.21	43,327	0.57	21,124	---	---	0.0	18.3	1.8	1.6	0.3
37.4	39.2	347	1.06	22.1	100%	0%	101.3	75.0	39.2	90.8	0.83	6.00	2.21	43,327	0.61	22,102	---	---	0.0	18.3	2.0	1.6	0.3
39.2	41.0	337	1.07	22.4	100%	0%	101.3	75.0	41.0	90.1	0.81	6.00	2.21	43,327	0.65	23,207	---	---	0.0	18.3	2.3	1.6	0.3
41.0	42.8	196	1.07	22.7	100%	0%	101.3	75.0	42.8	89.4	0.80	6.00	2.21	43,327	0.70	24,469	---	---	0.0	18.3	2.6	1.6	0.3
42.8	44.6	312	1.07	23.1	100%	0%	101.3	75.0	44.6	88.5	0.77	6.00	2.21	43,327	0.76	25,934	---	---	0.0	18.3	3.0	1.6	0.3
44.6	46.4	273	1.07	23.7	100%	0%	101.3	75.0	46.4	87.6	0.75	6.00	2.21	43,327	0.83	27,667	---	---	0.0	18.3	3.6	1.6	0.3
46.4	48.2	265	1.07	24.4	100%	0%	101.3	75.0	48.2	86.5	0.72	6.00	2.21	43,327	0.93	29,775	---	---	0.0	18.3	4.3	1.6	0.3
48.2	50.0	370	1.07	25.5	100%	0%	101.3	75.0	50.0	85.1	0.68	6.00	2.21	43,327	1.05	32,446	---	---	0.0	18.3	5.4	1.6	0.3
50.0	51.8	183	1.08	27.1	100%	0%	101.3	75.0	51.8	83.4	0.64	6.00	2.21	43,327	1.23	36,092	---	---	0.0	18.3	7.0	1.6	0.3
51.8	53.6	341	1.09	30.5	100%	0%	101.3	75.0	53.6	80.6	0.57	6.00	2.21	43,327	1.55	42,139	---	---	0.0	18.3	10.4	1.6	0.3
53.6	55.4	332	1.10	35.1	97%	3%	101.3	75.9	55.4	80.8	0.55	6.00	2.21	43,327	1.62	43,327	---	---	3.7	18.3	11.3	1.6	0.3
55.4	57.2	347	1.11	39.4	93%	7%	101.3	76.9	57.2	81.6	0.55	6.00	2.21	43,327	1.62	43,327	---	---	8.0	18.3	11.3	1.6	0.3
57.2	59.0	283	1.13	43.7	89%	11%	101.3	77.8	59.0	82.5	0.55	6.00	2.21	43,327	1.62	43,327	---	---	12.2	18.3	11.4	1.6	0.3
59.0	60.8	128	1.14	48.1	85%	15%	101.3	78.8	60.8	83.3	0.55	6.00	2.21	43,327	1.62	43,327	---	---	16.5	18.3	11.5	1.6	0.3
60.8	62.6	235	1.15	52.4	82%	18%	101.3	79.8	62.6	84.1	0.55	6.00	2.21	43,327	1.62	43,327	---	---	20.7	18.3	11.6	1.6	0.3
62.6	64.4	253	1.17	56.8	78%	22%	101.3	80.8	64.4	84.9	0.55	6.00	2.21	43,327	1.62	43,327	---	---	25.0	18.3	11.7	1.6	0.3
64.4	66.2	306	1.18	61.1	74%	26%	101.3	81.8	66.2	85.7	0.56	6.00	2.21	43,327	1.62	43,327	---	---	29.2	18.3	11.8	1.6	0.3
66.2	68.0	337	1.19	65.4	70%	30%	101.3	82.8	68.0	86.5	0.56	6.00	2.21	43,327	1.62	43,327	---	---	33.5	18.3	11.8	1.6	0.3
68.0	69.8	150	1.20	69.8	67%	34%	101.3	83.8	69.8	87.3	0.56	6.00	2.21	43,327	1.62	43,327	---	---	37.8	18.3	11.9	1.6	0.3
69.8	71.6	322	1.22	74.2	63%	37%	101.3	84.8	71.6	88.1	0.56	6.00	2.21	43,327	1.62	43,327	---	---	42.0	18.3	12.0	1.6	0.3
71.6	73.4	369	1.23	78.5	59%	41%	101.3	85.8	73.4	88.9	0.56	6.00	2.21	43,327	1.62	43,327	---	---	46.3	18.3	12.1	1.6	0.3
73.4	75.2	309	1.24	82.9	55%	45%	101.3	86.8	75.2	89.7	0.56	6.00	2.21	43,327	1.62	43,327	---	---	50.6	18.3	12.2	1.6	0.3
75.2	77.0	254	1.25	87.2	51%	49%	101.3	87.8	77.0	90.5	0.56	6.00	2.21	43,327	1.62	43,327	---	---	54.8	18.3	12.3	1.6	0.3
77.0	78.8	123	1.27	91.6	48%	52%	101.3	88.8	78.8	91.3	0.56	6.00	2.21	43,327	1.62	43,327	---	---	59.1	18.3	12.4	1.6	0.3
78.8	80.6	202	1.28	96.0	44%	56%	101.3	89.8	80.6	92.1	0.56	6.00	2.21	43,327	1.62	43,327	---	---	63.4	18.3	12.5	1.6	0.3
80.6	82.4	133	1.29	100.4	40%	60%	101.3	90.8	82.4	92.9	0.56	6.00	2.21	43,327	1.62	43,327	---	---	67.7	18.3	12.6	1.6	0.3
82.4	84.2	91	1.31	104.7	36%	64%	101.3	91.8	84.2	93.7	0.56	6.00	2.21	43,327	1.62	43,327	---	---	72.0	18.3	12.7	1.6	0.3
84.2	86.0	65	1.32	109.1	32%	68%	101.3	92.8	86.0	94.5	0.56	6.00	2.21	43,327	1.62	43,327	---	---	76.3	18.3	12.7	1.6	0.3
86.0	87.8	18	1.33	113.5	29%	71%	101.3	93.8	87.8	95.3	0.56	6.00	2.21	43,327	1.62	43,327	---	---	80.5	18.3	12.8	1.6	0.3
87.8	89.6	23	1.34	117.9	25%	75%	101.3	94.8	89.6	96.1	0.56	6.00	2.21	43,327	1.62	43,327	---	---	84.8	18.3	12.9	1.6	0.3
89.6	91.4	7	1.36	122.3	21%	79%	101.3	95.8	91.4	96.9	0.56	6.00	2.21	43,327	1.62	43,327	---	---	89.1	18.3	13.0	1.6	0.3
91.4	93.2	5	1.37	126.7	17%	83%	101.3	96.8	93.2	97.7	0.56	6.00	2.21	43,327	1.62	43,327	---	---	93.4	18.3	13.1	1.6	0.3
93.2	95.0	4	1.38	131.1	13%	87%	101.3	97.8	95.0	98.5	0.56	6.00	2.21	43,327	1.62	43,327	---	---	97.7	18.3	13.2	1.6	0.3
98.6	100.4	1	1.38	131.3	0%	100%	101.3	101.3	100.4	100.4	---	---	2.21	43,327	0.00	0	---	---	112.8	18.3	---	---	0.3

2.3.5 Electrical System

Applicable codes and standards:

- Building Code of New York State (NYSBC)
- National Electrical Code, NFPA 70
- Standard for Electrical Safety in the Workplace, NFPA 70E
- National Fire Alarm Code, NFPA 72
- Fire Protection of Information Technology Equipment, NFPA 75
- Life Safety Code, NFPA 101
- Emergency and Standby Power Systems, NFPA 110

- » Standard on Stored Electrical Energy Emergency and Standby Power Systems, NFPA 111
- » Lightning Protection Code, NFPA 780
- » 29 CFR 1910 Occupational Safety and Health Standards
- » 29 CFR 1926 Safety and Health Regulations for Construction
- » Energy Conservation Code of New York State
- » Americans with Disabilities Act Accessibility Guideline (ADAAG)

DEMOLITION

Building 725 is served by four 2500kVA transformers. Three outdoor substations are located in the equipment yard inside the storage ring area and serves the initial phase of construction. A fourth outdoor substation is located in a well just outside the northeast corner of the building and serves the second floor office addition.

Substations 1, 2 and 3 and all their associated conventional facilities distribution equipment will be removed (all branch circuits associated with experimental equipment has already been removed by BNL). Existing feeders and branch circuits serving lights, receptacles and mechanical equipment in portions of the building served by these substations that will not be occupied by the data center will be rerouted to Substation 4.

Substation 4 and its distribution system associated with supporting the second floor will remain. Portions of its distribution system that serve areas to be occupied by the new data center will be removed.

The southwest portion of the building not occupied by the data center and portions of the second floor which are currently served by Substations 1, 2 or 3, will be reconnected to Substation 4. New feeders will be routed from Substation 4 to these areas and to mechanical equipment supporting these areas.

An existing 125kW generator located in the well just outside the northeast corner of the building will remain. Existing distribution equipment within the data center will be removed. Generator loads outside the data center will be rerouted to this generator.

All distribution equipment serving non data center loads will be completely isolated from the data center space to reduce risk of disruptions to data center equipment.

POWER DISTRIBUTION OVERVIEW

The electrical power distribution system and equipment spaces have been sized to support an initial build-out of nominally 2400 kVA of computing load plus its associated mechanical and building loads, with the capability of expanding to an ultimate build-out of nominally 6000 kVA of computer load plus its associated mechanical and building loads. These nominal loads reflect nominal equipment capacities. Actual peak demands will be limited to typically 80% of these nominal equipment rated capacities.

The system will be configured to allow de-energized maintenance of any component without interruption of power to any dual corded computing load or the loss of mechanical system design capacity. Power to single corded loads will be interrupted if any component on the load side of the static transfer switches is de-energized for maintenance. This can be corrected if local static transfer switches are provided within the rack.

The ultimate build-out will consist of six distribution systems in an N+1 (5+1) redundant configuration. Each distribution system will support 1200 kVA of computing load and its associated mechanical and building loads. Initially, two of the five 1200 kVA primary systems will be provided to serve the initial 2400 kVA of computing load. The redundant 1200 kVA UPS unit in the bypass system can be provided under Alternate-02. Three additional 1200 kVA systems can be added incrementally as the computing load increases up to 6000 kVA. The one bypass system will be used to backup any one of the five systems. Each distribution system will be located within a dedicated 2-hour rated room to minimize risk of a fire in one room taking multiple systems off-line.

GENERATOR STUDY

With the availability of interior and exterior space to locate generators, 15kV switchgear and substations, there are a number of layouts and distribution options that will achieve the required redundancy and reliability. The options include variations on providing indoor or outdoor generators, 480 volt or 13,800 volt generators, indoor or outdoor 15kV switchgear, and indoor or outdoor unit substations. After initial discussions, five options were established for further cost benefit study (see Generator Study in Appendix 9.6).

Some of the non-cost considerations included safety, maintenance, ventilation, tank limitation, noise and vibration. Some of the cost differentiators included weatherproof enclosures and concrete pads for the outdoor equipment, large 480 volt feeders and duct banks vs. 15kV duct banks, 480 volt automatic transfer switches vs. switching 15kV breakers, and

the cost of indoor space used to house equipment that could be used for program space.

After presenting the options and further discussion, it was agreed to locate the 15kV generators and 15kV switchgear outdoor adjacent to the loading dock and to locate the unit substations indoors. The decision was largely driven by a desire to reduce cost, complexity and voltage drop in the 480 volt feeders, and concerns with locating the generators indoors including safety, maintenance, accessibility, and the required modification to the existing building associated with ventilation and remote radiators.

CAMPUS DISTRIBUTION

Initially, the two existing 13.8 kV feeders serving Building 725 (725-1 and 725-2) will be utilized to serve the new data center. However, as the loads increase, the existing feeders will need to be upgraded in capacity and/or dedicated to the data center to serve the ultimate build-out condition. This upgrading will require the installation of a new duct bank back to the campus substation at Building 603 because the existing duct banks along Cornell Avenue are full.

Feeder 725-1 will be tapped in manhole MH-B3 at the intersection of Cornell Avenue and Renaissance Road. Feeder 725-2 will be tapped in manhole MH-E9 at the intersection of Brookhaven Avenue and Renaissance Road.

At the intersection of Cornell Avenue and Renaissance Road, a short section of 6-way 5” concrete encased duct bank will be provided to interconnect manholes MH-B3 and MH-A3. The existing duct banks between MH-A3 and MH-A3B via MH-A3A will be utilized. A new 6-way 5” concrete encased duct bank will be provided along Renaissance Road between MH-A3B and MH-E9 with a new manhole MH-A3C midway to serve B-725.

Feeder 725-1 will be tapped in MH-B3 and extended south to MH-A3C via MH-A3, MH-A3A and MH-A3B. Feeder 725-2 will be tapped in MH-E9 and extended north to MH-A3C.

From MH-A3C, two new 3-way 5” concrete encased duct banks will be routed to two new 15kV outdoor walk-in switchgear enclosures located near the loading dock. Each A/B redundant switchgear will include a main circuit breaker, a normal tie breaker, a generator tie breaker, and two outgoing feeder breakers.

SITE AND BUILDING DISTRIBUTION

Backup power will be provided by 1750/2000 kW/kVA, 13.8kV outdoor generators located east of the loading dock. Initially, two generators associated with Systems #1 and #2 will be provided. A third redundant

generator can be provided under Alternate-01. Space will be provided for three additional generators to support systems #3, #4 and #5. The outdoor, walk-in 15kV paralleling switchgear will also be located near the loading dock and consist of six generator input breakers, an output load bank breaker, and two output tie breakers to the two main switchgear line-ups.

From the main switchgear line-ups, two loop feeders will be routed in duct bank to pull boxes on the exterior wall of the building where the feeders will penetrate the wall and rise to the underside of the roof and across to the six secondary unit substations. The initial build-out will include one loop to serve substation #1, #2 and the bypass. The second loop will be provided in the future when System #3 is installed and will serve Substations #3, #4 and #5.

Each of the six distribution systems will include a 1750kW/2000kVA, 13,800V outdoor diesel generator, a 2000 kVA, 13,800-480Y/277V indoor secondary unit-substation with a 3000A 480Y/277V outgoing switchgear, a 1200 kVA UPS systems to serve computing loads, and a 1200A switchboard to serve mechanical and building support loads. A redundant 1200 kVA UPS unit in the bypass system can be provided under Alternate-02.

Each primary UPS system will include a 2000A output switchgear, two 2000A static transfer switches, two 2000A switchboards, and two sets of at least four 300 kVA transformers and secondary main breakers, 1200A distribution panels in the data halls, and overhead bus tracks mounted above each rack row with plug-in power taps to serve individual racks. The two sets of UPS distribution equipment will serve as the A/B redundant systems that serve each rack.

Each primary system will include a 50 kVA UPS to serve the chilled water pumps to insure adequate cooling of the high density water cooled racks during generator start-up following a utility outag. A redundant 50 kVA UPS unit in the bypass system can be provided under Alternate-02.

The technical switchgear in the bypass system will serve the bypass inputs of the two 2000A static switches associated with each of the five primary distribution systems. Initially, four breakers will be provided to serve the static switches associated with systems #1 and #2. Six spare breakers will be provided to serve future systems #3, #4 and #5.

In lieu of power distribution units within the data halls, traditional transformers, disconnects and distribution panels will be provided allowing the transformers to be located outside the data halls in nearby mechanical/electrical spaces with feeders to distribution panels located within the data halls. Transformers and panels will be deployed in pairs to maintain redundant A/B UPS power to the racks. Disconnects at the secondary of each transformer will be 1000A enclosed shunt trip circuit breakers. From the

A/B distribution panels, circuits will be routed to two A/B bus tracks located above each row of racks to serve single and dual corded racks via 1, 2 and 3 pole circuit breaker tap boxes. High density racks will be fed directly from the distribution panel.

Because air handling unit redundancy is being provided at the data hall and not at the block system level in order to maintain compartmentalization of each data hall, individual automatic transfer switches will be provided at each AHU to maintain system reliability.

ELECTRICAL EQUIPMENT

15kV cable will be single conductor, 500kcmil, copper, Type MV-105, EPR, 133 percent insulation level with copper tape overlapping shield and a PVC outer jacket. Duct banks will be concrete encased with multiple 5" PVC ducts.

The two normal and one generator paralleling 15kV switchgear line-ups will be metal-clad outdoor walk-in type with 1200A copper bus and drawout electrically operated vacuum interrupter circuit breakers with microprocessor-based multi-function overcurrent protection relays. Switchgear will be in accordance with ANSI/IEEE C37.04 and C37.20.2, and NEMA SG-4 and SG-5. To reduce arc-flash energies, differential relays and optical relays will be provided.

The 1750kW/2000kVA, 13.8kV data center rated, diesel engine driven generator will be UL 2200 listed, NFPA 110 compliant and EPA Tier 2 emissions compliant. Each generator will be provided with an outdoor walk-in, sound attenuated enclosure, a minimum 8 hour sub-base fuel tanks and a low resistant neutral ground resister. Longer outage runtimes will be obtained by refilling the sub-base tanks from the on-site 100,000 gal tank via BNL delivery trucks. An outdoor 1750kW resistive type load bank will be provided for generator testing.

The indoor unit substations will consist of two 15kV non-fused load interrupter switches in a loop configuration, a 15kV vacuum interrupter circuit breaker, a 2000kVA, 13800-480Y/277V, cast-coil transformer, and a 3000A, 480V, 3-phase, 3-wire outgoing section. The switchgear will be low voltage metal enclosed type with main and feeder electrically operated, drawout, power air circuit breakers in accordance with UL 1558 and NEMA SG-3 and SG-5 standards. To reduce arc-flash hazards, breakers will be capable of being racked out with a remote racking device. Trip units will include an instantaneous trip over-ride to lower settings to reduce arc-flash during maintenance procedures. And breaker open/close operations will be controlled by pushbuttons located in a remote panel.

Each 1200kVA UPS system will consist of a single 1200kVA on-line, double conversion, solid-state, static type uninterruptible power system units with a static by-pass switch and a maintenance bypass. In lieu of batteries, DC flywheels will be provided with a run time of 30 seconds to allow the generators to start and parallel.

UPS output switchgear will be provided with electrically operated, drawout, power-air circuit breakers and will be close-coupled to the UPS maintenance bypass.

Each separately derived 480V distribution system will be wye connected with the neutral grounded via a high resistance neutral ground resistor. All 480V distribution will be three phase, three wire. No 277V single phase loads will be connected. Pulsing type resistors will be provided at each unit substation, generator and UPS system.

Static transfer switches will be provided with two solid state three-phase static switches, two input breakers, two bypass breakers and two output breakers.

Switchboards will be front accessible with manually operated, individually mounted molded case circuit breakers. Breaker will be provided with electronic trip units.

Transformers serving computing equipment will be K20 shielded isolation 480-208Y/120V transformers.

Surge protection devices (SPD) will be provided at the 3000A switchgear, UPS output switchgear, and at each 208Y/120V UPS distribution panel. SPD's connected to 480 volt systems will be delta connected. SPD's connected to 208Y/120V systems will be wye connected.

The emergency system will be powered by a central battery inverter in accordance with NFPA 111. The inverter will serve egress lighting, exit lights, and the fire alarm and security systems.

A power monitoring and control system will be provided to collect and monitor data from all meters and all breaker trip units. It will interface with the Building Monitoring and Control System (BMCS) for remote monitoring and control. All electrically operated breakers will be monitored for status and be capable of being remotely operated. Advanced digital meters will be provided at 15kV mains and 480V mains. All generator and UPS system functions will be monitored. Digital meters will be provided at all 208Y/120V UPS distribution panel output breakers. Loads at the rack level will be monitored by the DCIM system.

UPS ENERGY STORAGE STUDY

Because of issues BNL has had with select battery systems, the availability of flywheel storage, and with newer battery technologies coming on the market, a cost benefit study was provided to compare different battery and flywheel energy storage systems (see UPS Energy Storage Study in Appendix 9.6). Six systems were compared including wet cell, 10 and 20 year VRLA, and lithium batteries, 30 second flywheel, and a hybrid of 10 year VRLA batteries with 15 second flywheels.

Trusting the reliability of the generators to start and parallel in less than 20 seconds, it was agreed that the study would compare five minute batteries and 30 second flywheels.

Some of the non-cost considerations included safety, maintenance, life expectancy, footprint, environmental requirements, and sustainability. Over the 30 year life cycle, the battery options were within 30 percent of each other and half the cost of the two flywheel options. Despite their higher cost, it was agreed to provide the 30 second flywheels. This is largely based on negatives associated with batteries and the positives associated with the flywheels.

EMERGENCY POWER OFF (EPO) SYSTEM

Each data hall will be provided with a separate emergency power off (EPO) system. Double action pushbutton will be located at each exit door from the space.

The EPO system will be initiated by the manual activation of a double action pushbutton, or by the automatic activation of the air aspirated smoke detection system at an alarm level.

Activation of the EPO system will open shunt trip breakers serving the data hall UPS distribution panels, shutdown air handling units serving the data hall, and close dampers penetrating the perimeter of the data hall.

A three position switch will be provided to allow testing of the system without tripping off the data center.

GROUNDING

A main grounding bus will be provided at each unit substation. They will be interconnected with each other and with the existing grounding buses associated with the existing unit substations, building steel, new and existing incoming water lines, and the existing perimeter counterpoise.

Each unit substation, generator and UPS system will be provided with a neutral ground resistor. A pulsing type neutral ground resistor will be connected to building steel and the main grounding bus.

Each data hall will be provided with a ground bus. A signal reference ground grid will be located below the raised floor in all raised floor spaces. The grid will be bonded to each steel column and each data hall ground bus.

Each low voltage transformer will be bonded to building steel and to its associated data hall ground bus.

Racks and the telecommunication system will be grounded in accordance with ANSI/EIA/TIA 607.

The existing building does not have a lightning protection system. Therefore, a complete lightning protection system in accordance with NFPA 780 will be provided for the entire building.

LIGHTING

All existing exterior lighting will remain.

All existing interior lighting within the data center footprint will be replaced with new fluorescent and/or LED fixtures. Fluorescent sources will include a combination of T8, 32 watt, T5, 28 watt and T5 54 watt lamps with a color temperature of 4100K and a CRI of at least 75. LED sources will be used for all other applications. As the design develops, LEDs may become more feasible than fluorescent for all application as their efficiency increases and their initial cost decrease.

Data halls will be provided with 50 FC of illumination from 2x4 fluorescent troffers. Offices will be provided with 30 FC of illumination from linear fluorescent pendant fixtures supplemented by task lighting. Corridors will be provided with 10 FC of illumination from LED downlights. Mechanical and electrical room will be provided with 15 FC of illumination from pendant mounted fluorescent industrial reflectors.

Some type of automatic lighting control will be provided in all spaces. Multi-level switching will be provided in all occupied spaces. Occupancy sensors will generally be provided in data halls, offices, corridors, and in support spaces. Countdown timer switches will be provided in mechanical and electrical rooms with a blink before off feature.

Egress and exit lighting will be provided per NFPA 101 and powered by the emergency central battery inverter.

All light fixtures will operate at 120V.

TELECOMMUNICATIONS

The existing campus network room will remain in the existing data center in Building 515.

Redundant service will be provided from the campus network room to Building 725. For improved reliability, these services will be routed thru different manholes and duct banks.

A complete pathways and structured cabling distribution system will be provided to support the new data center including a centrally located network room for copper and fiber optic services. Separate cable trays will be provided for copper and fiber optic cables. In the data halls, cable trays will be routed above each rack row. The raised floor space will not be utilized for cable distribution.

FIRE ALARM

A complete manual and automatic, supervised, fire detection and mass notification system will be provided. It will be a non-coded, addressable, microprocessor-based fire alarm system with initiating devices, notification appliances, and monitoring and control devices. Initiating and appliance circuits will be Class B. The fire alarm system will be in accordance with DOE requirements and NFPA 72.

The fire alarm control panel will be located at the building main lobby.

Manual stations will be located at all exits.

Photoelectric spot type smoke detectors will be located in electrical rooms. Duct smoke detectors will be provided in air handling systems as required by NYS Mechanical Code or NFPA 90A.

An air aspirated smoke detection system will be provided in the data halls designed and optimized to provide early detection of smoke. A pre-alarm condition will be annunciated at the fire alarm control panel as a supervisory signal. An alarm condition will annunciate as an alarm signal to activate the building evacuation alarm, initiate EPO shutdown, and be one of two interlocked inputs to the dual action dry-pipe sprinkler system.

Combination audio/visual and/or visual only devices will be provided throughout the data center.

Common alarm and trouble signals will be transmitted to the campus fire alarm system.

SECURITY

The existing intrusion detection, access control and video surveillance security system will be replaced. New devices will be placed at existing building perimeter entrances. Additional devices will be located at entrances to the data center and at individual data halls to provide additional levels of control. Card-in/card-out access controls will be provided at the data center

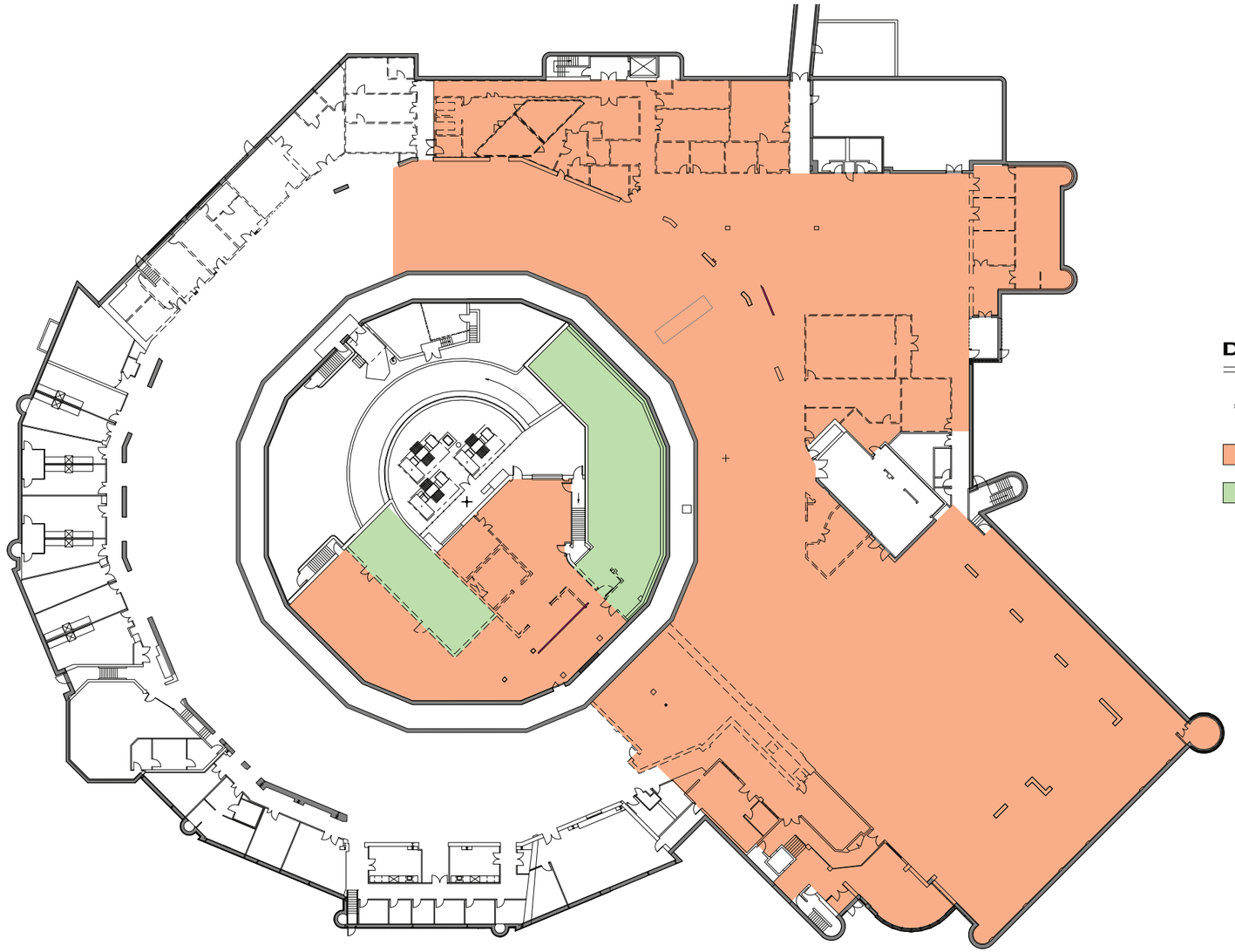
perimeter and individual data halls. CCTV cameras will be located at all controlled doors.

The security system will consist of empty conduit and back boxes only. All control panels, cabling and devices will be provided by BNL.

LEAK DETECTION

A complete cable type water detection system will be provided under all raised floor areas. The system will be monitored by the BMCS system.

2.4 Drawings



DEMOLITION LEGEND

= = = = = = = = = = = =	COMPONENTS TO BE DEMOLISHED	
	GENERAL DEMOLITION	57401 SQ. FT.
	MECHANICAL DEMOLITION	4579 SQ. FT.
	TOTAL	61980 SQ. FT.

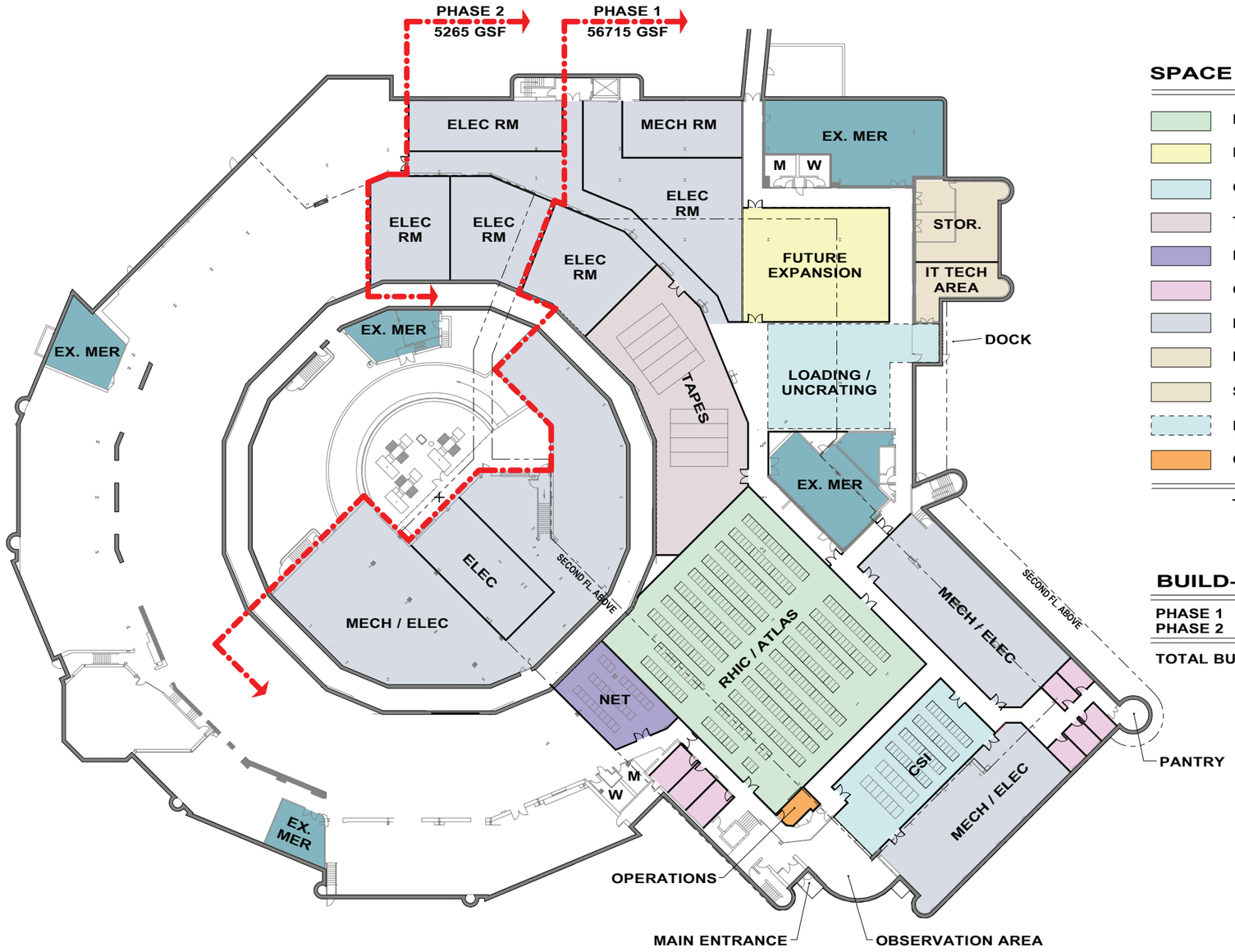
0 16' 32'

N

DATE:	01 AUGUST 2016
PROJECT:	CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE:	ARCHITECTURE
SHEET:	2.4.1.1 FIRST FLOOR - DEMOLITION

BROOKHAVEN NATIONAL LABORATORY

HDR



SPACE LEGEND

	PROGRAM NET AREA (NSF)	DELINEATED AREA (NSF)
RHIC / ATLAS	10800	9271
FUTURE EXPANSION	3450	2988
CSI	1950	2238
TAPES	3600	4159
NETWORK EQUIPMENT	1000	1156
OFFICES	1680	1156
MECH/ELEC	20200	28934
IT TECH AREA	500	643
STORAGE	1200	1200
LOADING / UNCRATING	560	2579
OPERATIONS	150	132
TOTAL NET AREAS	48090	54456

BUILD-OUT AREAS

	AREA (GSF)
PHASE 1	56715
PHASE 2	5265
TOTAL BUILD-OUT AREA	61980

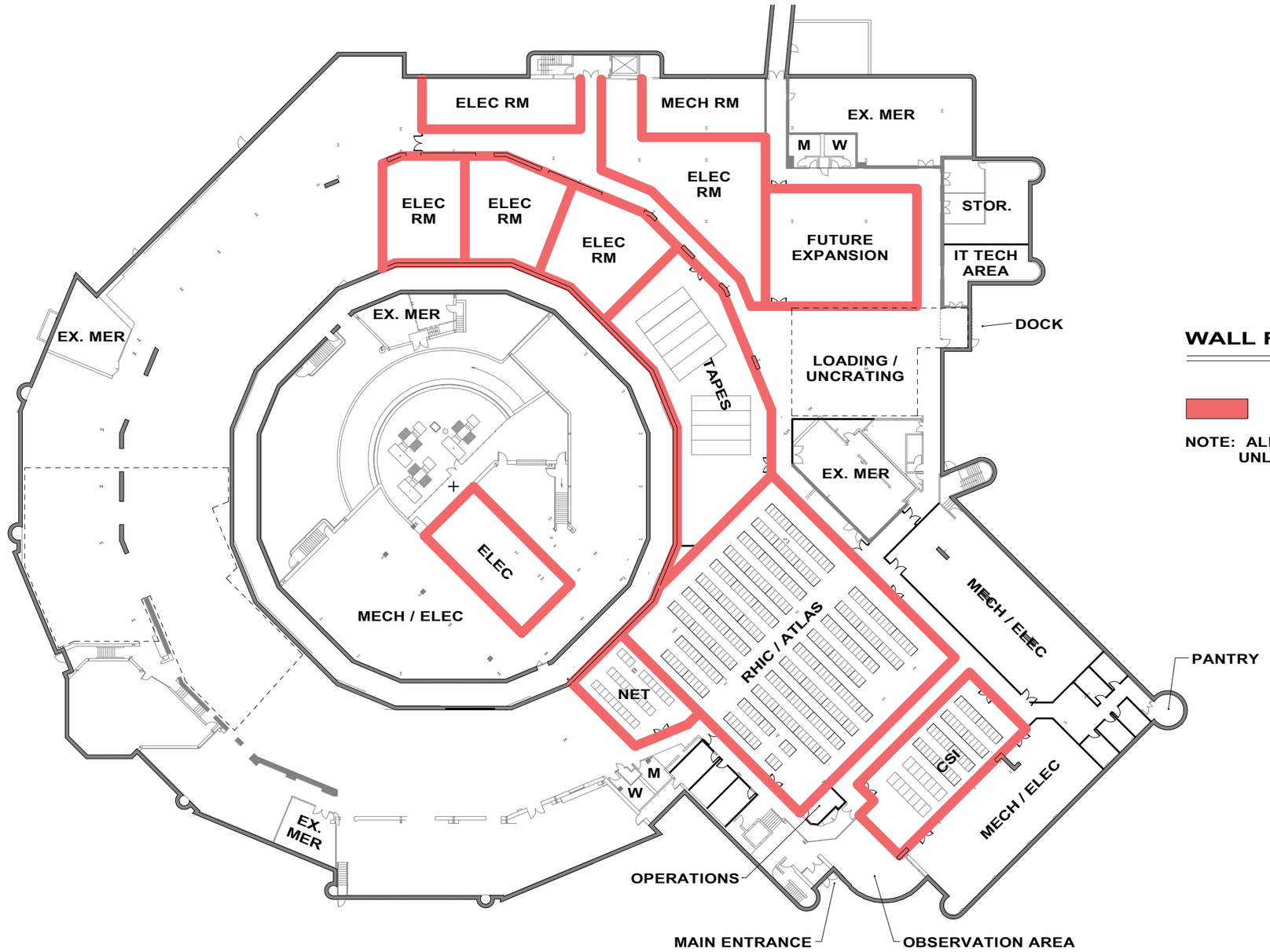
0 16' 32'

N

DATE:	01 AUGUST 2016
PROJECT:	CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE:	ARCHITECTURE
SHEET:	2.4.1.2 FIRST FLOOR PLAN

BROOKHAVEN NATIONAL LABORATORY

HDR



WALL RATING LEGEND

2 HOURS / FIRE AND SMOKE BARRIERS

NOTE: ALL PARTITIONS ARE NON-RATED UNLESS NOTED OTHERWISE

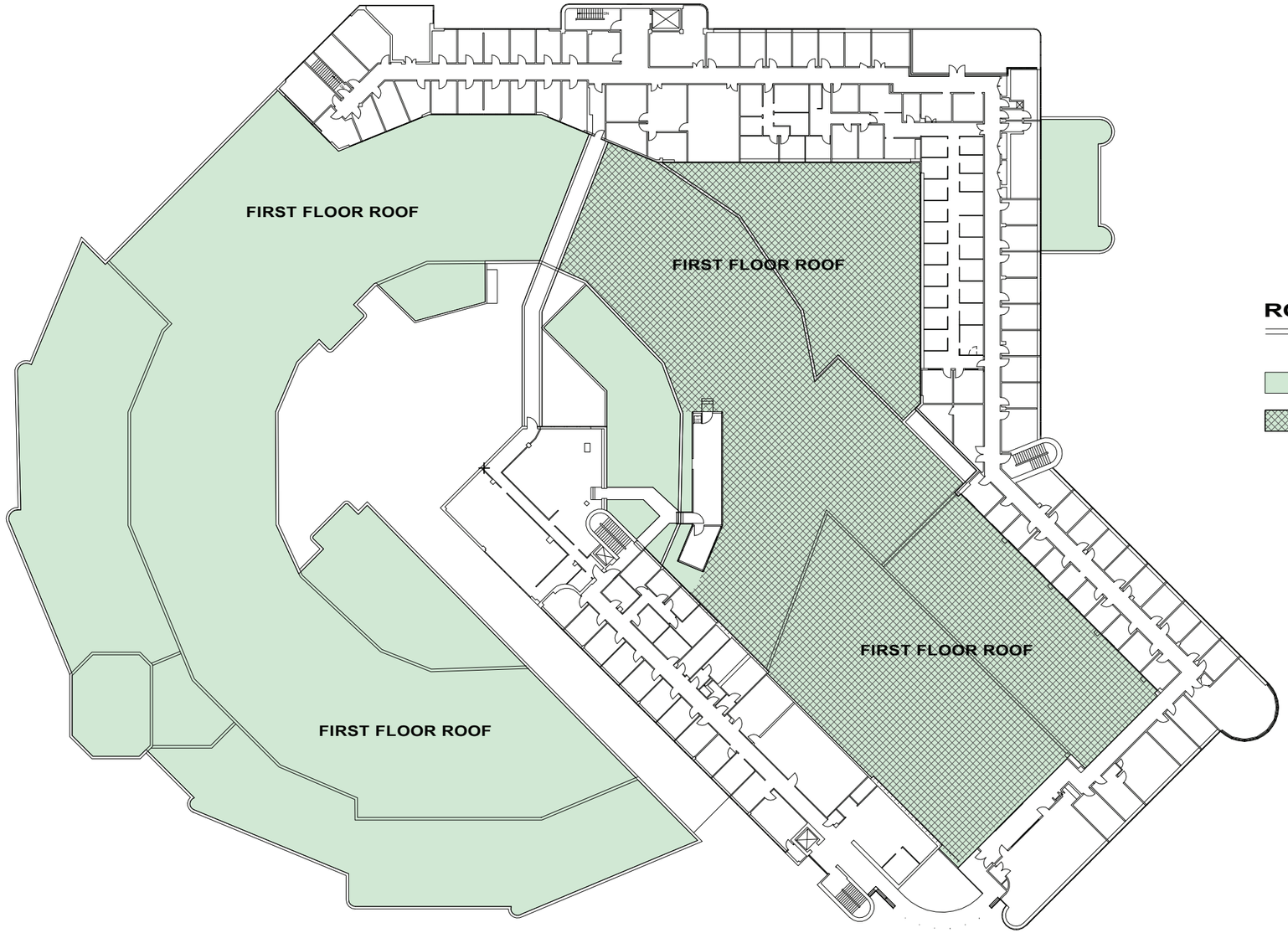
0 16' 32'

N

DATE:	01 JULY 2016
PROJECT:	CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE:	ARCHITECTURE
SHEET:	2.4.1.3 FIRST FLOOR WALL RATINGS

BROOKHAVEN NATIONAL LABORATORY

HDR



ROOF LEGEND

STANDARD ROOF SYSTEM
74500 SF

DUAL ROOF / LEAK DETECTION SYSTEM
28107 SF

0 16' 32'

N

DATE: 01 JULY 2016
PROJECT: CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE: ARCHITECTURE
SHEET: 2.4.1.4 ROOF LEAK DETECTION SYSTEM

BROOKHAVEN NATIONAL LABORATORY

HDR

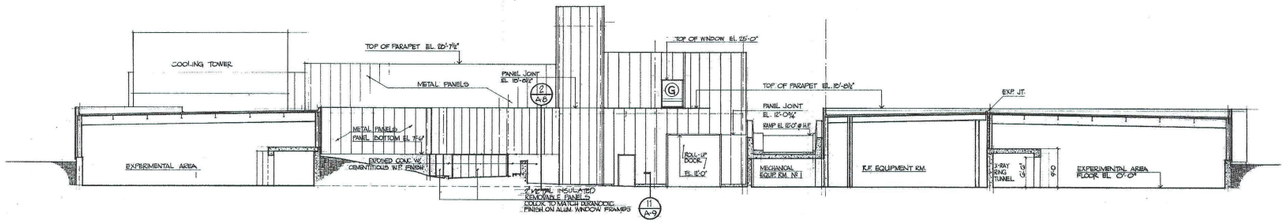
Window Replacement Scope:

Demolition:

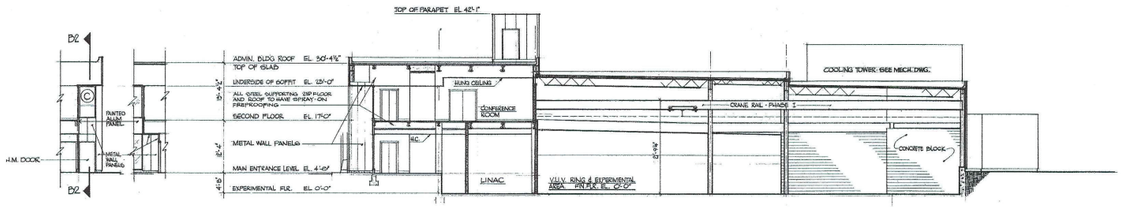
Remove existing window system highlighted in Orange.

Install:

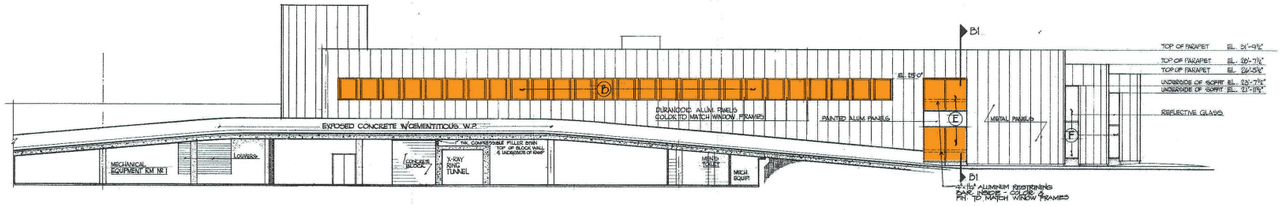
3 1/2 IN Deep Anodized Aluminum Thermally Broken Frame Fixed Window System; Glazed with 1 IN Clear Low - E, Insulated Glazing Units (IGU)



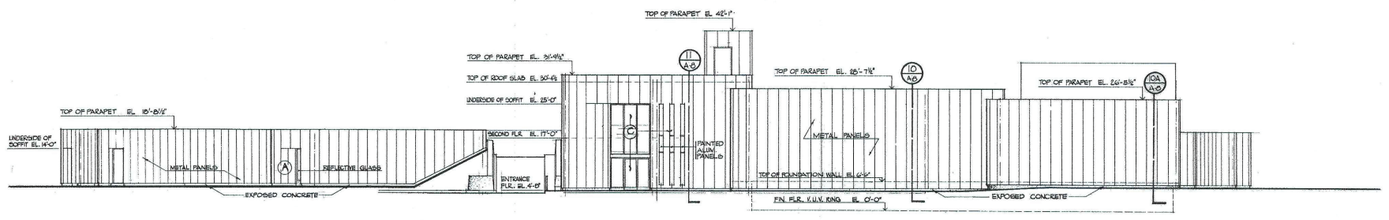
SECTION - ELEVATION A



SECTION - ELEVATION B



SECTION - ELEVATION C

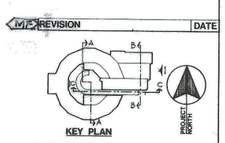


ELEVATION 1

NOTE: ALL EXTERIOR GLASS TO BE TINTED BRONZE U.O.N.
C. SEE INTERIOR & ENTRANCE DETAILS DNG-A10

AS BUILT
REFER TO AMENDMENTS AND SHOP DRAWINGS FOR ADDITIONAL INFORMATION.
6/2/83

NO.	REVISION	DATE



KEY PLAN

UNITED STATES
DEPARTMENT OF ENERGY
BROOKHAVEN NATIONAL LABORATORY
UPTON, N.Y.

NATIONAL SYNCHROTRON LIGHT SOURCE

MAX O. URBAHN ASSOCIATES INC.
SEELYE, STEVENSON, VALUE & KNECHT INC.
521 FIFTH AVENUE NEW YORK, N.Y. 10017

PHASE I - T.O.B. No. 5570

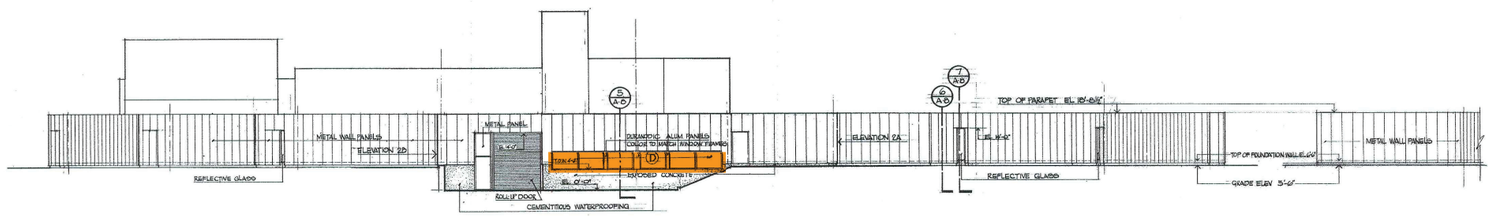
ELEVATIONS

DRAWN BY:	CHECKED BY:	SCALE:	DATE:	DRAWING NO.
DC	DHP	1/8"=1'-0"	11-10-78	A-6

0 16' 32'

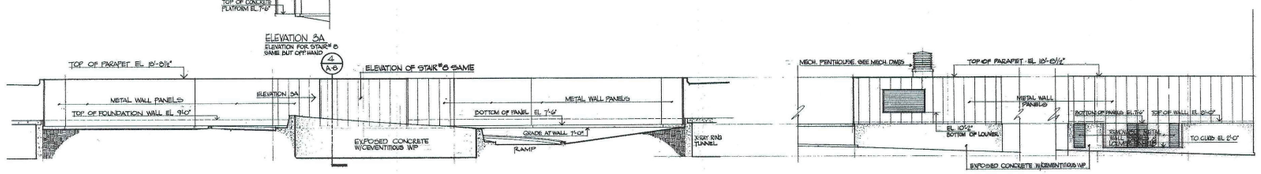
N

DATE: 01 JULY 2016
PROJECT: CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE:
SHEET:
BROOKHAVEN NATIONAL LABORATORY
HDR



ELEVATION 2

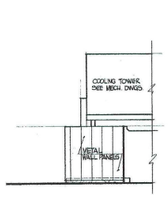
ELEVATION 2A
ELEVATION 2B SAME BUT OPPOSITE HAND



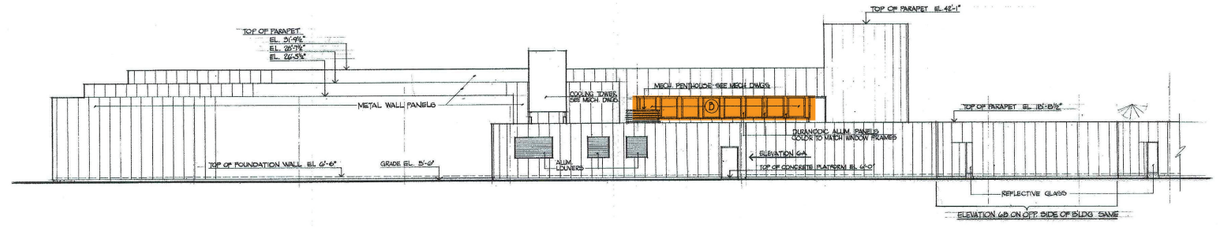
ELEVATION 3

ELEVATION 4

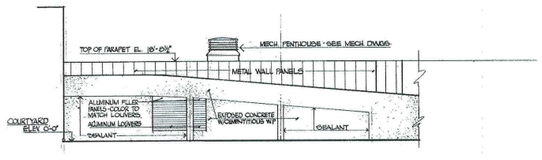
ELEVATION 5



ELEVATION 6A



ELEVATION 6



ELEVATION 7

GRAPHIC SCALE

1/8"=1'-0" 0 0' 5' 10' 15' 20' 25' 30'
1/4"=1'-0" 0' 5' 10'
3/8"=1'-0" 0' 5'
3/4"=1'-0" 0' 1' 2' 3' 4'
1 1/2"=1'-0" 0' 3' 6' 1'
3" =1'-0" 0' 3' 6' 1'

NOTE: CHECK GRAPHIC SCALE BEFORE SCALING

NO.	REVISION	DATE

KEY PLAN

NOTE: ALL EXTERIOR GLASS TO BE TINTED BRONZE U.O.N.
(SEE WINDOW & ENTRANCE DETAILS - DWG - A-10
ALL EXTERIOR H.M. DOORS, FRAMES & METAL PANELS OVER DOORS REQUIRING PAINT, SHALL BE PAINTED COLOR TO MATCH DURANODIC ALUM. WINDOWS.

AS BUILT
REFER TO AMENDMENTS AND SHOP DRAWINGS FOR ADDITIONAL INFORMATION.
6/2/85

UNITED STATES
DEPARTMENT OF ENERGY
BROOKHAVEN NATIONAL LABORATORY
UPTON, N.Y.

NATIONAL SYNCHROTRON LIGHT SOURCE

MAX O. URBAHN ASSOCIATES INC.
SEELYE, STEVENSON, VALUE & KNECHT INC.
521 FIFTH AVENUE NEW YORK, N.Y. 10017

PHASE II Job No 5870

ELEVATIONS

DRAWN BY:	CHECKED BY:	SCALE:	DATE:	DRAWING NO:
DC	(JMP)	1/8"=1'-0"	11/0/78	A-7

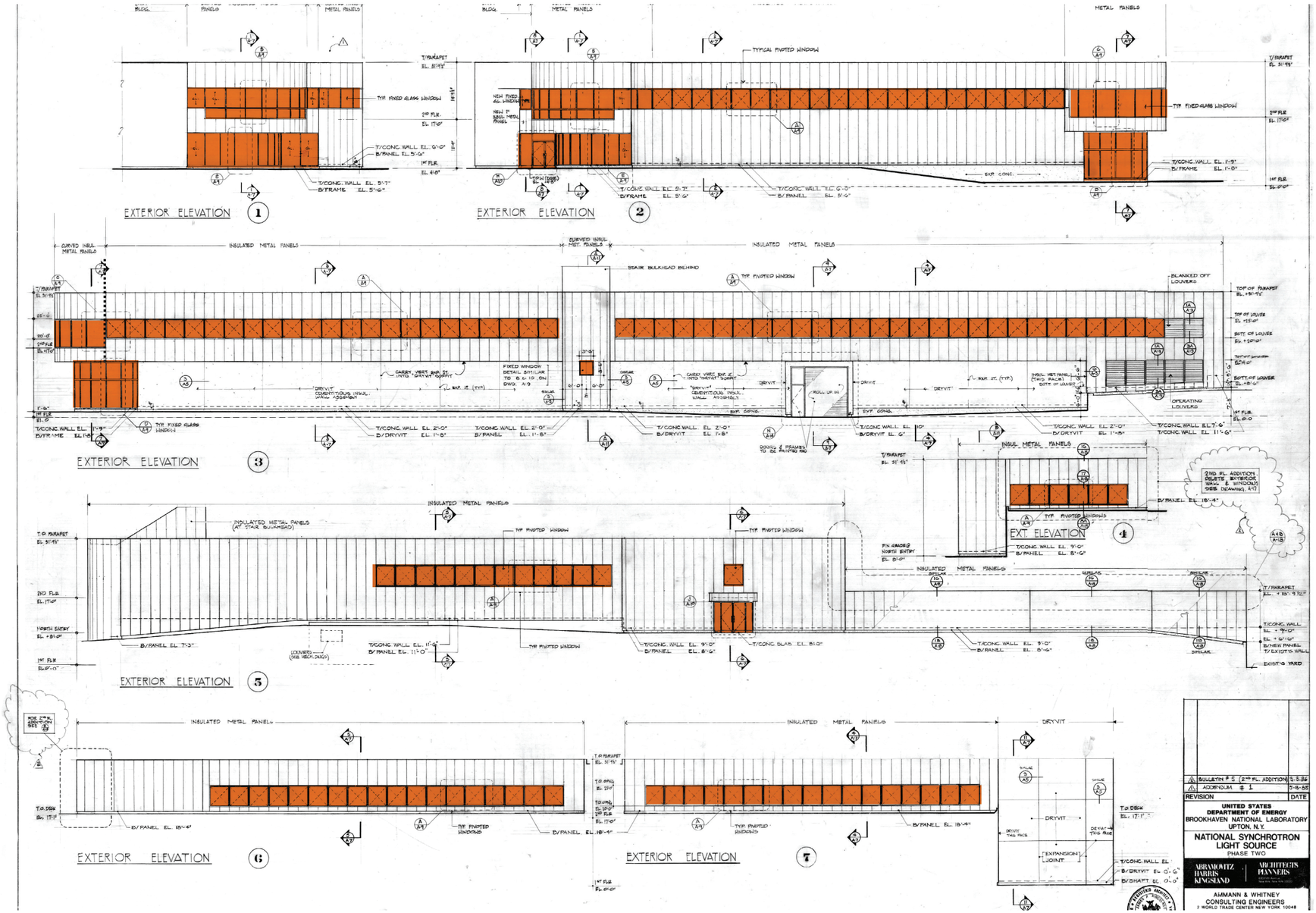
0 16' 32'

N

DATE: 01 JULY 2016
PROJECT: CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE:
SHEET:

BROOKHAVEN NATIONAL LABORATORY

HDR



DATE: 01 JULY 2016

PROJECT: CORE FACILITY REVITALIZATION (CFR) BUILDING 725

DISCIPLINE:

SHEET:

BROOKHAVEN NATIONAL LABORATORY

HDR

MECHANICAL LEGEND

- DRY AIR ECONOMISER (DAE) 400 kW Capacity ~50,000 cfm
- DEDICATED OUTSIDE AIR VENTILATION AHU ~15,000 cfm
- DAE SUPPLY AIR DUCT
- DAE RETURN AIR DUCT

0 16' 32'

N

DATE:	01 JULY 2016
PROJECT:	CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE:	M1.1 MECHANICAL - PHASE I
SHEET:	2.4.1.1 FIRST FLOOR PLAN

BROOKHAVEN NATIONAL LABORATORY

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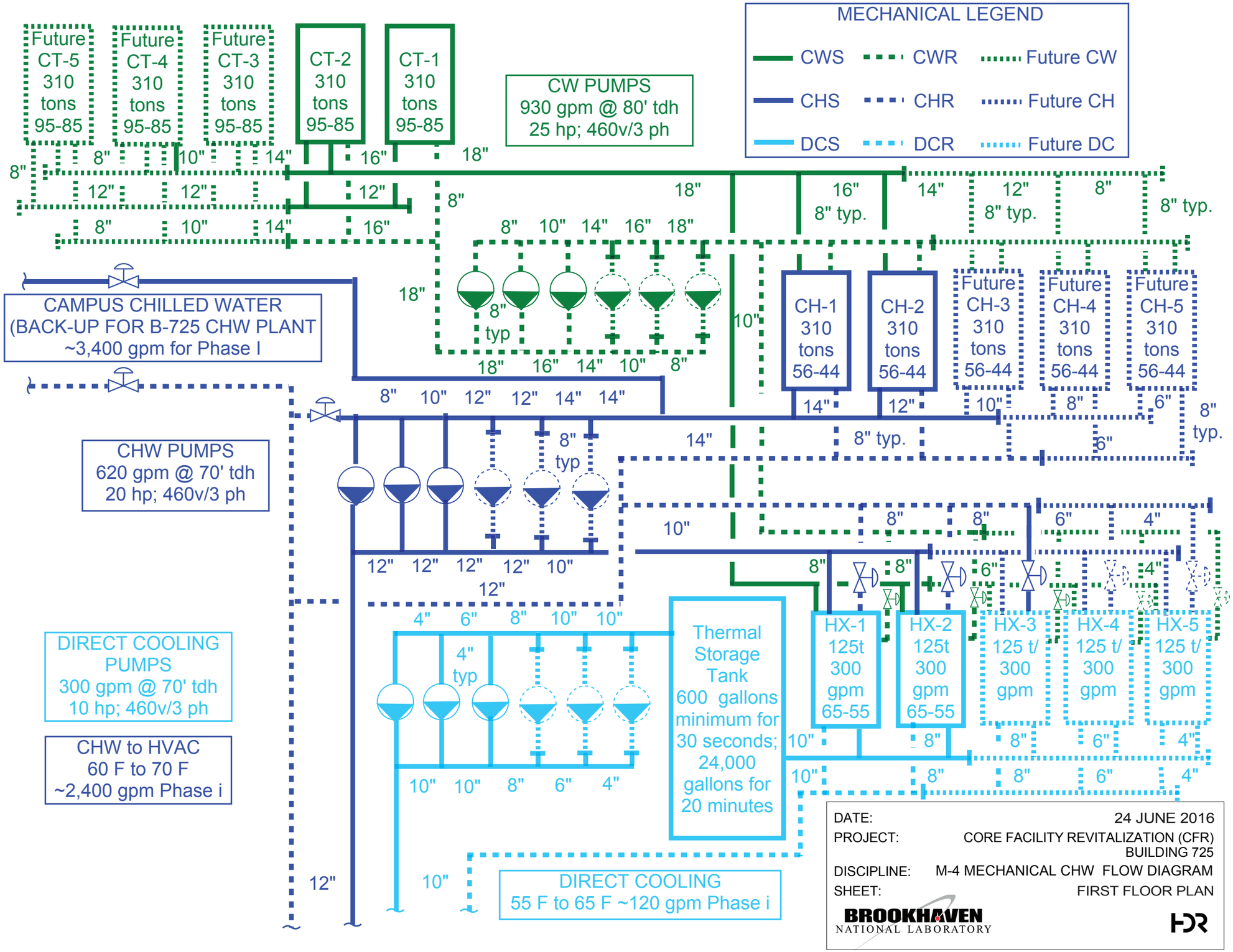
MECHANICAL LEGEND

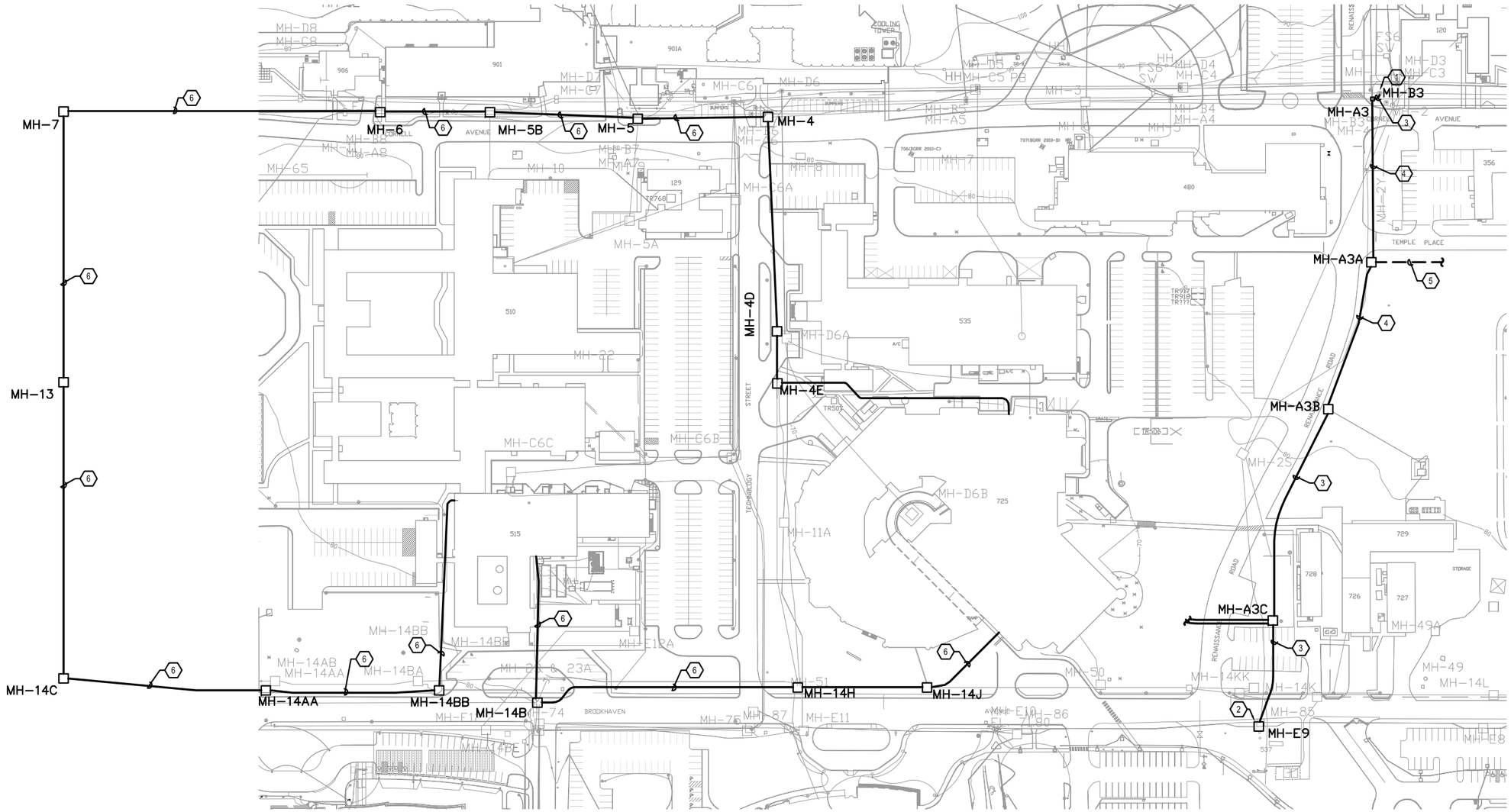
- DRY AIR ECONOMISER (DAE) 400 kW Capacity ~50,000 cfm
- DEDICATED OUTSIDE AIR VENTILATION AHU ~15,000 cfm
- DAE SUPPLY AIR DUCT
- DAE RETURN AIR DUCT

DATE:	01 JULY 2016
PROJECT:	CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE:	M1.2 MECHANICAL - BUILD OUT
SHEET:	2.4.1.2 FIRST FLOOR PLAN

BROOKHAVEN NATIONAL LABORATORY

HDR


MECHANICAL LEGEND
CWS
CWR
Future CW
CHS
CHR
Future CH
DCS
DCR
Future DC
Future CT-5 310 tons 95-85
Future CT-4 310 tons 95-85
Future CT-3 310 tons 95-85
CT-2 310 tons 95-85
CT-1 310 tons 95-85
CW PUMPS 930 gpm @ 80' tdh 25 hp; 460v/3 ph
CAMPUS CHILLED WATER (BACK-UP FOR B-725 CHW PLANT ~3,400 gpm for Phase I
CHW PUMPS 620 gpm @ 70' tdh 20 hp; 460v/3 ph
DIRECT COOLING PUMPS 300 gpm @ 70' tdh 10 hp; 460v/3 ph
CHW to HVAC 60 F to 70 F ~2,400 gpm Phase i
CH-1 310 tons 56-44
CH-2 310 tons 56-44
Future CH-3 310 tons 56-44
Future CH-4 310 tons 56-44
Future CH-5 310 tons 56-44
HX-1 125t 300 gpm 65-55
HX-2 125t 300 gpm 65-55
HX-3 125 t/ 300 gpm
HX-4 125 t/ 300 gpm
HX-5 125 t/ 300 gpm
Thermal Storage Tank 600 gallons minimum for 30 seconds; 24,000 gallons for 20 minutes
DIRECT COOLING 55 F to 65 F ~120 gpm Phase i
typ
8" typ.
6" typ.
DATE: 24 JUNE 2016
PROJECT: CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE: M-4 MECHANICAL CHW FLOW DIAGRAM
SHEET: FIRST FLOOR PLAN
BROOKHAVEN NATIONAL LABORATORY
HDR



NOTES:

1. PROVIDE 3-WAY SPLICE IN EXISTING FEEDERS 725-1.
2. PROVIDE 3-WAY SPLICE IN EXISTING FEEDERS 725-2.
3. PROVIDE 6-WAY 5" DUCT AND ONE SET OF 3-1/C 15KV, MV-105, 500 KCMIL COPPER, 133% EPR TAPE SHIELD FEEDER CONDUCTORS WITH ONE 600V, #4/0 GROUND.
4. PROVIDE ONE SETS OF 3-1/C 15KV, MV-105, 500 KCMIL COPPER, 133% EPR, TAPE SHIELD FEEDER CONDUCTORS WITH 600V #4/0 GROUND IN EXISTING DUCT BANK.
5. FUTURE DUCT BANK TO THE CAMPUS SUBSTATION AT BUILDING 603 TO BE INSTALLED WHEN THE INCREASING DATA CENTER LOAD EXCEEDS THE CAPACITY OF THE EXISTING FEEDERS.
6. REMOVE EXISTING ABANDONED COPPER COMMUNICATION CABLE(S) FROM ONE DUCT AS DIRECTED BY BNL. PROVIDE (3) 3"-CELL FABRIC INNERDUCTS. PROVIDE ??? FIBER OPTIC CABLES.

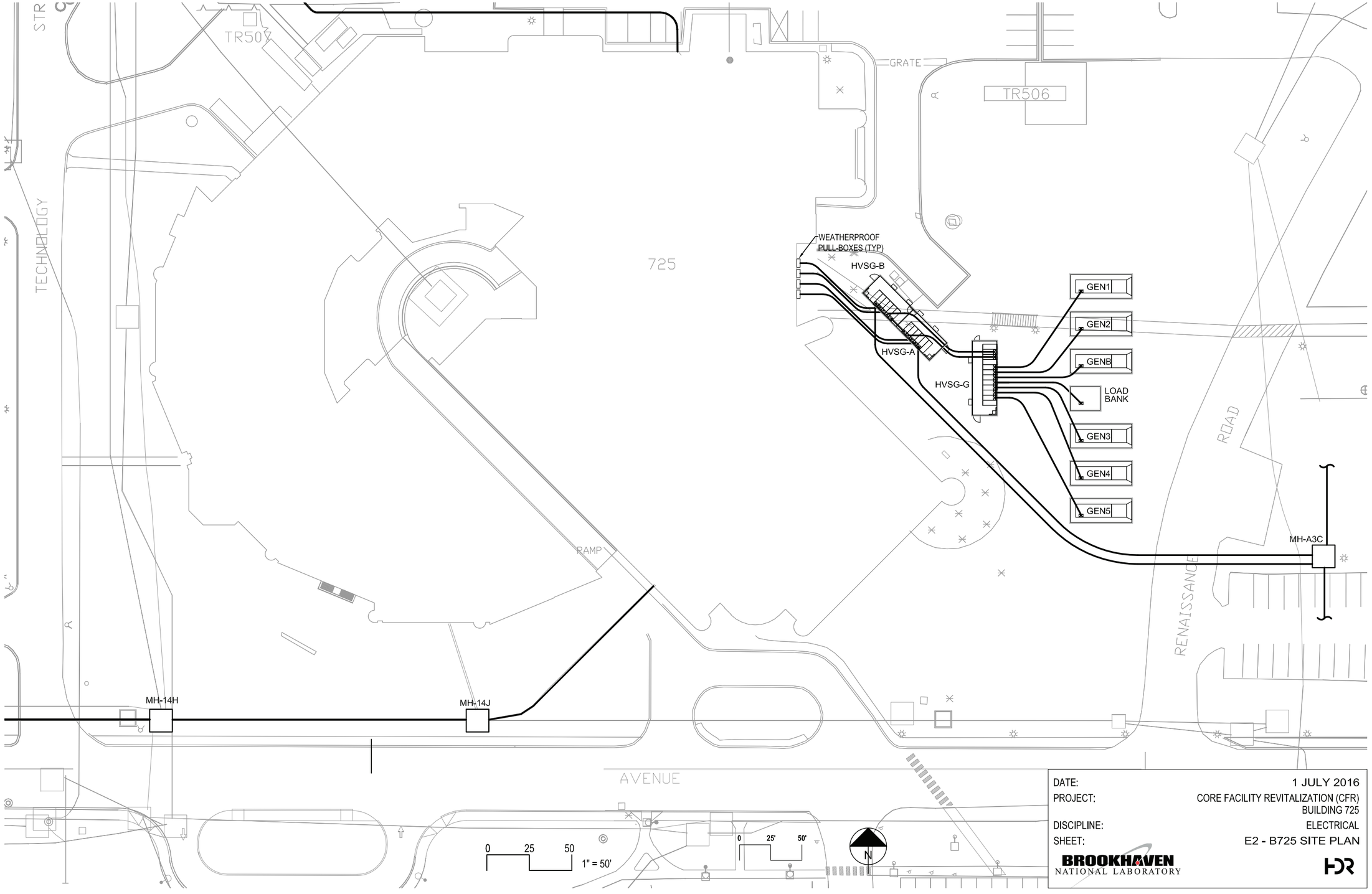
0 75' 150'

N

DATE:	1 JULY 2016
PROJECT:	CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE:	ELECTRICAL
SHEET:	E1 - CAMPUS SITE PLAN

BROOKHAVEN NATIONAL LABORATORY

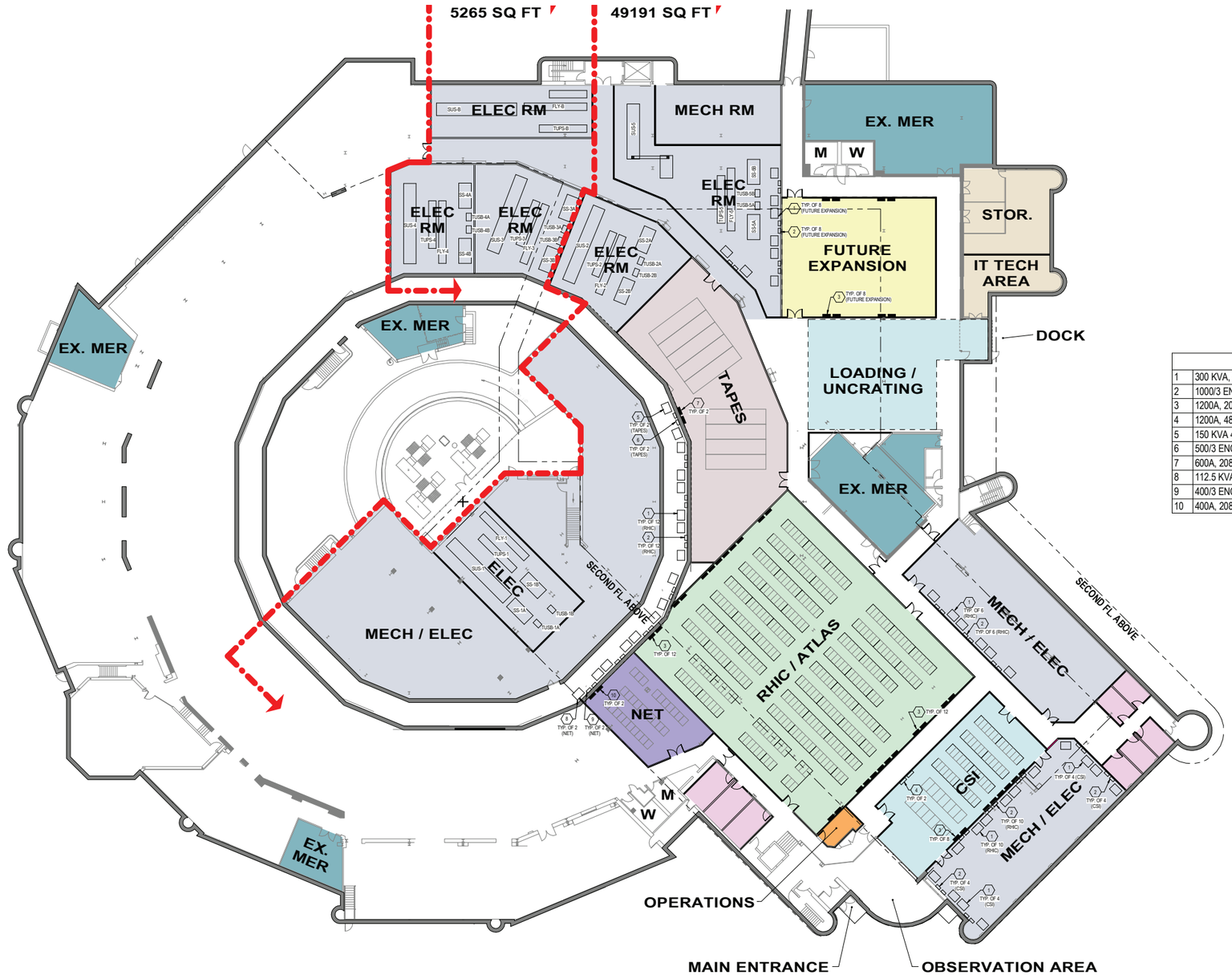
HDR



DATE:	1 JULY 2016
PROJECT:	CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE:	ELECTRICAL
SHEET:	E2 - B725 SITE PLAN

BROOKHAVEN NATIONAL LABORATORY

HDR

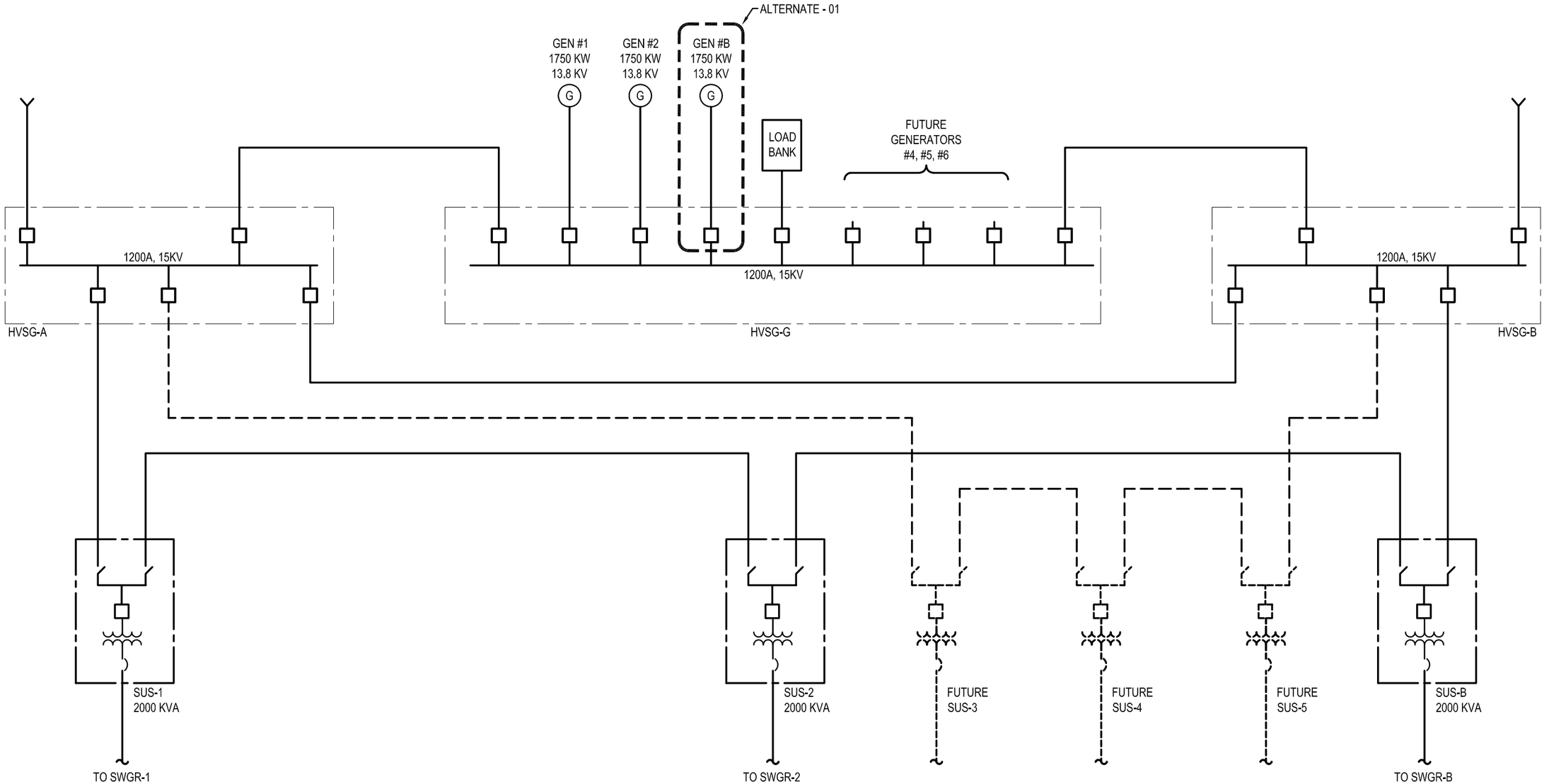


KEYED SHEET NOTES	
1	300 KVA, 480-208Y/120V TRANSFORMER.
2	1000/3 ENCLOSED CIRCUIT BREAKER.
3	1200A, 208Y/120V TULDP.
4	1200A, 480V TUHDP.
5	150 KVA 480-208Y/120V TRANSFORMER.
6	500/3 ENCLOSED CIRCUIT BREAKER.
7	600A, 208Y/120V TULDP.
8	112.5 KVA 480-208Y/120V TRANSFORMER.
9	400/3 ENCLOSED CIRCUIT BREAKER.
10	400A, 208Y/120V TULDP.

DATE:	1 JULY 2016
PROJECT:	CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE:	GENERATOR STUDY
SHEET:	E3 - FIRST FLOOR PLAN - POWER

BROOKHAVEN NATIONAL LABORATORY

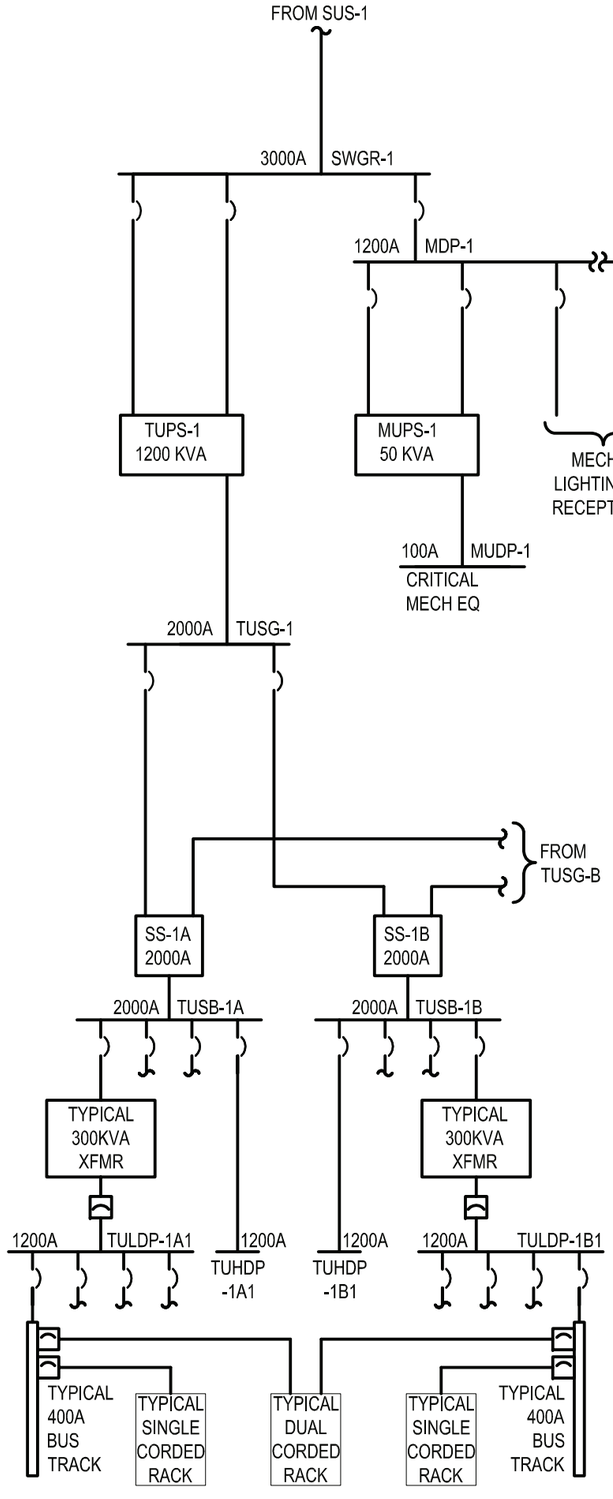
HDR



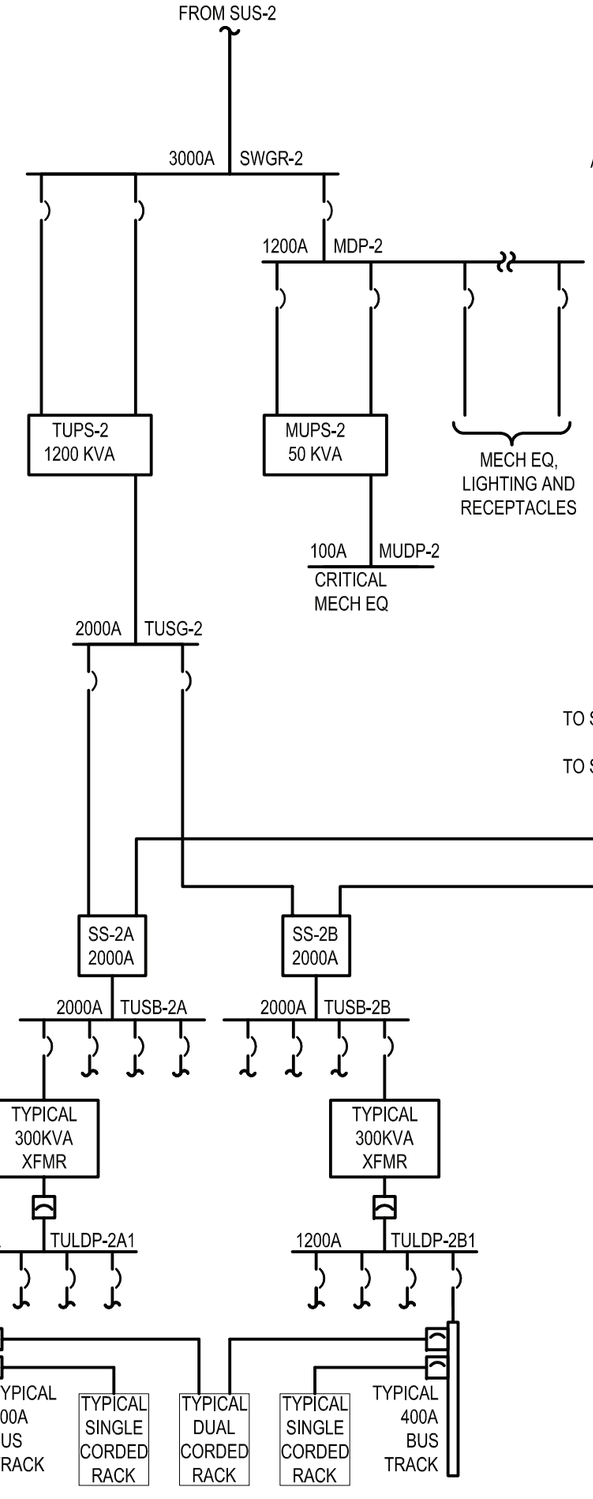
DATE:	1 JULY 2016
PROJECT:	CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE:	ELECTRICAL
SHEET:	E4 - 15 KV ONE-LINE

BROOKHAVEN NATIONAL LABORATORY

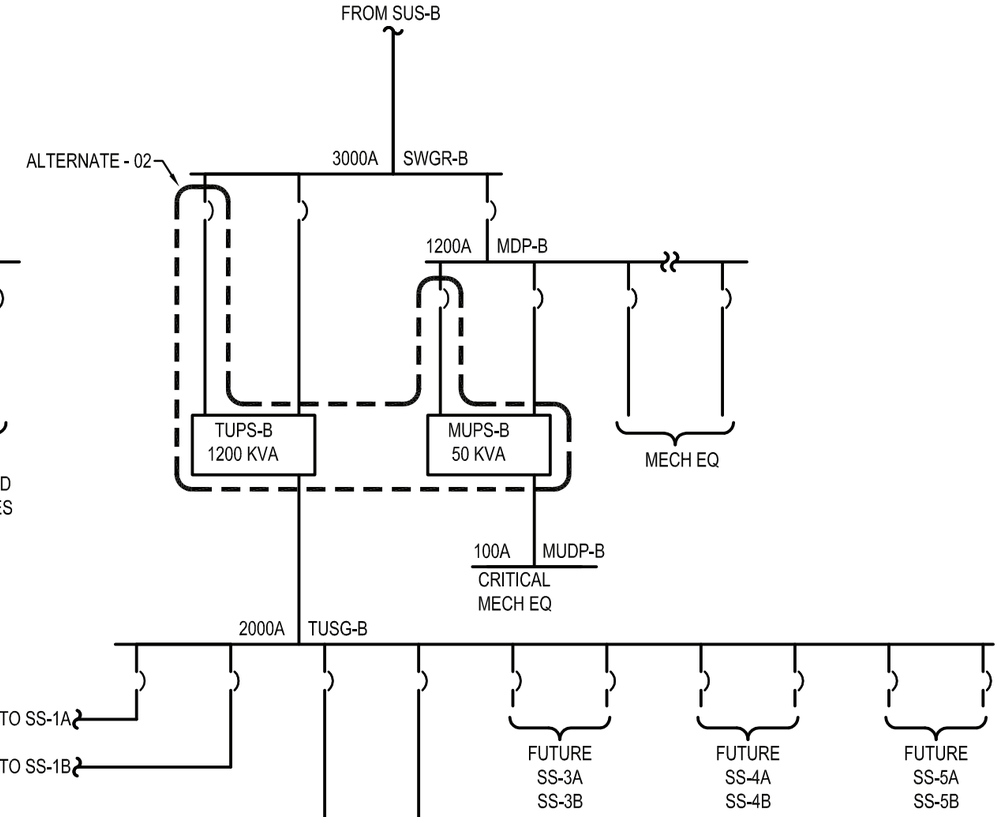
HDR



SYSTEM #1



SYSTEM #2



SYSTEM BYPASS

DATE:	1 JULY 2016
PROJECT:	CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE:	ELECTRICAL
SHEET:	E5 - 480V AND 208V ONE-LINE

BROOKHAVEN NATIONAL LABORATORY

HDR

2.5 Room Data Sheets

ROOM DATA SHEET

Home

ROOM NAME: **RHIC/Atlas Data Hall** PROGRAM CODE:

GENERAL:

Room Environment: **Data Processing Equipment Space** **Occupancy Type (IBC):** **B**

Space Requirements:

Space Size : (L) x (W) = nsf **x** # Spaces = Total **10,800** nsf

Adjacencies: (In order of Importance)	1.	**Network Equipment**	**Avoid:**	1.	
	2.	**Tape Library**		2.	
	3.			3.	

*** Population (Occupant Load) and Space Utilization:**

Current: Projected (max): ***0*** Days/week: ***7*** Hours/Day: ***24***

Room Function:

Data Hall space for RHIC/Atlas computing equipment.

STRUCTURAL DATA:

Structural Loads:

Floor Load: **250** psf Overhead Loads: **25** psf (uniform suspended load)

Equipment/Instrument Weight: lbs Equipment Footprint: **Cabinets**

Other Structural Requirements:

Pits/Trenches/Deflection (describe):

Hoist or Crane/Capacity & Type:

FINISHES:

	Material:	**Finish:**	**Ceiling Height:** **10 ft.**
Floors:	**Concrete**	**Sealer/Hardener**	**Special Floor Conditions:**
Walls:	**Gypsum Wallboard**	**Paint**	Conductive or Static Dissipative **Yes**
Ceilings:	**Acoustic Ceiling Panels**	**Washable**	Raised Access Floor (height?) **30 in.**
Other:	**Consider Topping Slab Over Existing**		Grounded Floor? **Yes**

ENVIRONMENTAL:

Design Noise Criteria (NC) : **N/A** Cleanroom Class: **N/A**

Temperature: Summer: **80.6** °F Range (+/-): °F Winter: **80-.6** °F Range (+/-): °F

Humidity (max/min): Summer: **41.9-59 dew pt.** F (+/-) % Winter: **41.9-59 dew pt.** F (+/-): %

NOTES: ***Temperature values are maximum in the cold aisle. Hot aisle containment required.***

ROOM DATA SHEET

Home

ROOM NAME: **RHIC/Atlas Data Hall** PROGRAM CODE:

SPECIAL REQUIREMENTS:

RFI/EMI Criteria:	**N/A**	Casework Material:	**N/A**
Vibration Criteria :	**N/A**	Benchtop Material:	**N/A**
Toxic/Hazardous Materials :	**None**	Safety Shower/Eye Wash:	**N/A**
Secondary Containment :	**Not Required**	Fume Hoods/Lab Equip:	
Special Door Hardware :	**Access Control**		
Oversized Equipment Access:	**8' x 8' Door Opening**		

Notes:

HVAC:

			Exhaust Systems/Types:	
Room Pressure (pos, neg, neutral):	**Positive**	☐	Lab (fume hood) Exhaust:	
Differential Pressure (in. w.g.):		☐	Dust Extraction:	
Room Velocity/ ACH:		☐		
Single Pass/Recirculating:	**Recirculating**	☐	General (Room) Exhaust :	
Snorkel Exhaust (count):	**N/A**	☐		
Exhaust Taps or Connections:	**N/A**	☐	Purge Exhaust (O2 depletion):	**Not Required**

Notes : ***Ventilation per ASHRAE 62.1***

FIRE PROTECTION:

Hazard Classification :	**Light Hazard**
Type:	**Double Interlock Pre-Action**

PLUMBING:

	# Outlets		**# Outlets (each)**
Lab Sinks :		Floor Sink/Floor Drain:	**Floor Drains Required**
☐ Non-Potable Water (Industrial):		Condensate Drain:	
☐ Eyewash/Shower (tempered, potable):		Other Drain Requirements:	
☐ Potable (domestic) Water:			

Notes: ***Containment (i.e., drip pans) and leak detection required at all wet piping.***

ROOM DATA SHEET

Home

ROOM NAME: **RHIC/Atlas Data Hall** PROGRAM CODE:

ELECTRICAL:

Hazard Area Class : **N/A** (NEC)

Lighting :

Light Level (footcandles) :	**50 fc**
Lighting Type (fluor, incan):	**Fluorescent or LED**
Light Switching Type:	**Occupancy Sensors**
[x] Dimmable Lighting Control	**Multi-Level Switching**
[x] Special Fixtures :	**Overhead Busway**
[x] Other :	**2 levels Cable Tray**
Type:	

Equipment Power: watts/sf

[x] 120V/208V (1 Phase):	**PDU Output**
[ ] 208V (3 Phase) :	
[x] 480V (3 Phase) :	**UPS Output**
[x] Conditioned Power :	**via UPS**
[x] Stand-by Power:	**8 hours fuel**
[x] UPS:	
[ ] 400 Hz Power	

Notes : ***Power provisioning is 1,600 kW on day one, 3,000 kW ultimate.***

TELECOMMUNICATIONS AND SPECIAL SYSTEMS:

[x] VOIP Connections:	**Locations TBD**	[x] Data Connections:	**By Others**
[ ] PA System :		[x] Access Control :	**Card Readers**
[ ] Gas Detection/Type:		Fire Detection Type:	**Air Aspirating**
[x] Liquid Leak Detection:	**At all wet piping**	Other:	**EPO System Required**

Notes :

ROOM DATA SHEET

Home

ROOM NAME: **CSI** PROGRAM CODE:

GENERAL:

Room Environment: **Data Processing Equipment Space** **Occupancy Type (IBC):** **B**

Space Requirements:

Space Size : (L) x (W) = nsf **x** # Spaces = Total **1,950** nsf

Adjacencies: (In order of Importance)	1. **Lobby for Visibility**		**Avoid:**	1.
	2. **Second Floor Corridor for Visibility**			2.
	3. **Network Equipment**			3.

*** Population (Occupant Load) and Space Utilization:**

Current: Projected (max): **0** Days/week: **7** Hours/Day: **24**

Room Function:

Data Hall space for Computational Sciences Initiative (CSI). May include IBM Blue Gene equipment (IBMBG)

STRUCTURAL DATA:

Structural Loads:

Floor Load: **250** psf Overhead Loads: **25** psf (uniform suspended load)

Equipment/Instrument Weight: lbs Equipment Footprint: **HPC 2'x3.5' nominal**

Other Structural Requirements: **400 psf for IBMBG areas** **IBMBG 4'x4' nominal**

Point Loads: **1,125 lbs. for IBMBG areas**

Hoist or Crane/Capacity & Type:

FINISHES:

	Material:	**Finish:**	**Ceiling Height:** **10 ft.**
Floors:	**Concrete**	**Sealer/Hardener**	**Special Floor Conditions:**
Walls:	**Gypsum Wallboard**	**Paint**	Conductive or Static Dissipative **Yes**
Ceilings:	**Acoustic Ceiling Panels**	**Washable**	Raised Access Floor (height?) **30 in.**
Other:	**Consider Topping Slab over Existing**		Grounded Floor? **Yes**

ENVIRONMENTAL:

Design Noise Criteria (NC) : **N/A** Cleanroom Class: **N/A**

Temperature: Summer: **80.6** °F Range (+/-): °F Winter: **80-.6** °F Range (+/-): °F

Humidity (max/min): Summer: **41.9-59 dew pt.** F (+/-) % Winter: **41.9-59 dew pt.** F (+/-): %

NOTES: ***Temperature values are maximum in the cold aisle. Hot aisle containment required.***

SPECIAL REQUIREMENTS:

RFI/EMI Criteria:	**N/A**	Casework Material:	**N/A**
Vibration Criteria :	**N/A**	Benchtop Material:	**N/A**
Toxic/Hazardous Materials :	**None**	Safety Shower/Eye Wash:	**N/A**
Secondary Containment :	**Not Required**	Fume Hoods/Lab Equip:	
Special Door Hardware :	**Access Control**		
Oversized Equipment Access:	**8' x 8' Door Opening**		

Notes:

HVAC:

				Exhaust Systems/Types:
Room Pressure (pos, neg, neutral):	**Positive**	☐	Lab (fume hood) Exhaust:	
Differential Pressure (in. w.g.):		☐	Dust Extraction:	
Room Velocity/ ACH:		☐		
Single Pass/Recirculating:	**Recirculating**	☐	General (Room) Exhaust :	
Snorkel Exhaust (count):	**N/A**	☐		
Exhaust Taps or Connections:	**N/A**	☐	Purge Exhaust (O2 depletion):	**Not Required**

Notes : ***Ventilation per ASHRAE 62.1***

FIRE PROTECTION:

Hazard Classification :	**Light Hazard**
Type:	**Double Interlock Pre-Action**

PLUMBING:

	# Outlets		**# Outlets (each)**
Lab Sinks :		Floor Sink/Floor Drain:	**Floor Drains Required**
☐ Non-Potable Water (Industrial):		Condensate Drain:	
☐ Eyewash/Shower (tempered, potable):		Other Drain Requirements:	
☐ Potable (domestic) Water:			

Notes: ***Containment (i.e., drip pans) and leak detection required at all wet piping.***

ELECTRICAL:

Hazard Area Class : **N/A** (NEC)

Lighting :

Light Level (footcandles) :	**50 fc**
Lighting Type (fluor, incan):	**Fluorescent or LED**
Light Switching Type:	**Occupancy Sensors**
[x] Dimmable Lighting Control	**Multi-Level Switching**
[x] Special Fixtures :	**Overhead Busway**
[x] Other :	**2 levels Cable Tray**
Type:	

Equipment Power: watts/sf

[x] 120V/208V (1 Phase):	**PDU Output**
[ ] 208V (3 Phase) :	
[x] 480V (3 Phase) :	**UPS Output**
[x] Conditioned Power :	**via UPS**
[x] Stand-by Power:	**8 hours fuel**
[x] UPS:	
[ ] 400 Hz Power	
	480 V power for IBMBG

Notes : ***Power provisioning is 580 kW on day one, 2,725 kW ultimate. IBMBG demand of 100 kW per rack not provisioned in Phase 1.***

TELECOMMUNICATIONS AND SPECIAL SYSTEMS:

[x] VOIP Connections:	**Locations TBD**	[x] Data Connections:	**By Others**
[ ] PA System :		[x] Access Control :	**Card Readers**
[ ] Gas Detection/Type:		Fire Detection Type:	**Air Aspirating**
[x] Liquid Leak Detection:	**At all wet piping**	Other:	**EPO System Required**

Notes :

ROOM DATA SHEET

Home

ROOM NAME: **Future Expansion** PROGRAM CODE:

GENERAL:

Room Environment: **Data Processing Equipment Space** **Occupancy Type (IBC):** **B**

Space Requirements:

Space Size : ____ (L) x ____ (W) = ____ nsf **x** ____ # Spaces = Total **3,450** nsf

Adjacencies:	1.	**Network Equipment**	**Avoid:**	1.	
(In order of	2.	**Tape Library**		2.	
Importance)	3.			3.	

*** Population (Occupant Load) and Space Utilization:**

Current: ____ Projected (max): **0** Days/week: **7** Hours/Day: **24**

Room Function:

Data Hall space for Users To Be Determined.

STRUCTURAL DATA:

Structural Loads:

Floor Load: **250** psf Overhead Loads: **25** psf (uniform suspended load)

Equipment/Instrument Weight: ____ lbs Equipment Footprint:

Other Structural Requirements:

Pits/Trenches/Deflection (describe):

Hoist or Crane/Capacity & Type:

FINISHES:

	Material:	**Finish:**		
Floors:	**Concrete**	**Sealer/Hardener**	**Ceiling Height:**	**10 ft.**
			Special Floor Conditions:	
Walls:	**Gypsum Wallboard**	**Paint**	Conductive or Static Dissipative	**Yes**
Ceilings:	**Acoustic Ceiling Panels**	**Washable**	Raised Access Floor (height?)	**30 in.**
Other:	**Consider Topping Slab over Existing**		Grounded Floor?	**Yes**

ENVIRONMENTAL:

Design Noise Criteria (NC) : **N/A** Cleanroom Class: **N/A**

Temperature: Summer: **80.6** °F Range (+/-): ____ °F Winter: **80-.6** °F Range (+/-): ____ °F

Humidity (max/min): Summer: **41.9-59 dew pt.** F (+/-) ____ % Winter: **41.9-59 dew pt.** F (+/-): ____ %

NOTES: ***Temperature values are maximum in the cold aisle. Hot aisle containment required.***

SPECIAL REQUIREMENTS:

RFI/EMI Criteria:	**N/A**	Casework Material:	**N/A**
Vibration Criteria :	**N/A**	Benchtop Material:	**N/A**
Toxic/Hazardous Materials :	**None**	Safety Shower/Eye Wash:	**N/A**
Secondary Containment :	**Not Required**	Fume Hoods/Lab Equip:	
Special Door Hardware :	**Access Control**		
Oversized Equipment Access:	**8' x 8' Door Opening**		

Notes:

HVAC:

			Exhaust Systems/Types:	
Room Pressure (pos, neg, neutral):	**Positive**	☐	Lab (fume hood) Exhaust:	
Differential Pressure (in. w.g.):		☐	Dust Extraction:	
Room Velocity/ ACH:		☐		
Single Pass/Recirculating:	**Recirculating**	☐	General (Room) Exhaust :	
Snorkel Exhaust (count):	**N/A**	☐		
Exhaust Taps or Connections:	**N/A**	☐	Purge Exhaust (O2 depletion):	**Not Required**

Notes : ***Ventilation per ASHRAE 62.1***

FIRE PROTECTION:

Hazard Classification :	**Light Hazard**
Type:	**Double Interlock Pre-Action**

PLUMBING:

	# Outlets		**# Outlets (each)**
Lab Sinks :		Floor Sink/Floor Drain:	**Floor Drains Required**
☐ Non-Potable Water (Industrial):		Condensate Drain:	
☐ Eyewash/Shower (tempered, potable):		Other Drain Requirements:	
☐ Potable (domestic) Water:			

Notes: ***Containment (i.e., drip pans) and leak detection required at all wet piping.***

ELECTRICAL:

Hazard Area Class : **N/A** (NEC)

Lighting :

Light Level (footcandles) :	**50 fc**
Lighting Type (fluor, incan):	**Fluorescent or LED**
Light Switching Type:	**Occupancy Sensors**
[x] Dimmable Lighting Control	**Multi-Level Switching**
[x] Special Fixtures :	**Overhead Busway**
[x] Other :	**2 levels Cable Tray**
Type:	

Equipment Power: watts/sf

[x] 120V/208V (1 Phase):	**PDU Output**
[ ] 208V (3 Phase) :	
[x] 480V (3 Phase) :	**UPS Output**
[x] Conditioned Power :	**via UPS**
[x] Stand-by Power:	**8 hours fuel**
[x] UPS:	
[ ] 400 Hz Power	

Notes : ***No power provisioning is provided.***

TELECOMMUNICATIONS AND SPECIAL SYSTEMS:

[x] VOIP Connections:	**Locations TBD**	[x] Data Connections:	**By Others**
[ ] PA System :		[x] Access Control :	**Card Readers**
[ ] Gas Detection/Type:		Fire Detection Type:	**Air Aspirating**
[x] Liquid Leak Detection:	**At all wet piping**	Other:	**EPO System Required**

Notes :

ROOM DATA SHEET

Home

ROOM NAME: **Tape Library** PROGRAM CODE:

GENERAL:

Room Environment: **Tape Library Equipment Space** **Occupancy Type (IBC):** **B**

Space Requirements:

Space Size : ____ (L) x ____ (W) = 400 nsf **x** **12** # Spaces = Total **4,800** nsf

Adjacencies:	1.	**Data Halls**	**Avoid:**	1.	
(In order of	2.			2.	
Importance)	3.			3.	

*** Population (Occupant Load) and Space Utilization:**

Current: ____ Projected (max): **0** Days/week: **7** Hours/Day: **24**

Room Function:

Tape Library / Silo area.

STRUCTURAL DATA:

Structural Loads:

Floor Load: **250** psf Overhead Loads: **15** psf (uniform suspended load)

Equipment/Instrument Weight: ____ lbs Equipment Footprint: **6 ft. x 24**

Other Structural Requirements:

Pits/Trenches/Deflection (describe):

Hoist or Crane/Capacity & Type:

FINISHES:

	Material:	Finish:	
Floors:	**Concrete**	**Sealer/Hardener**	**Special Floor Conditions:**
Walls:	**Gypsum Wallboard**	**Paint**	Conductive or Static Dissipative **Yes**
Ceilings:	**Acoustic Ceiling Panels**	**Washable**	Raised Access Floor (height?) **30 in.**
Other:	**Consider Topping Slab over Existing**		Grounded Floor? **Yes**

Ceiling Height: **10 ft.**

ENVIRONMENTAL:

Design Noise Criteria (NC) : **N/A** Cleanroom Class: **N/A**

Temperature:	Summer:	**80.6**	°F	Range (+/-):		°F	Winter:	**80.6**	°F	Range (+/-):		°F
Humidity (max/min):	Summer:	**41.9-59 dew pt.**	F	(+/-)		%	Winter:	**41.9-59 dew pt.**	F	(+/-):		%

NOTES: ***Temperature values are maximum in the room.***

SPECIAL REQUIREMENTS:

RFI/EMI Criteria:	**N/A**	Casework Material:	**N/A**
Vibration Criteria :	**N/A**	Benchtop Material:	**N/A**
Toxic/Hazardous Materials :	**None**	Safety Shower/Eye Wash:	**N/A**
Secondary Containment :	**Not Required**	Fume Hoods/Lab Equip:	N/A
Special Door Hardware :	**Access Control**		
Oversized Equipment Access:	**8' x 8' Door Opening**		

Notes: ***2-hr. separation to adjacent uses.***

HVAC:

			Exhaust Systems/Types:	
Room Pressure (pos, neg, neutral):	**Positive**	☐	Lab (fume hood) Exhaust:	
Differential Pressure (in. w.g.):		☐	Dust Extraction:	
Room Velocity/ ACH:		☐		
Single Pass/Recirculating:	**Recirculating**	☐	General (Room) Exhaust :	
Snorkel Exhaust (count):	**N/A**	☐		
Exhaust Taps or Connections:	**N/A**	☐	Purge Exhaust (O2 depletion):	**Not Required**

Notes : ***Ventilation per ASHRAE 62.1***

FIRE PROTECTION:

Hazard Classification :	**Light Hazard**
Type:	**Double Interlock Pre-Action**

PLUMBING:

	# Outlets		# Outlets (each)
Lab Sinks :		Floor Sink/Floor Drain:	**Floor Drains Required**
☐ Non-Potable Water (Industrial):		Condensate Drain:	
☐ Eyewash/Shower (tempered, potable):		Other Drain Requirements:	
☐ Potable (domestic) Water:			

Notes: ***Containment (i.e., drip pans) and leak detection required at all wet piping.***

ELECTRICAL:

Hazard Area Class : **N/A** (NEC)

Lighting :

Light Level (footcandles) :	**50 fc**
Lighting Type (fluor, incan):	**Fluorescent or LED**
Light Switching Type:	**Occupancy Sensors**
[x] Dimmable Lighting Control	**Multi-Level Switching**
Special Fixtures :	
[x] Other :	**Cable Tray**
Type:	

Equipment Power: watts/sf

[x] 120V/208V (1 Phase):	**PDU Output**
[ ] 208V (3 Phase) :	
[x] 480V (3 Phase) :	**UPS Output**
[x] Conditioned Power :	**via UPS**
[x] Stand-by Power:	**8 hours fuel supply**
[x] UPS:	
[ ] 400 Hz Power	

Notes : ***Power Provisioning is 180 kW on day one (12 machines at 15 kW). Power supply configuration is TBD.***

TELECOMMUNICATIONS AND SPECIAL SYSTEMS:

[x] VOIP Connections:	**Locations TBD**	[x] Data Connections:	**By Others**
[ ] PA System :		[x] Access Control :	**Card Readers**
[ ] Gas Detection/Type:		Fire Detection Type:	**Air Aspirating**
[x] Liquid Leak Detection:	**At all wet piping**	Other:	**EPO System Required**

Notes :

ROOM DATA SHEET

Home

ROOM NAME: **Network Equipment** PROGRAM CODE:

GENERAL:

Room Environment: **Network Equipment Space** **Occupancy Type (IBC):** **B**

Space Requirements:

Space Size : **50 ft.** (L) x **20 ft** (W) = nsf **x** # Spaces = Total **1,000** nsf

Adjacencies:	1.	**Data Halls**	**Avoid:**	1.	
(In order of	2.			2.	
Importance)	3.			3.	

*** Population (Occupant Load) and Space Utilization:**

Current: Projected (max): **0** Days/week: **7** Hours/Day: **8**

Room Function:

Local network equipment room. Must be located within 100 meters (fiber path) of all data halls.

STRUCTURAL DATA:

Structural Loads:

Floor Load: **250** psf Overhead Loads: **25** psf (uniform suspended load)

Equipment/Instrument Weight: lbs Equipment Footprint: **Racks 2.5'x4.0'**

Other Structural Requirements:

Pits/Trenches/Deflection (describe):

Hoist or Crane/Capacity & Type:

FINISHES:

	Material:	Finish:	
Floors:	**Concrete**	**Sealer/Hardner**	**Special Floor Conditions:**
Walls:	**Gypsum Wallboard**	**Paint**	Conductive or Static Dissipative **Yes**
Ceilings:	**Acoustic Ceiling Panels**	**Washable**	Raised Access Floor (height?) **30 in.**
Other:	**Consider Topping Slab over Existing**		Grounded Floor? **Yes**

Ceiling Height: **10 ft.**

ENVIRONMENTAL:

Design Noise Criteria (NC) : **N/A** Cleanroom Class: **N/A**

Temperature: Summer: **80.6** °F Range (+/-): °F Winter: **80.6** °F Range (+/-): °F

Humidity (max/min): Summer: **41.9-59 dew pt.** F (+/-) % Winter: **41.9-59 dew pt.** F (+/-) %

NOTES: ***Temperature values are maximum in the room.***

SPECIAL REQUIREMENTS:

RFI/EMI Criteria:	**N/A**	Casework Material:	**N/A**
Vibration Criteria :	**N/A**	Benchtop Material:	**N/A**
Toxic/Hazardous Materials :	**None**	Safety Shower/Eye Wash:	**N/A**
Secondary Containment :	**Not Required**	Fume Hoods/Lab Equip:	N/A
Special Door Hardware :	**Access Control**		
Oversized Equipment Access:	**8' x 8' Door Opening**		

Notes:

HVAC:

			Exhaust Systems/Types:	
Room Pressure (pos, neg, neutral):	**Positive**	☐	Lab (fume hood) Exhaust:	
Differential Pressure (in. w.g.):		☐	Dust Extraction:	
Room Velocity/ ACH:		☐		
Single Pass/Recirculating:	**Recirculating**	☐	General (Room) Exhaust :	
Snorkel Exhaust (count):		☐		
Exhaust Taps or Connections:	**N/A**	☐	Purge Exhaust (O2 depletion):	**Not Required**

Notes : ***Ventilation per ASHRAE 62.1***

FIRE PROTECTION:

Hazard Classification :	**Light Hazard**
Type:	**Double Interlock Pre-Action**

PLUMBING:

	# Outlets		**# Outlets (each)**
Lab Sinks :		Floor Sink/Floor Drain:	**Floor Drains Required**
☐ Non-Potable Water (Industrial):		Condensate Drain:	
☐ Eyewash/Shower (tempered, potable):		Other Drain Requirements:	
☐ Potable (domestic) Water:			

Notes: ***Containment (i.e., drip pans) and leak detection required at all wet piping.***

ELECTRICAL:

Hazard Area Class : **N/A** (NEC)

Lighting :

Light Level (footcandles) :	**50 fc**
Lighting Type (fluor, incan):	**Fluorescent or LED**
Light Switching Type:	**Occupancy Sensors**
[x] Dimmable Lighting Control	**Multi-Level Switching**
[x] Special Fixtures :	**Overhead Bussway**
[x] Other :	**2 levels Cable Tray**
Type:	

Equipment Power: watts/sf

[x] 120V/208V (1 Phase):	**PDU Output**
[ ] 208V (3 Phase) :	
[x] 480V (3 Phase) :	**UPS Output**
[x] Conditioned Power :	**via UPS**
[x] Stand-by Power:	**8 hours fuel supply**
[x] UPS:	
[ ] 400 Hz Power	

Notes : ***Power provisioning is 100 kW on day one.***

TELECOMMUNICATIONS AND SPECIAL SYSTEMS:

[x] VOIP Connections:	**Locations TBD**	[x] Data Connections:	**By Others**
[ ] PA System :		[x] Access Control :	**Card Readers**
[ ] Gas Detection/Type:		Fire Detection Type:	**Air Aspirating**
[x] Liquid Leak Detection:	**At all wet piping**	Other:	**EPO System Required**

Notes :

ROOM DATA SHEET

Home

ROOM NAME: **Typical Private Office** PROGRAM CODE:

GENERAL:

Room Environment: **Office** **Occupancy Type (IBC):** **B**

Space Requirements:

Space Size : **12'-0"** (L) x **10'-0"** (W) = **120** nsf **x** **6** # Spaces = Total **720** nsf

Adjacencies:	1.	**Other offices**	**Avoid:**	1.	**Mechanical Rooms**
(In order of	2.	**Control Room**		2.	
Importance)	3.	**Technicians**		3.	

*** Population (Occupant Load) and Space Utilization:**

Current: Projected (max): **1** Days/week: **5** Hours/Day: **10**

Room Function:

Single occupancy private office.

STRUCTURAL DATA:

Structural Loads:

Floor Load: **50** psf Overhead Loads: psf (uniform suspended load)

Equipment/Instrument Weight: lbs Equipment Footprint:

Other Structural Requirements:

Pits/Trenches/Deflection (describe):

Hoist or Crane/Capacity & Type:

FINISHES:

	Material:	**Finish:**	**Ceiling Height:** **9 ft.**
Floors:	**Carpet**	**Factory Finish**	**Special Floor Conditions:**
Walls:	**Gypsum Wallboard**	**Paint**	Conductive or Static Dissipative **No**
Ceilings:	**Acoustical Ceiling Panels**	**Factory Finish**	Raised Access Floor (height?) **N/A**
Other:	**Consider Topping Slab over Exist**		Grounded Floor? **No**

ENVIRONMENTAL:

Design Noise Criteria (NC) : **35** Cleanroom Class: **N/A**

Temperature: Summer: **72** °F Range (+/-): **2** °F Winter: **68** °F Range (+/-): **2** °F

Humidity (max/min): Summer: **50** % (+/-) **10** % Winter: **30** % (+/-): **10** %

NOTES:

SPECIAL REQUIREMENTS:

RFI/EMI Criteria:	**N/A**	Casework Material:	**N/A**
Vibration Criteria :	**N/A**	Benchtop Material:	**N/A**
Toxic/Hazardous Materials :	**None**	Safety Shower/Eye Wash:	**N/A**
Secondary Containment :	**Not Required**	Fume Hoods/Lab Equip:	N/A
Special Door Hardware :	**Accessible**		
Oversized Equipment Access:	**N/A**		

Notes:

HVAC:

			Exhaust Systems/Types:	
Room Pressure (pos, neg, neutral):	**Positive**	☐	Lab (fume hood) Exhaust:	
Differential Pressure (in. w.g.):		☐	Dust Extraction:	
Room Velocity/ ACH:	**See Below**	☐		
Single Pass/Recirculating:	**Recirculating**	☐	General (Room) Exhaust :	
Snorkel Exhaust (count):		☐		
Exhaust Taps or Connections:	**N/A**	☐	Purge Exhaust (O2 depletion):	

Notes : ***Provide ventilation per ASHRAE 62.1 guidelines.***

FIRE PROTECTION:

Hazard Classification :	**Light Hazard**
Type:	**Automatic Fire Sprinklers**

PLUMBING:

	# Outlets		# Outlets (each)
Lab Sinks :		Floor Sink/Floor Drain:	
☐ Non-Potable Water (Industrial):		Condensate Drain:	
☐ Eyewash/Shower (tempered, potable):		Other Drain Requirements:	
☐ Potable (domestic) Water:			

Notes:

ELECTRICAL:

Hazard Area Class : **N/A** (NEC)

Lighting :

Light Level (footcandles) :	**30 fc amb / 50 fc task**
Lighting Type (fluor, incan):	**Flluorescent or LED**
Light Switching Type:	**Occupancy Sensor**
[x] Dimmable Lighting Control	**Multi-Level Switching**
Special Fixtures :	**TBD**
[x] Other :	**Task Lighting**
Type:	

Equipment Power: watts/sf

[x] 120V/208V (1 Phase):	**Convenience Outlets**
[ ] 208V (3 Phase) :	
[ ] 480V (3 Phase) :	
[ ] Conditioned Power :	
[ ] Stand-by Power:	
[ ] UPS:	
[ ] 400 Hz Power	

Notes :

TELECOMMUNICATIONS AND SPECIAL SYSTEMS:

[x] VOIP Connections:	**Locations TBD**	[x] Data Connections:	**Locations TBD**
[ ] PA System :		[x] Access Control :	**Lockset**
[ ] Gas Detection/Type:		Fire Detection Type:	
[ ] Liquid Leak Detection:		Other:	

Notes :

ROOM DATA SHEET

Home

ROOM NAME: **Typical Shared Office** PROGRAM CODE:

GENERAL:

Room Environment: **Office** **Occupancy Type (IBC):** **B**

Space Requirements:

Space Size : **12'-0"** (L) x **16'-0"** (W) = **192** nsf **x** **6** # Spaces = Total **1,152** nsf

Adjacencies:	1.	**Other Offices**	**Avoid:**	1.	**Mechanical Rooms**
(In order of	2.	**Control Room**		2.	
Importance)	3.	**Technicians**		3.	

*** Population (Occupant Load) and Space Utilization:**

Current: Projected (max): **2** Days/week: **5** Hours/Day: **10**

Room Function:

Shared office space (2 occupants).

STRUCTURAL DATA:

Structural Loads:

Floor Load: **50** psf Overhead Loads: psf (uniform suspended load)

Equipment/Instrument Weight: lbs Equipment Footprint:

Other Structural Requirements:

Pits/Trenches/Deflection (describe):

Hoist or Crane/Capacity & Type:

FINISHES:

	Material:	**Finish:**	**Ceiling Height:** **9 ft.**
Floors:	**Carpet**	**Factory Finish**	**Special Floor Conditions:**
Walls:	**Gypsum Wallboard**	**Paint**	Conductive or Static Dissipative **No**
Ceilings:	**Acoustical Ceiling Panels**	**Factory Finish**	Raised Access Floor (height?) **N/A**
Other:	**Consider Topping Slab over Exist**		Grounded Floor? **No**

ENVIRONMENTAL:

Design Noise Criteria (NC) : **35** Cleanroom Class: **N/A**

Temperature:	Summer:	**72**	°F	Range (+/-):	**2**	°F	Winter:	**68**	°F	Range (+/-): **2** °F
Humidity (max/min):	Summer:	**50**	%	(+/-)	**10**	%	Winter:	**30**	%	(+/-): **10** %

NOTES:

SPECIAL REQUIREMENTS:

RFI/EMI Criteria:	**N/A**	Casework Material:	**N/A**
Vibration Criteria :	**N/A**	Benchtop Material:	**N/A**
Toxic/Hazardous Materials :	**None**	Safety Shower/Eye Wash:	**N/A**
Secondary Containment :	**Not Required**	Fume Hoods/Lab Equip:	N/A
Special Door Hardware :	**Accessible**		
Oversized Equipment Access:	**N/A**		

Notes:

HVAC:

			Exhaust Systems/Types:	
Room Pressure (pos, neg, neutral):	**Positive**	☐	Lab (fume hood) Exhaust:	
Differential Pressure (in. w.g.):		☐	Dust Extraction:	
Room Velocity/ ACH:	**See below**	☐		
Single Pass/Recirculating:	**Recirculating**	☐	General (Room) Exhaust :	
Snorkel Exhaust (count):		☐		
Exhaust Taps or Connections:	**N/A**	☐	Purge Exhaust (O2 depletion):	

Notes : ***Provide ventilation per ASHRAE 62.1 guidelines.***

FIRE PROTECTION:

Hazard Classification :	**Light Hazard**
Type:	**Automatic Fire Sprinklers**

PLUMBING:

	# Outlets		**# Outlets (each)**
Lab Sinks :		Floor Sink/Floor Drain:	
☐ Non-Potable Water (Industrial):		Condensate Drain:	
☐ Eyewash/Shower (tempered, potable):		Other Drain Requirements:	
☐ Potable (domestic) Water:			

Notes:

ELECTRICAL:

Hazard Area Class : **N/A** (NEC)

Lighting :

Light Level (footcandles) :	**30 fc amb / 50 fc task**
Lighting Type (fluor, incan):	**Fluorescent or LED**
Light Switching Type:	**Occupancy Sensor**
[x] Dimmable Lighting Control	**Multi-Level Switching**
Special Fixtures :	**TBD**
[x] Other :	**Task Lighting**
Type:	

Equipment Power: watts/sf

[x] 120V/208V (1 Phase):	**Convenience Outlets**
[ ] 208V (3 Phase) :	
[ ] 480V (3 Phase) :	
[ ] Conditioned Power :	
[ ] Stand-by Power:	
[ ] UPS:	
[ ] 400 Hz Power	

Notes : ***No equipment power is provided under this project.***

TELECOMMUNICATIONS AND SPECIAL SYSTEMS:

[x] VOIP Connections:	**Locations TBD**	[x] Data Connections:	**Locations TBD**
[ ] PA System :		[x] Access Control :	**Lockset**
[ ] Gas Detection/Type:		Fire Detection Type:	
[ ] Liquid Leak Detection:		Other:	

Notes :

ROOM DATA SHEET

Home

ROOM NAME: **MEP Infrastructure (Various)** PROGRAM CODE:

GENERAL:

Room Environment: **Mechanical and Electrical Equipment** **Occupancy Type (IBC):** **B**

Space Requirements:

Space Size : _____ (L) x _____ (W) = _____ nsf **x** _____ # Spaces = Total _____ nsf

Adjacencies: (In order of Importance)	1. **Outdoor Equipment Areas**	**Avoid:**	1.	
	2. **Loading Dock**		2.	
	3. **Data Halls**		3.	

*** Population (Occupant Load) and Space Utilization:**

Current: _____ Projected (max): 0 Days/week: 7 Hours/Day: 24

Room Function:

Rooms and areas supporting MEP equipment.

STRUCTURAL DATA:

Structural Loads:

Floor Load: **125** psf Overhead Loads: **35** psf (uniform suspended load)

Equipment/Instrument Weight: **TBD** lbs Equipment Footprint: **TBD**

Other Structural Requirements: **Point loads greater than 2,000 lbs. to be evaluated separately.**

Pits/Trenches/Deflection (describe): **TBD**

Hoist or Crane/Capacity & Type: **TBD**

FINISHES:

	Material:	Finish:	Ceiling Height: **Open to Structure**
Floors:	**Concrete**	**Sealer Hardener**	**Special Floor Conditions:**
Walls:	**Existing Structure or CMU**	**Paint**	Conductive or Static Dissipative **No**
Ceilings:	**Structure**	**Paint**	Raised Access Floor (height?) **N/A**
Other:	**Consider Topping Slab over Existing**		Grounded Floor? **No**

ENVIRONMENTAL:

Design Noise Criteria (NC) : **N/A** Cleanroom Class: **N/A**

Temperature:	Summer:	**80** °F	Range (+/-):	**25** °F	Winter:	**60** °F	Range (+/-):	**5** °F
Humidity (max/min):	Summer:	**N/A** %	(+/-)	%	Winter:	**N/A** %	(+/-):	%

NOTES: ***Fresh air ventilation to temperature set points above; Design Day not to exceed equipment requirements (105F and non-condensing). Heating by hot water unit heaters.***

SPECIAL REQUIREMENTS:

RFI/EMI Criteria:	**N/A**	Casework Material:	**N/A**
Vibration Criteria :	**N/A**	Benchtop Material:	**N/A**
Toxic/Hazardous Materials :	**None**	Safety Shower/Eye Wash:	**N/A**
Secondary Containment :	**Not Required**	Fume Hoods/Lab Equip:	N/A
Special Door Hardware :	**Access Control**		
Oversized Equipment Access:	**TBD**		

Notes:

HVAC:

			Exhaust Systems/Types:	
Room Pressure (pos, neg, neutral):	**Positive**	☐	Lab (fume hood) Exhaust:	
Differential Pressure (in. w.g.):		☐	Dust Extraction:	
Room Velocity/ ACH:		☐		
Single Pass/Recirculating:	**Fresh Air Ventilation**	☐	General (Room) Exhaust :	
Snorkel Exhaust (count):		☐		
Exhaust Taps or Connections:	**N/A**	☐	Purge Exhaust (O2 depletion):	

Notes : ***Fresh air ventilation to temperature set points above; Design Day not to exceed equipment requirements (105F and non-condensing). Heating by hot water unit heaters.***

FIRE PROTECTION:

Hazard Classification :	**Light Hazard**
Type:	**Automatic Fire Sprinklers**

PLUMBING:

		# Outlets		# Outlets (each)
	Lab Sinks :		Floor Sink/Floor Drain:	**Floor Drains Required**
☐	Non-Potable Water (Industrial):		Condensate Drain:	**Yes**
☐	Eyewash/Shower (tempered, potable):		Other Drain Requirements:	
x	Potable (domestic) Water:	**TBD**		

Notes:

ELECTRICAL:

Hazard Area Class : **N/A** (NEC)

Lighting :

Light Level (footcandles) :	**15 fc**
Lighting Type (fluor, incan):	**Fluorescent or LED**
[x] Light Switching Type:	**Countdown Timer**
[ ] Dimmable Lighting Control	
Special Fixtures :	**TBD**
Other :	**TBD**
Type:	

Equipment Power: watts/sf

[x] 120V/208V (1 Phase):	**Convenience Outlets**
[x] 208V (3 Phase) :	
[x] 480V (3 Phase) :	
[ ] Conditioned Power :	
[x] Stand-by Power:	**Mechanical Equipment**
[x] UPS:	**Chilled Water Pumps**
[ ] 400 Hz Power	

Notes :

TELECOMMUNICATIONS AND SPECIAL SYSTEMS:

[x] VOIP Connections:	**Locations TBD**	[x] Data Connections:	**Where Req'd by Equipment**
[ ] PA System :		[x] Access Control :	**Card Readers**
[ ] Gas Detection/Type:		Fire Detection Type:	**Duct smoke**
[ ] Liquid Leak Detection:		Other:	

Notes :

ROOM DATA SHEET

Home

ROOM NAME: **Loading Dock** PROGRAM CODE:

GENERAL:

Room Environment: **Deliveries and Service Access** **Occupancy Type (IBC):** **B**

Space Requirements:

Space Size : (L) x (W) = nsf **x** # Spaces = Total **320** nsf

Adjacencies:	1.	**MEP Equipment Areas**	**Avoid:**	1.	**Data Halls**
(In order of	2.	**Uncrate / Assembly**		2.	
Importance)	3.	**IT Technician Area**		3.	

*** Population (Occupant Load) and Space Utilization:**

Current: Projected (max): 0 Days/week: 7 Hours/Day: 24

Room Function:

Shipping and receiving, service access to MEP equipment areas.

STRUCTURAL DATA:

Structural Loads:

Floor Load: **125** psf Overhead Loads: **5** psf (uniform suspended load)

Equipment/Instrument Weight: lbs Equipment Footprint: **TBD**

Other Structural Requirements:

Pits/Trenches/Deflection (describe):

Hoist or Crane/Capacity & Type:

FINISHES:

	Material:	**Finish:**	**Ceiling Height:** **Open to Structure**
Floors:	**Concrete**	**Sealer Hardener**	**Special Floor Conditions:**
Walls:	**Existing Structure or CMU**	**Paint**	Conductive or Static Dissipative **No**
Ceilings:	**Structure**	**Paint**	Raised Access Floor (height?) **N/Z**
Other:	**Consider Topping Slab over Existing**		Grounded Floor? **No**

ENVIRONMENTAL:

Design Noise Criteria (NC) : **N/A** Cleanroom Class: **N/A**

Temperature:	Summer:	**80**	°F	Range (+/-):	**25**	°F	Winter:	**60**	°F	Range (+/-): **5** °F
Humidity (max/min):	Summer:	**N/A**	%	(+/-)		%	Winter:	**N/A**	%	(+/-): %

NOTES: ***Fresh air ventilation to temperature set points above; Design Day not to exceed equipment requirements (105F and non-condensing). Heating by hot water unit heaters.***

SPECIAL REQUIREMENTS:

RFI/EMI Criteria:	**N/A**	Casework Material:	**N/A**
Vibration Criteria :	**N/A**	Benchtop Material:	**N/A**
Toxic/Hazardous Materials :	**None**	Safety Shower/Eye Wash:	**N/A**
Secondary Containment :	**Not Required**	Fume Hoods/Lab Equip:	**N/A**
Special Door Hardware :	**Access Control**		
Oversized Equipment Access:	**Roll-up Door Size TBD**		

Notes:

HVAC:

			Exhaust Systems/Types:	
Room Pressure (pos, neg, neutral):	**Positive**	☐	Lab (fume hood) Exhaust:	
Differential Pressure (in. w.g.):		☐	Dust Extraction:	
Room Velocity/ ACH:		☐		
Single Pass/Recirculating:	**Fresh Air Ventilation**	☐	General (Room) Exhaust :	
Snorkel Exhaust (count):		☐		
Exhaust Taps or Connections:	**N/A**	☐	Purge Exhaust (O2 depletion):	

Notes : ***Fresh air ventilation to temperature set points above; Design Day not to exceed equipment requirements (105F and non-condensing). Heating by hot water unit heaters.***

FIRE PROTECTION:

Hazard Classification :	**Light Hazard**
Type:	**Automatic Fire Sprinklers**

PLUMBING:

	# Outlets		**# Outlets (each)**
Lab Sinks :		Floor Sink/Floor Drain:	**Floor Drains Required**
☐ Non-Potable Water (Industrial):		Condensate Drain:	
☐ Eyewash/Shower (tempered, potable):		Other Drain Requirements:	
☐ Potable (domestic) Water:			

Notes:

ELECTRICAL:

Hazard Area Class : **N/A** (NEC)

Lighting :

Light Level (footcandles) :	**15 fc**
Lighting Type (fluor, incan):	**Fluorescent or LED**
Light Switching Type:	**Occupancy Sensors**
☐ Dimmable Lighting Control	
Special Fixtures :	**TBD**
Other :	**TBD**
Type:	

Equipment Power: watts/sf

☒ 120V/208V (1 Phase):	**Convenience Outlets**
☐ 208V (3 Phase) :	
☐ 480V (3 Phase) :	
☐ Conditioned Power :	
☐ Stand-by Power:	
☐ UPS:	
☐ 400 Hz Power	

Notes :

TELECOMMUNICATIONS AND SPECIAL SYSTEMS:

☒ VOIP Connections:	**Locations TBD**	☐ Data Connections:	
☐ PA System :		☒ Access Control :	**Card Readers**
☐ Gas Detection/Type:		Fire Detection Type:	
☐ Liquid Leak Detection:		Other:	

Notes :

ROOM DATA SHEET

Home

ROOM NAME: **Uncrate and Assembly** PROGRAM CODE:

GENERAL:

Room Environment: **Removal and Disposal of Packaging** **Occupancy Type (IBC):** **B**

Space Requirements:

Space Size : (L) x (W) = nsf **x** # Spaces = Total **240** nsf

Adjacencies:	1.	**Loading Dock**	**Avoid:**	1.	
(In order of	2.	**IT Technician Area**		2.	
Importance)	3.			3.	

*** Population (Occupant Load) and Space Utilization:**

Current: Projected (max): **0** Days/week: **7** Hours/Day: **24**

Room Function:

Equipment uncrating, disposal of packing materials, potential for initial assembly of large components.

STRUCTURAL DATA:

Structural Loads:

Floor Load: **125** psf Overhead Loads: psf (uniform suspended load)

Equipment/Instrument Weight: lbs Equipment Footprint: **TBD**

Other Structural Requirements:

Pits/Trenches/Deflection (describe):

Hoist or Crane/Capacity & Type:

FINISHES:

	Material:	**Finish:**	**Ceiling Height:** **Open to Structure**
Floors:	**Concrete**	**Sealer Hardener**	**Special Floor Conditions:**
Walls:	**CMU**	**Paint**	Conductive or Static Dissipative **No**
Ceilings:	**Structure**	**Paint**	Raised Access Floor (height?) **N/A**
Other:	**Consider Topping Slab over Existing**		Grounded Floor? **No**

ENVIRONMENTAL:

Design Noise Criteria (NC) : **N/A** Cleanroom Class: **N/A**

Temperature:	Summer:	**72**	°F	Range (+/-):		°F	Winter:	**68**	°F	Range (+/-): **2** °F
Humidity (max/min):	Summer:	**50**	%	(+/-)	**10**	%	Winter:	**30**	%	(+/-): **10** %

NOTES:

SPECIAL REQUIREMENTS:

RFI/EMI Criteria:	**N/A**	Casework Material:	**N/A**
Vibration Criteria :	**N/A**	Benchtop Material:	**N/A**
Toxic/Hazardous Materials :	**None**	Safety Shower/Eye Wash:	**N/A**
Secondary Containment :	**Not Required**	Fume Hoods/Lab Equip:	N/A
Special Door Hardware :	**Access Control**		
Oversized Equipment Access:	**6' x 8' Door Opening**		

Notes: ***Dumpster to be provided.***

HVAC:

			Exhaust Systems/Types:	
Room Pressure (pos, neg, neutral):	**Neutral**	☐	Lab (fume hood) Exhaust:	
Differential Pressure (in. w.g.):		☐	Dust Extraction:	
Room Velocity/ ACH:		☐		
Single Pass/Recirculating:	**Recirculating**	☐	General (Room) Exhaust :	
Snorkel Exhaust (count):		☐		
Exhaust Taps or Connections:	**N/A**	☐	Purge Exhaust (O2 depletion):	

Notes : ***Provide ventilation per ASHRAE 62.1 recommendations.***

FIRE PROTECTION:

Hazard Classification :	**Light Hazard**
Type:	**Automatic Fire Sprinklers**

PLUMBING:

	# Outlets		**# Outlets (each)**
Lab Sinks :		Floor Sink/Floor Drain:	**Floor Drains Required**
☐ Non-Potable Water (Industrial):		Condensate Drain:	
☐ Eyewash/Shower (tempered, potable):		Other Drain Requirements:	
☐ Potable (domestic) Water:			

Notes:

ELECTRICAL:

Hazard Area Class : **N/A** (NEC)

Lighting :

Light Level (footcandles) :	**30 fc**
Lighting Type (fluor, incan):	**Fluorescent or LED**
Light Switching Type:	**Occupancy Sensors**
☐ Dimmable Lighting Control	
Special Fixtures :	**TBD**
Other :	**TBD**
Type:	

Equipment Power: watts/sf

☒ 120V/208V (1 Phase):	**Convenience Outlets**
☐ 208V (3 Phase) :	
☐ 480V (3 Phase) :	
☐ Conditioned Power :	
☐ Stand-by Power:	
☐ UPS:	
☐ 400 Hz Power	

Notes :

TELECOMMUNICATIONS AND SPECIAL SYSTEMS:

☐ VOIP Connections:		☐ Data Connections:	
☐ PA System :		☒ Access Control :	**Card Readers**
☐ Gas Detection/Type:		Fire Detection Type:	
☐ Liquid Leak Detection:		Other:	

Notes :

ROOM DATA SHEET

Home

ROOM NAME: **IT Technician Area** PROGRAM CODE:

GENERAL:

Room Environment: **Technical Shop Space** **Occupancy Type (IBC):** **B**

Space Requirements:

Space Size : (L) x (W) = nsf **x** # Spaces = Total **500** nsf

Adjacencies:	1.	**Uncrate / Assembly Area**	**Avoid:**	1.	
(In order of	2.	**Loading Dock**		2.	
Importance)	3.			3.	

*** Population (Occupant Load) and Space Utilization:**

Current: Projected (max): **3** Days/week: **5** Hours/Day: **10**

Room Function:

Shop space for configuration and installation of IT equipment and components. Work benches at perimeter of room.

STRUCTURAL DATA:

Structural Loads:

Floor Load: **125** psf Overhead Loads: **25** psf (uniform suspended load)

Equipment/Instrument Weight: lbs Equipment Footprint: **TBD**

Other Structural Requirements:

Pits/Trenches/Deflection (describe):

Hoist or Crane/Capacity & Type:

FINISHES:

	Material:	**Finish:**		
Floors:	**VCT**	**Sealer**	**Ceiling Height:**	**10 ft.**
			Special Floor Conditions:	
Walls:	**CMU or Gypsum Wallboard**	**Paint**	Conductive or Static Dissipative	**No**
Ceilings:	**Acoustical Ceiling Panels**	**Factory Finish**	Raised Access Floor (height?)	**N/A**
Other:	**Consider Topping Slab over Existing**		Grounded Floor?	**No**

ENVIRONMENTAL:

Design Noise Criteria (NC) : **35** Cleanroom Class: **N/A**

Temperature:	Summer:	**72**	°F	Range (+/-):	**2**	°F	Winter:	**68**	°F	Range (+/-): **2** °F
Humidity (max/min):	Summer:	**50**	%	(+/-)	**10**	%	Winter:	**30**	%	(+/-): **10** %

NOTES:

SPECIAL REQUIREMENTS:

RFI/EMI Criteria:	**N/A**	Casework Material:	**N/A**
Vibration Criteria :	**N/A**	Benchtop Material:	**N/A**
Toxic/Hazardous Materials :	**None**	Safety Shower/Eye Wash:	**N/A**
Secondary Containment :	**Not Required**	Fume Hoods/Lab Equip:	**N/A**
Special Door Hardware :	**Access Control**		
Oversized Equipment Access:	**6' x 8' Door Opening**		

Notes:

HVAC:

				Exhaust Systems/Types:
Room Pressure (pos, neg, neutral):	**Positive**	☐	Lab (fume hood) Exhaust:	
Differential Pressure (in. w.g.):		☐	Dust Extraction:	
Room Velocity/ ACH:		☐		
Single Pass/Recirculating:	**Recirculating**	☐	General (Room) Exhaust :	
Snorkel Exhaust (count):		☐		
Exhaust Taps or Connections:	**N/A**	☐	Purge Exhaust (O2 depletion):	

Notes : ***Provide ventilation per ASHRAE 62.1 recommendations.***

FIRE PROTECTION:

Hazard Classification :	**Light Hazard**
Type:	**Automatic Fire Sprinklers**

PLUMBING:

	# Outlets		**# Outlets (each)**
Lab Sinks :		Floor Sink/Floor Drain:	
☐ Non-Potable Water (Industrial):		Condensate Drain:	
☐ Eyewash/Shower (tempered, potable):		Other Drain Requirements:	
☐ Potable (domestic) Water:			

Notes:

ELECTRICAL:

Hazard Area Class : **N/A** (NEC)

Lighting :

Light Level (footcandles) :	**50 fc**
Lighting Type (fluor, incan):	**Fluorescent or LED**
Light Switching Type:	**Occupancy Sensors**
[x] Dimmable Lighting Control	**Multi-Level Switching**
Special Fixtures :	**TBD**
Other :	**TBD**
Type:	

Equipment Power: watts/sf

[x] 120V/208V (1 Phase):	**Convenience Outlets**
[x] 208V (3 Phase) :	**At Benches**
[ ] 480V (3 Phase) :	
[ ] Conditioned Power :	
[ ] Stand-by Power:	
[ ] UPS:	
[ ] 400 Hz Power	

Notes :

TELECOMMUNICATIONS AND SPECIAL SYSTEMS:

[x] VOIP Connections:	**Locations TBD**	[x] Data Connections:	**Path to Network Room**
[ ] PA System :		[x] Access Control :	**Card Readers**
[ ] Gas Detection/Type:		Fire Detection Type:	
[ ] Liquid Leak Detection:		Other:	

Notes :

ROOM DATA SHEET

Home

ROOM NAME: **Control Room** PROGRAM CODE:

GENERAL:

Room Environment: **Control Room / Operations Office** **Occupancy Type (IBC):** **B**

Space Requirements:

Space Size : (L) x (W) = nsf **x** # Spaces = Total **150** nsf

Adjacencies:	1.	**Facility Entrance**	**Avoid:**	1.	
(In order of	2.	**Data Halls**		2.	
Importance)	3.			3.	

*** Population (Occupant Load) and Space Utilization:**

Current: Projected (max): **1** Days/week: **7** Hours/Day: **24**

Room Function:

Provisions for monitoring and control of infrastructure systems. Can also provide location for security / access control functions.

STRUCTURAL DATA:

Structural Loads:

Floor Load: **50** psf Overhead Loads: psf (uniform suspended load)

Equipment/Instrument Weight: lbs Equipment Footprint: **TBD**

Other Structural Requirements:

Pits/Trenches/Deflection (describe):

Hoist or Crane/Capacity & Type:

FINISHES:

	Material:	**Finish:**	**Ceiling Height:** **9 ft.**
Floors:	**VCT**	**Sealer**	**Special Floor Conditions:**
Walls:	**Gypsum Wallboard**	**Paint**	Conductive or Static Dissipative **No**
Ceilings:	**Acoustical Ceiling Panels**	**Factory Finish**	Raised Access Floor (height?) **N/A**
Other:	**Consider Topping Slab over Exist**		Grounded Floor? **No**

ENVIRONMENTAL:

Design Noise Criteria (NC) : **35** Cleanroom Class: **N/A**

Temperature: Summer: **72** °F Range (+/-): **2** °F Winter: **68** °F Range (+/-): **2** °F

Humidity (max/min): Summer: **50** % (+/-) **10** % Winter: **30** % (+/-): **10** %

NOTES:

SPECIAL REQUIREMENTS:

RFI/EMI Criteria:	**N/A**	Casework Material:	**N/A**
Vibration Criteria :	**N/A**	Benchtop Material:	**N/A**
Toxic/Hazardous Materials :	**None**	Safety Shower/Eye Wash:	**N/A**
Secondary Containment :	**Not Required**	Fume Hoods/Lab Equip:	N/A
Special Door Hardware :	**Access Control**		
Oversized Equipment Access:	**N/A**		

Notes:

HVAC:

			Exhaust Systems/Types:	
Room Pressure (pos, neg, neutral):	**Neutral**	☐	Lab (fume hood) Exhaust:	
Differential Pressure (in. w.g.):		☐	Dust Extraction:	
Room Velocity/ ACH:		☐		
Single Pass/Recirculating:	**Recirculating**	☐	General (Room) Exhaust :	
Snorkel Exhaust (count):		☐		
Exhaust Taps or Connections:	**N/A**	☐	Purge Exhaust (O2 depletion):	

Notes : ***Provide ventilation per ASHRAE 62.1 recommendations.***

FIRE PROTECTION:

Hazard Classification :	**Light Hazard**
Type:	**Automatic Fire Sprinkler**

PLUMBING:

	# Outlets		# Outlets (each)
Lab Sinks :		Floor Sink/Floor Drain:	
☐ Non-Potable Water (Industrial):		Condensate Drain:	
☐ Eyewash/Shower (tempered, potable):		Other Drain Requirements:	
☐ Potable (domestic) Water:			

Notes:

ELECTRICAL:

Hazard Area Class : **N/A** (NEC)

Lighting :

Light Level (footcandles) :	**50 fc**
Lighting Type (fluor, incan):	**Fluorescent or LED**
Light Switching Type:	**Occupancy Sensors**
☐ Dimmable Lighting Control	**Multi-Level Switching**
Special Fixtures :	**TBD**
Other :	**TBD**
Type:	

Equipment Power: watts/sf

☒ 120V/208V (1 Phase):	**Convenience Outlets**
☐ 208V (3 Phase) :	
☐ 480V (3 Phase) :	
☐ Conditioned Power :	
☐ Stand-by Power:	
☒ UPS:	**Yes**
☐ 400 Hz Power	

Notes :

TELECOMMUNICATIONS AND SPECIAL SYSTEMS:

☒ VOIP Connections:	**Locations TBD**	☒ Data Connections:	**Path to Network Room**
☐ PA System :		☒ Access Control :	**Card Readers**
☐ Gas Detection/Type:		Fire Detection Type:	**Spot Smoke**
☐ Liquid Leak Detection:		Other:	

Notes :

ROOM DATA SHEET

Home

ROOM NAME: **Pantry** PROGRAM CODE:

GENERAL:

Room Environment: **Break Area / Coffee Bar** **Occupancy Type (IBC):** **B**

Space Requirements:

Space Size : (L) x (W) = nsf **x** # Spaces = Total **100** nsf

Adjacencies:	1.	**Office Areas**	**Avoid:**	1.	
(In order of	2.			2.	
Importance)	3.			3.	

*** Population (Occupant Load) and Space Utilization:**

Current: Projected (max): **0** Days/week: **5** Hours/Day: **10**

Room Function:

STRUCTURAL DATA:

Structural Loads:

Floor Load: **50** psf Overhead Loads: psf (uniform suspended load)

Equipment/Instrument Weight: lbs Equipment Footprint: **TBD**

Other Structural Requirements:

Pits/Trenches/Deflection (describe):

Hoist or Crane/Capacity & Type:

FINISHES:

	Material:	**Finish:**	**Ceiling Height:** **9 ft.**
Floors:	**VCT**	**Sealer**	**Special Floor Conditions:**
Walls:	**Gypsum Wallboard**	**Paint**	Conductive or Static Dissipative **No**
Ceilings:	**Acoustical Ceiling Panels**	**Factory Finish**	Raised Access Floor (height?) **N/A**
Other:	**Consider Topping Slab over Exist**		Grounded Floor? **No**

ENVIRONMENTAL:

Design Noise Criteria (NC) : **35** Cleanroom Class: **N/A**

Temperature:	Summer:	**72**	°F	Range (+/-):	**2**	°F	Winter: **68**	Range (+/-): **2**	°F
Humidity (max/min):	Summer:	**50**	%	(+/-)	**10**	%	Winter: **30**	% (+/-): **10**	%

NOTES:

SPECIAL REQUIREMENTS:

RFI/EMI Criteria:	**N/A**	Casework Material:	**N/A**
Vibration Criteria :	**N/A**	Benchtop Material:	**N/A**
Toxic/Hazardous Materials :	**None**	Safety Shower/Eye Wash:	**N/A**
Secondary Containment :	**Not Required**	Fume Hoods/Lab Equip:	N/A
Special Door Hardware :	**N/A**		
Oversized Equipment Access:	**N/A**		

Notes:

HVAC:

			Exhaust Systems/Types:	
Room Pressure (pos, neg, neutral):	**Neutral**	☐	Lab (fume hood) Exhaust:	
Differential Pressure (in. w.g.):		☐	Dust Extraction:	
Room Velocity/ ACH:		☐		
Single Pass/Recirculating:	**Recirculating**	☐	General (Room) Exhaust :	
Snorkel Exhaust (count):		☐		
Exhaust Taps or Connections:	**N/A**	☐	Purge Exhaust (O2 depletion):	

Notes : ***Provide ventilation per ASHRAE 62.1 recommendations.***

FIRE PROTECTION:

Hazard Classification :	**Light Hazard**
Type:	**Automatic Fire Sprinklers**

PLUMBING:

		# Outlets		# Outlets (each)
	Lab Sinks :		Floor Sink/Floor Drain:	
☐	Non-Potable Water (Industrial):		Condensate Drain:	
☐	Eyewash/Shower (tempered, potable):		Other Drain Requirements:	
☒	Potable (domestic) Water:	**1**		

Notes: ***Provide sink with hot and cold domestic water.***

ELECTRICAL:

Hazard Area Class : **N/A** (NEC)

Lighting :

Light Level (footcandles) :	**30 fc**
Lighting Type (fluor, incan):	**Fluorescent or LED**
Light Switching Type:	**Occupancy Sensors**
☐ Dimmable Lighting Control	
Special Fixtures :	**TBD**
Other :	**TBD**
Type:	

Equipment Power: watts/sf

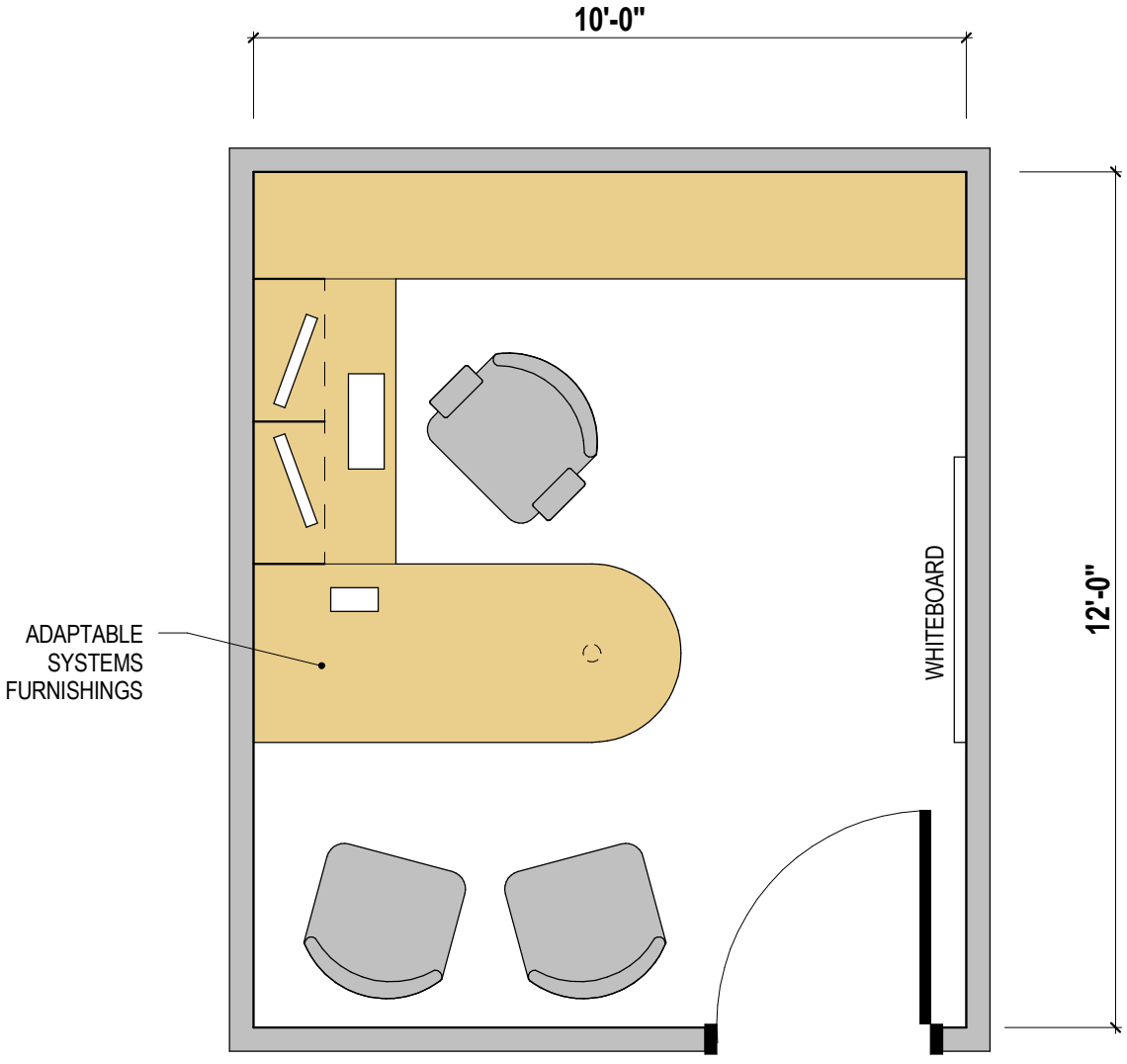
☒ 120V/208V (1 Phase):	**Convenience Outlets only**
☐ 208V (3 Phase) :	
☐ 480V (3 Phase) :	
☐ Conditioned Power :	
☐ Stand-by Power:	
☐ UPS:	
☐ 400 Hz Power	

Notes :

TELECOMMUNICATIONS AND SPECIAL SYSTEMS:

☒ VOIP Connections:	**Locations TBD**	☐ Data Connections:	
☐ PA System :		☐ Access Control :	
☐ Gas Detection/Type:		Fire Detection Type:	
☐ Liquid Leak Detection:		Other:	

Notes :

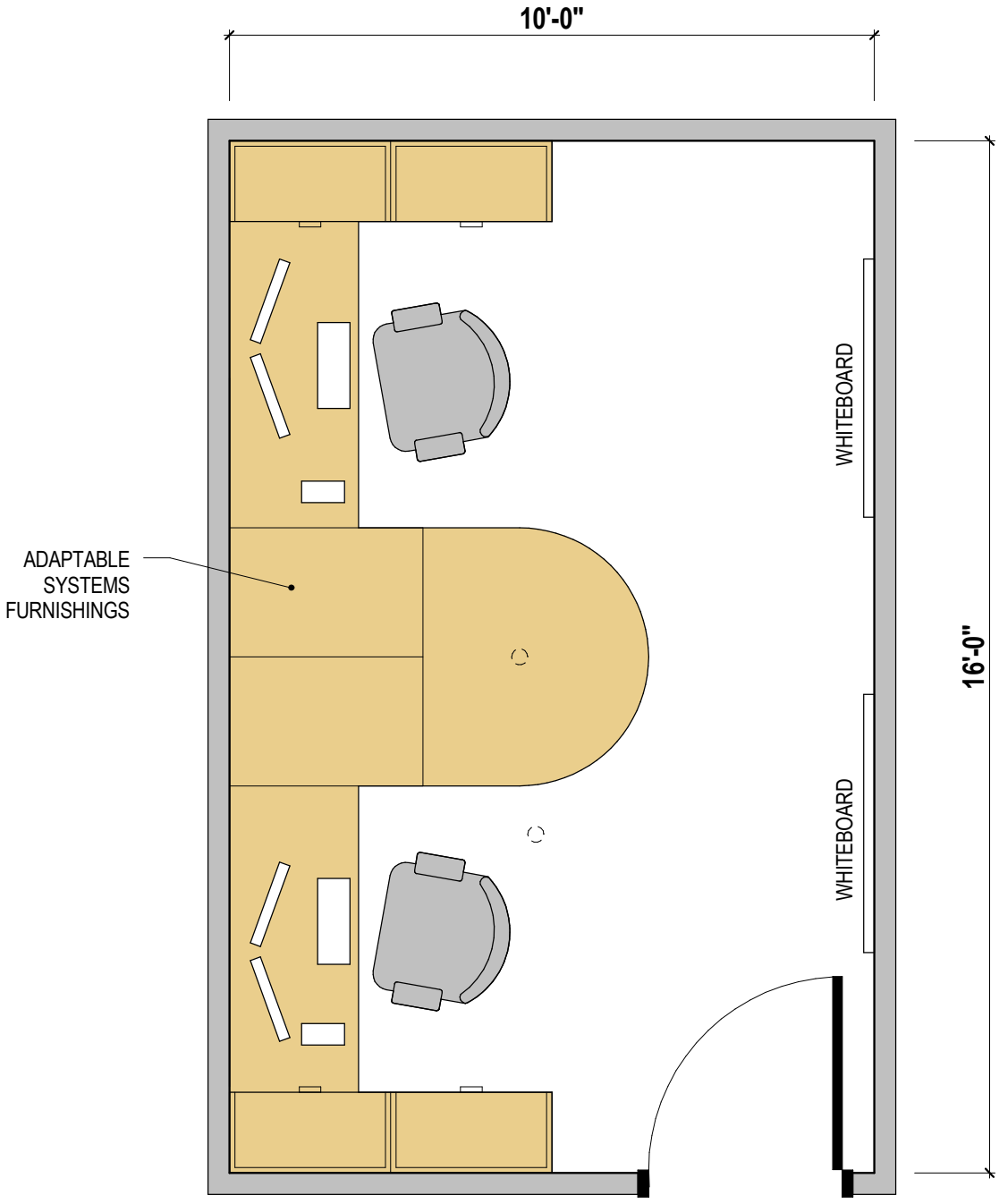


0 1' 2'

Single Office - 120 SF

BROOKHAVEN
NATIONAL LABORATORY

HDR

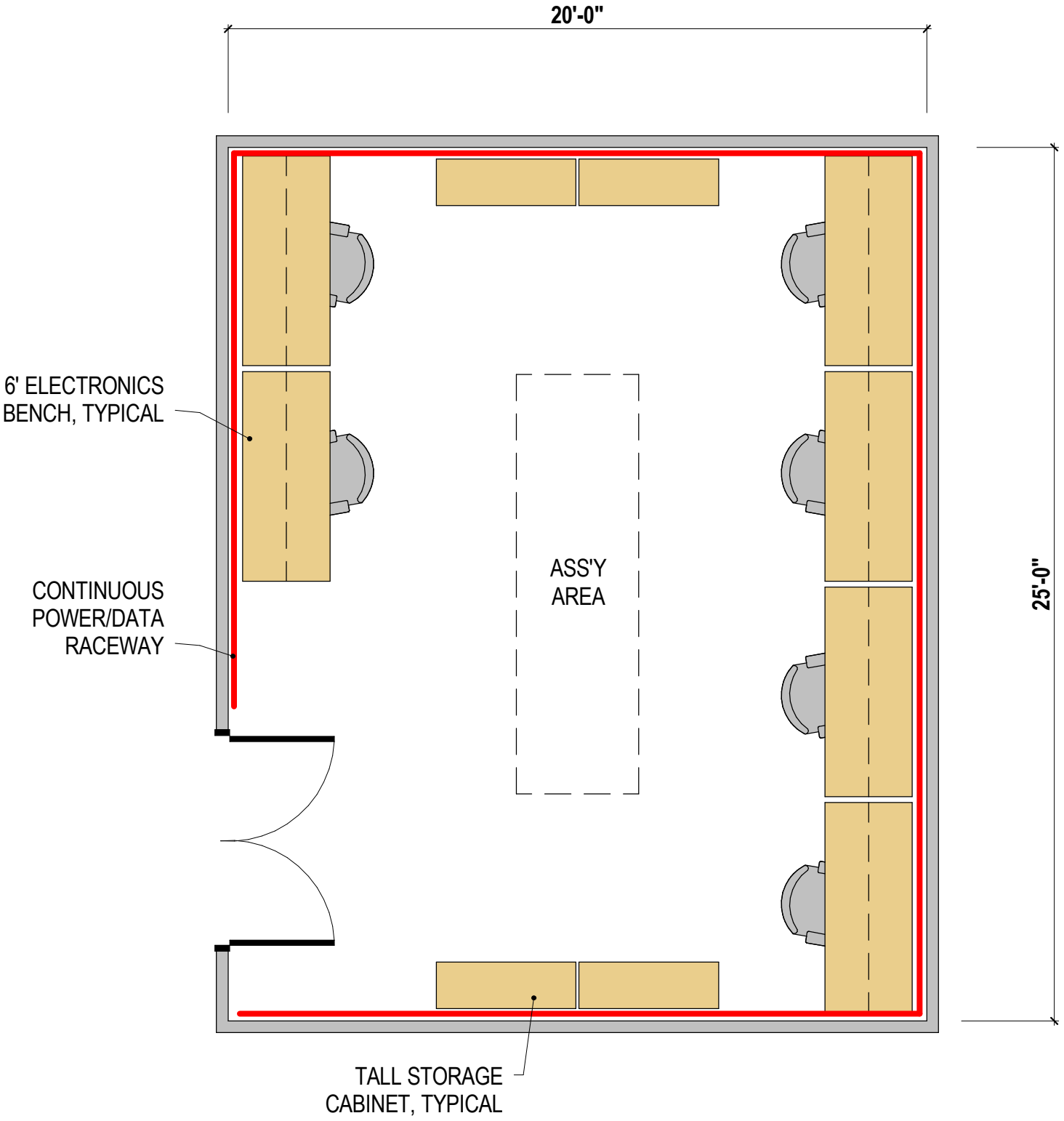


0 1' 2'

Double Office - 160 SF

BROOKHAVEN
NATIONAL LABORATORY

HDR



IT TECHNICIAN AREA - 500 SF

BROOKHAVEN NATIONAL LABORATORY

HDR

Section 3
JUSTIFICATION

3.0 Justification

3.1 Strategic Needs

3.1.1 Statement of Mission Need

The Mission Need Statement for the Core Facility revitalization Project (CFR) was approved September 1, 2015.

The mission of the Department of Energy (DOE) is to advance the energy, environmental, and nuclear security of the United States; promote scientific and technological innovation in support of that mission; and ensure the environmental cleanup of the national nuclear weapons complex. The DOE Strategic Plan 2014-2018 includes the following goals and objectives that are relevant to this mission:

GOAL 1: **Science and Energy**	**STRATEGIC OBJECTIVE 3** – Deliver the scientific discoveries and major scientific tools that transform our understanding of nature and strengthen the connection between advances in fundamental science and technology innovation
GOAL 3: **Management and Performance**	**STRATEGIC OBJECTIVE 9** – Manage our assets in a sustainable manner that supports the DOE mission
	STRATEGIC OBJECTIVE 10 – Effectively manage projects, financial assistance agreements, contracts and contractor performance
	STRATEGIC OBJECTIVE 11 – Operate DOE enterprise safely, securely, and efficiently

The mission of the Office of Science (SC) is to deliver the scientific discoveries and major scientific tools that transform our understanding of nature and advance the energy, economic, and national security of the United States. SC accomplishes this mission through direct support of research, construction, and operation of national scientific user facilities, and the stewardship of ten world-class national laboratories. The SC national laboratories collectively comprise a preeminent federal research system that develops unique, often multidisciplinary, scientific capabilities beyond the scope of academic and industrial institutions, to benefit the nation's researchers and national strategic priorities.

The Science Laboratories Infrastructure (SLI) program, managed by the SC Office of Operations Program Management, supports scientific and technological innovation at the SC laboratories by funding and sustaining mission-ready infrastructure and fostering safe and environmentally responsible operations. The SLI program's primary focus is on long-term modernization of SC laboratory facilities and infrastructure to ensure the mission readiness of SC laboratories with state-of-the-art facilities and infrastructure that are flexible, reliable and sustainable.

Brookhaven National Laboratory (BNL) is a multi-purpose research institution funded primarily by SC that operates facilities for studies in physics, chemistry, biology, medicine, applied science, and a wide range of advanced technologies. Among BNL's core capabilities are: nuclear physics, particle physics, and large scale user facilities for advanced instrumentation. BNL also has programmatic strengths in data-centric and high-throughput "mid-scale" computational science, principally in support of the Relativistic Heavy Ion Collider (RHIC) and A Toroidal LHC Apparatus (ATLAS) programs. These capabilities and strengths support DOE's Strategic Objective 3 area of concentration with advanced scientific computing to analyze, model, simulate, and predict complex phenomena, including the scientific potential that exascale simulation and data will provide in the future. A significant amount of computation and data storage is currently conducted within the RHIC-ATLAS Computing Facility (RACF) that directly supports RHIC and US-ATLAS research operations. The RACF also provides mid-scale computing support to other research programs funded by SC, research efforts funded by Strategic Partners and computationally-intensive research that indirectly supports the broader SC mission.

3.1.2 Capability Gap/Mission Need

Within SC, the mission of the Nuclear Physics (NP) program is to discover, explore, and understand all forms of nuclear matter. NP supports experimental and theoretical research - along with the development and operation of particle accelerators and advanced technologies - to create, detect, and describe the different forms and complexities of nuclear matter that can exist in the universe, including those that are no longer found naturally. The RHIC facility, funded by NP, is located at BNL. RHIC is a collider used for transformative studies of extreme states of nuclear matter and the origin of the proton spin with unique capabilities for heavy ion research.

Within SC, the High Energy Physics (HEP) program seeks to understand how the universe works at its most fundamental level by discovering the most elementary constituents of matter and energy, exploring the basic nature of space and time, and probing the interactions among them. HEP supports theoretical and experimental research in both elementary particle physics and fundamental accelerator science and technology. The US-ATLAS program is the United States consortium jointly funded by HEP and the National Science Foundation to support research using ATLAS at the Large Hadron Collider (LHC) located in Switzerland. ATLAS and the Compact Muon Solenoid (CMS) are the primary Energy Frontier detectors used to obtain experimental data that provide insight into fundamental forces of nature and the conditions of the early universe. BNL is currently designated as the United States Tier 1 site for ATLAS under an agreement between CERN (*Conseil Européen pour la Recherche Nucléaire*, or European Organization for Nuclear Research) and BNL. As a Tier 1 site, BNL must provide round-the-clock support for the LHC Computing Grid and store a proportional share of raw and reconstructed data, perform large-scale data reprocessing and store the corresponding output.

In May 2014, the Particle Physics Project Prioritization Panel (P5) issued a report that included a recommendation to "Complete the LHC phase-1 upgrades and continue the strong collaboration in the LHC with the phase-2 (HL-LHC) upgrades of the accelerator and both general-purpose experiments (ATLAS and CMS). The LHC upgrades constitute our highest-priority near-term large project." Implementing this recommendation will require robust, flexible, and reliable computational and data storage capabilities.

A mission need exists to provide mid-range computational and data storage support to current and planned particle physics experiments using RHIC and the ATLAS detector at CERN that are funded by NP and HEP, respectively. Significant infrastructure in terms of space, power and cooling within the existing RACF are projected to degrade over time due to existing conditions and increasingly stringent operating standards for data centers. Capable, reliable and efficient computing facilities are required to support experiments that are expected to generate ever greater amounts of data that must be stored and analyzed. Additionally, the evolution of the technologies employed to deliver computation and data storage capabilities is expected to require higher levels of reliability and demand more robust infrastructure, such as space and utilities. These factors combine to effectively make almost half of the current computing and data storage facility functionally obsolete and unable to accommodate future generations of computation and data storage technologies. Therefore, the projected capability gaps in computing infrastructure are due to a combination of *decreases* due to degrading capacities and *increases* in future requirements of mid-scale computing performed by RACF. The impacts of these combined effects are described further below.

The following table provides the current and future capacities of each capability of the RACF. A capacity gaps exists whenever a required quantity exceeds the associated capacity.

CAPABILITY	Current (FY 2015)		Future (FY 2025)	
	Capacity	*Requirement*	*Capacity*	*Requirement*
Processing – Disk Data (Petabytes)	~75	~35	~40	100 - 200
Storage – Tape Data (Petabytes)	~75	~55	~100	180 - 250
Server Racks (Each)	~320	~255	~170	300 - 395
Power [KW]	~1,250	~1,200	~525	1,750 - 3,700

The RACF currently occupies over 15,000 square feet of space in three rooms within Building 515 that was originally constructed in the 1960s and expanded in 2009. The existing RACF facilities and infrastructure have finite capacities in terms of processing (computer cores), storage (petabytes of tape data), server space (racks),

and power (kilowatts of electricity). The existing RACF facility also has significant deficiencies due to its age, limited amount of usable area for data center equipment, rigid building configuration and marginally adequate power distribution and cooling systems.

Although the RACF is adequate to meet current demands, the facility will be unable to meet future requirements in terms of capacity and reliability due to the evolution of technology and data center operating standards. The overall computing capacity of the RACF is expected to decrease over the next ten years, beginning in FY 2018 and significantly decreasing after FY 2020. This overall reduction will be caused primarily by the limitations of Building 515 in terms of space and utilities, despite increases in computation power of new hardware. When server and tape storage equipment will be replaced at the end of their useful lives (approximately four years), the racks to accommodate new equipment will need to be reoriented with increased distances between them to enable the necessary cooling and to account for limitations of the existing floor structure. These adjustments in server rack spacing will result in a reduction of server rack capacity by approximately 50 percent from the current level. Since the power distribution must be integral to the server racks, these adjustments will also result in a reduction of available power distributed within the racks by approximately 50 percent.

The data volume generated by the RHIC experiments and ATLAS are expected to increase three to six times over the next ten years and will require proportional increases in computation and data storage capacities. These increases will drive increased requirements for space, power and cooling of computing and data center facilities. The existing capacity limitations and facility deficiencies of the RACF will negatively impact the availability and reliability of computational support to NP and HEP funded research. Failure to accommodate these projected increases over the next five to ten years will result in significant infrastructure capacity gaps, will significantly impede mission readiness of the RACF and will impose significant risks on research funded by NP and HEP, as well as other programs that may rely on BNL data storage and computational capabilities in the future.

Filling the programmatic capability gaps and infrastructure capacity gaps is consistent with the SLI program mission to support scientific and technological innovation at the SC laboratories by funding and sustaining mission-ready infrastructure and fostering safe and environmentally responsible operations. The SLI program conducted a Mission Validation Independent Review (MVIR) of the proposed mission need July 21-22, 2015. The MVIR committee consisted of representatives from NP, HEP, Office of Advanced Scientific Computing Research (ASCR) and other SC headquarters offices. The MVIR committee concluded that a mission need exists, and that the programmatic requirements are valid. In addition, the committee noted that uncertainty exists on computation data storage projections, and that reasonable cost and schedule ranges should account for the level of project definition. NP and HEP (as the primary beneficiaries of closing the capability gaps)

concurred with this mission need and ASCR, as subject matter expert in computation and data storage, provided input to and reviewed this mission need.

3.2 Technical Alternatives Analysis

Beginning in the spring of 2014, preliminary planning efforts were initiated by BNL to address the growing capability gap at the B515 RHIC/ATLAS Computing Facility. Lists of potential alternatives were identified as well as potential locations. The alternatives considered can generally be organized into five (5) categories. A summary of each approach is presented below. A Life Cycle Cost Analysis (LCCA) was prepared by HDR Architects with support from the CFR Integrated Project Team Members including BNL Energy and Utility Professionals (Ref. CFR Analysis of Alternatives).

When the purpose of a life cycle cost analysis is to evaluate cost-effectiveness, lease purchase, internal government investment, and asset sales rather than to primarily assess energy-related savings, the analysis is subject to OMB Circular A-94. The Building Life-Cycle Cost (BLCC5 5.3-15) software, developed by the National Institute of Standards and Technology (NIST) contains modules designed to perform life-cycle-cost analyses subject to OMB Circular A-94 and was used to perform this analysis.

Alternative 1 – Maintain Status Quo (do nothing)

Under this option, the use of the existing RACF at B515 would be continued to the greatest extent possible. The required deferred maintenance and compliance upgrades would be performed. Substantial productivity loss and programmatic opportunity loss would be realized. The significant risk of catastrophic failure due to the lack of backup chilled water service remains. This alternative does not address the capability gap or contribute to the support of the HEP/NP mission need.

Alternative 2 – Renovate Existing Facilities at BNL

This alternative involves the renovation of existing available facilities on the BNL site. Multiple facilities were considered including the renovation of the existing facility. B725, originally constructed in 1980 with multiple additions and expansion from 1985 through 1995, served as the former home of the NSLS-I program. A sound building of approximately 155,000 GSF, the facility contains adequate space for all of the present and future computing and support space needs. The building is ideally located with respect to available utility infrastructure and proximity to the researchers. The facility contains significant existing quality office space (approx. 38,000 GSF) and other space easily configured for use by other BNL research groups. Re-use and re-purpose of this facility supports federal “Freeze the Footprint” principles with respect to office space. Significant investment in hazardous material remediation and maintenance has been made over the past several years.

Renovating this facility would avoid adding significant vacant space to the BNL inventory. The CFR Project would renovate approximately 50% of the first floor gross square footage of this facility to address the capability gaps.

Alternative 3 – Construct New Building at BNL (Line Item Funding)

This alternative involves the utilization of Line Item funding for the construction of a new building to house the computing facility scope plus future expansion capabilities on the BNL site. Included in the scope is approximately 20,000 SF required to house the required supporting technical and research staff. The new facility would be centrally located on the BNL site. This alternative assumes the B725 facility will remain vacant.

Alternative 4 – Construct New Building at BNL (Alternative Financing)

This category of alternatives involves the construction of a new building to house the Computing Facility base scope on existing land contiguous to or in close proximity to the BNL site. Also included is the approximately 20,000 GSF required to house the required supporting technical and research staff. In both cases, fixed lease payments would be made to a 3rd party developer. New funding would be required to service the alternative financed debt. OMB approvals would be required. This option was considered for preliminary study only. DOE recommended that this option not be considered for further evaluation for this project.

Alternative 5 – Establish Capability at Another Location/Cloud Computing Services

This category of alternatives considered two options: Option A – Establish the capability at another national laboratory computing facility; and Option B – Establish the capability via private cloud computing resources.

Option A will not be considered for further evaluation as the RACF computing facility will require significant additional infrastructure, space, and hardware, which is not available at this time at other institutions and would require significant investment at the respective sites. In addition, the necessary expertise to support the mission need resides at BNL. Significant cost and effort would be required to develop this expertise elsewhere and establish the efficient communication/data transfer protocols and communication infrastructure required.

Option B establishes the computing capabilities via cloud computing services. While conventional alternatives lend themselves to objective life cycle cost analysis, private cloud computing options remain less defined. They are highly case sensitive, technically problematic, and subject to rapid change in the market due to changing economic pressures. Prior DOE studies have concluded that cloud computing is more expensive than DOE High Performance Computing (HPC) facilities and demonstrated poor performance with communication and I/O intensive scientific

applications. These findings are detailed in the Magellan Report on Cloud Computing for Science, Dec 2011. These findings have been validated by recent studies by BNL RACF researchers. The results are presented in the CFR Analysis of Alternatives documentation.

While progress is evident over the last few years, predicting cost for the next 25 years and making long term financial decisions based on limited historic data is extremely risky. There has not been adequate data to analyze, nor documented success to validate, the long term commitment of significant large scientific research program funding, such as that associated with the RHIC/ATLAS mission. These commitments are subject to continuous change brought on by economic factors. Once a program is committed, particularly with respect to data storage, it is costly to move back to any form of institutionally based computing infrastructure. Cloud computing is a long term commitment with significant risk tied directly to the ability to maintain consistent, long term funding. It is subject to volatility in the private cloud services market and does not provide scientific programs the opportunity to economically manage infrastructure to meet changing needs.

3.3 Economic Considerations

3.3.1 Total Life Cycle Costs and Benefits

The total life cycle costs of Alternatives 1, 2, and 3 were calculated and compared for cost effectiveness. The results are summarized below in Table 1 and are detailed in the separate CFR Analysis of Alternatives and Life Cycle Cost Analysis calculations. The cost of Alternative 5 vs. in-house capabilities was also studied. Those results are also presented in the Analysis of Alternatives. While the cost of Alternative 1 is less than Alternatives 2 and 3, it does not satisfy the mission need or address the capability gaps. Alternate 4 was not considered for economic analysis.

Table 1 – Life Cycle Cost Analysis (LCCA) Results

	ALTERNATIVE 1 Maintain Status Quo (Base Case)	ALTERNATIVE 2 Renovate Existing Facility	ALTERNATIVE 3 Construct New Facility
Total Life Cycle Cost	$109,328,869	$125,068,512	$147,479,171
Net Cost Savings	N/A	-$15,739,643	-$38,150,303
Meets Mission Need?	No	Yes	Yes

Alternative 2, renovate B725 yields significant economic benefits and is the preferred and recommended alternative. The recommendation is based on the evaluation of the quantitative data produced by Life Cycle Cost Analysis and other operational factors considered by both BNL Management and the Program Leadership that will populate the new computing facility.

Section 4
ASSESSMENTS

4.0 Assessments

4.1 Safety and Health – Integrated Safety Management

The CFR Project will be executed in a manner that ensures protection of the health and safety of workers, the public and the environment in compliance with DOE Worker Safety and Health Program 10CFR851. The guiding principles and core function of the Integrated Safety Management System (ISM) will be understood and applied by all project personnel in their management of Environmental, Safety and Health (ES&H) functions and activities. Management of all aspects of the project to a "zero accident" goal will be an integral part of the overall CFR project mission.

In accordance with the Brookhaven National Laboratory (BNL) operating Contract (DE-AC02-98CH10886) clause I.131, which implements DEAR Clause 970.5223-1 – Integration of Environment, Safety, and Health into Work Planning and Execution (Dec 2000), this program describes Brookhaven National Laboratory's (BNL) approach to integrating Environment, Safety, Health, and Quality (ESH&Q) requirements into the processes for planning and conducting work at the Laboratory. It also describes BNL's programs for accomplishing work safely and provides the road map of systems and processes that make up the BNL Integrated Safety Management System (ISMS).

This program description identifies core requirements that provide the foundation for ESH&Q management at BNL. BNL used the cross-reference between the ISM Principles and Core Functions provided in the former DOE Manual 450.4-1, Integrated Safety Management System Manual, and the Quality Assurance (QA) Criteria provided in DOE Guide 414.1-2A, Quality Assurance Management System Guide, to aid in developing the BNL ISMS Program. The ISMS Program continues to employ an integrated set of non-overlapping management systems that embody the requirements defined in DOE P 450.4A, Safety Management System Policy. These systems collectively form the Standards-Based Management System (SBMS) management systems, BNL's highest level of operating and business processes that define how work is conducted at the Laboratory. These management systems are defined via Management System Descriptions that identify each system's processes, standards of performance, external requirements, and the set of Laboratory procedures and guidelines (subject areas and other Laboratory-wide procedures) to carry-out the elements of each system. Management systems, program descriptions, and subject areas operate in an integrated fashion by providing programs and procedures that implement the Plan, Do, Check, Act framework. Within the context of DOE's ISMS language, this workflow process (called the Core Functions) is

described by defining work scope, identifying and analyzing hazards and risks associated with the work, developing and implementing controls to mitigate hazards and risks, performing work within the controls, and providing feedback for continuous improvement. Additional information is made publicly available vis BNL's SBMS website.

Each phase of the CFR project from conceptual design through operation turnover and ongoing operations has and will continue to reiterate the ISM Core Functions by implementing the following steps:

1. Review of project scope by Subject Matter Experts (SMEs) for identification of hazards prior to design commencement to assure that engineering controls can be incorporated to mitigate hazards wherever feasible.

2. Review of completed design by SMEs to analyze and verify that hazards have been addressed and mitigated wherever feasible in the facility design, and to assure appropriate safety requirements are included in design documents.

3. Selection of contractors based on their acceptable safety performance in addition to their technical qualifications.

4. Application of work control requirements to assure that contractors and in-house staff are not allowed to proceed with physical work until required safety documents are approved, all necessary training completed, and all applicable permits are in place.

5. Regular monitoring and inspection of project execution to assure all hazard mitigation requirements are properly carried out and communication as needed to review and approve any changes in work controls to address changed conditions.

6. Evaluation of project execution for feedback and continuous improvement of the safety and work controls program.

7. Evaluation of contractor safety performance at project 50% and 100% completion points to provide feedback for contractor's safety plan improvement and verify continued qualification to perform work for BNL.

Safety through design will be the primary driver throughout the design phases of the project. Complete management commitment and leadership in safety in the conduct of activities will continue as fundamental drivers through construction and turnover of the completed facilities.

Following transitions to operations, the owners will integrate the operation and maintenance of the completed facility and installed equipment into the existing ES&H management infrastructure.

4.2 Hazard Analysis

This Preliminary Hazard Analysis Report (RHA) has been prepared in accordance with principles of DOE Order 413.3A Program and Project Management for the Acquisition of Capital Assets; the BNL Integrated Safety Management (ISM) Plan; and BNL Environment, Health & Safety Policy Manual, for the Core Facility revitalization Project, in support of Critical Decision 1 (CD-1) approval. This report shall be updated throughout the design and engineering phase.

Mission success mandates planning and safeguards to insure the safety of building occupants, workers performing the construction, the neighboring public, and the surrounding environment are upheld. Assurance of this objective starts by conducting a preliminary hazard analysis to identify anticipated hazards in conjunction with planned work.

This Preliminary Hazard Analysis Report describes the initial efforts and results of the core Integrated Safety Management functions whereby work to be performed is studied to:

1. Identify fundamental hazards;
2. Assess underlying environment health and safety risks; and
3. Institute planning that mitigates the identified hazards during the design and construction project phases.

The hazard analysis report is the launching pad for successive and iterative hazard assessment stages as the project proceeds from preliminary design through construction. The final safety basis for construction operations will mature from this document.

4.3 Quality Assurance

4.3.1 Quality Assurance Program

The overall project was evaluated using the Brookhaven National Laboratory (BNL) Quality Assurance Program Description and was judged to meet the criteria of Quality Assurance Classification A-3 (Minor) with component classification being in quality levels (A-1 Critical, A-2 Major, A-3 Minor and A-4 other). Items judged to have sufficient impact on safety; reliability, cost or schedule will require individual attention.

Plan Engineer's (PEs) Quality Assurance (QA) program, specifically tailored to satisfy the requirements of this project and to assure the quality of all aspects of preliminary design, final design and construction, will be utilized. The QA program is based on sound engineering and technical requirements that delineate

responsibilities and specific measures to be followed in performing and monitoring design, construction and project management activities. The goal of this program is to achieve quality through quality control. BNL will appoint qualified staff members not participating in the design or construction effort, to perform independent quality assurance verifications at each stage of preliminary and final design and construction performance.

The following elements to be included, as a minimum, in PE's QA program for the design and construction effort, are tabulated below:

Design

1. A definition of the project's staff delineating interface responsibilities and authorities of the various personnel and organizations involved.

2. Identification of internal and external interfaces and channels of communication, including establishment of procedures for review, approval, release distribution and revision of design documents.

3. Requirements for strict control of project documentation including correspondence, minutes of meetings, reports, design computations, drawings and specifications, as well as changes. Specific change control procedures preclude the possibility of use of outdated or inappropriate information.

4. Provisions for the establishment of design requirements, methods, criteria, standards, codes and procedures, as well as for verification of all designs and reviews of design documents.

5. Provisions for a comprehensive system of formal, planned and periodic audits, utilizing prepared checklists, in order to verify compliance with all aspects of the quality program, and to determine its effectiveness.

6. Review of materials of construction and equipment on the basis of economics, compatibility with other components, and maintainability.

Construction

1. Requirements for control of the overall construction program in order to verify and document conformance with contract documents, performance specifications, instructions, procedures, and schedules; and to assure the quality of materials and workmanship.

2. A control system of submittal of shop drawings, test results, and certification from vendors and construction contractors.

3. Procedures for reporting the BNL construction observer's findings and for taking prompt effective action when non-conformances are documented.

4. Procedures for reporting and correcting the construction contractor's use of unqualified workers, improper materials and equipment, improper construction equipment or techniques.

5. Procedures for identifying existing underground utilities, and systematic and safety startups of equipment and acceptance testing.

6. Continual checks to ensure that all elements of the quality assurance program are being performed and prompt corrective actions are being taken in response to non-conforming conditions.

4.3.2 Environmental Protection and NEPA

The CFR Project will be designed, constructed, and operated in a manner to protect the safety of workers, the public, and the environment. This will be accomplished by designing, procuring, constructing, commissioning, and operating the facility in accordance with the principles of ISM. The CFR's environmental impact will be minimized through the use of appropriate building materials, waste minimization, minimization of energy use and atmospheric impact, and water use efficiency. Project waste disposal and recycling requirements are incorporated into the project procurement documents. In addition, the National Environmental Policy Act (NEPA) documentation was prepared to inform the public and decision makers about potential environmental impacts and opportunities associated with the CFR project.

NEPA reviews were conducted during the CFR Project conceptual design phase. Based on preliminary analysis information presented by BNL, the Department of Energy is considering that the proposed CFR project may be Categorically Excludable as defined in 10 CFR Part 1021.410 and Subpart D Appendix A. NEPA review documentation is included in the appendix of this report.

4.4 Energy Conservation

The impact that energy use has on the environment is broad and long-lived. Almost every aspect of conventional energy use poses some threat to the natural environment. To create energy requires fuel. Harvesting these fuel resources from Earth, whether they are coal, natural gas, oil or wood, is destructive to natural habitats. The Federal Energy Management Program (FEMP) at the US Department of Energy (DOE) released an interim final rule for new federal building energy efficiency standard that requires new buildings to achieve an energy consumption level that is at least 30% below the level achieved under the ASHRAE 90.1-2010 standard.

Implementing energy efficient strategies will include high energy efficiency equipment, EMS optimization, ENERGY STAR and commissioning. These will all contribute to a reduction of energy use, creating a building which will perform at a higher level, ultimately reducing overall energy consumption and reducing operating and maintenance costs.

Some of the Energy Saving Strategies proposed to reach highest possible Energy Efficiency for this project follows:

- Air side economizer
- Hot Aisle / Cold Aisle
- Energy Efficient HVAC Equipment
- On-site renewable energy sources
- Energy Efficient Lighting System

Design and construction projects costs associated with the above energy efficiency strategies can be defined further as the project design progresses and LEED Level Silver is approved by BNL.

4.5 Sustainability

4.5.1 Sustainable Design Report

INTRODUCTION

BNL is an Office of Science (SC) Laboratory that maintains a primary mission focus in the physical sciences, energy sciences, and national security. Over the past few years, BNL has invested substantial resources in refurbishing its facilities and infrastructure to ensure continuing support of its science mission.

This project anticipates enabling growth and providing expanded data processing resources for two major User facilities; RHIC/ATLAS, as well as supporting expansion of the Computational Science Initiative (CSI). These new computational capabilities will support more rapid advances in photon sciences, energy and material sciences, systems biology, climate science, and other programs.

KEY SUSTAINABILITY DRIVERS AND APPLICABLE CODES

- Meet the administrative requirements of the DOE and other oversight agencies.
- Pursue LEED credits allowing a minimum certification level of LEED Certified; but aiming for LEED Silver as the goal.
- Executive Order 13693 – Strengthening Federal Environmental, Energy, and Transportation Management
- Memorandum of Understanding – Federal Leadership in High Performance and Sustainable Buildings
- Energy Policy Act of 2005 – Federal Building Performance
- Building Code of New York State (NYSBC) – 2007 Edition
- Energy Conservation Code of New York State - 2007 Edition
- ASHRAE Standard 90.1-2010
- Leadership in Energy and Environmental Design for New Construction (LEED-NC) – Data Center – v4

FEDERAL ENERGY MANDATES

The new Executive Order (EO) 13693 and the clarifying guidance dated March 19, 2015 have guidance to instruct new federal facility design to demonstrate

conformance with the guiding principles of sustainable design. Described in the mentioned documents is for new projects to pursue LEED certification by the U.S. Green Building Council to work toward the potential of earning a Silver rating.

Federal Agencies shall, where life-cycle cost-effective, beginning in fiscal year 2016, unless otherwise specified, improves data center energy efficiency at agency facilities by:

- ensuring the agency chief information officer promotes data center energy optimization, efficiency, and performance;
- installing and monitoring advanced energy meters in all data centers by fiscal year 2018; and
- establishing a power usage effectiveness target of 1.2 to 1.4 for new data centers and less than 1.5 for existing data centers.

The project is making every effort to meet the federal requirements for sustainable design. With each phase of the project, proposed design elements which promote the spirit of sustainability and environmental responsibility are evaluated against the project budget.

SECTION II: LEED CERTIFICATION STATUS REPORT

This section of the Sustainable Design Report tracks the progress of the LEED certification process. It includes the LEED Scorecard Checklist.

The LEED Scorecard Checklist identifies each potential point in the LEED rating system. It further identifies for each point whether the project will pursue that point, will not pursue that point, or it is still undetermined whether the point is achievable or not. The Scorecard Checklist originated during the Conceptual Design Phase of the project and will be maintained throughout the life of the project.

Current Status: The project is on track to be awarded a LEED certification at the Silver Level.

Yes	?	No	
53	13	**44**	**LEED Project Totals (pre-certification estimate)** — **110** Points

Certified: 40 to 49 points, **Silver:** 50 to 59 points, **Gold:** 60 to 79 points, **Platinum:**80 to 110 points

53 points have been identified as achievable at this time. An additional 13 points are considered to be potential. With 53 points, the project is 3 credits above the Silver rating.

The action needed at this stage of the design process is for BNL to thoroughly review the credits identified as "potential" and provide written comments to the HDR team regarding BNL's commitment to pursuing further action in those categories.

4.5.2 Preliminary Scorecard

LEED v4 for BD+C: Data Centers

Project Checklist

Y	?	N			
1			Credit	Integrative Process	1
5	3	8	**Location and Transportation**		16
		na	Credit	LEED for Neighborhood Development Location	16
		1	Credit	Sensitive Land Protection	1
		2	Credit	High Priority Site	2
2	3		Credit	Surrounding Density and Diverse Uses	5
		5	Credit	Access to Quality Transit	5
1			Credit	Bicycle Facilities	1
1			Credit	Reduced Parking Footprint	1
1			Credit	Green Vehicles	1
5	1	4	**Sustainable Sites**		10
Y			Prereq	Construction Activity Pollution Prevention	Required
		1	Credit	Site Assessment	1
		2	Credit	Site Development - Protect or Restore Habitat	2
1			Credit	Open Space	1
2	1		Credit	Rainwater Management	3
2			Credit	Heat Island Reduction	2
		1	Credit	Light Pollution Reduction	1

5	**1**	**5**	**Water Efficiency**		**11**
Y			Prereq	Outdoor Water Use Reduction	Required
Y			Prereq	Indoor Water Use Reduction	Required
Y			Prereq	Building-Level Water Metering	Required
1	1		Credit	Outdoor Water Use Reduction	2
3		3	Credit	Indoor Water Use Reduction	6
		2	Credit	Cooling Tower Water Use	2
1			Credit	Water Metering	1

16	**1**	**16**	**Energy and Atmosphere**		**33**
Y			Prereq	Fundamental Commissioning and Verification	Required
Y			Prereq	Minimum Energy Performance	Required
Y			Prereq	Building-Level Energy Metering	Required
Y			Prereq	Fundamental Refrigerant Management	Required
6			Credit	Enhanced Commissioning	6
6		12	Credit	Optimize Energy Performance	18
1			Credit	Advanced Energy Metering	1
		2	Credit	Demand Response	2
2	1		Credit	Renewable Energy Production	3
1			Credit	Enhanced Refrigerant Management	1
		2	Credit	Green Power and Carbon Offsets	2

4	**2**	**7**	**Materials and Resources**		**13**
Y			Prereq	Storage and Collection of Recyclables	Required
Y			Prereq	Construction and Demolition Waste Management Planning	Required
		5	Credit	Building Life-Cycle Impact Reduction	5
		2	Credit	Building Product Disclosure and Optimization - Environmental Product Declarations	2
1	1		Credit	Building Product Disclosure and Optimization - Sourcing of Raw Materials	2

1	1		Credit	Building Product Disclosure and Optimization - Material Ingredients	2
2			Credit	Construction and Demolition Waste Management	2

12	**0**	**4**		**Indoor Environmental Quality**	**16**
Y			Prereq	Minimum Indoor Air Quality Performance	Required
Y			Prereq	Environmental Tobacco Smoke Control	Required
2			Credit	Enhanced Indoor Air Quality Strategies	2
3			Credit	Low-Emitting Materials	3
1			Credit	Construction Indoor Air Quality Management Plan	1
2			Credit	Indoor Air Quality Assessment	2
1			Credit	Thermal Comfort	1
2			Credit	Interior Lighting	2
		3	Credit	Daylight	3
		1	Credit	Quality Views	1
1			Credit	Acoustic Performance	1

1	**5**	**0**		**Innovation**	**6**
	5		Credit	Innovation	5
1			Credit	LEED Accredited Professional	1

4	**0**	**0**		**Regional Priority Zip code: 11973**	**4**
1			Credit	Regional Priority: Enhanced Commissioning (4-point threshold)	1
1			Credit	Regional Priority: Advanced Energy Metering (1-point threshold)	1
1			Credit	Regional Priority: Optimize Energy Performance (6-point threshold)	1
1			Credit	Regional Priority: Construction Waste Management (2-point threshold)	1

53	**13**	**44**	**TOTALS**	Possible Points: **110**

Certified: 40 to 49 points, **Silver:** 50 to 59 points, **Gold:** 60 to 79 points, **Platinum:** 80 to 110 points

4.5.3 Identified Scope with Potential LEED Impacts

MATRIX OF SUSTAINABLE DESIGN FEATURES

The following table identifies the credits within the LEED point system and identifies the elements that will be incorporated into the design of the facility to capture the intent of the credit. This matrix serves as one tool to ensure that elements of sustainable design are integrated seamlessly into the facility design, and tracks the project progress against the LEED Certified goal. This matrix is intended to be updated regularly throughout the design progress.

Matrix of Sustainable Design Features

SUSTAINABLE DESIGN CATEGORY	SPECIFIC REQUIREMENTS	DESIGN FEATURES	STATUS
LOCATION & TRANSPORTATION			
Surrounding Density and Diverse Uses	Option 1: Locate on a site whose surrounding existing density within a ¼-mile radius of the project. Option 2: Construct or renovate a building or a space within a building such that the building's main entrance is within a ½-mile walking distance of the main entrance of four to seven (1 point) or eight or more (2 points) existing and publicly available diverse uses.	BBNL Campus is previously developed site; within 1/2 mile of residential zone with 10 units/acre and 1/2 mile of 10 services with pedestrian access.	YES
Bicycle Facilities	Create a map of bicycle networks in the area of the project. Promote bicycle transportation: provide bike racks (for 5% of all facility users) and showering facilities (for 0.5% of all facility users). Facility users are calculated at the peak period and referred to as FTEs or Full Time Equivalents.	BNL will provide bike racks and one on-site shower with changing facility. The calculations for bike racks and showering facilities are based on intended occupancy. It has been assumed that, at a peak period, there will be 10 full time staff, 2 visitors. Therefore, it has been calculated that a minimum of 4 bike parking spaces and 1 shower for each sex is required for building.	YES
Reduced Parking Footprint	The intent of this credit is to reduce the impacts from single occupant vehicle use and to size parking capacity to meet (but not exceed) local zoning requirements.	Determine local code requirements. Requirements for parking space is 6/1,000 ft2 for Data Centers. Provide preferred parking for carpools for 5% of the total parking spaces after reductions are made from the base ratios. Preferred parking is not required if no off-street parking is provided.	YES
Green Vehicles	Promote use of Low-Emitting and Fuel Efficient vehicles through combination of preferred parking spaces, vehicles, and/or refueling stations. Designate 5% of all parking space used by the project as preferred parking for green vehicles.	The BNL campus has a refueling station for alternative-fuel commuter vans that may also be used by employees. If the refueling stations can also be used for employees with LNG vehicles, the credit intent is met and preferred parking for such vehicles is not required. If the refueling stations are not able to be utilized for LNG vehicles, then 5% of the parking spaces must be striped as preferred parking for Low Emitting & Fuel Efficient Vehicles.	YES

SUSTAINABLE SITES			
Construction Activity Pollution Prevention	To reduce pollution from construction activities by controlling soil erosion, waterway sedimentation, and airborne dust.	Erosion and sedimentation control plan will create and implement for all construction activities associated with the project. The plan must conform to the erosion and sedimentation requirements of the 2012 U.S. Environmental Protection Agency (EPA) Construction General Permit (CGP) or local equivalent, whichever is more stringent.	REQUIRED
Open Space	Provide vegetated open space required by one of 3 options: 1) Exceed local zoning's open space req't by 25%; 2) With no local zoning (university campuses, military bases) - equal to building footprint; OR 3) with local zoning but no open space req't - 25% of project site area.	BNL has no local zoning so open area provided by the site must equal the building footprint. The current layout provides more than double this requirement.	YES
Rainwater Management	Reduce runoff volume and improve water quality by replicating the natural hydrology and water balance of the site.	BNL maintain a stormwater management plan. They will also consider porous paving and shade trees if in fact restoration of the parking areas are required.	YES
Heat Island Effect	Reduce heat island effects by: Option 1: Site hardscape shall be shaded, open grid pavement, or light-colored pavement OR Option 2: Place 75% of parking spaces under cover. Any roof to shade or cover parking.	Use the existing plant material or install plants that provide shade over paving areas (including playgrounds) on the site within 10 years of planting. Install vegetated planters. Plants must be in place at the time of occupancy permit and cannot include artificial turf. Provide shade with architectural devices or structures that have a three-year aged solar reflectance (SR) value of at least 0.28. If three-year aged value information is not available, use materials with an initial SR of at least 0.33 at installation. Place a minimum of 75% of parking spaces under cover.	YES
WATER EFFICIENCY			
Outdoor Water Use Reduction	Option 1. No irrigation required Option 2. Reduced Irrigation	BNL meets the intent of this credit with their no irrigation policy. Additionally, plantings will be native species	REQUIRED

		(predominately a seed mix) that thrive on the climate and rainfall of the area.	
Indoor Water Use Reduction	Reduce aggregate water consumption by 20% from the baseline.	This credit will be achieved with dual flow and high efficiency toilets, sinks, urinals, and showers.	REQUIRED
Building-Level Water Metering	Install permanent water meters that measure the total potable water use for the building and associated grounds. Meter data must be compiled into monthly and annual summaries; meter readings can be manual or automated.	Permanent water meters will be installed.	REQUIRED
Outdoor Water Use Reduction	Option 1. No irrigation required Option 2. Reduced Irrigation	BNL meets the intent of this credit with their no irrigation policy.	YES
Indoor Water Use Reduction	To reduce indoor water consumption.	BNL will accept further reduce fixture and fitting water use from the calculated baseline in WE Prerequisite Indoor Water Use Reduction.	YES
Water Metering	To support water management and identify opportunities for additional water savings by tracking water consumption.	Permanent water meters will be install irrigation system and indoor plumbing fixture and fittings.	YES
ENERGY & ATMOSPHERE			
Fundamental Commissioning and Verification	Complete the following commissioning (Cx) process activities for mechanical, electrical, plumbing, and renewable energy systems and assemblies, in accordance with ASHRAE Guideline 0-2005 and ASHRAE Guideline 1.1–2007 for HVAC&R Systems, as they relate to energy, water, indoor environmental quality, and durability.	A commissioning agent has to be directly hired by BNL and will provide the commissioning specifications to ensure the intent of this credit will achieved.	REQUIRED
Minimum Energy Performance	Comply with the mandatory provisions and prescriptive (or performance) requirements of ASHRAE 90.1-2010. Determine the power utilization effectiveness (PUE) value of the proposed design. For this prerequisite, a minimum of 2% of the 5% energy savings must come from building power and cooling infrastructure.	The design of the mechanical systems, electrical systems, and envelope will meet the prescriptive requirements for ASHRAE.	REQUIRED
Building-Level Energy Metering	To support energy management and identify opportunities for additional energy savings by tracking building-level energy use.	New or use existing building-level energy meters will install, or submeters that can be aggregated to provide building-level data representing total	REQUIRED

		building energy consumption (electricity, natural gas, chilled water, steam, fuel oil, propane, biomass, etc.).	
Fundamental Refrigerant Management	Do not use CFC-based refrigerants in new HVAC systems. When reusing existing HVAC equipment, complete a comprehensive CFC phase-out.	CFC-based refrigerants will not be allowed in any new equipment. The process cooling water is provided by a central chilled water plant. Verify that no CFCs are used in the plant.	REQUIRED
Enhanced Commissioning	In addition to prerequisite commissioning required, bring the CxA on to the project earlier in the design process.	A commissioning agent has to be hired directly by BNL and will provide the commissioning specifications to ensure the intent of this credit is met.	YES
Optimize Energy Performance	Analyze efficiency measures focused on IT load reduction and HVAC-related strategies (air-side economizers, hot aisle–cold aisle, etc.). Project the potential energy savings and cost implications for all affected systems.	Building will have Whole Building energy Simulation Analyze efficiency focused on IT load reduction and HVAC-related strategies(air-side economizers, hot aisle-cold aisle)	YES
Advanced Energy Metering	Install advanced energy metering for the following: • all whole-building energy sources used by the building; and • any individual energy end uses that represent 10% or more of the total annual consumption of the building.	To support energy management and identify opportunities for additional energy savings by tracking building-level and system-level energy use advanced energy metering devices will install.	YES
Renewable Energy Production	Use on-site renewable energy systems to offset building energy cost. (1% = 1 credit, 5% = 2 credits, 10% = 3 credits)	BNL has on site solar garden in the campus.	YES
Enhanced Refrigerant Management	No refrigerants or low-impact refrigerants. Do not use refrigerants, or use only refrigerants (naturally occurring or synthetic) that have an ozone depletion potential (ODP) of zero and a global warming potential (GWP) of less than 50.	Refrigerants will be selected to comply with this credit.	YES
MATERIALS & RESOURCES			
Storage & Collection of Recyclables	Provide a collection and storage area for recycling of paper, corrugated cardboard, glass, plastics and metals.	Dedicated areas will be provided, accessible to waste haulers and building occupants for the collection and storage of recyclable materials for the entire building.	REQUIRED

Construction and Demolition Waste Management Planning	Establish waste diversion goals for the project by identifying at least five materials (both structural and nonstructural) targeted for diversion. Approximate a percentage of the overall project waste that these materials represent. Specify whether materials will be separated or commingled and describe the diversion strategies planned for the project. Describe where the materials will be taken and how the recycling facility will process the material.	Construction and demolition waste management plan will develop and implement.	REQUIRED
Building Product Disclosure and Optimization – Sourcing of Raw Materials	To encourage the use of products and materials for which life cycle information is available and that have environmentally, economically, and socially preferable life cycle impacts.	Compliant products will select and specify. Track purchases throughout construction. Calculate compliant products and materials and compile documentation. Design team will need to evaluate materials to ensure they meet these requirements	YES
Building Product Disclosure and Optimization – Material Ingredients	To encourage the use of products and materials for which life-cycle information is available and that have environmentally, economically, and socially preferable life-cycle impacts.	Use at least 20 different permanently installed products from at least five different manufacturers that use any of the following programs to demonstrate the chemical inventory of the product to at least 0.1% (1000 ppm).	YES
Construction and Demolition Waste Management	Divert at least 50% of the total construction and demolition material; diverted materials must include at least three material streams. (1 point) Divert at least 75% of the total construction and demolition material; diverted materials must include at least four material streams. (2 points)	Construction and demolition materials will recycle and/or salvage nonhazardous. Design team will target 75% diversion rate.	YES
INDOOR ENVIRONMENTAL QUALITY			
Minimum IAQ Performance	Ventilation rates and requirements to follow ASHRAE 62.1-2010, minimum requirements of Sections 4 through 7.	Project will be design based on ASHRAE 62.1-2010 standard requirements, with design attention paid to providing the recommended minimum outdoor air being supplied to each zone.	REQUIRED
Environmental Tobacco Smoke (ETS) Control	Control impacts of tobacco smoke by locating external smoking areas at least 25 feet from points of air entry AND either prohibiting smoking in the building or limiting	Smoking will not be allowed in the buildings. Locations for external smoking areas will be determined, if any, with BNL, and will be located away	REQUIRED

	to designated smoking rooms. Signage must be posted within 10 feet (3 meters) of all building entrances indicating the no-smoking policy.	from air intakes, windows, and doors.	
Enhanced Indoor Air quality Strategies	Mechanically ventilated spaces: A. entryway systems; Install permanent entryway systems at least 10 feet (3 meters) long in the primary direction of travel to capture dirt and particulates entering the building at regularly used exterior entrances B. interior cross-contamination prevention; Sufficiently exhaust each space where hazardous gases or chemicals may be present or used C. C. filtration; Each ventilation system that supplies outdoor air to occupied spaces must have particle filters or air-cleaning devices that meet one of the following filtration media requirements: minimum efficiency reporting value (MERV) of 13 or higher, in accordance with ASHRAE Standard 52.2–2007	Entryway system will be provided. Exhaust systems will be provided for hazardous gases or chemicals may be present spaces. HVAC System will provide minimum efficiency value (MERV) 13 or higher filtration. Filtration media requirements are required only for ventilation systems serving regularly occupied spaces.	YES
Low-Emitting Materials	To reduce concentrations of chemical contaminants that can damage air quality, human health, productivity, and the environment. This credit covers volatile organic compound (VOC) emissions in the indoor air and the VOC content of materials, as well as the testing methods by which indoor VOC emissions are determined.	Technical specifications will identify the VOC limits for adhesives, sealants, paints and coating, flooring, composite wood and furniture in individual sections. The contractor is required to submit product data identifying VOC quantities, including MSDS sheets, for all sections.	YES
Construction IAQ Management Plan	Develop and implement an IAQ Management Plan for the construction phases to meet the recommendations of SMACNA, protect absorptive materials from moisture, and install MERV 8 filters on return air grilles during construction. Replace media immediately prior to occupancy. To establish better quality indoor air in the building after construction and during occupancy. Select one of the following two options, to be implemented after construction ends and the building has been completely cleaned. All interior finishes, such as millwork, doors, paint, carpet,	IAQ Management Plan will develop and implement for the construction phases to meet the recommendations of SMACNA. MERV 8 filters will install on return grilles during construction. Immediately before occupancy, all filtration media will replace with the final design filtration media.	YES

	acoustic tiles, and movable furnishings must be installed. Option 1. Flush-out Before Occupancy During Occupancy Option 2. Air Testing		
Thermal Control	Design heating, ventilating, and air-conditioning (HVAC) systems and the building envelope to meet the requirements of ASHRAE Standard 55–2010, Thermal Comfort Conditions for Human Occupancy. Provide individual thermal comfort controls for at least 50% of individual occupant spaces. Provide group thermal comfort controls for all shared multi occupant spaces, and for any individual occupant spaces without individual controls.	HVAC Design will meet ASHRAE Standard 55-2010, Thermal Comfort for Human Occupancy. Individual thermal comfort controls will be provided at least 50% of individual occupant spaces.	YES
Interior Lighting	Provide individual lighting controls for 90% of occupied spaces.	Individual lighting controls and task lighting will be provided.	YES
Acoustic Performance	To provide workspaces promote occupants' well-being, productivity, and communications through effective acoustic design.	All occupied spaces, will meet sound transmission class rating requirements, as applicable, for HVAC background noise, sound isolation, reverberation time, and sound reinforcement and masking.	YES
LEED INNOVATION CREDITS			
Innovation	To encourage projects to achieve exceptional or innovative performance.	Project teams can use any combination of innovation, pilot, and exemplary performance strategies.	MAYBE
LEED Accredited Professional	At least one principal participant of the project team must be a LEED Accredited Professional.	At least one principal participant of the project team will be a LEED Accredited Professional.	YES
REGIONAL PRIORITY (ZIP CODE: 11973)			
Enhanced Commissioning	In addition to prerequisite commissioning required, bring the CxA on to the project earlier in the design process.	A commissioning agent has to be hired directly by BNL and will provide the commissioning specifications to ensure the intent of this credit is met.	YES

Advanced Energy Metering	Install advanced energy metering for the all whole-building energy sources used by the building.	To support energy management and identify opportunities for additional energy savings by tracking building-level metering.	YES
Optimize Energy Performance	Analyze efficiency measures focused on IT load reduction and HVAC-related strategies (air-side economizers, hot aisle–cold aisle, etc.). Project the potential energy savings and cost implications for all affected systems.	Building will have Whole Building energy Simulation Analyze efficiency focused on IT load reduction and HVAC-related strategies(air-side economizers, hot aisle-cold aisle)	YES
Construction and Demolition Waste Management	Recycle and/or salvage nonhazardous construction and demolition materials. Calculations can be by weight or volume but must be consistent throughout.	Construction and demolition waste management plan will develop and implement.	YES

4.5.4 Determining Compliance with the Guiding Principles for Sustainable for Federal Buildings

FEBRUARY 2016

New Construction or Modernization

For new construction, metrics number one through 20 are required, and for modernization, metrics number one through 18 and number 21 are required, as specified below.

I. EMPLOY INTEGRATED DESIGN PRINCIPLES		Yes/No
1	**Integrated Design:** Consider the environmental impact of siting decisions and use an integrated project team to: establish energy and other environmental performance goals in the design process; follow sustainable landscape design principles; evaluate electric vehicle charging needs; consider design choices that improve environmental performance, support health and wellness of building occupants and consider climate risks including wildfire; and consider all stages of the building's life cycle. **[Required]**	Yes
2	**Commissioning:** Commission and recommission at least every 4 years to optimize building performance using commissioning agents who are independent of the design and construction or operating team. Commissioning should be consistent with the Energy independence and Security Act (EISA) section 432[1] and Federal Energy Management Program (FEMP) commissioning guidance.[2] **[Required]**	Yes
II. OPTIMIZE ENERGY PERFORMANCE		
3	**Energy Efficiency:** A. For new construction, ensure energy efficiency is 30% better than the current American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 90.1 standard, OR B. For modernization, ensure: 1) Energy use is 20% below the fiscal year (FY) 2015 energy use baseline, OR 2) Energy use is 30% below the FY 2003 energy use baseline, OR 3) The building has an ENERGY STAR® rating of 75 or higher, OR 4) For building types not in ENERGY STAR Portfolio Manager, where adequate benchmarking data exists, the building is in the top quartile of energy performance for its building type, AND B. For new construction and modernization, use energy efficient products, as required by statute.[3] **[Required]**	Yes

[1] Guidance for the Implementation and Follow-up on Identified Energy and Water Efficiency Measures in Covered Facilities (per 42 U.S.C. 8253(f), Use of Energy and Water Measures in Federal Buildings September 2012: energy.gov/sites/prod/files/2013/10/f4/eisa_project_guidance.pdf)
[2] energy.gov/sites/prod/files/2014/07/f17/commissioning_fed_facilities.pdf
[3] 42 U.S.C. § 8259(b) and 10 C.F.R. § 436.40 et seq.

4	**Renewable and Clean Energy:** Evaluate and implement, where appropriate, life cycle cost-effective renewable energy projects on-site; consider long-term off-site renewable sources and Renewable Energy Certificates (RECs); and utilize clean and alternative energy where possible. **[Required]**	Yes
5	**Metering:** Install building level meters for electricity, natural gas, and steam; install advanced or standard meters as appropriate. **[Required]**	Yes
6	**Benchmarking:** Benchmark building performance at least annually, preferably using ENERGY STAR Portfolio Manager; regularly monitor building energy performance against historic performance data and peer buildings.[4] **[Required]**	Yes
III. PROTECT AND CONSERVE WATER		
7	**Indoor Water Use:** A. Build to ASHRAE standard 189.1-2014 sections 6.3.2, 6.4.2, and 6.4.3, or current comparable ASHRAE standards, AND B. Use water-efficient products; install building level water meters; optimize cooling tower operations; and eliminate single pass cooling. **[Required]**	Yes
8	**Outdoor Water Use:** A. Separately meter water for irrigation systems greater than 25,000 square feet, AND B. Use water efficient landscapes, AND C. Limit potable water use for irrigation to 50% or more below conventional practices using methodologies from (but not the numeric requirements contained in) ASHRAE standard 189.1-2014 section 6.5.1, or current comparable ASHRAE standards, to calculate water use of conventional practices. **[Required]**	Yes
9	**Alternative Water:** Consider alternative sources of water where cost- effective and permitted by local laws and regulations. **[Required]**	Maybe
10	**Stormwater Management:** For new construction meet or exceed EISA section 438 stormwater management requirements. **[Required]**	Yes
IV. ENHANCE INDOOR ENVIRONMENTAL QUALITY		
11	**Ventilation and Thermal Comfort**: Meet current ASHRAE standards 55 and either 62.1 or 62.2 for ventilation and thermal comfort. **[Required]**	Yes
12	**Daylighting and Lighting Controls:** Maximize opportunities for daylighting in regularly occupied space, automatic dimming controls or accessible manual controls, task lighting, and shade and glare control. **[Required]**	Yes
13	**Indoor Air Quality:** Develop and implement an indoor air quality policy that considers the following: moisture control, use of low emitting materials and products with low pollutant emissions, necessary protocols to protect indoor air quality during construction and in the finished building, prohibition of smoking in any form inside and within 25 feet of all building entrances, operable windows, and building ventilation intakes, and use of integrated pest management techniques. **[Required]**	Yes

[4] 42 U.S.C. § 8253(f) (8); energy.gov/sites/prod/files/2014/09/f18/benchmarking_guidance08-2014.pdf

14	**Occupant Health and Wellness:** Promote opportunities for voluntary increased physical movement of building occupants such as making stairwells an option for circulation, active workstations, fitness centers, and bicycle commuter facilities; and support convenient access to healthy dining options, potable water, daylight, plants, and exterior views. **[Required]**	Yes
V. REDUCE THE ENVIRONMENTAL IMPACT OF MATERIALS		
15	**Material Content and Performance:** Procure products that meet the following requirements where applicable: A. Resource Conservation and Recovery Act (RCRA) section 6002, AND B. Farm Security and Rural Investment Act (FSRIA) section 9002, AND C. Federally Recommended Specifications, Standards and Ecolabels[5] or are on the Federal Green Procurement Compilation for other green products, as appropriate,[6] AND D. Avoid ozone depleting compounds and high global warming potential (GWP) chemicals. **[Required]**	Yes
16	**Waste Diversion:** Where markets exist, provide reuse and recycling services for building occupants and divert at least 50% of non-hazardous, non- construction related materials from landfills. **[Required]**	Yes
17	**Materials Management:** Where markets exist, divert at least 50% of construction and demolition materials from landfills. **[Required]**	Yes
VI. ASSESS AND CONSIDER CLIMATE CHANGE RISKS		
18	**Mission Criticality:** Determine long-term mission criticality of the physical asset and operations to be housed in the facility to inform the design of new construction and modernization to increase climate resilience. **[Required]**	Yes
19	**Floodplain Considerations:** For new construction, avoid, to the extent possible, the long- and short-term adverse impacts associated with the occupancy and modification of floodplains and avoid floodplain development whenever there is a practicable alternative.	Not Required
20	**Facility Design:** For new construction, balance options to address predicted climate change impacts against mission criticality, cost, and security to determine design parameters; at a minimum, include low and no cost resilience measures to address predicted climate conditions.	Not Required
21	**Facility Adaptation:** For modernization, take action to mitigate identified risks, considering mission criticality, climate impacts, cost, and phased adaptation over time. **[Required]**	Yes

[5] www2.epa.gov/greenerproducts/epas-recommendations-specifications-standards-and-ecolabels
[6] Green Procurement Compilation: sftool.gov/greenprocurement

4.6 Alternates

ALT-01 Bypass Generator

Add the bypass generator GEN-B and its associated concrete pad, 15kV circuit breaker in the paralleling switchgear and the feeder and duct bank between the paralleling switchgear and the generator.

This will provide generator redundancy and prevent a partial data center shutdown if one of the active generators is out of service and utility power is interrupted.

ALT-02 Bypass UPS

Provide the two bypass UPS units TUPS-B and MUPS-B and their associated bypass input feeders.

These bypass units provide UPS redundancy to rack loads and to critical mechanical cooling equipment respectively. Although this UPS unit will not carry load under normal operating conditions, they will maintain uninterrupted power in the event of a primary UPS failure. Without these units, rack loads and critical mechanical equipment will continue to operate, but on raw utility power without the power conditioning provided by the UPS units.

If ALT-02 is not accepted, then ALT-10 must be accepted in order to maintain a UPS source in the bypass to the Network Equipment Room.

ALT-03 Generator/CUP

Provide a generator at the existing Central Utility Plant (CUP) to provide a backup source of chilled water either from the existing 22,000 ton/hr chilled water storage tank and/or from the 1,200 ton absorption chiller. Locate the generator adjacent to the existing 15kV switchgear 600B. This will maintain chilled water redundancy to the Data Center in the event of a campus wide power outage.

The generator will be a 1200kW, 13.8kV standby diesel engine driven generator, EPA Tier 2 emissions compliant with an outdoor walk-in, sound attenuated enclosure, a minimum 8 hour sub-base fuel tank and a 1200kW radiator mounted load bank. Longer outage runtimes will be obtained by refilling the sub-base tanks from the on-site 100,000 gal tank via BNL delivery trucks.

Provide two new sections at the existing 15kV outdoor switchgear for the paralleling controls and a new 15kV circuit breaker. Provide a 2-way 5” duct bank and 15kV feeder conductors between the generator and switchgear.

Modify the existing mechanical control system to include an emergency power operation mode which will shed all loads except those necessary to support the B-

725 backup cooling requirement. Load shedding control will also incorporate any existing chilled water control valves that can shed campus chilled water loads during emergency power operation mode.

Future considerations include increasing the size of the generator to allow a second chiller and associated pumps and cooling towers to operate during a utility power failure to increase the available chilled water capacity.

ALT-04 Not Used

ALT-05 1.2 MW Power

Provide System 3 and all it associated power and mechanical distribution equipment to increase the initial computing load capacity from 2.4 MW to 3.6 MW and from a 2+1 system configuration to a 3+1 configuration. System 3 will be similar to either System 1 or 2.

Provide one complete 1.2 MW power distribution system including a 1750kW/2000kVA, 13,800V outdoor diesel generator, a 2000 kVA, 13,800-480Y/277V indoor secondary unit-substation with a 3000A 480Y/277V switchgear, a 1200 kVA UPS systems to serve computing loads, and a 1200A switchboard to serve mechanical and building support loads. The UPS system will include a 2000A output switchgear, two 2000A static transfer switches, two 2000A switchboards, and two sets of at least four 300 kVA transformers and secondary main breakers, 1200A distribution panels in the data halls, and overhead bus tracks mounted above each rack row with plug-in power taps to serve individual racks. The mechanical system will include a 50 kVA UPS to serve the chilled water pumps.

Provide a new concrete pad for the generator, a 2-way 5” duct bank to the paralleling switchgear and associated feeder, and a 15kV circuit breaker in the paralleling switchgear.

The existing 15kV loop serves Systems 1, 2 and the bypass. System 3 will be the first of three systems installed on the second loop. Therefore, System 3 has the additional burden of providing the majority of the second loop. Provide one 15kV circuit breaker in each of the two 15kV normal main switchgear lineups. Provide two 2-way 5” duct banks to the exterior wall the building. Extend these feeders at the underside of the roof to Unit Substation 3.

Provide two 2000A feeders from the bypass system UPS output switchgear to the two new static switches.

Mechanically add three (3) Dry Air Economizers (DAE) including ductwork connection to distribution duct at mechanical room as well as connecting piping to the DAEs.

In addition to the DAEs; provide the following:

- One 310 ton chiller (CH-3) and chilled water pump (CHP-4)
- One 310 ton cooling tower (CT-3) and condenser water pump (CWP-4)
- One 100 ton plate & frame heat exchanger (HX-3) and direct cooling pump (DCHP-4)
- All interconnecting piping and controls.

ALT-06 Exterior Envelope - Insulated Metal Wall Panel Refurbishing

The Insulated Metal Panel Wall Panel Refurbishing Alternate scope includes the removal of all wet seals, cleaning, repairing of all damage panels, priming and final painting with an air dried Kynar system and sealing of the entire exterior envelope.

ALT-07 Solar Water Heating

Provide domestic solar hot water heating panels to be mounted on the roof; capacity to serve Pantry and Toilets as part of this scope of work only.

ALT-08 Exterior Envelope – Dual Membrane Roof / Leak Detection System - Deletion

Deductive Alternate to DELETE dual membrane roof system with leak detection in its entirety and replace with the Standard Roof Membrane as described in Section 2.3.

ALT-09 Build-out of Phase II

Provide build-out of Phase II equipment rooms ready for future installation of mechanical and electrical equipment.

ALT-10 UPS for Network Equipment

Provide a separate 100kVA distribution system dedicated to the Network Equipment Room which will provide UPS power in both the primary and bypass sources. The Alternate is only necessary if ALT-02, which provides the 1200kVA bypass UPS, is not accepted. There's no requirement for two UPS units in series in the bypass, but there is a requirement that Network Equipment be served by two sources of power each with UPS backup.

Add a 100kVA UPS, an UPS output panelboard, two 200A static switches, two 112.5kVA transformers, two 400A distribution panels and two 100A bus tracks above each row of racks. At the UPS output switchgear TUSG-2, provide two power circuit breakers primary UPS input of the two static switches. Bypass UPS power will come from the dedicated 100kVA UPS. See attached one-line diagram for ALT-10.

If ALT-02 is not accepted, then ALT-10 must be accepted in order to maintain a UPS source in the bypass to the Network Equipment Room.

ALT-11 Future Expansion Fitout

Provide Fitout of the Future Expansion area which includes installation of 30 in. high access floor system, ceiling, lighting, two 400 kW DAEs for cooling, connection of DAEs to piping and ductwork at mechanical room as well as distribution ductwork within the Data Hall and power distribution.

Power distribution will include one pair of redundant 300 kVA transformers and secondary main breakers in the adjacent electrical room, a pair of 1200A distribution panels in the data halls, and pairs of overhead bus tracks mounted above each rack row with plug-in power taps to serve individual racks.

ALT-12A Network Room Gaseous Fire Suppression

Provide Clean Agent Fire Suppression System for the Network Room: The Network room will be provided with a clean agent fire suppression system in accordance with NFPA 2001 and FM LPDS 4-9. The clean agent will be FM-200 a halogenated hydrocarbon which is a halon replacement gas which is environmentally friendly. This type of system suppresses a fire by chemical reaction rather than smothering a fire by displacing oxygen.

The system consists of pressurized cylinders containing the gas which are piped to open nozzles within the space. A control panel is wired to the actuating valve at the cylinders and to smoke or heat detectors within the space. Upon actuation of a detector the system goes into alarm, with lights and horns activated. Doors to the space will automatically close. Dampers in the HVAC ducts will close to seal the space airtight to contain the gas within the space. Only upon another detector activating does the system arm and a timer starts counting down. A dead-man type abort switch is located within the space in the event of a false alarm or trapped person. This will hold the timer and prevent the release of the gas. When the timer counts out the system will discharge the gas.

The cylinders and control panel will be located in the mechanical room closest to the space. Signs will be provided inside and outside the space to alert people as to the type of suppression system within the space and to get out in the event of an alarm.

ALT-12B Tape Library Gaseous Fire Suppression

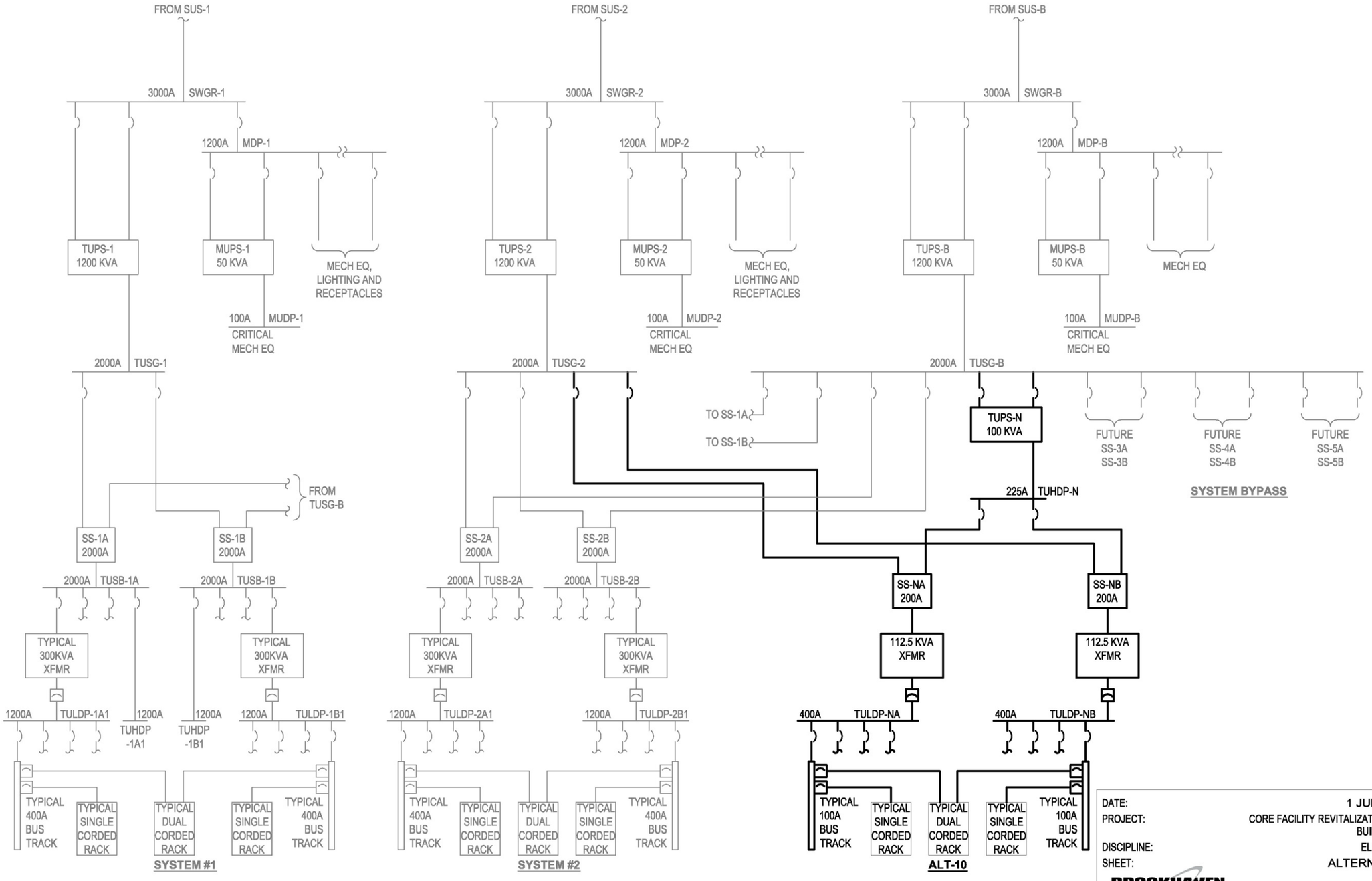
Provide Clean Agent Fire Suppression System for the Tape Library: The Tape Library will be provided with a clean agent fire suppression system in accordance with NFPA 2001 and FM LPDS 4-9. The clean agent will be FM-200 a halogenated hydrocarbon which is a halon replacement gas which is environmentally friendly. This type of system suppresses a fire by chemical reaction rather than smothering a fire by displacing oxygen.

The system consists of pressurized cylinders containing the gas which are piped to open nozzles within the space. A control panel is wired to the actuating valve at the cylinders and to smoke or heat detectors within the space. Upon actuation of a detector the system goes into alarm, with lights and horns activated. Doors to the space will automatically close. Dampers in the HVAC ducts will close to seal the space airtight to contain the gas within the space. Only upon another detector activating does the system arm and a timer starts counting down. A dead-man type abort switch is located within the space in the event of a false alarm or trapped person. This will hold the timer and prevent the release of the gas. When the timer counts out the system will discharge the gas.

The cylinders and control panel will be located in the mechanical room closest to the space. Signs will be provided inside and outside the space to alert people as to the type of suppression system within the space and to get out in the event of an alarm.

ALT-13 RHIC/ATLAS Chilled Water Piping for IT Equipment Cooling

Provide chilled water piping for IT equipment cooling in the RHIC/ATLAS data hall.



DATE:	1 JULY 2016
PROJECT:	CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE:	ELECTRICAL
SHEET:	ALTERNATE 10

BROOKHAVEN NATIONAL LABORATORY

4.7 Risk Management

Risk Management is an overarching process that encompasses identification, analysis, mitigation planning, mitigation implementation and tracking. Risk Management (RM) is critical to acquisition success and an integral part of project management and engineering activities. Risk is a measure of future uncertainties in achieving project performance goals and objectives within defined cost, schedule and performance constraints. Risks are therefore associated with all aspects of a project and how these aspects relate across the Work Breakdown Structure (WBS) and Integrated Master Schedule.

Risks have three components:

1. A future root cause, which, if eliminated or corrected, would prevent a potential consequence from occurring.

2. A probability (or likelihood) of the root cause occurring, assessed at the present time.

3. The consequence (or effect) of that future occurrence.

Risk addresses the potential variation in the planned approach and its expected outcome. Risk assessment and identification is performed as early as possible in the life cycle to ensure that critical technical, scope, schedule, and cost risks are identified and/or addressed as part of the program and project planning, execution, and budget activities.

The risks anticipated for the Core Facility Revitalization (CFR) Project will be analyzed and managed in accordance with the methods identified in the DOE O 413.3B, *Program and Project Management for the Acquisition of Capital Assets* and DOE G 413.3-7, *Risk Management Guide.*

This Preliminary Risk Management Plan was developed to support approval of Critical Decision 1 (CD-1) and will be updated throughout the life of the project.

The estimated costs and contingencies to mitigate these risks are incorporated in the project's preliminary baseline cost and schedule estimates. Once the Performance Baseline is established at CD-2, the use of contingency will be managed via the Baseline Change Control processes described in the CFR Project *Preliminary Project Execution Plan*.

This Risk Management plan defines the processes and methods to be used to identify, assess, quantify, monitor, and mitigate risks for the project. It describes the roles and responsibilities of the project team in performing the risk management functions, and defines reporting and tracking requirements for risk-related information.

Project Assumptions

The goals of the CFR project RMP are as follows:

1. Risk assessment will be a continuous and iterative process throughout the project life cycle.
2. The project will be executed in accordance with DOE and Brookhaven National Laboratory policies and procedures.
3. A close partnership with users and stakeholders will be maintained throughout project implementation.
4. Comprehensive mitigation plans will be developed and implemented.

4.8 Security

Security and Safeguard requirements for this facility under this project is adequately covered by the existing site security arrangements established at BNL and at the current RHIC/ATLAS Computing Facility. It has been confirmed that BNL Laboratory Protection has evaluated all of their facilities for security risks. The CFR project does not create any significant changes to the current evaluations as per the BNL Laboratory protection Division. Their assessment of this project is attached in Appendix 9.3 Assessment of Security Risks.

4.9 Facility Commissioning

An important element in the ultimate success of the CFR Project will be the proper commissioning of the facilities and the new systems. Systems or equipment must be properly calibrated, balanced, tuned or shielded to prevent detrimental impact to the research and assure proper performance with respect to meeting energy efficiency requirements. During the Preliminary Design Phase, a detailed Facility Commissioning Plan will be prepared to assure that appropriate commissioning requirements have been included in the CFR design. Elements of the commissioning plan are:

- Present a schedule and sequence for start-up of building equipment and systems.
- Identify references and sources of start-up procedures and performance, test and acceptance criteria for systems and equipment.
- Identify whether the equipment will be commissioned by BNL staff, contractor staff, vendor staff or if the services of a specialty commissioning contractor are warranted.
- Identify the point at which equipment has been accepted and can be turned over to operations staff.

A Third Party Commissioning Agent (CxA) will work with the A/E, Project Manager, Maintenance and Operations staff, the CM/GC, and pertinent subcontractors to coordinate:

- Equipment pre-start check, start up, testing and balancing.
- Fine tuning systems for proper coordination between systems and for efficient operation under all anticipated conditions.
- Operational instruction and assembly of the Operations and Maintenance manuals.

The CxA will be engaged to review design documents to ascertain performance and operational test requirements for all major building systems. A commissioning plan to test and evaluate system performance both individually and collectively against approved design criteria will be prepared. Functional performance tests will be established and all designated systems will be tested against the performance.

4.10 Value Engineering

Value Engineering (VE) will be performed for this project as required under DOE Order 413.3B, Program and Project Management for the Acquisition of Capital Assets. An independent value engineering team will perform VE review during the Preliminary Design.

Value Engineering is a continual process. Value engineering exercises shall be conducted during the schematic design phase, and on the 30% Design Development deliverable. VE assessments will be performed during the final design phases when required. Alternative design approaches, construction techniques and materials, as well as the flexibility of the design, will be evaluated and incorporated into the project design as appropriate.

Section 5
METHOD OF ACCOMPLISHMENT

5.0 Method of Accomplishment

This section presents the roles and responsibilities for project participants and depicts the organizational structure for the CFR project.

5.1 Department of Energy, Office of Science Headquarters

Associate Deputy Director for Field Operations

The SC Associate Deputy Director for Field Operations will serve as the Project Management Executive (PME). The key responsibilities of the PME are:

- Approves Critical Decisions.
- Ensures the FPD appointed to a project is qualified and has appropriate communication and leadership skills prior to designation.
- Approves the Acquisition Strategy and PEP, and IPT Charter.
- Conducts monthly or quarterly project reporting/meetings.
- Delegates approval authority for baseline changes.
- Initiates definition of mission need and objectives of the Project.
- Approves PME Level 1 baseline changes.
- Initiates formal periodic reviews of the Project.
- Provide HQ technical guidance and resources to the FPD and Program Manager.
- Provides funding for the construction and operation of the facility.

SLI Program Manager, Office of Operations Program Management

The SLI Program Manager within OPM will report to the PME. The SLI Program Manager serves as the primary interface between the FPD and the PME. The Program Manager's role and responsibilities are:

- Functions as DOE-Headquarters (DOE-HQ) point-of-contact for Project matters.
- Serves as the representative in communicating the interests of the SLI program.
- Coordinates with the FPD, IPT, other SC staff offices, and DOE-HQ program offices, as needed, to execute the Project.

- Assists with budget formulation.
- Reviews formal project documents (MNS, AS, PEPs, IPT Charter, etc.) and recommends changes and/or approval.
- Reviews project progress reports and deliverables, and concurs with FPD monthly assessments in PARSIIe.
- Supports formal periodic reviews of the Project including SC Office of Project Assessment (OPA) Independent Project Reviews (IPRs) and tracks issues to resolution.
- Oversees development of project definition, scope, and budget.
- Prepares, defends, and provides the project budget with support from the field and SC Headquarters organizations.
- Reviews and provides recommendations to the PME consistent with the baseline change control process.
- Develops project performance measures, and monitors and evaluates project performance throughout the life cycle of the Project.
- Ensures that Environment Safety & Health (ES&H) requirements are implemented by the Project.
- Coordinates with other SC offices and the DOE Office of Acquisition and Project Management as needed to execute the Project.

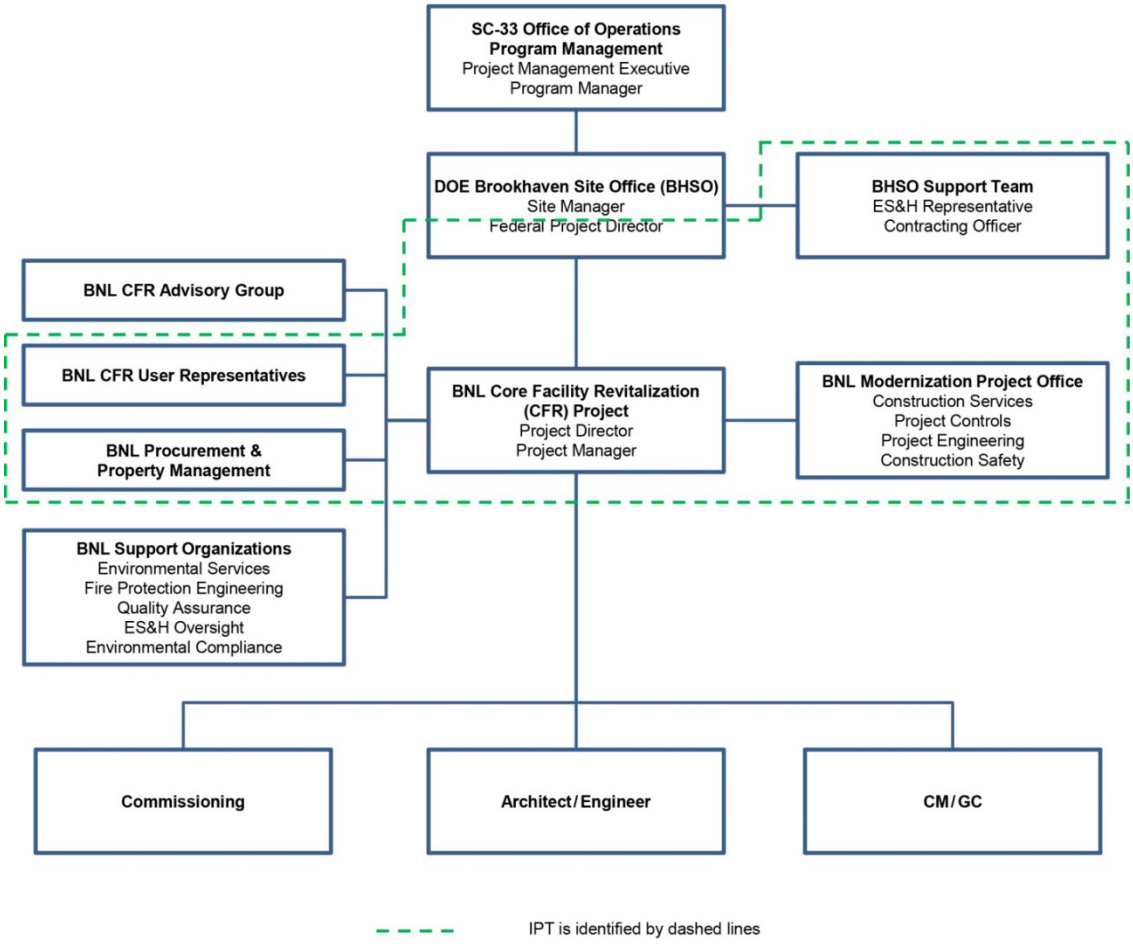


Figure 5.1 – CFR Project Organization Chart

5.2 Integrated Project Team

The IPT is part of the CFR Project Organization and is indicated by the light blue dotted line in the chart above.

Only certain members of the DOE Support Team, the User Representatives and the BNL Project Team are members of the IPT. The IPT Charter in Appendix B outlines the composition of the IPT and the roles and responsibilities of each member. The IPT Charter is a living document and will be updated as necessary.

The FPD will be the primary point of contact with the SLI Program Manager for coordination and submittal of CD documentation. The FPD will also routinely contact the SLI Program Manager to communicate project status and discuss issues or concerns. The IPT will solicit from the SLI Program Manager on institutional developments that may affect project performance. For CD approvals and project

reviews, it may be necessary for the FPD to interface with other DOE Headquarters organizations. However, the SLI Program Manager will be the point of contact for interfaces between the IPT and organizations within SC and external to the IPT.

The DOE Support Team consists of the BHSO staff assigned to the project. Specific roles and responsibilities of the DOE Support Team assigned to the IPT are described in the IPT Charter.

Interface with BNL management and affected personnel will be necessary for coordination with site activities that may impact project performance or where project activities may have broader site impacts. These interfaces will be necessary for planning and implementing a well-organized project. The BNL Project Director will be the primary IPT point of contact for day-to-day interfaces with both the FPD and BNL management, and will also obtain input for coordination of project activities from various stakeholder groups.

Federal Project Director – DOE Brookhaven Site Office

The BHSO reports to SC Deputy Director for Field Operations and administers the M&O contract and day-to-day oversight of BNL. Overseeing the execution of the CFR Project is the responsibility of the FPD. The FPD will lead the IPT and will be the primary point of contact for communication and coordination with entities external to the IPT. The FPD is responsible, with the assistance of the IPT members, for the following tasks:

- Serves as the single point of contact between Federal and contractor staff for all matters relating to the project and its performance.
- Prepares and maintain the IPT Charter and operating guidance with IPT support and ensure the IPT is properly staffed. Define and oversee the roles and responsibilities of each IPT member.
- Leads the IPT and provide broad program guidance. Delegates appropriate decision-making authority to the IPT members.
- Appointed as the Contracting Officer's Technical Representative, as determined by the Contracting Officer.
- Ensures development and implementation of key project documentation.
- Defines project cost, schedule, performance, and scope baselines.
- Ensures design, construction, environmental, safety, security, health and quality efforts performed comply with the contract, public law, regulations and Executive Orders.
- Submits monthly status reports to DOE-HQ in PARS-IIe.
- Evaluate and verify reported progress; make projections of progress and identify trends.

- Approves (in coordination with the Contracting Officer) changes in compliance with the approved change control process documented or referenced in the PEP.
- Plan, implement, and complete the Project using a systems engineering approach.
- Tailor DOE project management requirements to the Project.
- Oversee development and implementation of the Acquisition Strategy and the Project Execution Plan.
- Ensure timely completion and quality of required project documentation.
- Assess contractor project performance versus contract requirements.
- Proactively identify and resolve critical issues within Federal control.
- Integrate and manage the timely delivery of government reviews, approvals, property, services, and information.

Project Director – BNL

The CFR Project will be executed by a BNL team that is headed by the BNL Project Director. The BNL Project Director has established a project organization to accomplish the Project which includes the Project Manager, engineering support, ES&H, Quality Assurance (QA), construction oversight and safety, procurement, project controls, and finance personnel. The BNL Project Director provides senior management oversight and approves changes in accordance with the approved change control process. The Project Director is the primary point of contact with all user representatives.

Project Manager – BNL

The BNL Project Manager is responsible for the design, construction, testing, and turnover to operations of the Project. The BNL Project Manager will:

- Manage day-to-day execution of the Project at BNL.
- Manage and supervise project personnel, the A/E Firm, the CM/CG and various consultants.
- Establish technical and administrative controls to ensure the Project is executed within approved cost, schedule, and technical scope.
- Implement an Earned Value Management System (EVMS) to track performance against the approved Project baseline.
- Ensure ES&H responsibilities and requirements are integrated into the Project.

- Participate in management meetings and communicate the Project status and issues.
- Identify and manage project risks and conduct the risk register review meetings
- Monitor expenditures and review invoices.
- Prepare and provide recommendations for baseline change control proposals.
- Manage project cost and schedule.
- Submits Monthly Reports to the Project FPD.

Procurement Representative – Member of the BNL Project Team

A representative from BNL Procurement provides subcontract administration and contractual support. The procurement representative will:

- Solicit sources and administer subcontracts.
- Assist in source selection.
- Direct preparation of Requests for Proposal.
- Perform price and cost analysis.
- Ensure all contractual provisions are approved and met. Negotiate terms, recommend award of subcontract and prepare necessary justification documentation.
- Prepare subcontract modification changes in scope of work, funding and schedules.
- Recommend resolution of disputes and subcontractor claims.
- Upon completion perform subcontract closeout.

Environment, Safety, and Health Representative(s) – Member of the BNL Project Team

The ES&H Team Lead will:

- Ensure ES&H resources are available for project activities.

The ES&H Deputy Team Lead will coordinate all ES&H technical aspects including:

- Ensure ES&H programs are fully integrated into the Project.
- Work with the IPT and ES&H to identify and document all ES&H requirements and best practices are incorporated into the Project.

- Coordinate the ES&H review and approval of the design documents, involving ES&H staff as needed.
- Participate in the oversight of project activities involving ES&H staff during all phases of the project.
- Provide advice and support to the IPT on continuous improvement of ES&H items throughout the Project.
- Review the CM/GC and construction subcontractor safety plans.
- Provide guidance and support to the project team in the areas of ES&H to include, but not limited to, participation in the review of project documentation, oversight of contractor activities in the ES&H areas including project walkthroughs and assessments.

Integrated Project Team Members

The IPT members will:

- Support the FPD.
- Develop project contracting strategies.
- Ensure project interfaces are identified, defined, and managed to completion.
- Identify, define, and manage to completion the project environmental, safety, health, security, and quality assurance requirements.
- Identify and define appropriate and adequate project technical scope, schedule, and cost parameters.
- Perform periodic reviews and assessments of project performance and status against established performance parameters, baselines, milestones, and deliverables.
- Plan and participate in project reviews, audits, and appraisals as necessary.
- Assist in preparation of Critical Decision packages.
- Review and comment on project deliverables (e.g., drawings, specifications, procurement, and construction packages).
- Review change requests as appropriate and support Change Control Boards as requested.
- Participate, as required, in Readiness Reviews
- Support preparation, review, and approval of project completion and closeout documentation.

User Representatives

User Representatives from the RHIC and ATLAS Computing Programs will provide technical guidance on their programming requirements for the Project and will continue to serve as technical advisors through project completion. User Representatives will:

- Represent the interests of all program groups and occupants of the buildings.
- Participate in project meetings and communication planning.
- Participate in project design reviews as well as value engineering sessions.
- Ensure ES&H operational requirements are integrated into the Project.
- Participate in risk assessment meetings.

BNL Modernization Project Office

- Perform periodic reviews and assessments of the Project to ensure that it is executed within approved cost, schedule, and technical scope.
- Execute Readiness to Operate assessments, including pre-review of all CD submittals and all status reviews by SLI.
- Provide periodic assurance that project earned value management data conforms to BNL's certified EVMS.
- The Project will provide monthly status updates to the MPO.

CFR Advisory Committee

BNL established an Advisory Committee for the Project consisting of representation from BNL Energy and Utilities, Information and Technology Division, BNL Strategic Site Planning, the User Representatives, the Project Manager, the Project Director, and IFM Complex Manager. The Committee provided input to the development and planning for the CFR Project. This committee was and will be called on, as necessary, to review various high level aspects of the CFR Project.

Commissioning Agent

The commissioning contract will be a firm fixed price contract based on technical qualifications. Testing and commissioning activities will be coordinated and managed in concurrence with the integrated project schedule throughout the design and execution periods of this project.

BNL Construction Manager/Site Supervisor

A construction manager will be included in the project team prior to construction and will be responsible for interfacing the construction efforts with the BNL processes including coordinating penetration permits, LOTO permits, hot work permits, utility

shutdowns, commissioning, and the inspection/testing. The construction manager will also provide safety oversight on the project and will participate in the Project Hazard Analysis (PHA) process, as well as take an active role in the safety plan of the day meeting. The construction manager will maintain daily logs for the duration of the construction.

BNL Safety Engineer

A safety engineer will be included in the project team prior to construction and will be responsible for safety oversight of all construction activities. The safety engineer will provide safety inspections and issue safety deficiency notices, as necessary, and work with the construction manager and project manager to proactively plan safe work practices into all construction efforts.

Architecture and Engineering (A/E) Design Firm

The A/E design firm will prepare the preliminary and final design and construction documents. The A/E will also provide construction administration support including submittal reviews, preparing RFI responses, and field change resolution.

CM/GC

A Construction Manager/General Contractor (CM/GC) will perform two phases of work for the Project. Phase 1 will consist of pre-construction management support services during the preliminary design, final design and bid phases. Duties during this phase include constructability reviews, developing independent cost and schedules, performing feasibility studies, develop logistics plans, develop an energization plan, perform outreach to the subcontractor community to develop interest in the Project, and to conduct the subcontractor bid process including pre-qualification and recommendation of award of construction subcontractors. Phase 2 will consist of managing the overall construction process, entering into and administering subcontracts with trades, vendors and suppliers to deliver portions of the Project, and may self-perform portions of the work.

5.3 Readiness Assessment/Review

A BSA transitions to operations review team will verify that the CFR project has been constructed to comply with all the requirements and specifications of the design and that the project has been completed prior to CD-4 approval. A Transition to Operations Plan will be prepared and approved prior to CD-2.

Section 6
PROJECT SCHEDULE

6.0 Project Schedule

6.1 Schedule Summary

CD-0, approve mission need for the Core Facility revitalization Project was approved on September 1, 2015.

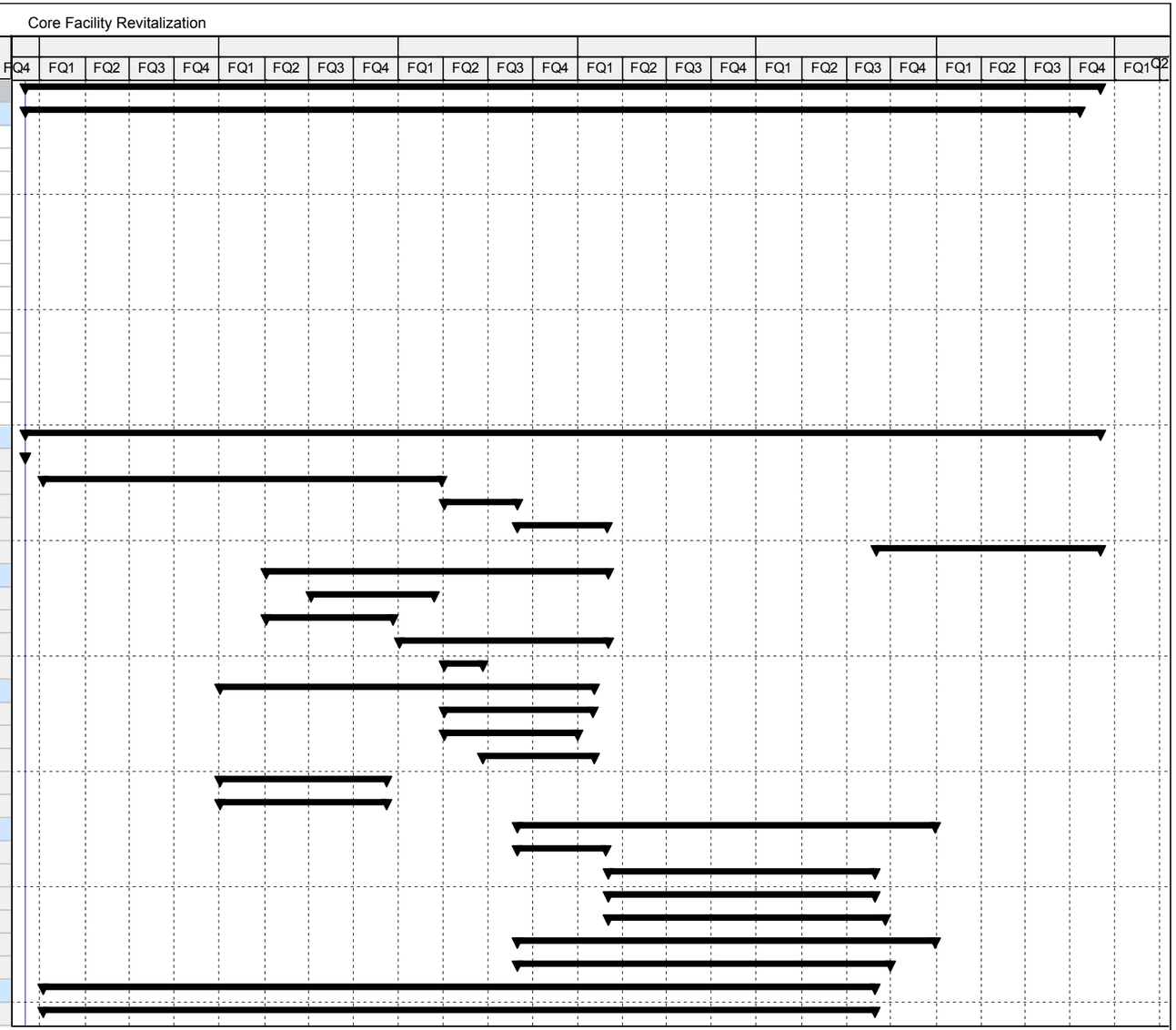
Conceptual Design will be completed in fiscal year 2016. CD-1 approval of alternative selection and cost range is scheduled for the 4th quarter of FY 2016. The preliminary and final design phase is to be funded from project engineering and design (PED) funds and will start in fiscal year 2017.

CD-2/3A is scheduled for 3rd quarter FY 2018. A CD-3A is proposed to facilitate the early procurements of significant long lead equipment and to initiate site preparation activities. Conventional construction is scheduled to begin 1st quarter of fiscal year 2019. The CFR project will be a single phase project. The entire work area shall be vacated and isolated from other areas of the building.

Start up and commissioning of the project is scheduled to be complete 4th quarter fiscal year 2020. See Section 6.1 for Project Schedule.

6.1.1 Schedule Summary

Activity ID	Activity Name	Planned Duration	Start	Finish
1 CFR CD-1		1502d	01-Sep-15	01-Sep-21
1.M Milestones		1472d	01-Sep-15	21-Jul-21
MS4000	CD-4 Approve Project Completeion	0d		21-Jul-21*
MS3150	Construction Substantially Complete	0d		29-May-20
MS3100	Start Construction - Issue NTP	0d	03-Dec-18	
MS3050	Award CM/GC Construction Services - Phase 2	0d		03-Dec-18
MS3000	CD-3 Approve Start of Construction	0d		30-Nov-18
MS2300	Start Site Preparation Activities	0d	01-Jun-18	
MS2250	Complete Final Design (Bid Documents)	0d		31-Oct-18
MS2000	CD-2/3A Approve Performance Baseline/Site Prep	0d		31-May-18
MS1150	Complete Preliminary Design (30% Document)	0d		30-Apr-18
MS1100	Award CM/GC Pre-Construction Services - Phase	0d		31-Jan-18
MS1050	1 Award A/E Design Contract	0d		11-Dec-17
MS1000	CD-1 Approve Alternative Selection & Cost Range	0d		30-Sep-16
MS0000	CD-0 Approve Mission Need	0d	01-Sep-15	
1.A Critical Decisions		1502d	01-Sep-15	01-Sep-21
1.A.01 CD-0		0d	01-Sep-15	01-Sep-15
1.A.02 CD-1		556d	07-Oct-15	29-Dec-17
1.A.3 CD-2/3A		105d	02-Jan-18	31-May-18
1.A.4 CD-3B		126d	01-Jun-18	30-Nov-18
1.A.5 CD-4		317d	01-Jun-20	01-Sep-21
1.B Procurement		480d	03-Jan-17	03-Dec-18
1.B.1 Procure A/E Services		171d	06-Apr-17	11-Dec-17
1.B.2 Procure CMGC Pre-Construction Services - Develop RFP		181d	03-Jan-17	20-Sep-17
1.B.3 Procure CMGC Construction		292d	02-Oct-17	03-Dec-18
1.B.4 Procure Facility Commissioning Agent		55d	02-Jan-18	21-Mar-18
1.01 Project Design and Engineering - Planning Packages		524d	03-Oct-16	05-Nov-18
1.01.01 A/E Preliminary and Final Design		212d	02-Jan-18	31-Oct-18
1.01.02 CMGC - Pre-Construction Services - Phase I		191d	02-Jan-18	02-Oct-18
1.01.03 Commissioning Services - Pre-Construction Services		160d	22-Mar-18	05-Nov-18
1.01.04 Project Management - Pre-Construction Phase		231d	03-Oct-16	06-Sep-17
1.01.05 BNL/MPO Engineering Support - Pre-Construction Phase		231d	03-Oct-16	06-Sep-17
1.02 Construction - Planning Packages		585d	01-Jun-18	30-Sep-20
1.02.01 Site Prep/Long Lead Procurements		124d	01-Jun-18	28-Nov-18
1.02.02 Building Construction		373d	03-Dec-18	29-May-20
1.02.03 A/E Construction Administration Services		373d	03-Dec-18	29-May-20
1.02.04 Commissioning - Construction Phase		388d	03-Dec-18	19-Jun-20
1.02.05 Project Management - Construction Phase		585d	01-Jun-18	30-Sep-20
1.02.06 Projeet Support - Construction Phase		521d	01-Jun-18	30-Jun-20
1.03 Other Project Costs (OPC)		1160d	07-Oct-15	29-May-20
1.03.01 Other Project Costs		1160d	07-Oct-15	29-May-20



Summary

TASK filter: All Activities

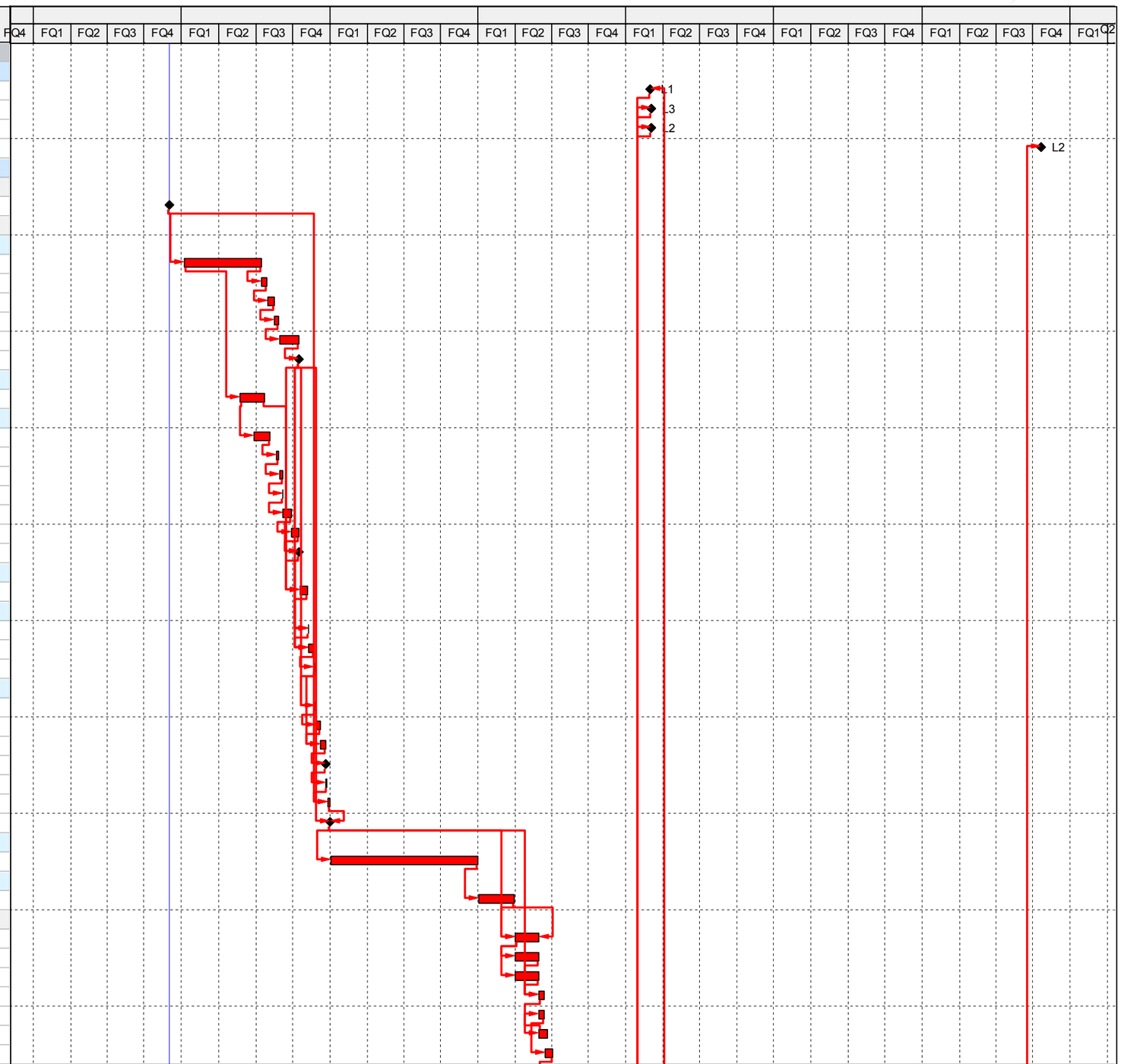
Data Date: 01-Sep-15 Current Date: 04-Aug-16

6.1.2 Critical Path

Core Facility Revitalization

BROOKHAVEN NATIONAL LABORATORY

Activity ID	Activity Name	Planned Duration	Start	Finish
1 CFR CD-1		1502d	01-Sep-15	01-Sep-21
1.M Milestones		660d	30-Nov-18	21-Jul-21
MS3000	CD-3 Approve Start of Construction	0d		30-Nov-18
MS3050	Award CM/GC Construction Services - Phase 2	0d		03-Dec-18
MS3100	Start Construction - Issue NTP	0d	03-Dec-18	
MS4000	CD-4 Approve Project Completion	0d		21-Jul-21*
1.A Critical Decisions		1502d	01-Sep-15	01-Sep-21
1.A.01 CD-0		0d	01-Sep-15	01-Sep-15
CD0000	CD-0 Approval	0d	01-Sep-15	
1.A.02 CD-1		556d	07-Oct-15	29-Dec-17
1.A.02.1 Conceptual Design Report		193d	07-Oct-15	15-Jul-16
CD1000	Prepare CDR 30%	129d	07-Oct-15	14-Apr-16
CD1010	Review CDR 30%	11d	15-Apr-16	29-Apr-16
CD1020	Prepare CDR 60%	12d	02-May-16	17-May-16
CD1030	Review CDR 60%	8d	18-May-16	27-May-16
CD1040	Prepare 100% CDR	33d	31-May-16	15-Jul-16
CD1050	Issue Final CDR	0d		15-Jul-16
1.A.02.2 Life Cycle Cost Analysis		45d	22-Feb-16	22-Apr-16
CD1060	Prepare Draft LCCA - Alt. Analysis	45d	22-Feb-16	22-Apr-16
1.A.02.3 Preliminary PEP		78d	28-Mar-16	15-Jul-16
CD1090	Prepare Draft PPEP	30d	28-Mar-16	06-May-16
CD1100	BHSO Review Draft PPEP	5d	23-May-16	27-May-16
CD1110	Revise Draft PPEP	5d	31-May-16	06-Jun-16
CD1120	Submit Draft PPEP to HQ	1d	07-Jun-16	07-Jun-16
CD1130	HQ Review Draft PPEP	15d	08-Jun-16	28-Jun-16
CD1140	Revised PPEP	12d	29-Jun-16	15-Jul-16
CD1150	Issue PreFIn PPEP	0d		15-Jul-16
1.A.02.9 Self Assessment		15d	18-Jul-16	05-Aug-16
CD1380	Self Assessment	15d	18-Jul-16	05-Aug-16
1.A.02.10 Independent Project Review		14d	08-Aug-16	25-Aug-16
CD1390	POST CD-1 Documents	1d	08-Aug-16	08-Aug-16
CD1400	IPR Team Review Documents	10d	09-Aug-16	22-Aug-16
CD1410	IPR Review at BNL	3d	23-Aug-16	25-Aug-16
1.A.02.11 CD-1 Approval Process		25d	26-Aug-16	30-Sep-16
CD1430	Prepare Briefing & Approval Memo	1d	26-Aug-16	26-Aug-16
CD1440	BHSO Review	7d	29-Aug-16	07-Sep-16
CD1450	Prepare Final Briefing & Memo	8d	08-Sep-16	19-Sep-16
CD1460	Final due to HQ	0d		20-Sep-16
CD1470	Dry Run w /DOE FPD	3d	21-Sep-16	23-Sep-16
CD1480	ESAAB Equivalent Meeting	5d	26-Sep-16	30-Sep-16
CD1500	CD-1 Approval	0d		30-Sep-16
1.A.02.12 FY 17 Continuing Resolution		248d	03-Oct-16	29-Sep-17
CRFY17	FY17 Continuing Resolution	248d	03-Oct-16	29-Sep-17
1.A.02.13 FY18 Continuing Resolution		61d	02-Oct-17	29-Dec-17
CRFY18	FY18 Continuting Resolution	61d	02-Oct-17	29-Dec-17
1.A.3 CD-2/3A		105d	02-Jan-18	31-May-18
CD2000	Update & Submit Hazard Analysis	40d	02-Jan-18	28-Feb-18
CD2010	Update & Submit Fire Hazard Analysis	40d	02-Jan-18	28-Feb-18
CD2020	Update & Submit Risk Mngmt Plan	40d	02-Jan-18	28-Feb-18
CD2040	EVM Self Assessment	10d	01-Mar-18	14-Mar-18
CD2050	BSA Self Assessment	10d	01-Mar-18	14-Mar-18
CD2060	Independent Cost Estimate Reconciliation	15d	01-Mar-18	21-Mar-18
CD2070	Revise & Post CD-2/3A Documents	15d	15-Mar-18	04-Apr-18



Critical Remaining Work

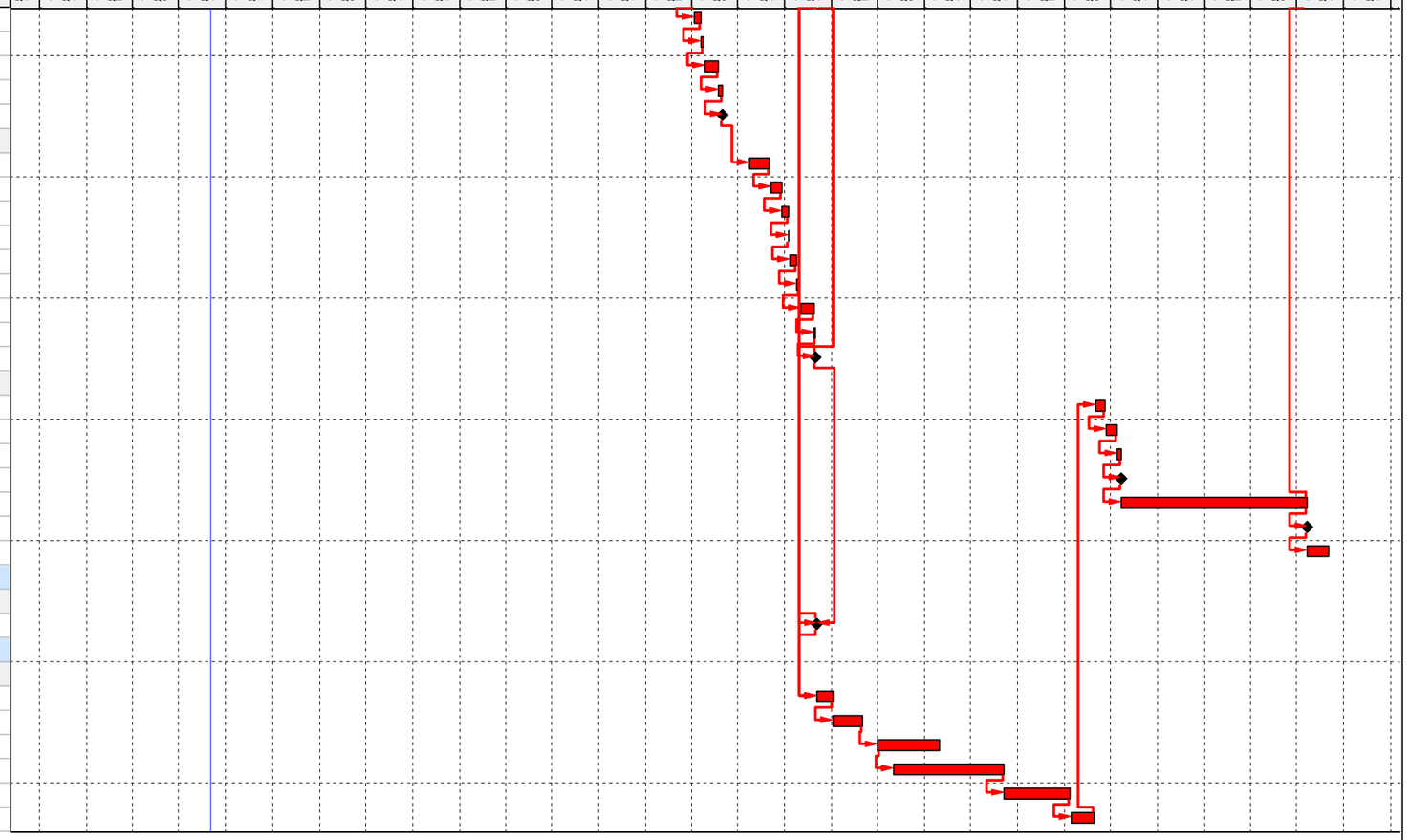
Milestone

TASK filter: Critical.

Data Date: 01-Sep-15 Current Date: 04-Aug-16

Core Facility Revitalization

Activity ID	Activity Name	Planned Duration	Start	Finish
CD2080	Independent Project Review/Preparation (IPR)	10d	05-Apr-18	18-Apr-18
CD2090	IPR Site Visit	5d	19-Apr-18	25-Apr-18
CD2100	IPR Report/CAP Review for CD-2/3A	20d	26-Apr-18	23-May-18
CD2200	ESAAB Equivalent Review	5d	24-May-18	31-May-18
CD2210	CD-2/3A Approve Performance Baseline	0d		31-May-18
1.A.4 CD-3B		91d	23-Jul-18	30-Nov-18
CD3010	Prepare & Submit Construction ES&H Plan	30d	23-Jul-18	31-Aug-18
CD3020	Independent Cost Estimate (ICE) Reconciliation	15d	04-Sep-18	24-Sep-18
CD3030	BSA Self Assessment	10d	25-Sep-18	08-Oct-18
CD3040	Revise & Post CD-3B Documents	1d	09-Oct-18	09-Oct-18
CD3050	IPR Team Preparation	10d	10-Oct-18	23-Oct-18
CD3060	IPR Site Visit	5d	24-Oct-18	30-Oct-18
CD3070	IPR Report/CAP	16d	31-Oct-18	26-Nov-18
CD3080	ESAAB Equivalent for CD-3B	4d	27-Nov-18	30-Nov-18
CD3100	CD-3B Approve Start of Construction	0d		30-Nov-18
1.A.5 CD-4		317d	01-Jun-20	01-Sep-21
CD4000	CD-4 Prep for Early Finish	15d	01-Jun-20	19-Jun-20
CD4010	CD-4 Documentation Review	15d	22-Jun-20	13-Jul-20
CD4020	ESAAB Equivalent for CD-4	5d	14-Jul-20	20-Jul-20
CD4030	CD-4 Approval for Early Finish	0d		20-Jul-20
CD4040	Schedule Contingency	252d	21-Jul-20	21-Jul-21
CD4050	CD-4 Approval for Baseline Finish	0d		21-Jul-21
CD4060	Project Closeout	30d	22-Jul-21	01-Sep-21
1.B Procurement		0d	03-Dec-18	03-Dec-18
1.B.3 Procure CMGC Construction		0d	03-Dec-18	03-Dec-18
PCMGC265	Award CMGC Contract	0d		03-Dec-18
1.02 Construction - Planning Packages		373d	03-Dec-18	29-May-20
1.02.02 Building Construction		373d	03-Dec-18	29-May-20
CON0100	Mobilization	20d	03-Dec-18	02-Jan-19
CON0200	Demolition	40d	03-Jan-19	01-Mar-19
CON0400	Interior Rough-in	84d	01-Apr-19	30-Jul-19
CON0500	M.E.P. Rough-in	149d	01-May-19	04-Dec-19
CON0800	M.E.P. Finish	89d	05-Dec-19	13-Apr-20
CON0900	Punchlist	33d	14-Apr-20	29-May-20



Critical Remaining Work

Milestone

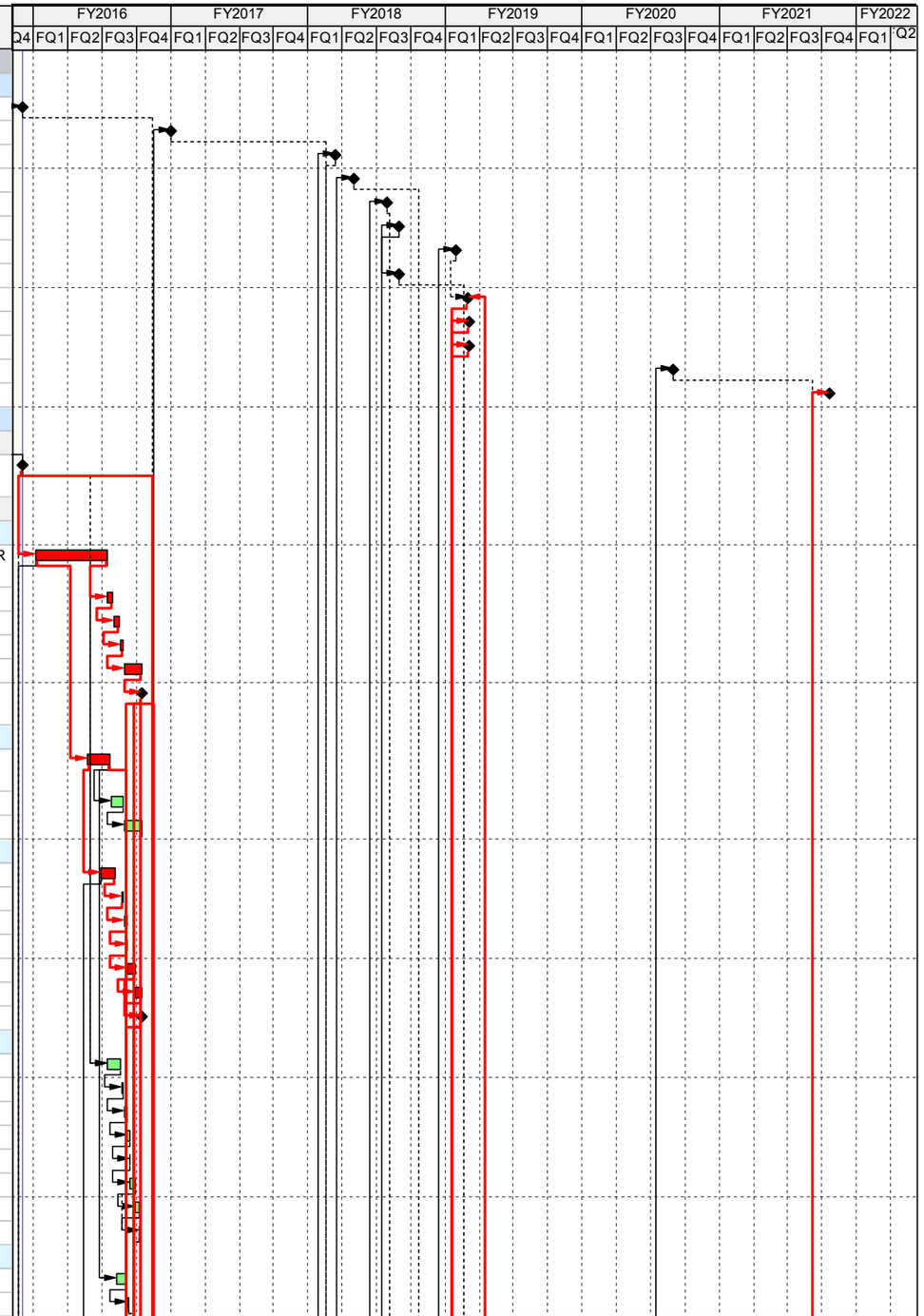
TASK filter: Critical.

Data Date: 01-Sep-15 Current Date: 04-Aug-16

6.1.3 Detail Schedule

Core Facility Revitalization

Activity ID	Activity Name	Planned Duration	Start	Finish	Predecessors	Successors
1 CFR CD-1		1502d	01-Sep-15	01-Sep-21		
1.M Milestones		1472d	01-Sep-15	21-Jul-21		
MS0000	CD-0 Approve Mission Need	0d	01-Sep-15		CD0000	CD1480
MS1000	CD-1 Approve Alternative Selection & Cost Range	0d		30-Sep-16	CD1500	DES0030
MS1050	Award A/E Design Contract	0d		11-Dec-17	PAE0800	DES0030
MS1100	Award CM/GC Pre-Construction Services - Phase 1	0d		31-Jan-18	PCMGC2450	PCMGC2500
MS1150	Complete Preliminary Design (30% Document)	0d		30-Apr-18	DES0030	DES0090
MS2000	CD-2/3A Approve Performance Baseline/Site Prep	0d		31-May-18	CD2210	MS2300
MS2250	Complete Final Design (Bid Documents)	0d		31-Oct-18	DES0100	MS3000
MS2300	Start Site Preparation Activities	0d	01-Jun-18		MS2000	CON0200
MS3000	CD-3 Approve Start of Construction	0d		30-Nov-18	CD3100, MS2250	CON0100
MS3050	Award CM/GC Construction Services - Phase 2	0d		03-Dec-18	PCMGC2650	CON0100
MS3100	Start Construction - Issue NTP	0d	03-Dec-18		CD3100	PCMGC2650
MS3150	Construction Substantially Complete	0d		29-May-20	CON0900	CD4060
MS4000	CD-4 Approve Project Completion	0d		21-Jul-21*	CD4040	
1.A Critical Decisions		1502d	01-Sep-15	01-Sep-21		
1.A.01 CD-0		0d	01-Sep-15	01-Sep-15		
CD0000	CD-0 Approval	0d	01-Sep-15			CD1160, CD1000, OPCCDR, CD1480, MS0000
1.A.02 CD-1		556d	07-Oct-15	29-Dec-17		
1.A.02.1 Conceptual Design Report		193d	07-Oct-15	15-Jul-16		
CD1000	Prepare CDR 30%	129d	07-Oct-15	14-Apr-16	CD0000	CD1010, CD1060, CD1160, OPCCDR
CD1010	Review CDR 30%	11d	15-Apr-16	29-Apr-16	CD1000	CD1020
CD1020	Prepare CDR 60%	12d	02-May-16	17-May-16	CD1010	CD1030
CD1030	Review CDR 60%	8d	18-May-16	27-May-16	CD1020	CD1040
CD1040	Prepare 100% CDR	33d	31-May-16	15-Jul-16	CD1030	CD1050
CD1050	Issue Final CDR	0d		15-Jul-16	CD1040	CD1400, CD1390, CD1380, CD1500, CD1430
1.A.02.2 Life Cycle Cost Analysis		103d	22-Feb-16	15-Jul-16		
CD1060	Prepare Draft LCCA - Alt. Analysis	45d	22-Feb-16	22-Apr-16	CD1000	CD1070, CD1240, CD1380, CD1090
CD1070	Prepare Pre-final LCCA - Alt. Analysis	25d	25-Apr-16	27-May-16	CD1060	CD1080
CD1080	Prepare Final LCCA - Alt. Analysis	33d	31-May-16	15-Jul-16	CD1070	CD1400, CD1390
1.A.02.3 Preliminary PEP		78d	28-Mar-16	15-Jul-16		
CD1090	Prepare Draft PPEP	30d	28-Mar-16	06-May-16	CD1060	CD1100, CD1260
CD1100	BHSO Review Draft PPEP	5d	23-May-16	27-May-16	CD1090	CD1110
CD1110	Revise Draft PPEP	5d	31-May-16	06-Jun-16	CD1100	CD1120
CD1120	Submit Draft PPEP to HQ	1d	07-Jun-16	07-Jun-16	CD1110	CD1130
CD1130	HQ Review Draft PPEP	15d	08-Jun-16	28-Jun-16	CD1120	CD1150, CD1140
CD1140	Revised PPEP	12d	29-Jun-16	15-Jul-16	CD1130	CD1150
CD1150	Issue PreFIn PPEP	0d		15-Jul-16	CD1130, CD1140	CD1390, CD1400, CD1380
1.A.02.4 Acquisition Strategy		58d	15-Apr-16	07-Jul-16		
CD1160	Prepare Draft AS	26d	15-Apr-16	20-May-16	CD0000, CD1000	CD1170
CD1170	BHSO review Draft AS	5d	23-May-16	27-May-16	CD1160	CD1180
CD1180	Revise Draft AS	5d	31-May-16	06-Jun-16	CD1170	CD1190
CD1190	BSA Review AS	5d	07-Jun-16	13-Jun-16	CD1180	CD1200
CD1200	Submit Draft AS to HQ	1d	14-Jun-16	14-Jun-16	CD1190	CD1210
CD1210	HQ Review AS	10d	15-Jun-16	28-Jun-16	CD1200	CD1220, CD1230
CD1220	Revise & Issue AS	5d	29-Jun-16	06-Jul-16	CD1210	CD1230
CD1230	AS Approved by SC-1	1d	07-Jul-16	07-Jul-16	CD1220, CD1210	CD1390, CD1400
1.A.02.5 NEPA Review & Determination		24d	09-May-16	10-Jun-16		
CD1240	Review Period	19d	09-May-16	03-Jun-16	CD1060	CD1250
CD1250	Issue Determination	5d	06-Jun-16	10-Jun-16	CD1240	CD1390, CD1400

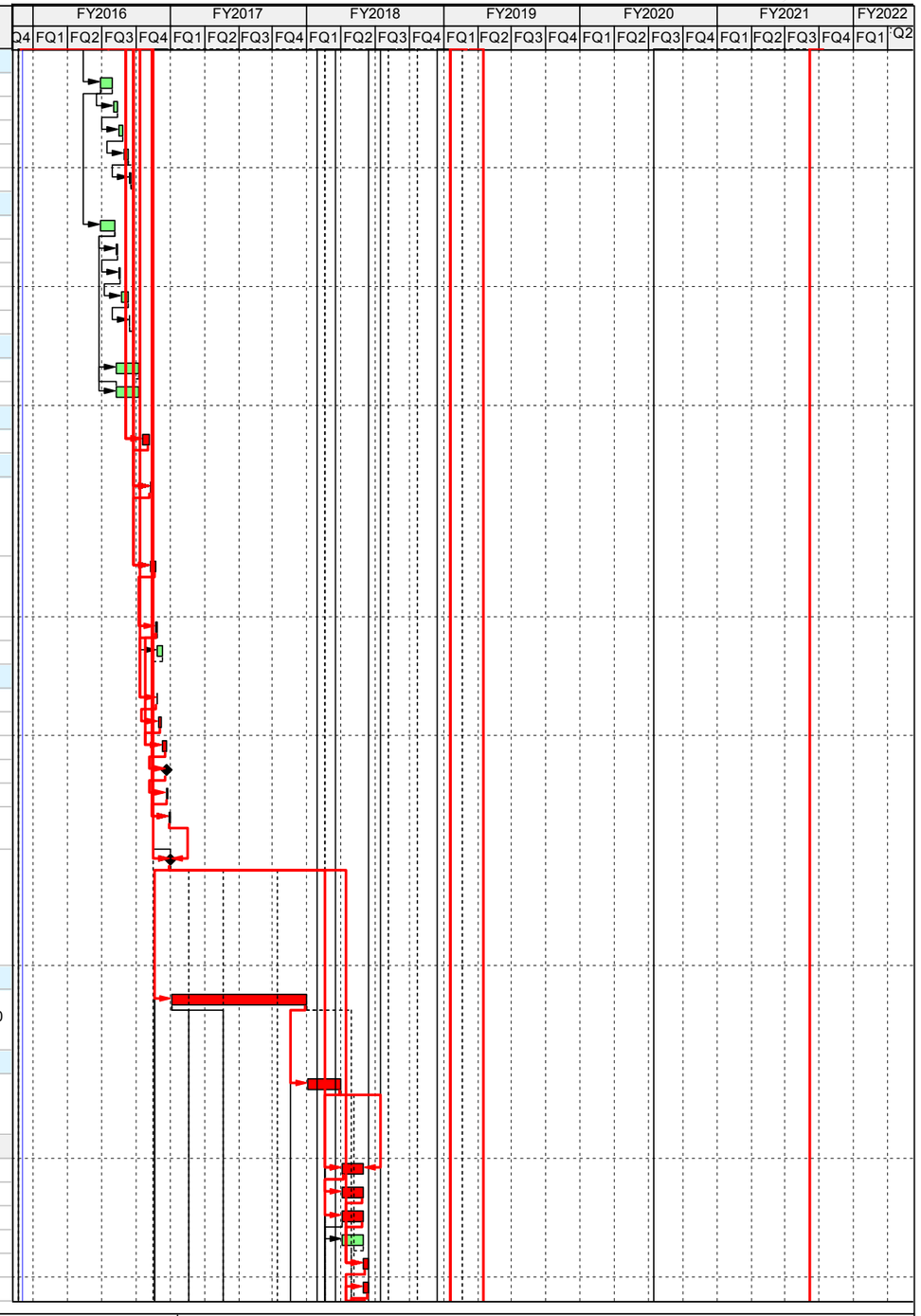


Remaining Level of Effort | Remaining Work | Milestone
Actual Level of Effort | Critical Remaining Work

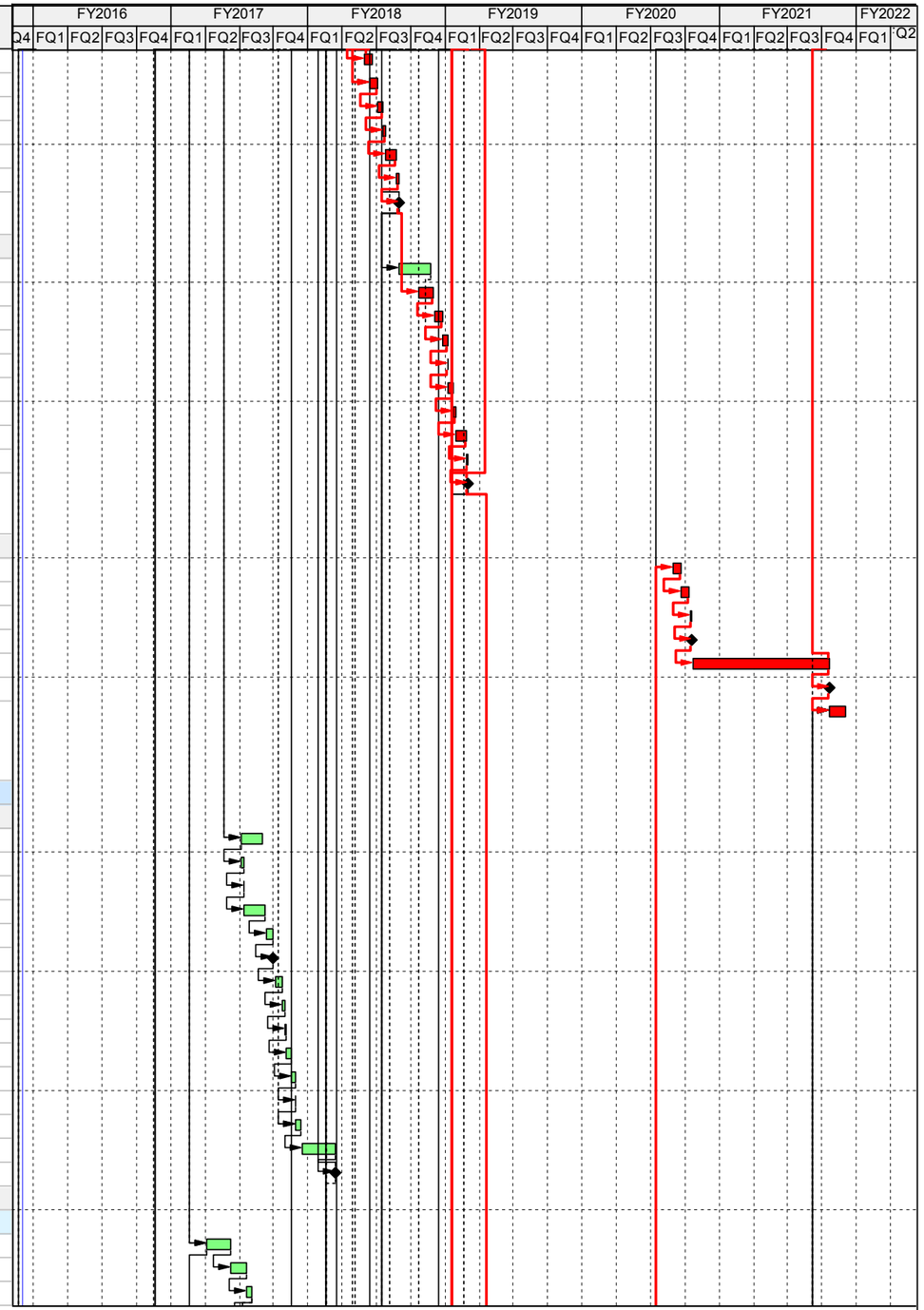
TASK filter: All Activities

Data Date: 01-Sep-15 Current Date: 04-Aug-16

Activity ID	Activity Name	Planned Duration	Start	Finish	Predecessors	Successors
1.A.02.6	**Preliminary Hazard Analysis**	57d	28-Mar-16	15-Jun-16		
CD1260	Prepare Draft PHA	25d	28-Mar-16	29-Apr-16	CD1090	CD1270, CD1310
CD1270	BHSO Review Draft PHA	10d	02-May-16	13-May-16	CD1260	CD1280
CD1280	Revise PHA	10d	16-May-16	27-May-16	CD1270	CD1290
CD1290	DOE Review PHA	9d	31-May-16	10-Jun-16	CD1280	CD1300, CD1390
CD1300	Issue Pre Final PHA	3d	13-Jun-16	15-Jun-16	CD1290	CD1400, CD1390
1.A.02.7	**Preliminary Fire Hazard Analysis**	56d	28-Mar-16	14-Jun-16		
CD1310	Draft Prelim FHA	30d	28-Mar-16	06-May-16	CD1260	CD1320, CD1370
CD1320	BHSO review Draft Prelim FHA	5d	09-May-16	13-May-16	CD1310	CD1330
CD1330	BNL revise Prelim FHA	5d	16-May-16	20-May-16	CD1320	CD1340
CD1340	DOE review Prelim FHA	14d	23-May-16	10-Jun-16	CD1330	CD1350
CD1350	Issue Preliminary FHA	2d	13-Jun-16	14-Jun-16	CD1340	CD1400, CD1390
1.A.02.8	**Preliminary Risk Management**	43d	09-May-16	08-Jul-16		
CD1360	Issue Preliminary Risk Management Plan	43d	09-May-16	08-Jul-16	CD1370	CD1390
CD1370	Prepare Preliminary Risk Management Plan	43d	09-May-16	08-Jul-16	CD1310	CD1360
1.A.02.9	**Self Assessment**	15d	18-Jul-16	05-Aug-16		
CD1380	Self Assessment	15d	18-Jul-16	05-Aug-16	CD1050, CD1060, CD1150	CD1390
1.A.02.10	**Independent Project Review**	24d	08-Aug-16	09-Sep-16		
CD1390	POST CD-1 Documents	1d	08-Aug-16	08-Aug-16	CD1150, CD1380, CD1230, CD1290, CD1360, CD1350, CD1300, CD1250, CD1080, CD1050	CD1400
CD1400	IPR Team Review Documents	10d	09-Aug-16	22-Aug-16	CD1390, CD1150, CD1300, CD1050, CD1350, CD1250, CD1230, CD1080	CD1410
CD1410	IPR Review at BNL	3d	23-Aug-16	25-Aug-16	CD1400	CD1450, CD1420, CD1430
CD1420	Corrective Action Implementation	10d	26-Aug-16	09-Sep-16	CD1410	CD1480
1.A.02.11	**CD-1 Approval Process**	25d	26-Aug-16	30-Sep-16		
CD1430	Prepare Briefing & Approval Memo	1d	26-Aug-16	26-Aug-16	CD1410, CD1050	CD1440
CD1440	BHSO Review	7d	29-Aug-16	07-Sep-16	CD1430	CD1450
CD1450	Prepare Final Briefing & Memo	8d	08-Sep-16	19-Sep-16	CD1440, CD1410	CD1460
CD1460	Final due to HQ	0d		20-Sep-16	CD1450	CD1470
CD1470	Dry Run w /DOE FPD	3d	21-Sep-16	23-Sep-16	CD1460	CD1480
CD1480	ESAAB Equivalent Meeting	5d	26-Sep-16	30-Sep-16	CD1470, CD1420, CD0000, MS0000	CD1500
CD1500	CD-1 Approval	0d		30-Sep-16	CD1480, CD1050, OPCCDR	PAE0700, CD2040, PMPC1000, MPOPC1000, CRFY17, CD2000, PCMGC0100, DES0030, PAE0100, MS1000, PFCA0100
1.A.02.12	**FY 17 Continuing Resolution**	248d	03-Oct-16	29-Sep-17		
CRFY17	FY17 Continuing Resolution	248d	03-Oct-16	29-Sep-17	CD1500	CRFY18, PAE0100, PCMGC0100, PCMGC2000, PFCA0100, PFCA0300
1.A.02.13	**FY18 Continuing Resolution**	61d	02-Oct-17	29-Dec-17		
CRFY18	FY18 Continuting Resolution	61d	02-Oct-17	29-Dec-17	CRFY17	DES0030, COMM1000, PFCA0100, CD2000, CD2000
1.A.3	**CD-2/3A**	105d	02-Jan-18	31-May-18		
CD2000	Update & Submit Hazard Analysis	40d	02-Jan-18	28-Feb-18	CD1500, CRFY18, CRFY18	CD2020, CD2010
CD2010	Update & Submit Fire Hazard Analysis	40d	02-Jan-18	28-Feb-18	CD2000	CD2040
CD2020	Update & Submit Risk Mngmt Plan	40d	02-Jan-18	28-Feb-18	CD2000	CD2040, CD2030
CD2030	Update & Submit Project Execution Plan (PEP)	40d	02-Jan-18	28-Feb-18	CD2020	CD2070
CD2040	EVM Self Assessment	10d	01-Mar-18	14-Mar-18	CD2020, CD1500, CD2010	CD2060
CD2050	BSA Self Assessment	10d	01-Mar-18	14-Mar-18	CD2060	CD2070



Activity ID	Activity Name	Planned Duration	Start	Finish	Predecessors	Successors
CD2060	Independent Cost Estimate Reconciliation	15d	01-Mar-18	21-Mar-18	CD2040	CD2050
CD2070	Revise & Post CD-2/3A Documents	15d	15-Mar-18	04-Apr-18	CD2050, CD2030	CD2080
CD2080	Independent Project Review/Preparation (IPR)	10d	05-Apr-18	18-Apr-18	CD2070	CD2090
CD2090	IPR Site Visit	5d	19-Apr-18	25-Apr-18	CD2080	CD2100
CD2100	IPR Report/CAP Review for CD-2/3A ESAAB	20d	26-Apr-18	23-May-18	CD2090	CD2200
CD2200	Equivalent Review	5d	24-May-18	31-May-18	CD2100	CD2210
CD2210	CD-2/3A Approve Performance Baseline	0d		31-May-18	CD2200, DES0030	CD3000, SP1000, MS2000, CD3010, OPCCONT
1.A.4 CD-3B		126d	01-Jun-18	30-Nov-18		
CD3000	Update CD-3B Documentation	60d	01-Jun-18	24-Aug-18	CD2210	CD3030
CD3010	Prepare & Submit Construction ES&H Plan	30d	23-Jul-18	31-Aug-18	CD2210	CD3020
CD3020	Independent Cost Estimate (ICE) Reconciliation	15d	04-Sep-18	24-Sep-18	CD3010	CD3030
CD3030	BSA Self Assessment	10d	25-Sep-18	08-Oct-18	CD3020, CD3000	CD3040
CD3040	Revise & Post CD-3B Documents	1d	09-Oct-18	09-Oct-18	CD3030	CD3050
CD3050	IPR Team Preparation	10d	10-Oct-18	23-Oct-18	CD3040	CD3060
CD3060	IPR Site Visit	5d	24-Oct-18	30-Oct-18	CD3050	CD3070
CD3070	IPR Report/CAP	16d	31-Oct-18	26-Nov-18	CD3060	CD3080
CD3080	ESAAB Equivalent for CD-3B	4d	27-Nov-18	30-Nov-18	CD3070	CD3100
CD3100	CD-3B Approve Start of Construction	0d		30-Nov-18	CD3080	AE1000, MS3000, PCMGC2650, COMM2000, MS3100
1.A.5 CD-4		317d	01-Jun-20	01-Sep-21		
CD4000	CD-4 Prep for Early Finish	15d	01-Jun-20	19-Jun-20	CON0900	CD4010
CD4010	CD-4 Documentation Review	15d	22-Jun-20	13-Jul-20	CD4000	CD4020
CD4020	ESAAB Equivalent for CD-4	5d	14-Jul-20	20-Jul-20	CD4010	CD4030
CD4030	CD-4 Approval for Early Finish	0d		20-Jul-20	CD4020	CD4040
CD4040	Schedule Contingency	252d	21-Jul-20	21-Jul-21	CD4030	CD4050, MS4000
CD4050	CD-4 Approval for Baseline Finish	0d		21-Jul-21	CD4040	CD4060
CD4060	Project Closeout	30d	22-Jul-21	01-Sep-21	CD4050, AE1000, COMM2000, MPOFY20, FSFY20, PMFY20, MS3150, OPCCONT	
1.B Procurement		480d	03-Jan-17	03-Dec-18		
1.B.1 Procure A/E Services		171d	06-Apr-17	11-Dec-17		
PAE0100	Prepare S.O.W./Spec/Purchase Req.	40d	06-Apr-17	01-Jun-17	CRFY17, CD1500	PAE0150
PAE0150	Prepare Source List, Eval. Team & Criteria	5d	06-Apr-17	12-Apr-17	PAE0100	PAE0200
PAE0200	PPM accepts package from MPO	1d	13-Apr-17	13-Apr-17	PAE0150	PAE0250
PAE0250	Procurement Develop Solicitation	40d	14-Apr-17	09-Jun-17	PAE0200	PAE0300
PAE0300	BSA Approval of Solicitation	15d	12-Jun-17	30-Jun-17	PAE0250	PAE0350
PAE0350	Issue Solicitation	0d		30-Jun-17	PAE0300	PAE0400
PAE0400	A/E - Prepare and Submit Proposals	15d	05-Jul-17	25-Jul-17	PAE0350	PAE0450
PAE0450	Evaluate Proposals	5d	26-Jul-17	01-Aug-17	PAE0400	PAE0500
PAE0500	Notify Short List/Prepare for Oral Presentations	1d	02-Aug-17	02-Aug-17	PAE0450	PAE0550
PAE0550	Oral Presentations	10d	03-Aug-17	16-Aug-17	PAE0500	PAE0600
PAE0600	Final Evaluation of Proposals	8d	17-Aug-17	28-Aug-17	PAE0550	PAE0650
PAE0650	A/E Selection & Request Cost Proposal	1d	29-Aug-17	29-Aug-17	PAE0600	PAE0700
PAE0700	Cost Proposal Negotiation	10d	30-Aug-17	13-Sep-17	PAE0650, CD1500	PAE0750
PAE0750	BSA Contract Approval	60d	14-Sep-17	11-Dec-17	PAE0700	PAE0800
PAE0800	Award A/E Design Contract	0d		11-Dec-17	PAE0750	DES0030, MS1050
1.B.2 Procure CMGC Pre-Construction Services - Develop RFP		181d	03-Jan-17	20-Sep-17		
1.B.2.1 Draft RFP		116d	03-Jan-17	16-Jun-17		
PCMGC0100	Develop Scope of Work	45d	03-Jan-17	08-Mar-17	CD1500, CRFY17	PCMGC0150, PCMGC0650
PCMGC0150	Develop Division 1 Specifications	30d	09-Mar-17	19-Apr-17	PCMGC0100	PCMGC0200
PCMGC0200	Develop Evaluation Criteria	10d	21-Apr-17	04-May-17	PCMGC0150	PCMGC0300, PCMGC0250

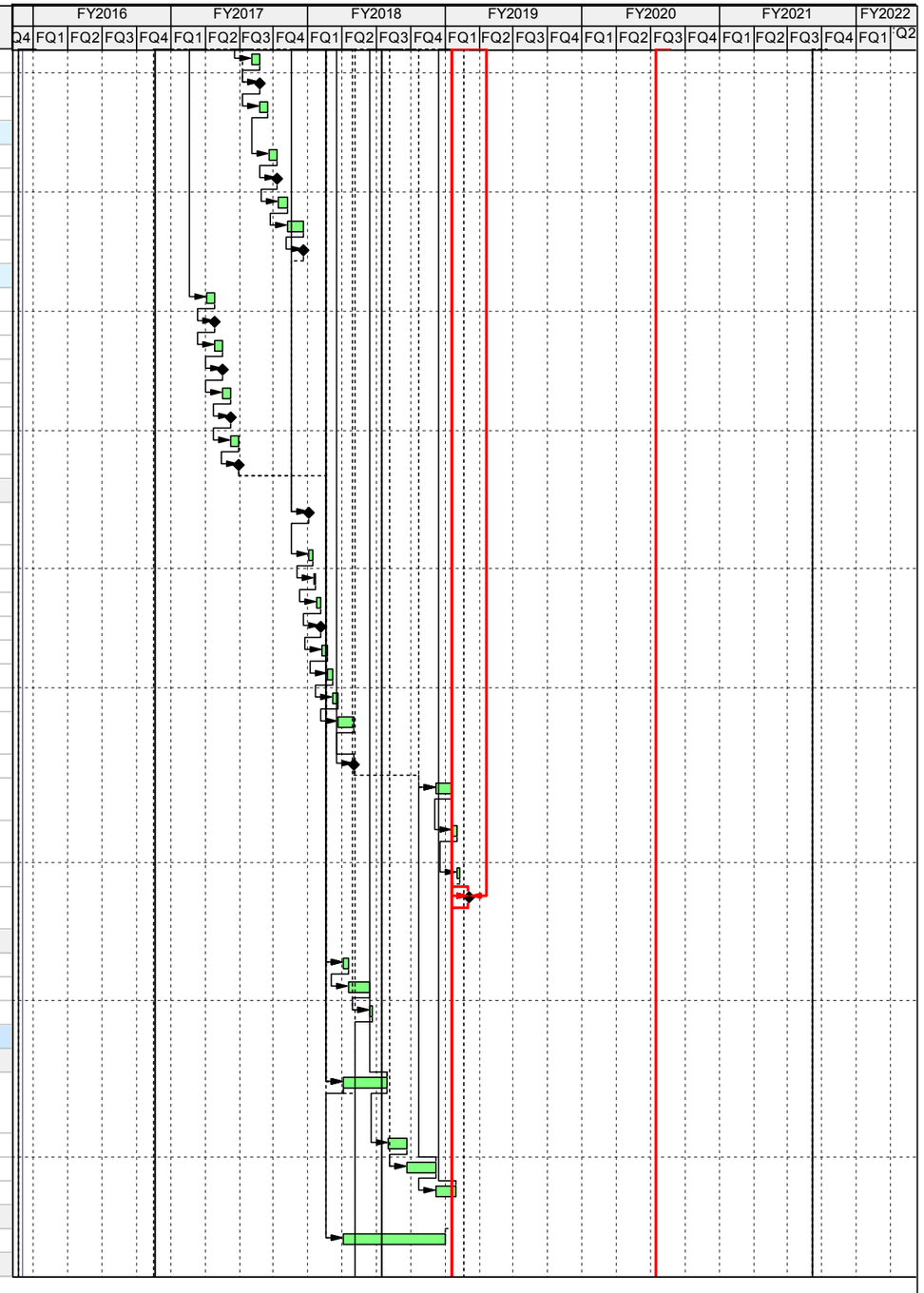


Remaining Level of Effort
Actual Level of Effort
Remaining Work
Critical Remaining Work
Milestone

TASK filter: All Activities

Data Date: 01-Sep-15 Current Date: 04-Aug-16

Activity ID	Activity Name	Planned Duration	Start	Finish	Predecessors	Successors
PCMGC0250	Develop Draft Contract	15d	05-May-17	25-May-17	PCMGC0200	PCMGC0300
PCMGC0300	Draft RFP	0d		25-May-17	PCMGC0250, PCMGC0200	PCMGC0350
PCMGC0350	Assemble Final Review	15d	26-May-17	16-Jun-17	PCMGC0300	PCMGC0400
1.B.2.2	**Review & Approval of RFP**	65d	19-Jun-17	20-Sep-17		
PCMGC0400	Final Revision of RFP	15d	19-Jun-17	11-Jul-17	PCMGC0350	PCMGC0450
PCMGC0450	Complete RFP & - Ready for BHSO Review	0d		11-Jul-17	PCMGC0400	PCMGC0500
PCMGC0500	BHSO Review & Update Documents	20d	12-Jul-17	08-Aug-17	PCMGC0450	PCMGC0550
PCMGC0550	DOE Review & Updates	30d	09-Aug-17	20-Sep-17	PCMGC0500	PCMGC0600
PCMGC0600	Ready to Issue RFP	0d		20-Sep-17	PCMGC0550	PCMGC2000
1.B.2.3	**Contractor Outreach & Prequalifications**	60d	03-Jan-17	29-Mar-17		
PCMGC0650	Prep Advertisement & PreQual Package	15d	03-Jan-17	24-Jan-17	PCMGC0100	PCMGC0700
PCMGC0700	Advertise Open House/Informational Meeting	0d		24-Jan-17	PCMGC0650	PCMGC0750
PCMGC0750	Wait Period	15d	25-Jan-17	14-Feb-17	PCMGC0700	PCMGC0800
PCMGC0800	Informational Meeting/Open House	0d		14-Feb-17	PCMGC0750	PCMGC0850
PCMGC0850	Wait Period	15d	15-Feb-17	08-Mar-17	PCMGC0800	PCMGC0900
PCMGC0900	Receive Prequalification Submittals	0d		08-Mar-17	PCMGC0850	PCMGC0950
PCMGC0950	Evaluate & Identify Qualified Vendors	15d	09-Mar-17	29-Mar-17	PCMGC0900	PCMGC1000
PCMGC1000	Prequalification Complete	0d		29-Mar-17	PCMGC0950	PCMGC2000, CMGC1000
1.B.3	**Procure CMGC Construction**	292d	02-Oct-17	03-Dec-18		
PCMGC2000	Issue RFP	0d	02-Oct-17		CRFY17, PCMGC1000, PCMGC0600	PCMGC2050
PCMGC2050	Proposal Preparation	10d	02-Oct-17	13-Oct-17	PCMGC2000	PCMGC2100
PCMGC2100	Issue RFP Changes/Addendum	5d	16-Oct-17	20-Oct-17	PCMGC2050	PCMGC2150
PCMGC2150	Finalize Proposals	10d	23-Oct-17	03-Nov-17	PCMGC2100	PCMGC2200
PCMGC2200	Recieve Proposals	0d		03-Nov-17	PCMGC2150	PCMGC2250
PCMGC2250	Initial Proposal Evaluation	10d	06-Nov-17	20-Nov-17	PCMGC2200	PCMGC2300
PCMGC2300	Subcontractor Interviews	10d	21-Nov-17	06-Dec-17	PCMGC2250	PCMGC2350
PCMGC2350	Finalize Evaluations	10d	07-Dec-17	20-Dec-17	PCMGC2300	PCMGC2400
PCMGC2400	DOE Review Award Recommendation & Approval Process	26d	21-Dec-17	30-Jan-18	PCMGC2350	PCMGC2450
PCMGC2450	Award CM/GC Phase 1 Service Contract	0d	31-Jan-18		PCMGC2400	PCMGC2500, MS1100
PCMGC2500	Bid Period for CM/GC Phase 2	30d	07-Sep-18	18-Oct-18	PCMGC2450, DES0090, MS1100	PCMGC2550
PCMGC2550	Review CM/GC Phase 2 Bids & Recommend Selection	10d	19-Oct-18	01-Nov-18	PCMGC2500	PCMGC2600
PCMGC2600	DOE/BHSO Review Contract	5d	02-Nov-18	08-Nov-18	PCMGC2550	PCMGC2650
PCMGC2650	Award CMGC Contract	0d		03-Dec-18	CD3100, CMGC1000, PCMGC2600, MS3100	CON0100, MS3050
1.B.4	**Procure Facility Commissioning Agent**	55d	02-Jan-18	21-Mar-18		
PFCA0100	Prepare S.O.W./Spec/Purchase Req.	10d	02-Jan-18	16-Jan-18	CD1500, CRFY17, CRFY18	PFCA0200
PFCA0200	PPM accepts package from MPO	40d	17-Jan-18	14-Mar-18	PFCA0100	PFCA0300
PFCA0300	Award Contract	5d	15-Mar-18	21-Mar-18	PFCA0200, CRFY17	COMM1000
1.01	**Project Design and Engineering - Planning Packages**	524d	03-Oct-16	05-Nov-18		
1.01.01	**A/E Preliminary and Final Design**	212d	02-Jan-18	31-Oct-18		
DES0030	Preliminary Design (0 - 30%)	83d	02-Jan-18	30-Apr-18	PAE0800, CD1500, CRFY18, MS1050, MS1000	CMGC1000, CD2210, MS1150, COMM1000, DES0060
DES0060	60% Design Complete	35d	01-May-18	19-Jun-18	DES0030	DES0090
DES0090	90% Design Complete	55d	20-Jun-18	06-Sep-18	DES0060, MS1150	DES0100, PCMGC2500
DES0100	100% Design Complete	39d	07-Sep-18	31-Oct-18	DES0090	MS2250
1.01.02	**CMGC - Pre-Construction Services - Phase I**	191d	02-Jan-18	02-Oct-18		
CMGC1000	CMGC - Pre-Construction Services	191d	02-Jan-18	02-Oct-18	DES0030, PCMGC1000	PCMGC2650
1.01.03	**Commissioning Services - Pre-Construction Services**	160d	22-Mar-18	05-Nov-18		



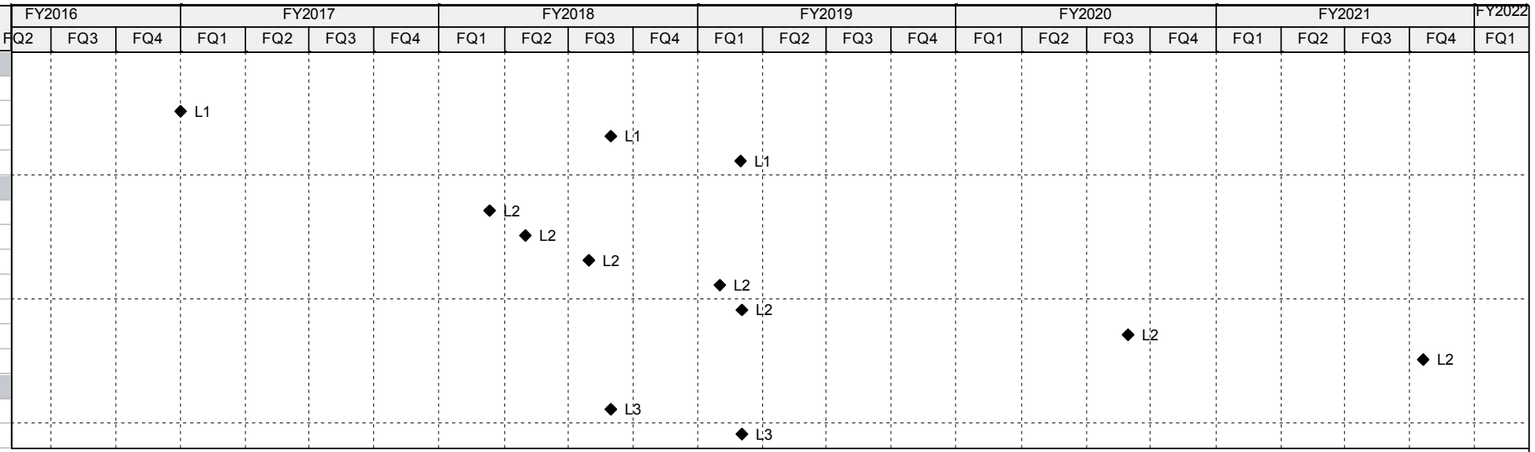
Activity ID	Activity Name	Planned Duration	Start	Finish	Predecessors	Successors
COMM1000	Commissioning Services - Pre-Construction Services	160d	22-Mar-18	05-Nov-18	PFCA0300, CRFY18, DES0030	COMM2000
1.01.04 Project Management - Pre-Construction Phase		231d	03-Oct-16	06-Sep-17		
PMPC1000	Project Management Pre-Construction Phase	231d	03-Oct-16	06-Sep-17	CD1500	PMFY18
1.01.05 BNL MPO Engineering Support - Pre-Construction Phase		231d	03-Oct-16	06-Sep-17		
MPOPC1000	MPO Engineering Support - Pre-Construction Phase	231d	03-Oct-16	06-Sep-17	CD1500	MPOFY18
1.02 Construction - Planning Packages		585d	01-Jun-18	30-Sep-20		
1.02.01 Site Prep/Long Lead Procurements		124d	01-Jun-18	28-Nov-18		
SP1000	Site Prep	124d	01-Jun-18	28-Nov-18	CD2210	CON0100, PMFY18
1.02.02 Building Construction		373d	03-Dec-18	29-May-20		
CON0100	Mobilization	20d	03-Dec-18	02-Jan-19	PCMGC2650, SP1000, MS3050, MS3000	CON0200, AE1000, COMM2000
CON0200	Demolition	40d	03-Jan-19	01-Mar-19	CON0100, MS2300	CON0300, CON0400
CON0300	Sitework	64d	04-Mar-19	31-May-19	CON0200	CON0900
CON0400	Interior Rough-in	84d	01-Apr-19	30-Jul-19	CON0200	CON0700, CON0500, CON0600
CON0500	M.E.P. Rough-in	149d	01-May-19	04-Dec-19	CON0400	CON0800
CON0600	Exterior (Roof/Windows)	126d	01-May-19	29-Oct-19	CON0400	CON0900
CON0700	Interior Finish	165d	31-Jul-19	27-Mar-20	CON0400	CON0900
CON0800	M.E.P. Finish	89d	05-Dec-19	13-Apr-20	CON0500	CON0900
CON0900	Punchlist	33d	14-Apr-20	29-May-20	CON0700, CON0600, CON0800, CON0300	CD4000, MS3150
1.02.03 A/E Construction Administration Services		373d	03-Dec-18	29-May-20		
AE1000	A/E Construction Administration Services	373d	03-Dec-18	29-May-20	CD3100, CON0100	CD4060
1.02.04 Commissioning - Construction Phase		388d	03-Dec-18	19-Jun-20		
COMM2000	Commissioning - Construction Phase	388d	03-Dec-18	19-Jun-20	CON0100, CD3100, COMM1000	CD4060
1.02.05 Project Management - Construction Phase		585d	01-Jun-18	30-Sep-20		
PMFY18	Project Management Support FY 18 (Site Prep)	84d	01-Jun-18	28-Sep-18	SP1000, PMPC1000	PMFY19, MPOFY18
PMFY19	Project Management Support FY19	249d	01-Oct-18	30-Sep-19	PMFY18	PMFY20
PMFY20	Project Management Support FY 20	252d	01-Oct-19	30-Sep-20	PMFY19	CD4060
1.02.06 Project Support - Construction Phase		521d	01-Jun-18	30-Jun-20		
1.02.06.01 BNL/MPO Engineering Support Construction Phase		521d	01-Jun-18	30-Jun-20		
MPOFY18	MPO Engineering Support FY 18 (Site Prep)	84d	01-Jun-18	28-Sep-18	PMFY18, MPOPC1000	MPOFY19, FSFY18
MPOFY19	MPO Engineering Support FY 19	249d	01-Oct-18	30-Sep-19	MPOFY18	MPOFY20
MPOFY20	MPO Engineering Support FY 20	188d	01-Oct-19	30-Jun-20	MPOFY19	CD4060
1.02.06.02 BNL Field Support Construction Phase		521d	01-Jun-18	30-Jun-20		
FSFY18	Field Support FY 18 (Site Prep)	84d	01-Jun-18	28-Sep-18	MPOFY18	FSFY19
FSFY19	Field Suport FY 19	249d	01-Oct-18	30-Sep-19	FSFY18	FSFY20
FSFY20	Field Support FY 20	188d	01-Oct-19	30-Jun-20	FSFY19	CD4060
1.03 Other Project Costs (OPC)		1160d	07-Oct-15	29-May-20		
1.03.01 Other Project Costs		1160d	07-Oct-15	29-May-20		
OPCCDR	Conceptual Design Report	179d	07-Oct-15	24-Jun-16	CD0000, CD1000	CD1500
OPCCONT	Cost Contingency	499d	01-Jun-18	29-May-20	CD2210	CD4060

6.2 Key Milestones

Core Facility Revitilization

BROOKHAVEN NATIONAL LABORATORY

Activity ID	Activity Name	Start	Finish
Milestone Level: L1		01-Sep-15	30-Nov-18
MS0000	CD-0 Approve Mission Need	01-Sep-15	
MS1000	CD-1 Approve Alternative Selection & Cost Range		30-Sep-16
MS2000	CD-2/3A Approve Performance Baseline/Site		31-May-18
MS3000	Prep CD-3 Approve Start of Construction		30-Nov-18
Milestone Level: L2		11-Dec-17	21-Jul-21
MS1050	Award A/E Design Contract		11-Dec-17
MS1100	Award CM/GC Pre-Construction Services - Phase		31-Jan-18
MS1150	1 Complete Preliminary Design (30% Document)		30-Apr-18
MS2250	Complete Final Design (Bid Documents)		31-Oct-18
MS3100	Start Construction - Issue NTP	03-Dec-18	
MS3150	Construction Substantially Complete		29-May-20
MS4000	CD-4 Approve Project Completion		21-Jul-21*
Milestone Level: L3		01-Jun-18	03-Dec-18
MS2300	Start Site Preparation Activities	01-Jun-18	
MS3050	Award CM/GC Construction Services - Phase 2		03-Dec-18

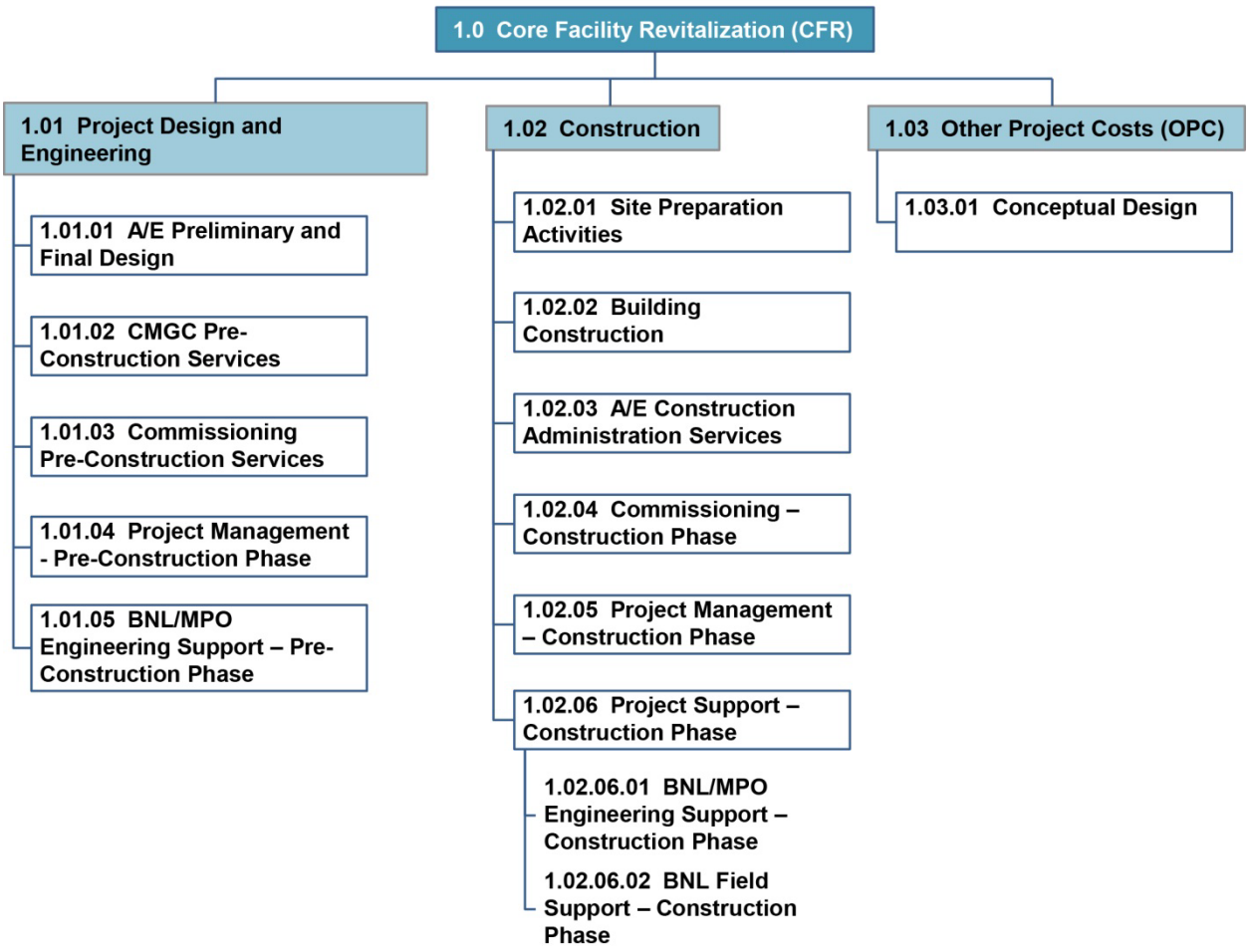


◆◆ Milestone

TASK filter: CFR Milestone.

Data Date: 01-Sep-15 Current Date: 04-Aug-16

6.3 Work Breakdown Structure



6.3.1 Preliminary Work Breakdown Structure (WBS) Dictionary

WBS 1.0 CORE FACILITY REVITALIZATION (CFR)

The objective of the proposed CFR project is to execute design and construction activities which shall provide new computing facilities, enabling BNL researchers and users to continue to accomplish Brookhaven National Laboratory (BNL) missions in Nuclear and High Energy Physics. A mission need exists to provide mid-range computational and data storage support to current and planned particle physics experiments using RHIC and the ATLAS detector at CERN that are funded by NP and HEP, respectively. Capable, reliable and efficient computing facilities will be provided to support experiments that will generate ever greater amounts of data, beyond current capabilities, that must be stored and analyzed.

- **WBS 1.01 Project Design & Engineering** – Scope includes providing the total design and engineering effort required through the preliminary and final design phases of the project. Also includes the pre-construction project management, CM/GC, and Modernization Project Office (MPO) engineering activities in direct support of project design and engineering.
- **WBS 1.01.01 A/E Preliminary and Final Design** – Provide for all A/E preparation of Preliminary design, drawings, specifications, special studies, A/E travel expenses, estimates, and value engineering. Also includes A/E preparation of final design detailed drawings, final specifications, estimates, bid documents, and all reproductions. Work includes all design progress submittals for both project team and independent reviews.
- **WBS 1.01.02 CM/GC Pre-Construction Services** – Scope includes CM/GC support services during the pre-construction phase. Services include constructability reviews, development of independent cost estimates, development of construction schedules, feasibility/value engineering studies, and pre-qualification of potential subcontractors.
- **WBS 1.01.03 Commissioning Pre-Construction Services** – Scope includes Commissioning Agents pre-construction activities and participation including preparation of pre-construction commissioning plan.
- **WBS 1.01.04 Project Management Pre-Construction Phase** – Scope includes the level of effort required by the MPO project manager to manage the project during the pre-construction phase in accordance with the approved Project Execution Plan and DOE Order 413.3B, “Program and Project Management for the Acquisition of Capital Assets”. Activities include project controls, contract management, and management of the A/E, CMGC, and MPO facilities engineering team, review of contract deliverables, preparation for reviews, travel expenses, and preparation of solicitations, bidding, and procurement of services. Also included is the coordination with end users throughout the pre-construction phase.

- **WBS 1.01.05 BNL/MPO Engineering Support Pre-Construction Phase** – This work element represents the BNL support staff (i.e. Fire Protection and ES&H) and MPO facilities engineering support division time and effort throughout the pre-construction phase to provide system data to A/E, review A/E deliverables, and integrate A/E effort with technical and conventional facilities requirements as needed. Also included is BNL staff review of A/E drawings and specifications for compliance with BNL construction safety policy, standards, and procedures.
- **WBS 1.02 Construction** - Scope includes the execution of all construction activities and the required management and support components throughout the projects construction phase in accordance with the requirements outlined in the construction contract documents Also included is punch-list activities and final project commissioning.
- **WBS 1.02.01 Site Preparation Activities** - Scope includes all work required for the physical preparation of the project work areas. Specific work includes but is not limited to selective hazardous material remediation, Utility isolation and lock out tag out (LOTO) activities, facilities support, and other tasks required to prep the work areas for turn-over to the contractor.
- **WBS 1.02.02 Building** Construction - Scope includes all construction specific activities as required for the execution of the work as defined by the final bid documents and construction contract, including approved changes and modifications executed during the construction phase.
- **WBS 1.02.03 A/E Construction Administration Services** – Provide all A/E construction phase support services, including home office engineering support, shop drawing review, periodic field inspections, and preparation of as-built drawings/documentation.
- **WBS 1.02.04 Commissioning – Construction Phase** - Scope includes the final commissioning effort to validate conformance with the project contract documents. Includes providing the required support of the MPO and BNL operations and maintenance during commissioning activities along with a Commissioning Agent.
- **WBS 1.02.05 Project Management – Construction Phase** – Scope includes the level of effort required by the MPO project manager to manage the project during the construction phase in accordance with the approved Project Execution Plan and DOE Order 413.3B, “Program and Project Management for the Acquisition of Capital Assets”, and includes implementation of the BNL Construction Safety Program.. Construction phase activities include project controls, contract management, review of deliverables, preparation for reviews, travel expenses, preparation of solicitations, bidding, procurement of services, and change management. Also included are the project managers required commissioning activities and the continued coordination with end users throughout the construction phase.

- **WBS 1.02.06 Project Support – Construction** Phase – Scope consists of MPO construction services and field support during the construction phase of work. Coordinate and assure compliance with BNL construction safety programs. Includes on site construction supervision and coordination, utility interconnect coordination and shut-downs/start-ups, execution of engineering/construction changes, and construction testing, inspections, and reporting as required.
- **WBS 1.02.06.01 BNL/MPO Engineering Support – Construction Phase** – Provide all MPO Engineering support services during the construction phase to assure compliance with BNL construction standards and orderly connection and start-up with existing BNL systems during the construction phase. Includes inspections and reporting on work in place, utility interconnect coordination, review of shop drawings, review of engineering changes, and permit preparation as required.
- **WBS 1.02.06.02 BNL/MPO Field Support – Construction Phase** – Provide all BNL field support and F&O engineering (i.e. fire Protection engineering, ES&H services, and BNL trades) during the construction phase to assure compliance with BNL construction standards and orderly connection and start-up with existing BNL systems during the construction phase. Includes inspections and reporting on work in place, utility interconnect coordination, review of shop drawings, review of engineering changes, and permit preparation as required.
- **WBS 1.03 Other Project Costs** – Scope includes costs that are not identified within the total estimated cost; generally, costs incurred during the initiation and definition phases for planning, conceptual design, research and development, and during the execution phase for startup and operation. Other project costs are always operating funds.
- **WBS 1.03.01 Conceptual Design** – Conceptual planning and preparation of supporting documentation. Scope includes preparation of the CDR. The CDR summarizes preliminary investigations to establish baseline scope, schedule, and cost information specific to the proposed work. The CDR is the basis for the preliminary design.

6.4 WBS in 2019 Dollar Calculations

Core Facility Revitalization (CFR) Project
Preliminary Cost Estimate - B725 Renovation Point Estimate

Date: 7/15/2016

WBS Level 1	WBS Level 2	WBS Level 3	WBS Level 4	Description	in $K		in $K
1.0	**Core Facility Revitalization**						
	1.01	**Project Design & Engineering**					**$5,344**
		1.01.01		A/E Preliminary & Final Design	**$4,202**		
		1.01.02		CM Pre-Construction Services & ICE	**$439**		
		1.01.03		Project Commissioning - Pre-Construction	**$75**		
		1.01.04		Project Management Pre-Construction	**$485**		
		1.01.05		BNL/MPO Engineering Support Pre-Construction Phase	**$143**		
	1.02	**Construction**					**$50,549**
		1.02.01		Site Preparation Activities	**$2,000**		
		1.02.02		CFR Construction - (18 Months)	**$43,872**		
		1.02.03		A/E Construction Administration Services	**$439**		
		1.02.04		Project Commissioning - Construction	**$200**		
		1.02.05		Project Management - Construction	**$1,425**		
		1.02.06		Project Support - Construction			
			1.02.06.01	BNL/MPO Engineering Support - Construction	**$230**		
			1.02.06.02	BNL Field Support - Construction	**$2,129**		
				Escalation - (Included in Const Est. @ 3% for 3 yrs.)			
				Subtotal			**$55,893**
				Total Project Contingency (20%)			**$11,179**
				Total Estimated Cost (TEC)			**$67,072**
	1.03	**Other Project Costs (OPC)**					
		1.03.01		Conceptual Design (BSA Cost)	**$850**		**$850**
				Total Line Item Project Cost (TPC)			**$67,922**

Section 7
SUMMARY OF COST ESTIMATE

7.0 Summary of Cost Estimate

7.1 Basis of Estimate

The Cost Estimate factors experience with similar projects that have been completed and also takes into account local market conditions. The estimate range of probable construction costs is a conservative estimate derived from unit costs and quantity take-offs. This estimate is based on conceptual drawings and architecture and engineering narratives which are found in this report. These estimated line item costs are derived by the following methods:

- Experience with projects of similar size and function;
- Experience with complex technical projects including mission critical data centers;
- Discussions with material suppliers and sub-contractors to obtain mid-level range of costs;
- Review of the schedule of values of recently bid projects of similar scope and complexity; and,
- Proprietary cost data base maintained by the cost estimating consultant.

7.2 Alternate Bid Item Strategy

The project team has identified several project “Add and Deduct Alternates” that are standalone scope items that will enable BNL to add or reduce project scope in the event market conditions create excess or shortage of cost commitment. These scope items and their associated costs have been summarized and detailed in Section 9.1.

7.3 Material Cost and Labor Hours

Unit prices for each line item includes material price and labor costs which in turn are based on local labor rates and estimated production based on site access restrictions and transportation of the labor and material.

7.4 Escalation

The construction cost estimate is based on FY2016 costs and is escalated according to a rate derived by considering information from the cost estimating consultant’s data base, data from the Bureau of Labor Statistics, and information available from the Federal Reserve Bank. Refer to the project schedule in Section 6.

Schedule assumptions and escalation calculations have assumed that design will not commence until BNL award of A/E contract in 1Q2017.

7.5 Contingency

The Total Estimated Cost (TEC) for the project is based on the general scope, method of accomplishment, and schedule. All supporting cost documentation including identification of design and construction contingencies are included in the Cost Estimate.

Section 8

BASIS OF DESIGN - TECHNICAL CRITERIA

8.0 Basis of Design – Technical Criteria

8.1 Building Code Analysis

Introduction

This section is intended to identify minimum requirements of the proposed Data Center as mandated by the applicable codes and standards, campus guidelines and the jurisdiction having authority.

Codes, Standards and Guidelines

The design and repurposing of the facility area that comprises the Data Center will comply with all relevant codes and standards as defined by the jurisdictions having authority. These include but are not limited to the following:

- New York State Building Codes (NYSBC)
  - Building Code of New York State – 2010
  - Existing Building Code of New York State – 2010
  - Energy Conservation Construction Code of New York State – 2010
  - Fire Code of New York State - 2010
  - Fuel Gas Code of New York State - 2010
  - Mechanical Code of New York State - 2010
  - Plumbing Code of New York State – 2010
- NFPA 10 – Portable Fire Extinguishers
- NFPA 13 – Installation of Sprinkler Systems
- NFPA 70 – National Electrical Code with Local Amendments
- NFPA 72 – Fire Alarm and Signaling Code
- NFPA 75 – Standard for the Fire Protection of Information Technology Equipment
- 29 CFR 1910 Occupational Safety and Health Standards
- 29 CFR 1926 Safety and Health Regulations for Construction
- ANSI/BICSI 002-2014 – Data Center Design and Implementation Best Practices
- FM Property Loss Prevention Data Sheets 5-32 – Data Centers
- High Performance and Sustainable Building provisions per Executive Order 13693

- American with Disabilities Act (ADA) Accessibility Guideline (ADAAG)

Occupancy Classification

The original occupancy classification for the Building 725 - NSLS is primarily High-Hazard Group H-3. The new occupancy classification for the repurposed NSLS Data Center will be Business Group B in accordance with the New York State Building Code.

Height and Area

Building 725 floor elevation varies from approximately 2 to 7 feet below finish grade depending on the location around the building. The approximate floor heights above the First Floor are as follows:

- First Floor 0 Feet
- First Floor Roof / Second Floor 17 Feet – 0 Inches
- Second Floor Roof 30 Feet – 9 Inches

Building 725 approximate gross floor areas are as follows:

- First Floor 115,000 GSF
- Second Floor 37,800 GSF

Construction Type

The existing construction type classification for the Building 725 is Type IIB (unprotected). The allowable area for a Group B, building of Type IIB construction, equipped with an automatic sprinkler system, is only 69,000 GSF per floor; however, this facility complies with, NYSBC Section 507.5, this requirement allows a Two – Story Building of Unlimited Area. Under this section the type of construction is not restricted by area and the existing structure can remain unprotected.

Means of Egress

The new occupancy classification for the Data Center is Business Group B.

The occupancy load factor for Group B is one person per 100 gross square feet (GSF). The approximate area of the Data Center is 84,800 GSF. Therefore, the maximum number of occupants for Center will be approximately 848 (84,800 GSF / 100 SF = 848 occupants)

The existing number of exits and their associated exit widths in the facility will remain unaltered. The maximum travel distance to an exit is 300 feet; the maximum travel distance in a dead end corridor is 50 feet and the common path of travel shall not exceed 100 feet provided the building is equipped throughout an automatic sprinkler system.

Fire and Smoke Barriers

Fire and smoke barriers exist and are being maintain at all exits and elevator enclosures and shafts.

Additional 2 hour fire and smoke barriers are being provided, at the request of BNL, at the perimeters of all Data Halls and Electrical Rooms to establish compartmentalization, protection of assets, and minimize damage potential from a fire event. Refer to Diagram 2.4.1.3 for fire and smoke barrier layouts.

Accessibility

The majority of the existing Building 725 is in compliance with New York State ADA with the following exceptions. Door hardware and room signage are not incompliance.

Fire Protection

Fire Protection Systems will be in compliance with the FM 5-32 and NFPA 13/NFPA 75 standards for all areas within the B-725 project scope. Refer to 2.3.2 Fire Protection for system description.

Section 9
APPENDIX

9.1 Cost Estimate Supporting Details

VJ ASSOCIATES
A CONSTRUCTION CONSULTING FIRM
100 DUFFY AVENUE, HICKSVILLE NY 11801
TEL: (516) 932-1010

100% CDR ESTIMATE

BROOKHAVEN NATIONAL LAB

UPTON, NY 10023

July 28, 2016

VJ ASSOCIATES
100% CDR ESTIMATE
BROOKHAVEN NATIONAL LAB

UPTON, NY 10023

07/28/16

QUALIFICATIONS/EXCLUSIONS

1 This estimate is based on the 100% issue Conceptual Design Report for the BNL Core Facility Renovation project dated 7-1-2016 by HDR Architects, Inc.

2 Architectural and/or Engineering Fees are not included.

3 Overtime Labor rates are not anticipated or included.

4 No Asbestos Abatement/Hazmat Removal allowance is provided excepting removal of existing roofing.

5 Included are the following margins in addition to the Cost of the Work:

General Conditions	10%
GC Overhead and Profit	15%
Bid Contingency	BNL
Escalation	9.3%

6 Basis of Estimate
VJ Associates maintains a proprietary data base reflecting current market prices.
VJ Associates has substantial experience preparing estimates for Data Center projects.
VJ has substantial experience estimating projects in the greater area of Washington DC, New York, and Boston.
Material and labor prices are continuously updated based on information from suppliers and contractors.

7 The indicated escalation rate is based on the following resources:
VJ Associates Data Base
Bureau of Labor Statistics
Federal Reserve Bank

VJ ASSOCIATES

100% CDR ESTIMATE

BROOKHAVEN NATIONAL LAB

UPTON, NY 10023

07/28/16

SUMMARY

			VJ Associates
	DESCRIPTION		100% AMOUNT
1	GENERAL CONDITION		0
2	SITE WORK/DEMOLITION		891,504
3	CONCRETE		133,286
4	MASONRY		0
5	METAL		20,000
6	WOOD & PLASTICS		31,822
7	THERMAL & MOISTURE PROTECTION		2,620,000
8	DOORS AND WINDOWS		1,039,600
9	FINISHES		2,051,340
10	SPECIALTIES		3,000
11	FURNISHINGS		0
12	EQUIPMENT		0
13	SPECIAL CONSTRUCTION		132,757
15.1	FIRE PROTECTION		578,000
15.2	PLUMBING		85,500
15.3	HVAC		8,512,036
16	ELECTRICAL		15,748,548
			----------
	subtotal		$31,847,393
	GENERAL CONDITIONS	10%	3,184,739
			----------
	subtotal		$35,032,132
	OVERHEAD AND PROFIT	15%	5,254,820
			----------
	subtotal		$40,286,952
	CONTINGENCY		0
			----------
	subtotal		$40,286,952
	ESCALATION to Mid-Point of Construction	9.3%	3,746,687
	VJ Historical Data & Market/Economic Conditions		----------
	CONSTRUCTION COSTS		$44,033,638

	ALTERNATES		
	ALT-01 Bypass Generator		$ 1,488,494
	ALT-02 Bypass UPS		$ 1,197,730
	ALT-03 GENERATOR/CUP		$ 1,388,409
	ALT-4: Chillers, Cooling Tower, HX, Pumps (3)		$ (799,939)
	ALT-05 1.2 MW Power		$ 10,448,466
	ALT-06 Exterior Envelope - Metal Wall Panels		$ 489,124
	ALT-07 Solar Hot Water		$ 20,740
	ALT-08 Exterior Envelope-Roof/Leak Detection System		$ (1,548,562)
	ALT-09 Build Phase II		$ 309,609
	ALT-10 UPS for Network Equipment (instead of ALT-02)		$ 672,086
	ALT-11 Fitout		$ 1,790,910
	ALT-12a Network Gaseous Fire Suppression FM 200		$ 80,193
	ALT-12b Network Gaseous Fire Suppression FM 200		$ 262,703
	AALT-13 RHIC/ATLAS - Direct ooling Infrastructure		$ 124,438

	DESCRIPTION	QTY	UNIT	UNITS	AMOUNT
2	**SITE WORK/DEMOLITION**				
	Trench for electric run from HVAC to Building Mechanical room-Excavation	See electric			0
	Backfill	See electric			0
	General Demolition-Concrete,Masonry,Steel,Doors,Gypsum Board	53,643	sf	$ 15.00	804,645
	Mechanical Demolition	28,953	sf	$ 3.00	86,859

	TOTAL SITE WORK/DEMOLITION				**891,504**
3	**CONCRETE**				
	Trench for electric run from HVAC to Building Mechanical room	see electric			0
	Concrete Pad - Generator pads	600	sf	$ 10.00	6,000
	Concrete Sealer	53,643	sf	$ 2.00	107,286
	Misc	1	allow	$ 20,000.00	20,000

	TOTAL CONCRETE				**133,286**
5	**METAL**				
	Dunnage & Misc Metals	1	ls	$ 20,000.00	20,000

	TOTAL METAL				**20,000**
6	**WOOD & PLASTICS**				
	Rough carpentry:				
	Blocking & misc carpentry	53,643	ls	$ 0.50	26,822
	Millwork:				
	Pantry	1	ls	$ 5,000.00	5,000

	TOTAL WOOD & PLASTICS				**31,822**
7	**THERMAL & MOISTURE PROTECTION**				
	Ist floor roof 75,000sf	75,000	sf	$ 20.00	1,500,000
	Leak Detection System-dual roof	28,000	sf	$ 30.00	840,000
	Leak Detection System	28,000	sf	$ 10.00	280,000
					0

	TOTAL THERMAL & MOISTURE PROTECTION				**2,620,000**
8	**DOORS AND WINDOWS**				
	Demo	830	sf	$ 20.00	16,600
	Windows	830	sf	$ 100.00	83,000
	Demo	5,000	sf	$ 20.00	100,000
	Windows	5,000	sf	$ 100.00	500,000
	Demo for Louvers (Provide new openings)	2,000	sf	$ 20.00	40,000
	Louvers & Relate Work (Flashing, Interior Repairs & Steel Bracing)	2,000	sf	$ 150.00	300,000

	TOTAL DOORS AND WINDOWS				**1,039,600**
9	**FINISHES**				
	Ceilings:				
	ACT	1,680	sf	$ 7.00	11,760
	Mylar ACT	20,900	sf	$ 9.00	188,100
			sf		0
	Walls:				
	GWB - 2 hour 26'ht 6" stud	15,000	sf	$ 22.00	330,000
	GWB - 2 hour 13''ht 6" stud	40,000	sf	$ 18.00	720,000
	GWB - 2 hour 10''ht 6" stud	6,000	sf	$ 15.00	90,000
	GWB - Non-Rated 13'ht 3 5/8" Stud	15,000	sf	$ 12.00	180,000
	Ceramic Tile	2	loc	$ 2,500.00	5,000
	Floors: Raised Floor/Static Dissipative Vinyl Tile				
	Raised Floor w/Dissipative Vinyl Tile	14350	sf	$ 25.00	358,750
	Static Dissipative Vinyl Tile	6550	sf	$ 5.00	32,750
	Carpet Tile	1680	sf	$ 6.00	10,080
	Base	4,300	lf	$ 3.00	12,900
	Paints and Coatings:				
	Paint - GWB Walls -	140,000	sf	$ 0.80	112,000

	TOTAL FINISHES				**2,051,340**
10	**SPECIALTIES**				
	Toilet Accessories & Toilet Patitions	1	allow	$ 3,000.00	3,000

	TOTAL SPECIALTIES				**3,000**
12	**EQUIPMENT**				
	Floor Mounted Infrastructure (Polargy-Cold Aisle Containment-Cary Frame)	See HVAC			0

	TOTAL EQUIPMENT				**0**

	DESCRIPTION	QTY	UNIT	UNITS	AMOUNT
13	**SPECIAL CONSTRUCTION**				
	ELECTRICAL COMMUNICATIONS				
	Remove Abandoned Cable	80	hrs	$ 133.58	10,686
	Corning ALTOS 288 SM Fiber Optics Cable OS2	5,000	lf	$ 6.98	34,900
	1 Inner Duct, Plenum Ratred	1,500	lf	$ 5.29	7,935
	Labor, Pull Fiber Thru Manholes Route 1-3m7d	168	hrs	$ 133.58	22,441
	Labor, Pull Fiber Thru Manholes Route 1-2m4d	64	hrs	$ 133.58	8,549
	Labor, Pull Fiber Thru Manholes Route 2-3m4d	96	hrs	$ 133.58	12,824
	Labor, Pull Fiber Thru Manholes Route 2-2m2d	32	hrs	$ 133.58	4,275
	LC Terminations 288x4	1	ls	$ 14,049.00	14,049
	Terminate Both Ends of Cable 2m4d	64	ls	$ 133.58	8,549
	Testing/Labling 2m2d	64	hrs	$ 133.58	8,549
					0

	TOTAL SPECIAL CONSTRUCTION				**132,757**
	FIRE PROTECTION				
	Remove existing sprinkler system, within the data center and Office	1	allow	10,000.00	10,000
	New double interlocked pre-action system, includes valve assembly, sprinkler head, distribution piping and Main/Loop pipes assumed 4" dia. (Data Center)	12,700	SF	15.00	190,500
	New Wet system, includes sprinkler head, distribution piping and Main/Loop pipes assumed 2 1/2"-3" dia.	36,300	SF	10.00	363,000
	FM 200 System, Assume 300 lbs Main/Reserve NET 1,000SF		see alt 12		
	NSLS see alt 11 fit out 3,450sf		see alt 11		
	Seismic bracing and supports	1	LS	7,000.00	7,000
	Hydraulic Calculation and Testing	1	LS	2,000.00	2,000
	Shop drawings/Submittals	1	LS	2,000.00	2,000
	Identification and Cleaning	1	LS	1,000.00	1,000
	Cutting and Patching	1	LS	2,500.00	2,500

	TOTAL FIRE PROTECTION				**578,000**
15.2	**PLUMBING**				
	Bathrooms & Pantry Fixtures	1	ls	30000	30,000
	Miscellaneous				
	Remove existing cw piping within data center, Assumed 250 LF	1	LS	3000	3,000
	New make up water for HVAC, Includes backflow preventer	1	LS	20000	20,000
	Floor Drains -Modify Existing w/some new drains	1	ls	30000	30,000
	Miscellaneous				
	Shop Drawings, Submittals, cutting , patching and Testing	1	LS	2,500	2,500

	Subtotal Plumbing				85,500
15.3	**HVAC**				
	Equipment				
	CH-1&2 Water Cooled Chillers 310 Tons	2	EA	$ 193,296.00	386,592
	CT-1&2 Cooling Tower 310 Tons	2	EA	$ 63,057.60	126,115
	SHX-1,2&3 Heat Exchanger capacity at 4.320 MBtuh	3	EA	$ 51,996.00	155,988
	HX-1&2 Flat Plate HX ; 300 gpm	2	EA	$ 42,729.60	85,459
	HWP-1,2&3 Hot Water Preheat Pumps 435 gpm, 70 ft of head, 40 HP	3	EA	$ 9,732.00	29,196
	PCHWP-1,2&3 Primary Chilled Water Pumps 620 gpm, 70 ft of head, 20 HP	3	EA	$ 7,932.00	23,796
	CWP-1,2&3 Condenser Water Pumps 930 gpm, 80 ft of head, 25 HP	3	EA	$ 8,532.00	25,596
	DCHWP-1,2&3 Direct Cooling Water Pumps 300 gpm, 70 ft of head, 10 HP	3	EA	$ 4,665.60	13,997
	VFD (Supply Only / Installed by Electrical Contractor)	1	LS	$ 50,400.00	50,400
	Dry Air Economizer 50,000 CFM	7	EA	$ 313,264.70	2,192,853
	Dry Air Economizer 12,500 CFM	4	EA	$ 90,996.00	363,984
	DOAS Units 2,500 CFM	2	EA	$ 35,328.00	70,656
	Thermal Storage Tank 600 Gallon	1	EA	$ 6,465.60	6,466
	Floor Mounted Infrastructure (Polargy - Hot Aisle Containment-Cary Frame)	1	LS	$ 500,000.00	500,000
	Piping				
	Chilled Water Pipe, fittings, valves, insulation, equipment connection etc	49,191	GSF	$ 8.60	423,043
	Direct Cooling Chilled Water Pipe, fittings, valves, insulation, equipment connection etc	49,191	GSF	$ 3.10	152,492
	Campus Chilled Water Pipe, fittings, valves, insulation, equipment connection etc	49,191	GSF	$ 3.60	177,088
	Steam & condensate Pipe, fittings, valves, insulation, equipment connection etc	49,191	GSF	$ 3.90	191,845
	Hot Water Pipe, fittings, valves, insulation, equipment connection etc	49,191	GSF	$ 6.30	309,903
	Condenser Water Pipe, fittings, valves, insulation, equipment connection etc	49,191	GSF	$ 5.70	280,389
	Condensate Drain Pipe, fittings, hangers, insulation etc	49,191	GSF	$ 1.60	78,706
	Ducting and accessories				
	GI Duct	156,208	LB	$ 11.00	1,718,286
	FG Insulation	21,088	SF	$ 7.00	147,614
	Liner	6,326	SF	$ 8.00	50,610
	Grills & Diffusers	1	LS	$ 22,485.60	22,486
	FDs, FSDs, Louvers, Motorized Dampers etc	1	LS	$ 13,740.00	13,740
	DD Control				
	Control Points	607	EA	$ 1,050.00	637,350
	Software, programming, training, tie in	1	LS	$ 26,388.00	26,388
	Miscellaneous				
	Shop Drawings & Submittals	1	LS	$ 20,000.00	20,000
	Identification and tagging	1	LS	$ 50,000.00	50,000
	Rigging	1	LS	$ 101,000.00	101,000
	Air & Water Balancing	1	LS	$ 80,000.00	80,000
	Testing and commissioning				By BNL

	TOTAL HVAC				**8,512,036**

	DESCRIPTION	QTY	UNIT	UNITS	AMOUNT
16.0	**ELECTRICAL**				
	SITE WORKS				
	MV Duct bank - Manholes to HVSG-A,B				
	3W Splice in existing Feeders (725-1, 725-2)	2	EA	3,180.00	6,360
	6W Duct bank to HVSG (1 Active, 5 Spare) - 725-1, 725-2 to HVSG-A,B				
	5" PVC Sch 40	3,930	LF	35.92	141,166
	3-1/C - 500 MCM , 15 KV	655	LF	52.20	34,191
	Concrete	317	CY	387.00	122,550
	Excavation & backfill	1,267	CY	82.80	104,880
	3-1/C - 500 MCM , 15 KV in exisitng Ductbank	600	LF	52.20	31,320
	Remove existing CU Comm Cables fron one Duct, Provide (3)-3" Cell Fabric Innerduct	4,632	LF	16.53	76,567
	Manholes , Pull boxes				
	Manholes	2	EA	26,250.00	52,500
	Pull boxes - NEMA 4X	4	EA	3,180.00	12,720
	Bldg. Penetrations	4	Locs	6,888.00	27,552
	Generator to HVSG-G				
	5" PVC Sch 40	150	LF	35.92	5,388
	3-1/C - 500 MCM , 15 KV	150	LF	52.20	7,830
	Concrete	6	CY	387.00	2,150
	Excavation & backfill	22	CY	82.80	1,840
	HVSG-G to Feeders to HVSG - A, B				
	5" PVC Sch 40	100	LF	35.92	3,592
	3-1/C - 500 MCM , 15 KV	100	LF	52.20	5,220
	Concrete	4	CY	387.00	1,548
	Excavation & backfill	16	CY	82.80	1,325
	EMERGENCY POWER				
	POWER EQUIPMENT				
	1750KW Generators, 13.8KV w/ Load bank	2	EA	937,100.00	1,874,200
	HVSG-G-1200A, 15KV	1	EA	1,246,300.00	1,246,300
	SYSTEM 1				
	15KV EQUIPMENT				
	HVSG-A-1200A-15KV	1	EA	565,200.00	565,200
	SYS-1 (15 kV non-fused load interrupter switches-2Ea, 2000KVA X'mer)	1	EA	273,540.00	273,540
	480V EQUIPMENT				
	SWGR-1 - 3000A	1	EA	297,600.00	297,600
	ATS-1 - 1200A	1	EA	55,050.00	55,050
	MDP-1 - 1200A	1	EA	103,800.00	103,800
	UPS DOWNSTREAM				
	T-UPS-1 - 1200 KVA	1	EA	625,900.00	625,900
	M-UPS-1 - 50 KVA	1	EA	98,700.00	98,700
	TUSG-1-2000A-480V	1	EA	106,560.00	106,560
	MUDP-1-100A-480V	1	EA	7,650.00	7,650
	SS-1A,1B-2000A-480V	2	EA	41,610.00	83,220
	TUSB-1A,1B-2000A-480V	2	EA	136,560.00	273,120
	300KVA X'mers - K20 shielded isolation 480-208Y/120V transformers	6	EA	60,210.00	361,260
	1000A enclosed shunt trip CB - Disconnects at the secondary X'mer	6	EA	9,540.00	57,240
	TULDP-1A1 thru 1A3, 1B1 thru 1B3 - 1200A - 208Y/120V	6	EA	90,240.00	541,440
	TUHDP-1A1 , 1B1 - 208Y/120V	2	EA	90,240.00	180,480
	Overhead bus track above each rack row with snap-in power taps to serve individual racks	875	LF	395.40	345,975
	Ckt Breaker Drop Cords - Assume	300	EA	816.00	244,800
	Misc. Floor Panels Reqd	5	EA	12,300.00	61,500
	POWER FEEDERS				
	TO SS-1, 2				
	4" EMT	600	LF	35.32	21,192
	3-1/C - 500 MCM , 15 KV	600	LF	52.20	31,320
	PB to Swgr				
	4" EMT	300	LF	35.32	10,596
	#500 MCM	1,200	LF	16.50	19,800
	SWGR-1 to TUPS-1				
	4" EMT	240	LF	35.32	8,477
	#500 MCM	960	LF	16.50	15,840
	SWGR-1 to ATS-1,MDP-1				
	4" EMT	180	LF	35.32	6,358
	#500 MCM	720	LF	16.50	11,880
	MDP-1 to MUPS-1				
	4" EMT	25	LF	35.32	883
	#500 MCM	100	LF	16.50	1,650
	MUPS-1 to MUPD-1				
	4" EMT	15	LF	35.32	530
	#500 MCM	60	LF	16.50	990
	T-UPS-1 to T-USG-1				
	4" EMT	100	LF	35.32	3,532
	#500 MCM	400	LF	16.50	6,600
	T-UPS-1 to SS-1A,1B				
	4" EMT	200	LF	35.32	7,064
	#500 MCM	800	LF	16.50	13,200
	SS-1A,1B to T-UDP-1A,1B				
	4" EMT	250	LF	35.32	8,830
	#500 MCM	1,000	LF	16.50	16,500
	1200A Feeders				
	4" EMT	2,880	LF	35.32	101,722
	#500 MCM	11,520	LF	16.50	190,080

VJ ASSOCIATES
100% CDR ESTIMATE
BROOKHAVEN NATIONAL LAB

UPTON, NY 10023

7/28/2016

	DESCRIPTION	QTY	UNIT	UNITS	AMOUNT
	SYSTEM 2				
	15KV EQUIPMENT				
	SYS-2(15 kV non-fused load interrupter switches-2Ea, 2000KVA X'mer)	1	EA	273,540.00	273,540
	480V EQUIPMENT				
	SWGR-2 - 3000A	1	EA	297,600.00	297,600
	MDP-2 - 1200A	1	EA	103,800.00	103,800
	UPS DOWNSTREAM				
	T-UPS-2 - 1200 KVA	1	EA	625,900.00	625,900
	M-UPS-2 - 50 KVA	1	EA	98,700.00	98,700
	TUSG-2-2000A-480V	1	EA	106,560.00	106,560
	MUDP-2-100A-480V	1	EA	7,650.00	7,650
	SS-2A,2B-2000A-480V	2	EA	41,610.00	83,220
	TUSB-2A,2B-2000A-480V	2	EA	136,560.00	273,120
	300KVA X'mers - K20 shielded isolation 480-208Y/120V transformers	8	EA	60,210.00	481,680
	1000A enclosed shunt trip CB - Disconnects at the secondary X'mer	8	EA	9,540.00	76,320
	TUDP-2A1 thru 2A4, 2B1 thru 2B4 - 1200A - 208Y/120V	8	EA	90,240.00	721,920
	Overhead bus track above each rack row with snap-in power taps to serve individual racks	875	LF	395.40	345,975
	Ckt Breaker Drop Cords - Assume	300	EA	816.00	244,800
	POWER FEEDERS				
	4" EMT	600	LF	35.32	21,192
	3-1/C - 500 MCM , 15 KV	600	LF	52.20	31,320
	PB to Swgr				
	4" EMT	300	LF	35.32	10,596
	#500 MCM	1,200	LF	16.50	19,800
	SWGR-1 to TUPS-1				
	4" EMT	280	LF	35.32	9,890
	#500 MCM	1,120	LF	16.50	18,480
	SWGR-1 to ATS-1,MDP-1				
	4" EMT	186	LF	35.32	6,570
	#500 MCM	744	LF	16.50	12,276
	MDP-1 to MUPS-1				
	4" EMT	30	LF	35.32	1,060
	#500 MCM	120	LF	16.50	1,980
	MUPS-1 to MUPD-1				
	4" EMT	20	LF	35.32	706
	#500 MCM	80	LF	16.50	1,320
	T-UPS-1 to T-USG-1				
	4" EMT	120	LF	35.32	4,238
	#500 MCM	480	LF	16.50	7,920
	T-UPS-1 to SS-1A,1B				
	4" EMT	220	LF	35.32	7,770
	#500 MCM	880	LF	16.50	14,520
	SS-1A,1B to T-UDP-1A,1B				
	4" EMT	270	LF	35.32	9,536
	#500 MCM	1,080	LF	16.50	17,820
	1200A Feeders				
	4" EMT	3,000	LF	35.32	105,960
	#500 MCM	12,000	LF	16.50	198,000
	BY PASS				
	15 KV				
	HVSG-B-1200A-15KV	1	EA	565,200.00	565,200
	SYS-B (15 kV non-fused load interrupter switches-2Ea, 2000KVA X'mer)	1	EA	273,540.00	273,540
	POWER FEEDERS				
	TO SS-1, 2				
	4" EMT	600	LF	35.32	21,192
	3-1/C - 500 MCM , 15 KV	600	LF	52.20	31,320
	PB to Swgr				
	4" EMT	300	LF	35.32	10,596
	#500 MCM	1,200	LF	16.50	19,800
	Lighting, Lighting Control system & Cktry	1	LS	333,500.00	333,500
	Wiring Devices & Cktry	1	LS	58,200.00	58,200
	Fire Alarm System including VESDA System	49,191	SF	7.00	344,337
	Telecommunications (Cabling & Infrastructure only)				
	FO Redundant Feed	650	LF	20.28	13,182
	Telecommunications (Cabling only)	1	LS	210,900.00	210,900
	4" EMT	350	LF	35.32	12,362
	2-1/2" EMT	60	LF	22.82	1,369
	24" W X 4" D Wire Basket Tray	800	LF	74.70	59,760
	12" W X 4"D Fiber runner	800	LF	55.80	44,640
	Spit outs over each rack	1	LS	29,880.00	29,880
	SECURITY SYSTEM				
	Card Readers & Tie into existing System	14	EA	1,590.00	22,260
	CCTV Cameras & Tie into existing System	14	EA	2,766.00	38,724
	MISC				
	Grounding including Raised Floor Grounding at Data Halls	1	LS	137,900.00	137,900
	Leak Detection System	1	LS	77,600.00	77,600
	Allowance for Misc. Feeders for Lighting & Receptacles Panels	1	LS	87,300.00	87,300
	Power Monitoring System	1	LS	66,900.00	66,900
	Mechanical Equipment Connections	1	LS	300,700.00	300,700
	30A ATS w/feeders - For Dry Air Economizers.	4	ea	3,850.00	15,400
	100A ATS w/feeders - For Dry Air Economizers.	14	ea	8,600.00	120,400
	Power to exterior cooling tower (100 LF concrete encased)	100	LF	267.60	26,760
	EPMS System	1	LS	16,770.00	16,770
	Temp Power & Lighting	1	ls	36,000.00	36,000
	Tie into DDC System	1	LS	11,040.00	11,040
	Testing & Commissioning		BNL		-

					15,748,548

VJ ASSOCIATES
SCHEMATIC ESTIMATE
BROOKHAVEN NATIONAL LAB
UPTON, NY 10023

100% Design-Alternates

7/11/2016

	DESCRIPTION	QTY	UNIT	UNITS	AMOUNT
	ALT-01 Bypass Generator Delete				
	1750KW Generators, 13.8KV w/ Load bank	1	EA	$ 937,100.00	937,100
	15KV Ckt Breaker	1	EA	$ 131,900.00	131,900
	5" PVC Sch 40	100	LF	$ 35.92	3,592
	3-1/C - 500 MCM , 15 KV	50	LF	$ 52.20	2,610
	Concrete	2	CY	$ 387.00	774
	Excavation & backfill	7	CY	$ 82.80	580
	Total				1,076,556
				10%	107,656
					1,184,211
				15%	177,632
					1,361,843
				9.3%	126,651

	ALT-01 Bypass Generator				**1,488,494**
	ALT-02 Bypass UPS				
	UPS DOWNSTREAM				
	T-UPS-B - 1200 KVA	1	EA	$ 625,900.00	625,900
	M-UPS-B - 50 KVA	1	EA	$ 98,700.00	98,700
	T-USGB-2000A	1	EA	$ 134,010.00	134,010
	MUDP-B-100A-480V	1	EA	$ 7,650.00	7,650
	Total				866,260
				10%	86,626
					952,886
				15%	142,933
					1,095,819
				9.3%	101,911

	ALT-02 Bypass UPS				**1,197,730**
	ALT-03 Generator/CUP				
	1200KW Generators, 13.8KV w/ Load bank at CUP	1	EA	$ 701,750.00	701,750
	New sections to the existing 15kV outdoor switchgear for the paralleling controls and a new 15kV circuit breaker	1	LS	$ 290,700.00	290,700
	5" PVC Sch 40	170	LF	$ 35.92	6,106
	3-1/C - 500 MCM , 15 KV	80	LF	$ 52.20	4,176
	Concrete	2	CY	$ 387.00	774
	Excavation & backfill	8	CY	$ 82.80	662
	Total				1,004,169
				10%	100,417
					1,104,586
				15%	165,688
					1,270,274
				9.3%	118,135

	ALT-03 Generator/CUP				**1,388,409**
	Alternate-4: Chillers, Cooling Tower, HX, Pumps (3) Campus Utility Pipe for CW				
	HVAC				
	Equipment				
	CH-2 Water Cooled Chillers 310 Tons	(1)	EA	$ 193,296.00	-193,296
	CT-2 Cooling Tower 310 Tons	(1)	EA	$ 63,057.60	-63,058
	HX-2 Flat Plate HX 110 tons/each; 265 gpm @ 10ΔT/each	(1)	EA	$ 39,463.20	-39,463
	PCHWP-3 Primary Chilled Water Pumps 620 gpm, 70 ft of head, 20 HP	(1)	EA	$ 11,798.40	-11,798
	CWP-3 Condenser Water Pumps 930 gpm, 80 ft of head, 25 HP	(1)	EA	$ 8,532.00	-8,532
	DCHWP-3 Direct Cooling Water Pumps 300 gpm, 70 ft of head, 10 HP	(1)	EA	$ 4,665.60	-4,666
	VFD (Furnish only)	(1)	LS	$ 9,000.00	-9,000
	Piping				
	Chilled Water Pipe, fittings, valves, insulation, equipment connection etc	(1)	LS	$ 31,065.60	-31,066
	Direct Cooling Chilled Water Pipe, fittings, valves, insulation, equipment connection etc	(1)	LS	$ 27,120.00	-27,120
	Campus Chilled Water Pipe, fittings, valves, insulation, equipment connection etc	(1)	LS	$ 24,288.00	-24,288
	Steam & condensate Pipe, fittings, valves, insulation, equipment connection etc	(1)	LS	$ 23,421.60	-23,422
	Condenser Water Pipe, fittings, valves, insulation, equipment connection etc	(1)	LS	$ 29,652.00	-29,652
	Condensate Drain Pipe, fittings, hangers, insulation etc	(1)	LS	$ 4,905.60	-4,906
	DD Control				
	Control Points	(68)	EA	$ 1,079.40	-73,399
	Programming, training, tie in	(1)	LS	$ 3,998.40	-3,998
	Miscellaneous				
	Shop Drawings & Submittals	(1)	LS	$ 3,000.00	-3,000
	Identification and tagging	(1)	LS	$ 5,250.00	-5,250
	Rigging	(1)	LS	$ 8,524.80	-8,525
	Air & Water Balancing	(1)	LS	$ 14,119.20	-14,119
	Testing and commissioning				By BNL
					-578,557
				10%	-57,856
					-636,413
				15%	-95,462
					-731,875
				9.3%	-68,064

	Alternate-4: Chillers, Cooling Tower, HX, Pumps (3)				**-799,939**

	Alternate-5: 1.2 MW POWER				
	HVAC				
	Equipment				
	CH-3 Water Cooled Chillers 310 Tons	1	EA	$ 193,296.00	193,296
	CT-3 Cooling Tower 310 Tons	1	EA	$ 63,057.60	63,058
	HX-3 Flat Plate HX 110 tons/each; 265 gpm @ 10ΔT/each	1	EA	$ 39,463.20	39,463
	PCHWP-4 Primary Chilled Water Pumps 620 gpm, 70 ft of head, 20 HP	1	EA	$ 11,798.40	11,798
	CWP-4 Condenser Water Pumps 930 gpm, 80 ft of head, 25 HP	1	EA	$ 8,532.00	8,532
	DCHWP-4 Direct Cooling Water Pumps 300 gpm, 70 ft of head, 10 HP	1	EA	$ 4,665.60	4,666
	VFD (Furnish only)	1	LS	$ 9,000.00	9,000
	Dry Air Economizer 50,000 CFM	3	EA	$ 313,264.70	939,794
	Piping				
	Chilled Water Pipe, fittings, valves, insulation, equipment connection etc	1	LS	$ 31,065.60	31,066
	Condensate Drain Pipe, fittings, hangers, insulation etc	1	LS	$ 4,905.60	4,906
	Ducting and accessories				
	GI Duct	26,134	LB	$ 12.00	313,609
	FG Insulation	700	SF	$ 9.00	6,300
	Liner	210	SF	$ 8.49	1,783
	Grills & Diffusers	1	LS	$ 11,984.80	11,985
	FDs, FSDs, Louvers, Motorized Dampers etc	1	LS	$ 2,006.40	2,006
	DD Control				
	Control Points	140	EA	$ 1,079.40	151,116
	Programming, training, tie in	1	LS	$ 3,998.40	3,998
	Miscellaneous				
	Shop Drawings & Submittals	1	LS	$ 3,000.00	3,000
	Identification and tagging	1	LS	$ 5,600.00	5,600
	Rigging	1	LS	$ 20,779.20	20,779
	Air & Water Balancing	1	LS	$ 16,516.80	16,517
	ELECTRICAL				
	SYSTEM 2				
	1750kw Generator w/ associated Feeders	1	ea	$ 998,100.00	998,100
	15KV EQUIPMENT				
	SUS-3(15 kV non-fused load interrupter switches-2Ea, 2000KVA X'mer)	1	EA	$ 273,540.00	273,540
	Allowance for associated MV Feeders and Equipment Upgrade	1	LS	$ 398,100.00	398,100
	480V EQUIPMENT				
	SWGR-3 - 3000A	1	EA	$ 297,600.00	297,600
	MDP-3 - 1200A	1	EA	$ 103,800.00	103,800
	UPS DOWNSTREAM				
	T-UPS-3 - 1200 KVA	1	EA	$ 625,900.00	625,900
	M-UPS-3 - 50 KVA	1	EA	$ 98,700.00	98,700
	TUSG-3-2000A-480V	1	EA	$ 106,560.00	106,560
	MUDP-3-100A-480V	1	EA	$ 7,650.00	7,650
	SS-3A,3B-2000A-480V	2	EA	$ 41,610.00	83,220
	TUSB-3A,3B-2000A-480V	2	EA	$ 136,560.00	273,120
	300KVA X'mers - K20 shielded isolation 480-208Y/120V transformers	8	EA	$ 60,210.00	481,680
	1000A enclosed shunt trip CB - Disconnects at the secondary X'mer	8	EA	$ 9,540.00	76,320
	TUDP-2A1 thru 2A4, 2B1 thru 2B4 - 1200A - 208Y/120V	8	EA	$ 90,240.00	721,920
	Overhead bus track above each rack row with snap-in power taps to serve individual racks	875	LF	$ 395.40	345,975
	Ckt Breaker Drop Cords - Assume	300	EA	$ 816.00	244,800
	POWER FEEDERS				
	SUS-3 to Swgr - 3				
	4" EMT	300	LF	$ 35.32	10,596
	#500 MCM	1,200	LF	$ 16.50	19,800
	To SS-3A,3B				
	4" EMT	500	LF	$ 35.32	17,660
	#500 MCM	2,000	LF	$ 16.50	33,000
	SWGR-3 to TUPS-3				
	4" EMT	280	LF	$ 35.32	9,890
	#500 MCM	1,120	LF	$ 16.50	18,480
	SWGR-3 to MDP-3				
	4" EMT	186	LF	$ 35.32	6,570
	#500 MCM	744	LF	$ 16.50	12,276
	MDP-3 to MUPS-3				
	4" EMT	30	LF	$ 35.32	1,060
	#500 MCM	120	LF	$ 16.50	1,980
	MUPS-3 to MUPD-3				
	4" EMT	20	LF	$ 35.32	706
	#500 MCM	80	LF	$ 16.50	1,320
	T-UPS-3 to T-USG-3				
	4" EMT	120	LF	$ 35.32	4,238
	#500 MCM	480	LF	$ 16.50	7,920
	T-UPS-3 to SS-3A,3B			$ -	0
	4" EMT	220	LF	$ 35.32	7,770
	#500 MCM	880	LF	$ 16.50	14,520
	SS-3A,3B to T-UDP-3A,3B				
	4" EMT	270	LF	$ 35.32	9,536
	#500 MCM	1,080	LF	$ 16.50	17,820
	450A Feeders				
	2-1/2" EMT	480	LF	$ 22.82	10,954
	#4/0	1,920	LF	$ 8.80	16,896
	1200A Feeders				
	4" EMT	3,000	LF	$ 35.32	105,960
	#500 MCM	12,000	LF	$ 16.50	198,000
	To SS-3A,3B				
	4" EMT	500	LF	$ 35.32	17,660
	#500 MCM	2,000	LF	$ 16.50	33,000
					7,556,868
				10%	755,687
					8,312,555
				15%	1,246,883
					9,559,438
				9.3%	889,028

	TOTAL Alternate-5: 1.2 MW POWER				**10,448,466**

10 of 12

	ALT-06 Exterior Envelope - Metal Wall Panels				
	Refurbish Metal Wall Panel	40,200	sf	$ 8.00	321,600
				$ 0.10	32,160
					353,760
				10%	35,376
					389,136
				15%	58,370
					447,506
				9.3%	41,618

	ALT-06 Exterior Envelope - Metal Wall Panels				**489,124**
	ALT-07 Solar Hot Water	1	ls	$ 15,000.00	15,000
				10%	1,500
					16,500
				15%	2,475
					18,975
				9.3%	1,765

	ALT-07 Solar Hot Water				**20,740**
	ALT-08 Exterior Envelope-Dual Membrane/Leak Detection				
	THERMAL & MOISTURE PROTECTION				
	Leak Detection System-dual roof	(28,000)	sf	$ 30.00	-840,000
	Leak Detection System	(28,000)	sf	$ 10.00	-280,000
					-1,120,000
				10%	-112,000
					-1,232,000
				15%	-184,800
					-1,416,800
				9.3%	-131,762

	ALT-08 Exterior Envelope-Dual Membrane/Leak Detection				**-1,548,562**
	ALT-09 Build Phase II				
	Demolition	5,300	sf	$ 5.00	26,500
	Architectural	5,300	sf	$ 3.00	15,900
	2hr walls	5,300	sf	$ 3.00	15,900
	Doors	5,300	sf	$ 0.25	1,325
	Ventilation	5,300	sf	$ 7.00	37,100
	Fire Protection	5,300	sf	$ 5.00	26,500
	Fire Alarm	5,300	sf	$ 5.00	26,500
	Power	5,300	sf	$ 7.00	37,100
	Lighting	5,300	sf	$ 7.00	37,100
	Total				223,925
				10%	22,393
					246,318
				15%	36,948
					283,265
				9.3%	26,344

	ALT-09 Build Phase II				**309,609**
	ALT-10 UPS for Network Equipment				
	T-UPS-N-100KVA	1	EA	$ 190,500.00	190,500
	T-UHDP-N-225A	1	EA	$ 6,450.00	6,450
	SS-NA,NB - 200A	2	EA	$ 7,470.00	14,940
	112.5KVA X'mers	2	EA	$ 19,266.64	38,533
	TULDP-NA,NB-400A	2	EA	$ 13,140.00	26,280
	400A CBS	2	EA	$ 6,270.00	12,540
	Allowace for Bus Track & CB Drop cords	1	Allow	$ 140,100.00	140,100
	400A Feeders	200	LF	$ 101.32	20,264
	200-225A Feeders	600	LF	$ 58.00	34,800
	X'mer Primary Feedes	40	LF	$ 42.00	1,680
	Total				486,087
				10%	48,609
					534,696
				15%	80,204
					614,900
				9.3%	57,186

	ALT-10 UPS for Network Equipment				**672,086**

	Alternate-11: Fit out				
	HVAC				
	Equipment				
	Dry Air Economizer 50,000 CFM	2	EA	$ 313,264.70	626,529
	Piping				
	Chilled Water Pipe, fittings, valves, insulation, equipment connection etc	1	LS	$ 20,709.60	20,710
	Condensate Drain Pipe, fittings, hangers, insulation etc	1	LS	$ 3,270.00	3,270
	Ducting and accessories				
	GI Duct	16,823	LB	$ 12.00	201,873
	FG Insulation	467	SF	$ 9.00	4,200
	Liner	140	SF	$ 8.49	1,188
	Grills & Diffusers	1	LS	$ 1,323.20	1,323
	FDs, FSDs, Louvers, Motorzed Dampers etc	1	LS	$ 1,337.20	1,337
	DD Control				
	Control Points	48	EA	$ 1,079.40	51,811
	Programming, training, tie in	1	LS	$ 2,865.60	2,866
	Miscellaneous				
	Shop Drawings & Submittals	1	LS	$ 2,000.00	2,000
	Identification and tagging	1	LS	$ 4,200.00	4,200
	Rigging	1	LS	$ 6,393.60	6,394
	Air & Water Balancing	1	LS	$ 5,328.00	5,328
	Testing and commissioning				By BNL
	ELECTRICAL	3,450	sf	$ 20.00	69,000
	Fit out of NSLS	3,450	ls	$ 40.00	138,000
	30" high access floor	3,450	sf	$ 30.00	103,500
	Mylar ACT	3,450	sf	$ 9.00	31,050
	Sprinklers	3,450	sf	$ 6.00	20,700
					1,295,278
				10%	129,528
					1,424,806
				15%	213,721
					1,638,527
				9.3%	152,383

	Alternate-11: NSLS II BES Fit out				**1,790,910**
	ALT-12A Fire Suppression FM-200 Network	1	ls	$ 48,000.00	48,000
	1000SF Network				10,000
					58,000
				10%	5,800
					63,800
				15%	9,570
					73,370
				9.3%	6,823

	ALT-12 Fire Suppression FM-200				**80,193**
	ALT-12B Fire Suppression FM-200 Tapes Storage	1	ls	$ 180,000.00	180,000
	3600sf Tapes				10,000
					190,000
				10%	19,000
					209,000
				15%	31,350
					240,350
				9.3%	22,353

	ALT-12 Fire Suppression FM-200				**262,703**
	ALT-13 RHIC/ATLAS - DIRECT COOLING INFRASTUCTURE				
	Piping				
	Direct Cooling Chilled Water Pipe, fittings, valves, insulation, equipment connection etc	1	ls	$ 80,000.00	80,000
					10,000
					90,000
				10%	9,000
					99,000
				15%	14,850
					113,850
				9.3%	10,588

	ALT-13 RHIC/ATLAS				**124,438**

9.2 NEPA Documentation

Environmental Protection Division

120 E. Fifth Ave. Bldg 860
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managed by Brookhaven Science Associates
for the U.S. Department of Energy

BROOKHAVEN NATIONAL LABORATORY

Memo

Date: June 23, 2016

To: S. Cannella

From: J. Higbie

Subject: NEPA Review of Proposal – Core Facility Revitalization

I have reviewed the following proposal as required by 10 CFR 1021, DOE's Rules for Implementing the National Environmental Policy Act.

"Core Facility Revitalization"; Sponsor: Facilities & Operations; BNL PI: S. Cannella.

The scope of this project is to renovate and revitalize B725. This project includes repurposing a significant portion of the building for use as a new computing facility with associated support space and new infrastructure. The proposed project will renovate approximately 64,000 gross square feet of first floor area. New modern and reliable cooling and power infrastructure shall be provided with capabilities for expansion and incremental growth. Robust back-up capabilities shall be provided for both power and cooling including provision for new emergency generators and other UPS capabilities. Existing life-safety systems shall be upgraded and select exterior building system replacements (roof/windows/etc.) shall be included. ADA accessibility enhancements shall be incorporated into the design. Additional aspects include:

☒ Utilizes existing controls and procedures	☐ Continuation of existing experiment / program.	☐ Similar to research previously performed at BNL	☒ Utilizes existing facilities/equipment.
☒ BNL processes & procedures exist to manage waste generation/disposal	☐ Consists primarily of information gathering, data analysis, technical advice to organizations	☐ Bench-scale analysis of samples	Location(s): ☐ Biology Department ☐ Medical Department ☐ Chemistry Department
☐ Utilizes standard biochemical and molecular biology procedures	☐ Utilizes approved Life Sciences protocols reviewed by appropriate committee: IBS, IACUC		☒ Facilities & Operations ☐ NSLS beamline ☐ NSRL beamline ☐ AGS beamline

The proposed action falls within the scope of the July 2012 Maintenance of BNL Facilities (BNL-522) categorical exclusion. This review has been coordinated with C. Polanish, NEPA Coordinator for the DOE Brookhaven Site Office. Please keep in mind that should the scope of a project change, it would need to be resubmitted for NEPA review. If you have questions about this review please do not hesitate to contact me at extension 5919.

cc: T. Green, D. Bauer, S. Ferrone, S. Hulse, C. Polanish, (DOE-BHSO), J. Remien, T. Sperry, M. Theisen,

EC51ER.16

9.3 Assessment of Security Risks

Laboratory Protection Division

BROOKHAVEN
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for the U.S. Department of Energy

www.bnl.gov

May 6, 2016

Mr. Steven Cannella
Modernization Project Office
Bldg. 134C
Brookhaven Avenue
Upton, New York 11973

SUBJECT: A Report on an Assessment of Security Risks

Dear Mr. Cannella,

This will serve as a confirmation that the Brookhaven National Laboratory has an Official Use Only document titled: A Report on an Assessment of Security Risks. This document, as well as the BNL Site Security Plan, has addressed risks to research facilities and security areas, including Property Protection Areas.

As part of the project's construction operations, initial security requirements for the project have been coordinated with the BNL Laboratory Protection Division and DOE BHSO. Brookhaven National Laboratory access requirements and procedures are written into the planned project contract and shall be followed by all project personnel accessing the site, including foreign nationals. The CM/GC will be required to fence the project site for both safety and security consideration and is subject to BNL police patrols.

If you have any questions, concerns or comments please feel free to contact me at extension 4691.

Sincerely,

L. Butera

Lenny Butera
Security Operations Manager
Laboratory Protection Division

LP: mm

9.4 Life Cycle Cost Analysis (LCCA)

Analysis of Alternatives

Core Facility Revitalization (CFR) Project
Brookhaven National Laboratory

Project No. 17-SC-73
Preliminary Report
July 2016

CHANGE LOG

Rev. No.	Date	Change Description	Pages Modified
Rev. 0		Initial Draft to support CD-1 approval.	N/A
Rev. 1	06/07/16	Preliminary Report	N/A
Rev. 2	07/26/16	Updated Report and Sensitivity Analysis	N/A

Analysis of Alternatives for the Core Facility Revitalization (CFR) Project

Prepared by HDR Architects
and
Brookhaven National Laboratory

Table of Contents

1.0 INTRODUCTION

The Core Facility Revitalization (CFR) project has been requested by the U.S. Department of Energy (DOE) as a new start in the FY2017 federal budget within the Science Laboratories Infrastructure program. The CFR Mission Need was approved September 1, 2015. In accordance with DOE Order 413.3B, this Analysis of Alternatives and associated Life Cycle Cost Analysis (LCCA) sets forth the descriptions, costs, and benefits of the alternatives analyzed for this project. The Office of Management and Budget (OMB) Circular A-94 guidelines apply to any analysis used to support Government decisions to initiate projects which would result in a series of measurable benefits or costs extending for three or more years into the future. The analysis is consistent with the cost Effectiveness, Constant Dollar analysis requirements of OMB Circular A-94 and is intended to support DOE's request for funding of the CFR project.

HDR Architects have been retained for the purpose of preparing the Life Cycle Cost Analysis for the project alternatives with the assistance of select SME's at the Brookhaven National Laboratory Site.

2.0 EXECUTIVE SUMMARY

The existing RHIC/ATLAS Computing Facility (RACF) currently occupies over 16,000 square feet of space in three rooms within Building 515 that was originally constructed in the 1960s and most recently expanded in 2009. The existing RACF facilities and infrastructure have finite capacities in terms of processing (computer cores), storage (petabytes of data), server space (racks), and power (kilowatts of electricity). The existing facility also has significant deficiencies due to its age, limited amount of usable area for data center equipment, rigid building configuration and marginally adequate power distribution and cooling systems.

Although the RACF is adequate to meet current demands, the facility will be unable to meet future requirements in terms of capacity and reliability due to the evolution of technology and data center operating standards. The overall computing capacity of the RACF is expected to decrease over the next ten years, beginning in FY 2018 and significantly decreasing after FY 2020. This overall reduction will be caused primarily by the limitations of Building 515 in terms of space and utilities. As server and tape storage equipment is replaced at the end of their useful lives (approximately four years), the racks to accommodate new equipment will need to be deployed with increased distances between them and of lower density to enable the necessary cooling and to account for limitations of the existing floor structure.

The data volume generated by the RHIC experiments and ATLAS are expected to increase three to six times over the next ten years and will require proportional increases

in computation and data storage capacities. These increases will drive increased requirements for space, power and cooling capabilities. The existing capacity limitations and facility deficiencies of the RACF will negatively impact the availability and reliability of computational support to NP and HEP funded research as well as other BNL programs. Failure to accommodate these projected increases will result in significant infrastructure capacity gaps, will significantly impede mission readiness of the RACF and will impose significant risks on research funded by NP and HEP, as well as other programs that may rely on BNL data storage and computational capabilities.

Due to the rapid evolution of computing technologies and the expected service life for the major mechanical and electrical components of a modern computing facility, a 25-year study was selected for this analysis. It is unreasonable to assume we can project the future of computing facilities 25-30 years from today. In contrast, a typical LCCA for a conventional office/laboratory structure would typically utilize a 50 year study period. A facility service life of 80 years is assumed in BNL's master site planning for all facilities.

This analysis compares the life cycle cost of remaining in B515, Alternative 1 – Maintain Status Quo or "Do Nothing", with the life cycle cost of renovating an existing BNL facility (Alternative 2) or constructing a new facility (Alternative 3). The categories of cash flow considered in the evaluation of the life cycle cost consisted of capital investment costs, energy costs, general maintenance and major equipment repair and replacement costs, deferred maintenance cost, and costs associated with opportunity loss and productivity gains. The critical deferred maintenance cost is the minimum initial repair costs required to bring the existing facility and existing mechanical systems up to acceptable standards and safe operating conditions.

The Life Cycle Cost analysis results for the three (3) cases analyzed are summarized as follows. The Building Life Cycle Cost program (BLCC 5.3-15) developed by NIST was used for this analysis.

	Alternative 1 Maintain Status Quo (Base Case)	Alternative 2 Renovate Existing Facility	Alternative 3 Construct New Facility
Total Life Cycle Cost	$109,328,869	$125,182,303	$148,144,853

Table 1 - Life Cycle Cost Analysis Present Value Results

The present value of costs, average annual cost, simple payback period and rate of return on investment are the recommended measures to be used to gauge the economic performance of the alternatives. Summarized as follows are the estimated capital investment, average annual operating cost savings, simple payback period and rate of return on investment for Alternatives 2 and 3 compared to the Base Case (Alternative 1).

	Alternative 2 Renovate Existing Facility	Alternative 3 Construct New Facility
Capital Investment	$67,922,000	$106,141,000
Net Cost Saving	-$15,853,434	-$38,815,984
Simple Payback	25 years	Outside the study (>25 years)
Adjusted Internal Rate of Return	0.75%	- 0.53%

Table 2 - Simple Payback and Return on Investment

Appendix C contains a complete comparative analysis of the two alternatives to the base case. The analysis indicated that Base Case (Alternative 1) yields economic benefits. The initial investment of $8,420,241 would result in cost savings of $15,853,434 over Alternative -2 (Renovate Existing Facility) and $38,815,984 over Alternative-3 (New Facility) over a 25-year period. It is important to note that the significant potential benefits gained by other DOE programs at the BNL site are not addressed or quantified in this study.

A sensitivity study was also performed to determine the uncertainty of this outcome. The objectives of the sensitivity analyses were to: (a) account for uncertainty in certain key parameters, and (b) determine which alternative was more cost-effective under different assumptions. The sensitivity analysis consists of six scenario-based analyses. The results of the Sensitivity Study, shown in Table 3 below, indicate that in all scenarios, the Maintain Status Quo (Base Case) has the lowest LCC when compared to the other Alternative Cases (Alternative 2 and 3).

Analysis Scenario	Parameter Changed from Base Case Scenario	Lowest LCC Alternative	Maintain Status Quo	Renovation			New Facility		
			NPV	NPV	Payback Period	Discounted Payback Period	NPV	Payback Period	Discounted Payback Period
			[$M]	[$M]	[years]	[years]	[$M}	[years]	[years]
Base Case	None	Maintain Status Quo	$109.3	$125.2	25 years	None	$148.1	None	None
A	Decreased Discount Rate to 1.5%	Maintain Status Quo	$116.1	$128.9	25 years	None	$149.9	None	None
B	Increased Discount Rate to 2.9%	Maintain Status Quo	$94.6	$116.9	25 years	None	$143.9	None	None
C	Decreased Capital Costs by 20%	Maintain Status Quo	$107.6	$112.2	22 years	None	$131.0	25 years	None
D	Increased Capital Costs by 20%	Maintain Status Quo	$111.1	$138.2	None	None	$165.3	None	None
E	Decreased O&M & Repair Costs by 20%	Maintain Status Quo	$105.7	$119.9	25 years	None	$142.4	None	None
F	Decreased Productivity Loss	Maintain Status Quo	$109.3	$131.5	None	None	$154.4	None	None

Table 3 - Summary of Sensitivity Study Results

3.0 LIFE CYCLE COST ANALYSIS

3.1 Summary of Approach

When the purpose of a life cycle cost analysis is to evaluate cost-effectiveness, lease purchase, internal government investment, and asset sales rather than to primarily assess energy-related savings, the analysis is subject to Office of Management and Budget (OMB) Circular A-94. The Building Life-Cycle Cost (BLCC5 5.3-15) software, developed by the National Institute of Standards and Technology (NIST) contains modules designed to perform life-cycle-cost analyses subject to OMB Circular A-94 and was used to perform this analysis.

LCC estimates in present dollars; that is all future costs are discounted to a present value as of the base date and summed.

Section 3.2 Alternatives Description, summarizes the multiple strategies considered for addressing the capability gap and supporting the mission need. Two alternatives were identified for final/detailed evaluation. Alternative 2 – Renovate B725 and Alternative 3 – Construct a new facility. The purpose of this analysis was to perform life cycle cost analyses comparing these two alternatives with the base case of operating the existing B515 RACF (Alternative 1 – Maintain Status Quo or "base case") for the next 25 year time period. Alternative 1 includes the minimum initial repair costs (critical deferred maintenance and compliance modifications) required to maintain the computational facilities in building 515 in a minimally functional state but does not address the capability gap detailed in the sections above.

3.2 Alternatives Description

Beginning prior to the spring of 2014, preliminary planning efforts were initiated by BNL to address the growing capability gap at the B515 RHIC/ATLAS Computing Facility. Lists of potential alternatives were identified as well as potential locations. The alternatives considered can generally be organized into five (5) categories. A summary of each is presented below.

Category 1 – Maintain Status Quo (do nothing): Under this option, the use of the existing RACF at B515 would be continued to the greatest extent possible. The required deferred maintenance and compliance upgrades would be performed. Substantial productivity loss and programmatic opportunity loss would be realized. This category of alternatives does not address the capability gap or contribute to the support of the HEP/NP mission need.

Category 2 – Renovate Existing Facilities at BNL: This category of alternatives involves the renovation and/or expansion of existing available facilities on the BNL site.

Expand and Renovate B515 (The Existing RACF):
Similar to category 1, B515 would require the immediate execution of significant compliance upgrades and infrastructure replacement. B515, originally constructed in 1966, has significant limitations due to inadequate power/cooling infrastructure and physical configuration. Adequate

space does not exist to construct a new modern data center addition with required office space that would need significant mechanical and programmatic space nor accommodate future growth needs. It is highly unlikely the existing facility could be re-configured to meet current federal DCOI requirements. Siting of the required exterior infrastructure (Generators and electrical gear) would require the elimination of significant parking capabilities in what is already a problematic area of the site. As this is a fully operational critical facility, phased construction at this facility would add years to the project execution schedule and negatively impact research. This option was not considered for additional study.

Renovate B725:
B725, originally constructed in 1980 with multiple significant additions from 1985 through 1995, served as the former home of the NSLS-I program. A sound building containing approximately 155,000 GSF, the facility contains adequate space for all of the present and future computing and support space needs. The Building is ideally located with respect to available utility infrastructure and proximity to the users and researchers. The facility contains significant existing quality office space (approx. 38,000 GSF) and other space easily configured for use by other BNL research groups. Re-use and re-purpose of this facility supports federal "Freeze the Footprint" principles with respect to office space. Significant investment in hazardous material remediation and maintenance has been made over the past several years. Renovating this facility would avoid adding significant vacant space to the BNL inventory. The CFR Project would renovate approximately 50% of the first floor gross square footage of this facility to address the capability gaps noted above. This option will be considered for additional study.

Consider other BNL Facilities for Renovation:
Several other existing facilities/locations were considered. Both B462 and B477 were preliminarily analyzed but rejected as candidates for renovation based on their age (both constructed in 1945), poor proximity to BNL power and cooling infrastructure, inadequate size to meet the present and future program requirements, and logistical issues with building access and co-location with researchers/users. This option was not considered for additional study.

Category 3 – Construct New Building at BNL (Line Item Funding): This option involves the utilization of Line Item funding for the construction of a new building to house the computing facility scope plus future expansion capabilities on the BNL site. Included in the scope is approximately 20,000 SF required to house the required supporting technical and research staff.

Alternative strategies were considered with respect to satisfying the one-for-one demolition space offset requirement associated with the construction of new federal facilities. At present, BNL does not have adequate square footage available for immediate demolition without considering the demolition of the vacated B725 facility. A vacant B725 would also remain a significant liability on the BNL site with respect to carrying costs. There are also significant advantages to re-use of the B725 site with respect to site utility access (Power, Fiber, and Chilled Water). Therefore, it is determined that the option to construct a new facility at BNL will include the required demolition of the existing B725 facility. This option will be considered for additional study.

Category 4 – Construct New Building at BNL (Alternative Financing): This category of alternatives involves the construction of a new building to house the Computing Facility base scope on existing land contiguous to or in close proximity to the BNL site. Also included is the approximately 20,000 gsf required to house the required supporting technical and research staff. In both cases, fixed lease payments would be made to a 3rd party developer.

These options are problematic because of the following reasons -

a. Locating the facility and staff remote to the BNL site will result in a significant productivity loss.
b. Considering the Long Island real estate market, it is likely that a suitable developer does not exist with the capabilities and desire to operate and maintain a facility such as the RACF nor would they want to assume the risk associated with the facility reliability requirements. Therefore, the only potential path forward with respect to alternative financing would to be to identify a developer willing to construct a "white box", leaving the cost of all "tenant improvements" including the sophisticated electrical and mechanical systems, their maintenance, and strict performance requirements the responsibility of BNL.
c. OMB approval of a long term "tenant/landlord" lease agreement of this nature is highly unlikely.

This category of options will not be considered for further evaluation.

Category 5– Establish Capability at Another Location: This category considered two options.

Option A – Establish the capability at another national laboratory computing facility. *Option B* – Establish the capability via private Cloud Computing.

Option A will not be considered for further evaluation as The RACF computing facility will require significant additional infrastructure, space, and hardware which is not available at this time at other institutions and would require significant investment at the respective sites. This is particularly relative to the significant day one data storage needs (80PB "+") of the RHIC and ATLAS programs. Adequate capacity dos not exist at this time. In addition, the necessary expertise to support the mission need also resides at BNL. Significant cost and effort would be required to develop this expertise elsewhere and establish the efficient communication/data transfer protocols required. There is also high risk associated with outsourcing operational responsibilities away from the existing RACF team.

Option B establishes the computing capabilities via cloud computing services. While the first four alternatives lend themselves to an objective LCCA, private cloud computing options remain less defined, highly case sensitive, technically problematic, and subject to rapid change in the market due to economic pressures. Prior DOE studies have concluded that cloud computing is more expensive than DOE HPC facilities and demonstrated poor performance with

communication and I/O intensive scientific applications. These findings are detailed in the Magellan Report on Cloud Computing for Science, Dec 2011.

Progress is evident over the last few years. Data storage cost has dropped to approximately $0.03 per gigabyte per month. Alternative "SPOT" service agreements for computing have significant cost savings over "reserved" computing service capabilities by a factor of approximately 3. This "bidding" option is viable if programs are willing and capable to run workloads that can tolerate unexpected terminations. These rates have been monitored by BSA and remain constant for over one year. However, the total costs for compute and storage capabilities deployed at the RHIC/ATLAS Computing Facility remain approximately one-half the cost of comparable cloud-based services and when calculated for the entire RACF computing capability, they represent a significant savings to the programs. These calculations as presented and researched by Dr. Michael Ernst, former Director of the RACF, are summarized below:

		FY15 Cost	**Total 3-Yr. Cost**	
Procure In-House Capabilities	HEP/NP 3-Yr. Cost for In-house Infrastructure (7 PB storage + 10-15% of total compute capability)	$1,238,000	$1,238,000	
Procure Cloud Based Capabilities	3-Yr. Cost of AWS Data Storage (7 PB @ $0.03/GB/Month)	$2,030,000		
	3-Yr. Cost of AWS SPOT Computing Services (10-15% of total compute capability)	$225,000		
			$2,255,000	
			$1,017,000	**Total 3-Yr. Savings In-house vs. Cloud services**

Note: Calculation based on approximately 10-15% of the total HEP/NP computing and data storage requirement. Total 3-Yr. savings for entire facility capability is approximately $10,170,000 - $8,644,500.

Table A - In-House Vs. Cloud Computing Capabilities

The expectation is that cloud computing and storage costs should continue to decrease. That has not been the case for the last 2 years. Predicting cloud costs for the next 25 years and making long term financial decisions based on little historic data extremely risky. There has not been adequate historic cost data to analyze nor documented success to validate the long term commitment of significant large scientific research program funding, such as that which is associated with the RHIC/ATLAS computing mission.

Commitment to cloud computing capabilities is somewhat problematic as it is essentially remains an all or nothing approach. DOE Program funding is generally based on short term commitments. These commitments are subject to continuous change brought on by economic factors. Once a program is committed, particularly with respect to data storage, it is costly to move to back to any form of institutionally based computing infrastructure. Cloud computing is a long term commitment with significant risk tied directly to the ability to maintain consistent, long term funding. It is subject to volatility in the private cloud services market and does not provide scientific programs the opportunity to economically manage infrastructure to meet changing needs.

This category of options will not be considered for further evaluation.

3.3 Analysis Input

Input data for the BLCC software is organized into several levels. Overall project level parameters and multiple input parameter levels for each alternative are considered.
Project level parameters apply to each alternative. The multiple input parameters are specific to individual alternatives. The overall parameters, specific alternative parameters, and the analysis results are discussed below.

3.4 Overall Project Parameters

The table below summarizes the overall project level parameters. The study period is the length of the time covered by the economic analysis. The base date is the beginning of the first year of the study period and service date is the point in time during the study period when the alternative is put into use. All costs, other than capital investment, which occur prior to the service date are considered to be mutually exclusive and are therefore not addressed.

Parameter	**Value**
Discounting convention	End-Of -Year
Analysis Type	Constant Dollar
Real Discount Rate	1.9% as per OMB Circular A-94
Base Date	October 1, 2016
Service Date	October 1, 2020
Study Period	25 Years
Electric Cost – BNL Site	$0.07 / KWh
Fuel Cost (Blended Rate)	$2.57 / SF
Water Cost (Usage + Disposal)	$.50 / 1,000 Gal.
Average Annual Salary (RACF) Total Annual Salaries	$254,540 $6,877,681
Energy Price Escalation Rates	BLCC5.3-15 software

Table 4 - Overall Project Parameters

Electricity, natural gas, and fuel oil are the major energy sources used at BNL. Current unit costs are presented above. Electrical costs and fuel cost is a blended rate. These per unit energy costs are escalated throughout the study period using the DOE recommended values, which are internal to the BLCC software. The energy price escalation rate is the projected rate of price increase above the projected general rate of inflation.

Average annual salary reflects the current (FY2016) RHIC/ATLAS Computing Facility staffing level of 27 individuals. The calculation is fully burdened.

3.5 Alternative-specific Parameters

The categories of cash flow data required for evaluation of the life cycle cost of each alternative consists of non-recurring capital investment costs such as construction or renovation; energy consumption costs; general maintenance and major equipment repair and replacement costs; productivity and opportunity losses; demolition costs to remove excess facilities (i.e. one-for-one replacement for new construction); and future demolition costs of the new asset. The initial costs of critical deferred maintenance and compliance modifications represent the work which must be completed by BNL within the next year or two to keep the facility operational and safe. They are applicable to the base case. The specific constant dollar value for these parameters used for each alternative, as applicable, is presented in the discussion of each alternative.

Cost figures are based on conceptual design estimates and new building construction costs at BNL, historical data for energy consumption at BNL, actual BNL employee salary information, and maintenance and repair costs as reported by The Whitestone Building Maintenance and Repair Cost Reference 2014-2015.

Energy and Water Costs - The actual electric and steam consumption was taken from metered data (three year average) for the existing facility. Alternative 2 and 3 energy consumption estimates are based on incorporating sustainable design requirements increase energy efficiency by 40% over the base case (Alternative 1). This is a conservative estimate as P.U.E. requirements for the new facility approach half of the current facilities actual P.U.E. factor. The DOE escalation factors in the BLCC-5.3-13 were used to determine the energy costs based on estimated usage.

Operations, Maintenance and Repair Costs - Maintenance and repair costs were estimated based the distribution of costs in the Whitestone Building Maintenance and Repair Cost Reference (2014-2015) for a “Data Center, Tier III”. Age-adjusted maintenance and repair costs were required and developed as the CFR LCCA is a 25 year study period. Whitestone data is presented as a 50 year cost summary. An analysis of the cost per GSF by system resulted in a lower total M&R cost as it will be assumed all major equipment components will be at the end of their useful life and will not be replaced. This is applied consistently to both the new building and renovation alternative. M& R costs were also adjusted utilizing the Whitestone Local Cost Index for our area.

Incremental activities that are not captured by the Whitestone cost profile and are in addition to the base maintenance and repair cost projections were also included for the alternatives where appropriate. These include upkeep of LEED Certification; exterior site maintenance and operations activities involving snow removal, landscaping, on-going site improvements such as new sidewalks and paving; waste removal; additional training of HVAC technicians required for new complex building equipment and systems; and additional administrative and operational costs involving management systems implementation and reporting (DCIM).

Custodial costs were estimated as two full time employees for all alternatives. The salary for one additional new building manager was included in Alternative 2 – the new building.

Productivity Gain - The productivity analysis was based on a scientific staff of 27 researchers assigned to the RACF. A $254,540 weighted average annual salary was calculated for the scientific staff including benefits, overhead, and burden based on interviews with the scientific departments. A conservative estimate of a 10% productivity gain over Alternative 1 for the renovation (Alternative 2) and new building (Alternative 3) was used as described below.

Higher utilization of space, equipment, and people. The project will either transform or create space that will become the most flexible and desirable computational spaces on the BNL site with the most reliable support systems. The result will be an increased utilization of space and equipment and therefore increased productivity. + 5%

Improved facility conditions, environment, and life safety. The work will provide facilities that are modern and reliable. The facility will have improved lighting systems, temperature and humidity control. The project shall provide for energy efficiency and efficient use of potable water. The life safety upgrades will provide for a safe work environment and promote health and well-being. All of which will result in minimizing equipment failure and down time. + 3%

- Improved employee morale and ability to attract and retain the most promising and productive researchers. The current occupants will experience an improved sense of confidence in their infrastructure and built environment. The current facility and working conditions reduce employee morale and motivation and negatively impact the ability to hire and retain the brightest and most productive researchers. The existing facilities are approximately 45 years old. Although well maintained, they convey the false message to employees, and visiting scientists, that research conducted in these facilities is not very important. This inferred lower expectation negatively impacts productive research output and leads to less valid data produced for a given investment. Corporate America has realized that modern research facilities empower employees and convey the message of expected results. +2%

Productivity Loss – Productivity loss was applied only to Alternative 1
Catastrophic failure does remain a significant risk with Alternative 1 due to the lack of adequate back-up capabilities/services. However, no catastrophic failures were calculated in this life

cycle cost analysis. The base case does include the initial cost of the critical deferred maintenance and upgrades immediately required to keep the existing RACF "functional".

A conservative 5% per year productivity loss was applied to the base case as calculated from the RACF weighted average annual salary and staffing numbers identified above. This is primarily due to the frequent interruptions attributed to the completion of the required deferred maintenance and the on-going inability to execute concurrent maintenance tasks. Other contributing factors include the inability to efficiently deploy equipment due to the existing B515 power and cooling infrastructure limitations and space constraints.

Opportunity Loss - An opportunity loss was calculated for the base case (Alternative 1) due to the difficulty of performing research in the current facility and inability to meet future computing requirements. Failure to address the existing deficiencies will impact BNL's ability to retain scientific programs and could be expected to result in a loss of a portion of the research over time. This is due to the increasing number of interruptions attributed to ageing infrastructure and inability to expand the RACF computing capabilities. The significant planned growth of the RACF's capabilities is detailed in the CFR Conceptual Design Report.

The annual dollar value of the research performed (The RACF annual budget) in the study area is approximately $15M. It is estimated based on future needs and decreasing capabilities that beginning in 2021, an opportunity loss of approximately 4% per year for data storage and 8% per year for computing capabilities and will be realized. This is consistent with the RACF projections for future computing and data storage requirements. A cumulative estimated opportunity loss of 12% per year of the RACF annual program budget, beginning at the study's service date, was applied to the analysis of Alternative 1.

Replacement Costs - Replacement costs were not considered for this analysis because of the 25-year study period. No new systems and components would be required for the new building or the renovation alternative based on an expected 25-30 year service life of the computing facility and a 25 year analysis.

Residual Value - The residual value of a component is its remaining value at the end of the study period. The new building (Alternate 3) residual value is estimated at approximately 1/3 of the original construction cost of the building which reflects the future value of the core and shell of the building. Other building systems and components such as HVAC systems, lighting and ceilings, electrical distribution, roofing, plumbing fixtures, conveying systems, and general finishes/furniture will be near the end of their service life.

Based on an estimated 80 year service life for the facility, the residual value of B725 will be relatively low. A value of 1/8 of the replacement value will be assigned for the purpose of this study.

Demolition Costs - Demolition Costs were included at the end of the 25 year study period for all alternatives.

4.0 SUMMARY OF SELECTED ALTERNATIVES AND INPUT DATA

A summary of the alternatives and input data for each of the alternatives follows.

Alternative 1 - Base Case – Maintain Status Quo (Do nothing): Under this option, the use of the existing RACF at B515 would be continued. The required critical deferred maintenance and compliance upgrades would be performed. The actual electric is taken from metered data (FY 2015) for the existing computing facility. Support space usage is based on historic square foot data for BNL office and support space. Maintenance costs were calculated for the base case using the average actual cost for the last 3 fiscal years. Custodial costs were estimated as 75% of one full time employee. An opportunity loss (See detailed discussion) of 12 % per year of the research performed in the study area was assumed. An annual productivity loss (See detailed discussion) calculated as 5% of the annual research staff labor cost was assumed.

1. Service date October 2020
2. Annual Electrical Consumption, Data Center – 24,714,041 kWh (FY15)
3. Annual Electric Consumption, Support Space – 495,040 kWh
4. Annual Fuel Consumption – 5,461 MBTU
5. Annual Fuel Cost – $43,690
6. Annual Water Usage – 680,000 Gal. (40 Gal/SF/Yr.)
7. Required Critical Deferred Maintenance - $8,420,241 (FY 15)
8. Annual Maintenance - $882,393 (Avg. last 3 FY)
9. Annual Custodial - $106,798 (Actual)
10. RHIC/ATLAS Annual Research Opportunity Loss - $1,800,000 (12% / Yr.)
11. Annual Research Productivity Loss – $343,269 / Yr. (-5%)
12. Demolition of the Existing 515 computing facility, mechanical space, and associated support space at end of 25-year study period – $2,961,950

Alternative 2 – Renovate Existing Facilities at BNL: This alternative involves the renovation of existing available facilities at B725. Based on conceptual design efforts during FY 2016, approximately 54,998 SF of the buildings first floor would be renovated including approximately 20,800 SF of dedicated computing space. Approximately 20,000 SF of existing second floor office area required to house supporting technical and research staff will be occupied. The data center electric and fuel consumption will be modeled based on a preliminary program and new DOE energy efficiency/PUE requirements. Support space usage is based on an anticipated 30% improvement on square foot historic data. Annual maintenance costs are estimated using

Whitestone Research Data (See detailed discussion). Custodial costs are estimated as one full time employee. A conservative 10% annual productivity gain was assumed (See detailed discussion). The future demolition cost was also estimated at $50/gsf and escalated to the base date.

1. Service date October 2020
2. Annual Electrical Consumption, New Data Center – 24,125,040 kWh
3. Annual Electric Consumption, Support Space – 495,000 kWh
4. Annual Fuel Consumption –24,094 MBTU
5. Annual Fuel Cost – $192,750
6. Annual Water Usage – 560,000 Gal. (30% improvement over Base Case of 40 Gal/SF/Yr.)
7. Renovation Cost – $67,922,000
8. Annual Maintenance - $1,300,853
9. Annual Custodial - $142,397 (1 FTE)
10. Annual Research Productivity Gain – $687,258 / Yr. (10%)
11. Residual Value (12.5% of Construction cost) = $5,236,786
12. Pro-rated share of the future demolition of the 725 facility at end of study period – $3,720,000 (48% of 155,000 GSF @ $50/GSF)

Alternative 3 – Construct New Building at BNL (Line Item Funding): This alternative involves the construction of a new 71,488 gsf building to house the approximate 20,800 SF computing facilities base scope plus additional expansion capability on the BNL site. Also included is the approximately 20,000 SF required to house the required supporting technical and research staff. The total project cost of the new building is estimated and includes project management, engineering, escalation to midpoint of construction, etc. A residual value of approximately 1/3 of the original construction cost of the building which reflects the future value of the core and shell of the building. Other building systems and components such as HVAC systems, lighting and ceilings, electrical distribution, roofing, plumbing fixtures, conveying systems, and general finishes/furniture will be near the end of their service life. Annual maintenance costs were estimated using Whitestone Research Data. The data center electric and fuel consumption will be modeled based on a preliminary program and new DOE energy efficiency requirements. Support space usage is based on an anticipated 30% improvement on square foot historic data Custodial services were estimated at two full time employees. A conservative 10% productivity gain was used as described previously. The cost of the required one-for-one demolition to offset the new building is included at $50/gsf, escalated to the base date. The future demolition cost was also estimated at $50/gsf and escalated to the base date.

1. Service date October 2020
2. Annual Electrical Consumption, New Data Center – 24,125,000 kWh
3. Annual Electrical Consumption, support space - 495,600 kWh
4. Annual Fuel Consumption, New Building –24,094 MBTU
5. Annual Fuel Cost, New Building – $192,750
6. Annual Water Usage, New Building – 560,000 Gal.
7. Total Project Cost – $106,141,000 (Incl. one-to-one demolition)
8. Demolition of New Asset @ end of life - $3,574,000
9. Annual Maintenance, - $1,300,853
10. Annual BNL Site Support Costs - $125,000
11. Annual Custodial - $142,397 (1 FTE)
12. Annual Research Productivity Gain - $687,258 / Yr. (10%)
13. Residual Value (33.33% of the total project cost) = $35,376,795

5.0 SUMMARY OF RESULTS

The present value of costs, average annual cost, simple payback period and rate of return on investment are the recommended measures to be used to gauge the economic performance of the alternatives. Summarized as follows are the estimated capital investment, average annual operating cost savings, simple payback period and rate of return on investment for Alternatives 2 and 3 compared to the Alternative 1 (Base Case).

	Alternative 1 Maintain Status Quo (Base Case)	Alternative 2 Renovate Existing Facility	Alternative 3 Construct New Facility
Total Life Cycle Cost	$109,328,869	$125,182,303	$148,144,853

Table 5 - Life Cycle Cost Analysis Present Value Results

	Alternative 2 Renovate Existing Facilities	Alternative 3 Construct New Facility (Line Item)
Capital Investment	$67,922,000	$106,141,000
Net Cost Saving	-$15,853,434	-$38,815,984
Simple Payback	25 years	Outside the study (>25 years)
Adjusted Internal Rate of Return	0.75%	- 0.53%

Table 6 - Simple Payback and Return on Investment

The analysis indicated that Base Case (Alternative 1) yields economic benefits. The initial investment of $8,420,241 would result in cost savings of $15,853,434 over Alternative -2 (Renovate Existing Facility) and $38,815,984 over Alternative-3 (New Facility) over a 25-year period. Appendix C contains a complete comparative analysis of the two alternatives to the base case.

6.0 SENSITIVITY STUDY

Estimates of benefits and costs are typically uncertain because of imprecision in both underlying data and modeling assumptions. The effects of this uncertainty were analyzed.

Major assumptions were varied and the outcomes were recomputed to determine how sensitive the outcomes are to changes in the assumptions. The objectives of the sensitivity analyses were to: (a) account for uncertainty in certain key parameters, and (b) determine which alternative was more cost-effective under different assumptions. The sensitivity analyses consist of six scenario-based analyses. In each of the six scenarios, only the value of the key parameter of interest is changed, and the values of all other parameters assumed in the Base Case were held constant. Quantitative results are shown in Table 7

A. Lower Discount Rate

The purpose of this scenario is to test sensitivity of the Base Case results to uncertainty associated with general inflation and the time value of money. The 30 year nominal discount rate is used to adjust each annual cash flow throughout the period of analysis to reflect the time-value of money. This scenario decreases the assumed annual discount rate from 1.9% to 1.5%.

B. Higher Discount Rate

The purpose of this scenario is to test sensitivity of the Base Case results to uncertainty associated with general inflation and the time value of money. The 30 year nominal discount rate is used to adjust each annual cash flow throughout the period of analysis to reflect the time-value of money. This scenario increases the assumed annual discount rate from 1.9% to 2.9%.

C. Reduced Capital Costs

The purpose of this scenario is to test the sensitivity of the Base Case results to the assumed costs to construct/renovate the facilities. This scenario reduces estimated construction/renovation costs by 20% to determine the outcome if an over estimate of construction/renovation costs was assumed in the Base Case.

D. Increased Capital Costs

The purpose of this scenario is to test the sensitivity of the Base Case results to the assumed costs to construct/renovate the facilities. This scenario increases estimated construction/renovation costs by 20% to determine the outcome if an under estimate of construction/renovation costs was assumed in the Base Case.

E. Decreased O&M and Repair Costs

The purpose of this scenario is to test the sensitivity of the Base Case results to the assumed costs for annually recurring maintenance and repair. This scenario decreases estimated O&M and repair costs by 20% to determine the outcome if an over estimate of O&M and repair costs was estimated in the Base Case.

F. Decreased Productivity Loss

The purpose of this scenario is to test the sensitivity of the Base Case results to projected increases in productivity associated with updated work areas and collocation and consolidation of technical functions. This scenario decreases the estimated cost of productivity gain by 50% (or 5% productivity gain) for alternative 2 and 3 to determine the outcome if an over-estimate of productivity loss was assumed for Alternative 1 in the Base Case.

Analysis Scenario	Parameter Changed from Base Case Scenario	Lowest LCC Alternative	Maintain Status Quo	Renovation			New Facility		
			NPV	NPV	Payback Period	Discounted Payback Period	NPV	Payback Period	Discounted Payback Period
			[$M]	[$M]	[years]	[years]	[$M}	[years]	[years]
Base Case	None	Maintain Status Quo	$109.3	$125.2	25 years	None	$148.1	None	None
A	Decreased Discount Rate to 1.5%	Maintain Status Quo	$116.1	$128.9	25 years	None	$149.9	None	None
B	Increased Discount Rate to 2.9%	Maintain Status Quo	$94.6	$116.9	25 years	None	$143.9	None	None
C	Decreased Capital Costs by 20%	Maintain Status Quo	$107.6	$112.2	22 years	None	$131.0	25 years	None
D	Increased Capital Costs by 20%	Maintain Status Quo	$111.1	$138.2	None	None	$165.3	None	None
E	Decreased O&M & Repair Costs by 20%	Maintain Status Quo	$105.7	$119.9	25 years	None	$142.4	None	None
F	Decreased Productivity Loss	Maintain Status Quo	$109.3	$131.5	None	None	$154.4	None	None

Table 7 - Summary of Sensitivity Study Results

The results of the Sensitivity Study show that in all scenarios, the Maintain Status Quo (Alternative 1) has the lowest LCC when compared to the Renovation (Alternative 2) and new facility (Alternative 3) options.

APPENDIX A
Lowest Life Cycle Cost Analysis Report

NIST BLCC 5.3-15: LOWEST LCC

Consistent with Federal Life Cycle Cost Methodology in OMB Circular A-94

General Information

File Name:	C:\Users\nkhanna\BLCC 5\projects\Projects\BNL Study.xml
Date of Study:	Tue Jul 26 11:56:23 MDT 2016
Analysis Type:	OMB Analysis, Non-Energy Project
Analysis Purpose:	Cost Effectiveness, Lease Purchase, Government Investment or Asset Sale Analysis
Project Name:	BNL Study
Project Location:	New York
Analyst:	Nidhi Khanna
Base Date:	October 1, 2016
Service Date:	October 1, 2020
Study Period:	29 years 0 months (October 1, 2016 through September 30, 2045)
Discount Rate:	1.9%
Discounting Convention:	End-of-Year

Lowest LCC

Comparative Present-Value Costs of Alternatives

(Shown in Ascending Order of Initial Cost, * = Lowest LCC)

Alternative	Initial Cost (PV)	Life Cycle Cost (PV)	
Alternative 1 - Base Case	$8,420,241	$109,328,869	*
Alternative 2 - Renovate	$67,922,000	$125,182,303	
Alternative 3 - New Building	$106,141,000	$148,144,853	

APPENDIX B
Life Cycle Cost Analysis Summary Report

NIST BLCC 5.3-15: SUMMARY LCC

Consistent with Federal Life Cycle Cost Methodology in OMB Circular A-94

General Information

File Name:	C:\Users\nkhanna\BLCC 5\projects\Projects\BNL Study 060716.xml
Date of Study:	Tue Jul 26 12:36:17 MDT 2016
Analysis Type:	OMB Analysis, Non-Energy Project
Analysis Purpose:	Cost Effectiveness, Lease Purchase, Government Investment or Asset Sale Analysis
Project Name:	BNL Study
Project Location:	New York
Analyst:	Nidhi Khanna
Base Date:	October 1, 2016
Service Date:	October 1, 2020
Study Period:	29 years 0 months (October 1, 2016 through September 30, 2045)
Discount Rate:	1.9%
Discounting Convention:	End-of-Year

Discount and Escalation Rates are REAL (exclusive of general inflation)

ALTERNATIVE 1: BASE CASE

LCC Summary

	Present Value	Annual Value
Initial Cost Paid By Agency	$8,420,241	$380,370
Energy Consumption Costs	$41,786,760	$1,887,644
Energy Demand Costs	$0	$0
Energy Utility Rebates	$0	$0
Water Usage Costs	$6,230	$281
Water Disposal Costs	$0	$0
Annually Recurring OM&R Costs	$57,396,925	$2,592,806
Non-Annually Recurring OM&R Costs	$1,718,713	$77,640
Replacement Costs	$0	$0
Less Remaining Value	$0	$0
	---	---
Total Life-Cycle Cost	$109,328,869	$4,938,741

ALTERNATIVE 2: RENOVATE

LCC Summary

	Present Value	Annual Value
Initial Cost Paid By Agency	$67,922,000	$3,068,258
Energy Consumption Costs	$44,278,522	$2,000,205
Energy Demand Costs	$0	$0
Energy Utility Rebates	$0	$0
Water Usage Costs	$5,131	$232
Water Disposal Costs	$0	$0
Annually Recurring OM&R Costs	$13,852,249	$625,751
Non-Annually Recurring OM&R Costs	$2,158,582	$97,510
Replacement Costs	$0	$0
Less Remaining Value	-$3,034,181	-$137,064
	---	---
Total Life-Cycle Cost	$125,182,303	$5,654,892

ALTERNATIVE 3: NEW BUILDING

LCC Summary

	Present Value	Annual Value
Initial Cost Paid By Agency	$106,141,000	$4,794,735
Energy Consumption Costs	$44,279,428	$2,000,246
Energy Demand Costs	$0	$0
Energy Utility Rebates	$0	$0
Water Usage Costs	$5,131	$232
Water Disposal Costs	$0	$0
Annually Recurring OM&R Costs	$16,142,658	$729,216
Non-Annually Recurring OM&R Costs	$2,073,864	$93,683
Replacement Costs	$0	$0
Less Remaining Value	-$20,497,228	-$925,927
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Total Life-Cycle Cost	$148,144,853	$6,692,186

APPENDIX C
Comparative Analysis Report

NIST BLCC 5.3-15: COMPARATIVE ANALYSIS

Consistent with Federal Life Cycle Cost Methodology in OMB Circular A-94

Base Case: Alternative 1 - Base Case

Alternative: Alternative 2 - Renovate

General Information

File Name:	C:\Users\nkhanna\BLCC 5\projects\Projects\BNL Study 060716.xml
Date of Study:	Tue Jul 26 13:37:10 MDT 2016
Project Name:	BNL Study
Project Location:	New York
Analysis Type:	OMB Analysis, Non-Energy Project
Analysis Purpose:	Cost Effectiveness, Lease Purchase, Government Investment or Asset Sale Analysis
Analyst:	Nidhi Khanna
Base Date:	October 1, 2016
Service Date:	October 1, 2020
Study Period:	29 years 0 months(October 1, 2016 through September 30, 2045)
Discount Rate:	1.9%
Discounting Convention:	End-of-Year

COMPARISON OF PRESENT-VALUE COSTS

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	$8,420,241	$67,922,000	-$59,501,759
Future Costs:			
Energy Consumption Costs	$41,786,760	$44,278,522	-$2,491,763
Energy Demand Charges	$0	$0	$0
Energy Utility Rebates	$0	$0	$0
Water Costs	$6,230	$5,131	$1,099
Recurring and Non-Recurring OM&R Costs	$59,115,638	$16,010,831	$43,104,807
Capital Replacements	$0	$0	$0
Residual Value at End of Study Period	$0	-$3,034,181	$3,034,181
Subtotal (for Future Cost Items)	$100,908,628	$57,260,303	$43,648,325
Total PV Life-Cycle Cost	$109,328,869	$125,182,303	-$15,853,434

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings	$40,614,144
- Increased Total Investment	$56,467,578
Net Savings	-$15,853,434

Savings-to-Investment Ratio (SIR)

SIR = 0.72

SIR is lower than 1.0; project alternative is not cost effective.

Adjusted Internal Rate of Return

AIRR = 0.75%

AIRR is lower than your discount rate; project alternative is not cost effective.

Payback Period

Estimated Years to Payback (from beginning of Service Period)

Discounted Payback never reached during study period.

Simple Payback occurs in year 25

ENERGY SAVINGS SUMMARY

Energy Savings Summary (in stated units)

Units for every energy type not the same, can't report energy savings

Energy Savings Summary (in MBtu)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	91,477.9 MBtu	108,101.0 MBtu	-16,623.1 MBtu	-415,520.8 MBtu

EMISSIONS REDUCTION SUMMARY

Energy Type	-----Average Base Case	Annual Alternative	Emissions----- Reduction	Life-Cycle Reduction
Electricity				
CO2	10,822,381.21 kg	12,788,993.43 kg	-1,966,612.22 kg	-49,158,575.04 kg
SO2	31,854.10 kg	37,642.53 kg	-5,788.44 kg	-144,691.08 kg
NOx	11,486.78 kg	13,574.13 kg	-2,087.34 kg	-52,176.48 kg
Total:				
CO2	10,822,381.21 kg	12,788,993.43 kg	-1,966,612.22 kg	-49,158,575.04 kg
SO2	31,854.10 kg	37,642.53 kg	-5,788.44 kg	-144,691.08 kg
NOx	11,486.78 kg	13,574.13 kg	-2,087.34 kg	-52,176.48 kg

NIST BLCC 5.3-15: COMPARATIVE ANALYSIS

Consistent with Federal Life Cycle Cost Methodology in OMB Circular A-94

Base Case: Alternative 1- Base Case

Alternative: Alternative 2 - New Building

General Information

File Name:	C:\Users\nkhanna\BLCC 5\projects\Projects\BNL Study 060716.xml
Date of Study:	Tue Jul 26 13:38:38 MDT 2016
Project Name:	BNL Study
Project Location:	New York
Analysis Type:	OMB Analysis, Non-Energy Project
Analysis Purpose:	Cost Effectiveness, Lease Purchase, Government Investment or Asset Sale Analysis
Analyst:	Nidhi Khanna
Base Date:	October 1, 2016
Service Date:	October 1, 2020
Study Period:	29 years 0 months(October 1, 2016 through September 30, 2045)
Discount Rate:	1.9%
Discounting Convention:	End-of-Year

COMPARISON OF PRESENT-VALUE COSTS

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	$8,420,241	$106,141,000	-$97,720,759
Future Costs:			
Energy Consumption Costs	$41,786,760	$44,279,428	-$2,492,669
Energy Demand Charges	$0	$0	$0
Energy Utility Rebates	$0	$0	$0
Water Costs	$6,230	$5,131	$1,099
Recurring and Non-Recurring OM&R Costs	$59,115,638	$18,216,522	$40,899,116
Capital Replacements	$0	$0	$0
Residual Value at End of Study Period	$0	-$20,497,228	$20,497,228
Subtotal (for Future Cost Items)	$100,908,628	$42,003,853	$58,904,775
Total PV Life-Cycle Cost	$109,328,869	$148,144,853	-$38,815,984

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings	$38,407,547
- Increased Total Investment	$77,223,531
Net Savings	-$38,815,984

Savings-to-Investment Ratio (SIR)

SIR = 0.50

SIR is lower than 1.0; project alternative is not cost effective.

Adjusted Internal Rate of Return

AIRR = -0.53%

AIRR is lower than your discount rate; project alternative is not cost effective.

Payback Period

Estimated Years to Payback (from beginning of Service Period)

Simple Payback never reached during study period.

Discounted Payback never reached during study period.

ENERGY SAVINGS SUMMARY

Energy Savings Summary (in stated units)

Units for every energy type not the same, can't report energy savings

Energy Savings Summary (in MBtu)

Energy Type	-----Average Annual Consumption----- Base Case	Alternative	Savings	Life-Cycle Savings
Electricity	91,477.9 MBtu	108,103.0 MBtu	-16,625.0 MBtu	-415,568.6 MBtu

EMISSIONS REDUCTION SUMMARY

Energy Type	-----Average Annual Emissions----- Base Case	Alternative	Reduction	Life-Cycle Reduction
Electricity				
CO2	10,822,381.21 kg	12,789,219.49 kg	-1,966,838.28 kg	-49,164,225.74 kg
SO2	31,854.10 kg	37,643.20 kg	-5,789.10 kg	-144,707.71 kg
NOx	11,486.78 kg	13,574.37 kg	-2,087.58 kg	-52,182.48 kg
Total:				
CO2	10,822,381.21 kg	12,789,219.49 kg	-1,966,838.28 kg	-49,164,225.74 kg
SO2	31,854.10 kg	37,643.20 kg	-5,789.10 kg	-144,707.71 kg
NOx	11,486.78 kg	13,574.37 kg	-2,087.58 kg	-52,182.48 kg

9.5 Product Brochures

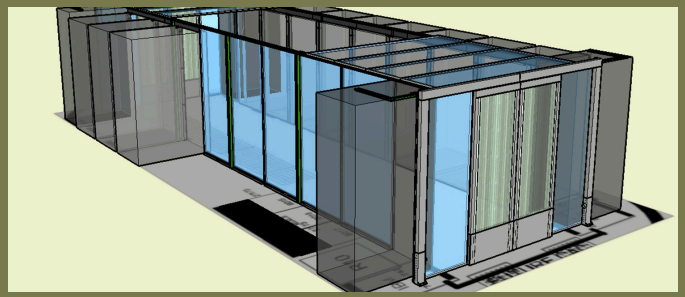
WE KEEP THE CLOUD COOL™

POLARGY

#1

Containment Contractor Since 2007 Polargy has been the leading manufacturer of hot and cold aisle containment solutions for new data center construction and retrofits, delivering turnkey projects with innovative solutions and expert services. Polargy is the provider of choice for world-class mission critical facilities owners and operators.

Polargy's precision specifications and expert trade support reassure new construction managers they'll finish on time and on budget, and ensure thermal safety and rapid ROI for retrofit projects. Polargy containment is deployed by the most demanding mission critical customers including Facebook, Verizon, Pixar Animation, Barclays and Dell. Data center architects, engineers, contractors, partners and owners are well supported with downloadable design files, system specifications, technical data sheets, installation guides, brochures and instructional videos.



In-House Design and Deployment Expertise

Turnkey Projects

Polargy specializes in turnkey containment projects with a focus on helping clients define and achieve successful outcomes. We handle all aspects of deploying containment into a new or existing site to ensure projects are completed on time and on budget. Polargy follows a documented project process and resources each project with a dedicated Project Manager ensuring that financial and operating objectives are met and projects run smoothly. From standard designs to fully custom configurations, from rack systems to comprehensive modular infrastructure, Polargy offers top-quality products, design expertise and installation experience to get your data center online on plan.

Innovative Solutions Drawing on years of experience serving top mission critical operators, Polargy has deep insight into all aspects of data center infrastructure and has developed ingenious solutions to common and costly problems. Modular white space infrastructure, rapid-deployment prefabricated containment, toolless containment installation and low-cost fire-safe air dam foam are just a few Polargy inventions raising the bar in data center containment. Start your data center infrastructure project right, with Polargy on your team, to reach the finish line on time and on budget with informed designs, smart solutions, technical resources, expert consultation and installation support.

Expert Services Polargy offers expert design services for hot and cold aisle containment projects of any size. For new construction, Polargy creates shop drawings from architectural drawings in CAD and prepares record drawings after installation. We also offer design support, where we assist architects and engineers in the development of a final project design. Since containment is typically the last thing installed in a new data center, Polargy's deep and varied experience and competency saves time and prevents rework. For retrofits with less specific documentation requirements Polargy prepares basic design documents from layout drawings and field measurements.

Modular Floor Mounted Infrastructure Complete modular data centers are gaining market traction, but what's new is modularizing the white space infrastructure based on a containment framework or chassis. We call our modular containment chassis Floor Mounted Infrastructure (FMI™). It brings together key infrastructure components of containment, cable pathways, power bus-ways and lighting into a single modular freestanding system. FMI allows owners to add capacity in phases, whether at initial construction, after commissioning or in response to demand. This modular approach provides a rack- and ceiling-independent solution that speeds deployment, paces investment and minimizes containment disruption and rework.

Prefabricated Containment Systems Polargy is changing the way containment is deployed during new construction to bring relief to build schedules and budgets. Polargy's prefabricated, flat-pack containment system is a smarter way to build because it installs in half the time of traditional stick built systems and costs about one third less. With the notion that containment is the project's last phase, speeding its installation gives tremendous advantage to meeting

Complete Solutions from Rack to Room

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schedules. And, by moving assembly steps into the factory and out of the field, costs are saved and quality is improved.

Vertical & Horizontal Containment Panels Polargy's PolarPlex™ vertical panels are available in cabinet supported or ceiling supported models and can be customized to fit any application. Made of anodized aluminum framing with fire-safe inserts, PolarPlex containment panels are lightweight, cost effective and easy to install. UL-listed for use below sprinkler heads, PolarPlex horizontal drop-away panels solve the "sprinkler head obstruction" problem. Anodized aluminum frames with frosted or clear heat-sensitive inserts engineered to drop away in the event of fire allow fire suppression systems to operate normally.

Swing & Sliding Aisle-End Doors Easy open, smooth glide, no threshold, auto-close, and hold-open are features of Polargy's PolarPlex sliding and swing aisle end doors that attach to any brand of server rack. The 54" wide PolarPlex P2 dual sliding door solves the problem of sizing a containment door for varying aisle widths and rack heights and covers most 4 foot aisles. With side extender panels, the aisle width coverage expands to 8 feet. Polargy's PolarPlex P2 swing door is a sturdy, lightweight and economical aisle end containment solution. Door inserts are twin-wall polycarbonate panels that allow light in while keeping weight down. Door frames are made with strong tube steel and fit standard 42U racks and 48" aisles.

Server Racks & Airflow Accessories PolarRack™ XG server racks are frugal with kilowatts and let cool air flow freely to server intakes but prevent air bypass inside the cabinet. Designed with square corners and a flat top, adding containment is quick and easy. PolarDam™ fire-safe air dam foam meets UL-94-HF-1 rating and is the best kept secret for sealing cable cutouts and other raised floor openings to prevent cold air bypass. It is self-forming foam that seals any opening, blocking cold air from escaping and mixing with hot air. It fills large and small air gaps quickly and easily without tools for a fraction of the cost of brush grommets. PolarFlex™ 42U blanking panels seal empty racks and large unoccupied spaces in server cabinets and are an easy and cost-effective alternative to hundreds of individual blanking panels. PolarFlex panels are made of fire-rated Lexan film printed with server images to give the appearance of a full racks, and are easily cut with scissors when a partial panel is all you need. PolarBlock™ air dam skirts and barriers prevent bypass air below, above and between racks and other equipment.

Ceiling Supported Hot Aisle Containment

Cabinet Supported Hot Aisle Containment

Cabinet Supported Cold Aisle Containment

Floor Mounted Hot Aisle Containment

POLARGY
256 Gibraltar Drive, Suite 106
Sunnyvale, CA 94089

(888) 816-8338

US PATENT 7,753,766 B2

Mission Critical

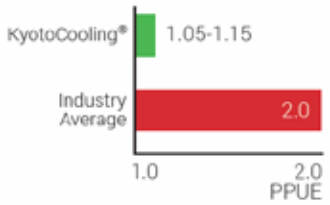
Solving global energy challenges

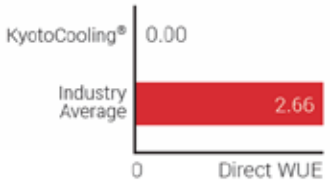
KYOTOCOOLING®
an AIR ENTERPRISES solution

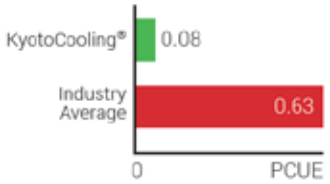
The Changing Face of Cooling Metrics

ΔT (Delta T) of IT Equipment is on the rise. This is the rise in temperature through IT equipment from intake to exhaust. This is increasing as OEM vendors seek ways to appear more Green by reducing fan power.

In legacy data centers that do not support higher ΔT by design this means installing more cooling and reduced efficiency. With KyotoCooling high ΔT Equipment can be cooled with 50% less Energy

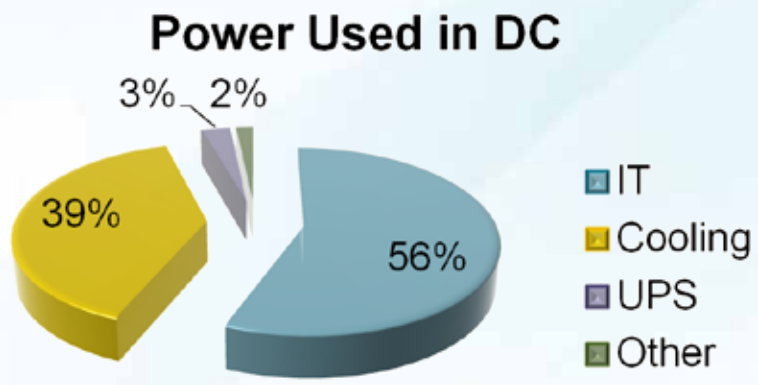






KyotoCooling Dynamically adapts to changing workloads, changing IT Equipment and Changing ΔT without operator intervention and in real time.

Data Center Cooling is the largest controllable cost in the facility. The workload of IT is fixed by needs of users and heat and resultant need for cooling results directly from the waste heat of IT workloads.



In most data centers in Canada and the United States today the relationship of IT workload (Critical Load) to Cooling (PUE(m)) is 1:.8. The derived cost therefore is Critical load kW x .8 x cost/kWhr x 8760. In a typical jurisdiction that's for a 1Mw Facility: 1000 x .8 x .11 x 8760 or $770,880/year.

A KyotoCooling Installation delivers a PUE(m) of 1.1. That means a cost basis of 1000 x .1 x .11 x 8760 or $96,360/year.

The facility savings are $674,520. Assuming 1mW is delivered at 100w/sq ft that's 10,000 sq ft and approximately 200 5kW cabinets. This amounts to $3373/cabinet/year input cost reduction. That's $281/month in input cost reduction plus taxes versus a competitor.

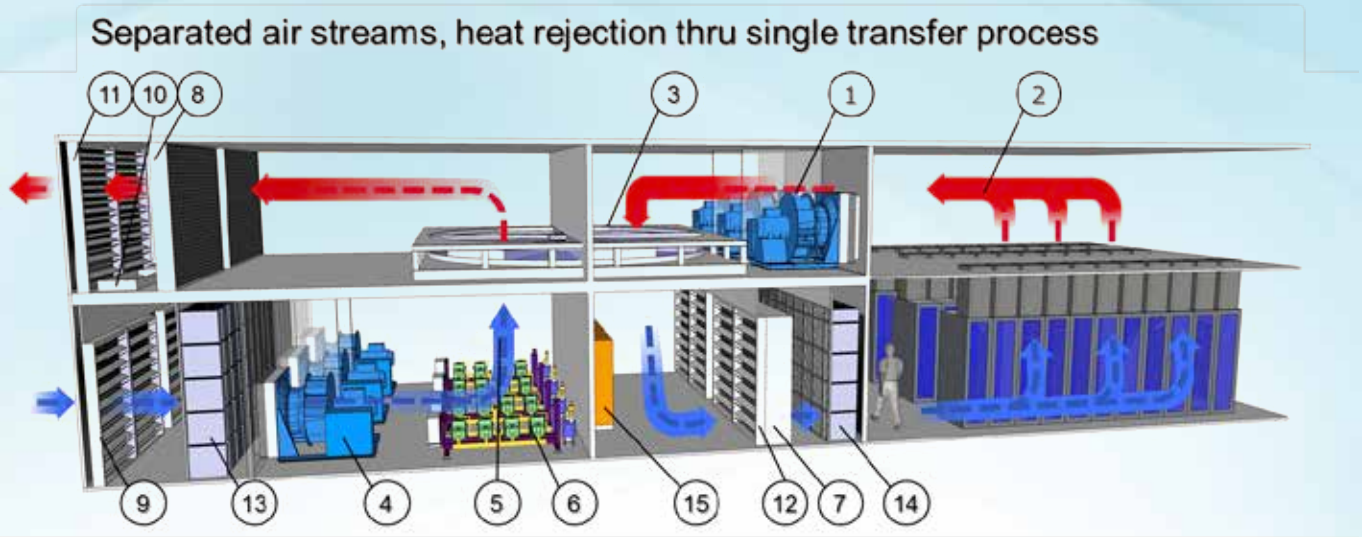
Comparing Co-location contracts in 2010, the average high to low standard deviation in RFP responses for cabinets of this class in Tier III class facilities was $300.

Containment by the Numbers

KyotoCooling reduces oversupply to a minor 2%, maximizes the inherent designs of OEM manufacturers and ensures consistent SLA 's on supply temperature across cabinet face.

KyotoCooling thrives on high ΔT equipment and in general makes best use of the thermal transfer efficiency of containment or "separation" of supply and return air streams.

Existing Data Centers today provide 40-50% too much air, a strategy required because air is not controlled. That creates lower ΔT reducing the efficiency of cooling systems and requiring more fan power.



Fans[1] maintain air flow circulation[2] in the data hall; A slowly rotating heat wheel[3] cools recirculation air. Fans[4] in the outside air plenum maintain outside air flow[5] through the heat wheel; DX (direct expansion) coolers[6], evaporator coils[7] and condenser coils[8] provide backup cooling. Control dampers[9],[10],[11] and [12] to control airflow; air filters[13] and [14]; electrical cabinet[15] with controls and power distribution;

Safe, Effective, KyotoCooling

KyotoCooling is designed from inception to support separated air flow distribution KyotoCooling utilizes new techniques and approaches to support air cooling cabinets to 40kva and above while maintaining best practice approaches of modularity, redundancy and absolute control through autonomous self-adaptive integrated controls. Each change in the data center is adapted to without intervention with the application of strategic approaches to energy efficiency and reliability. The result is the world's most efficient and reliable autonomous cooling solution for data centers.

KyotoCooling has the largest worldwide installed base of New Generation Mission Critical Cooling both in raw Megawatt Capacity and in terms of operating hours/unit capacity. KyotoCooling is proven, hardened Mission Critical Cooling Solution. With over 1.7 Million continuous hours of operation with common design, controls and engineering the concept is proven from -50F to 110F Ambient Conditions on 5 Continents.

- Rapid, Easy Installation

  Simple Commissioning

  Minimal Maintenance

KyotoCooling units are available from 35 KW to 1.3 MW designs providing sensible critical load capacity at 22F ΔT (to 13C ΔT) over IT.

Complete Control

Controls and Operational Issues account fully for 50% of facility failures. We recognize this real life fact. KyotoCooling Controls are designed to be robust, with no single point of failure and automatic in operation through all manner of failure modes and changing conditions inside or outside the facility.

We monitor vibration, filter conditions, and every aspect of supply and return air flow and conditions. Each KyotoCell monitors over 240 specific critical functions and self balances in real time.

Our controls are stable and proven across a wide range of environmental conditions from 5% load to 100% load in standard and emergency load conditions from -50C to +40C.

Simply put we eliminate the problem of operator experience. In addition we log, alert and escalate as needed and by design are anywhere manageable.

Basics of Operation

We are able to maintain precise balance in pressure between cold and hot spaces.

We do not underflow, nor overflow.

We deliver a precise volume of air at a precise temperature even under changing load conditions, all without operator intervention.

To cool with air you must control that air. Normally bypass and recirculation account for a 30% overall loss of efficiency in a data center. So we begin with the idea that we want to separate cold and warm air optimally. This can be by aisle containment, or chimney cabinet or fixtures for high density cabinets provided by a myriad of companies specializing in this control process.

The impact of this control is immediate and sensible. There is consistency in temperature of the air delivered to the IT systems in the data center. There is certainty in airflow. There are no longer anomalies and inconsistencies in temperature at inlet in the data center. We have resolved the first risk of cooling, knowing that we have a temperature that is constant across long aisle spaces from floor to top of rack.

We precisely control the flow of air based on measured ΔT, and air flow differentials using a monitoring system known as Airlull. We are able to maintain precise balance in pressure between cold and hot spaces created by containment systems to deliver to servers a perfect environmental condition. We do not underflow, nor overflow. We deliver a precise volume of air at a precise temperature to the cabinet face, even under changing load conditions, all without operator intervention.

The next question is how to cool this. Here we start with the traditional cooling process. We provide an adequate amount of direct expansion or chilled water-cooling to fully cool the intended load. Both are well-understood processes. We design this in traditional ways using proven engineering.

The next thing that we do is to add into the airflow a patented design use of a heat wheel. This is not a conventional heat wheel design. This heat wheel does not bring outside air into the data center. That would mean a risk. We have designed a system that uses the heat wheel for air-o-air heat transfer without bringing outside air into the data center. The heat wheel achieves exchange of heat without humidity or particulate impacts on the conditioned space. This heat wheel use is unique to us worldwide and we have received international patents on this application. (US PATENT 7753766). Fundamentally the only possible use of heat wheel in a data center is protected and unique to KyotoCooling. More importantly we are the experts in air leakage reduction, direct drive, integration and optimization in this use. The proof is in the results.

Approach over the wheel can be as low as 5°F, Leakage is at peak less than 0.3% (less in soon to be released designs), Rotational speed averages less than one (1) RPM yet we reject up to 850kW at 22°F ΔT and up to 1.7mW at 44°F ΔT scaling as IT equipment changes to higher ΔT. Effective economization runs to 8500 hours in Central and Northern United States and Canada.

KyotoCooling® provides mission-critical, water-free cooling with unparalleled levels of reliability, efficiency and modularity for data centers.

Our patented SmarterCooling™ technology is the best choice for providing the maximum ROI with the lowest risk and operating cost.

KyotoCooling® is available in modular building blocks from 8kW to 1.5MW that can be deployed in unlimited site capacities and cabinet densities.

KYOTOCOOLING®
an AIR ENTERPRISES solution

For more information about how a KyotoCooling® system can work for you, contact:

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330-322-0170 Cell
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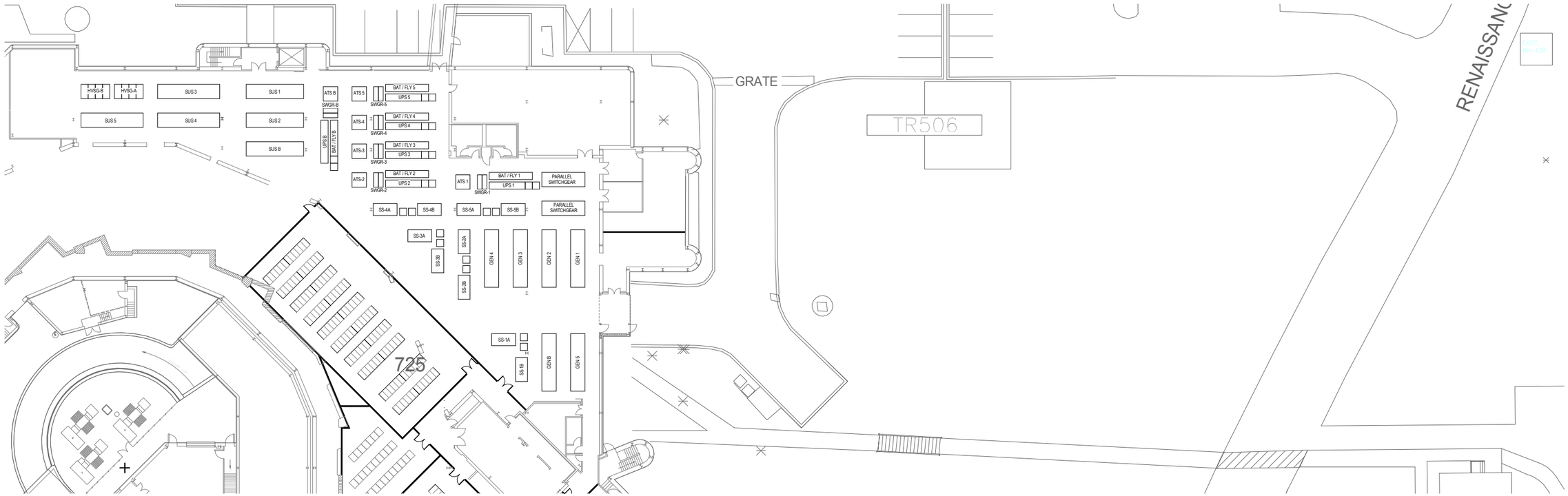
airenterprises.com • kyotocooling-usa.com

US PATENT 7,753,766 B2

9.6.1 Generator Study



0 16' 32'

DATE:	1 JULY 2016
PROJECT:	CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE:	GENERATOR STUDY
SHEET:	GENERATOR BASE OPTION

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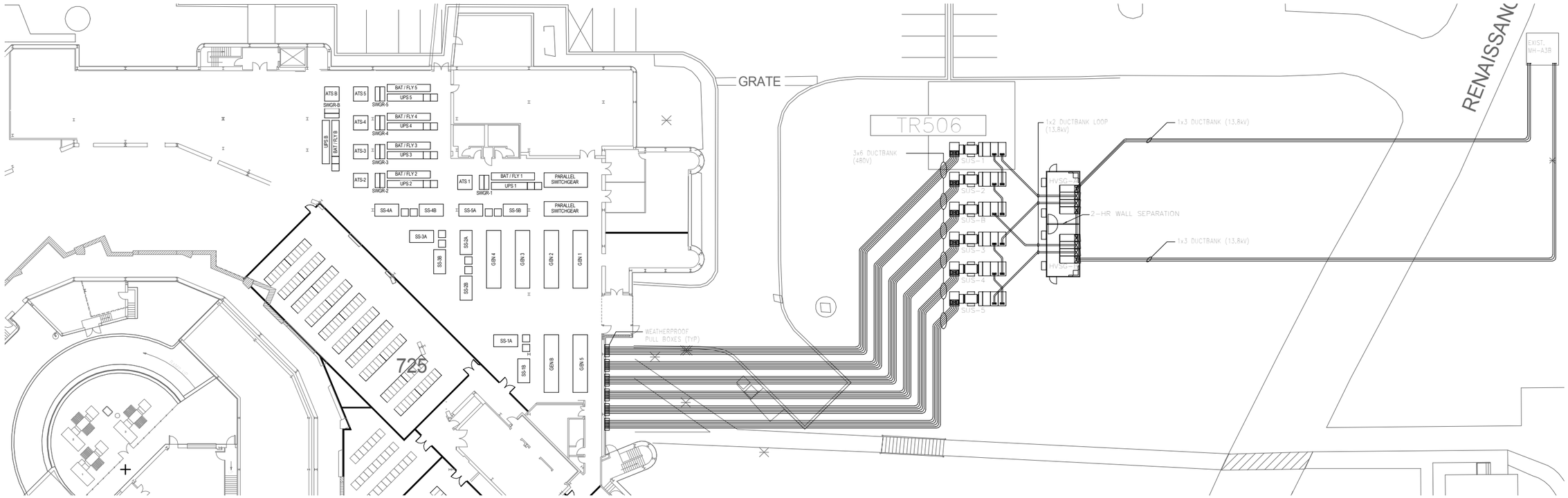

0 16' 32'

DATE:	1 JULY 2016
PROJECT:	CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE:	GENERATOR STUDY
SHEET:	GENERATOR OPTION #1

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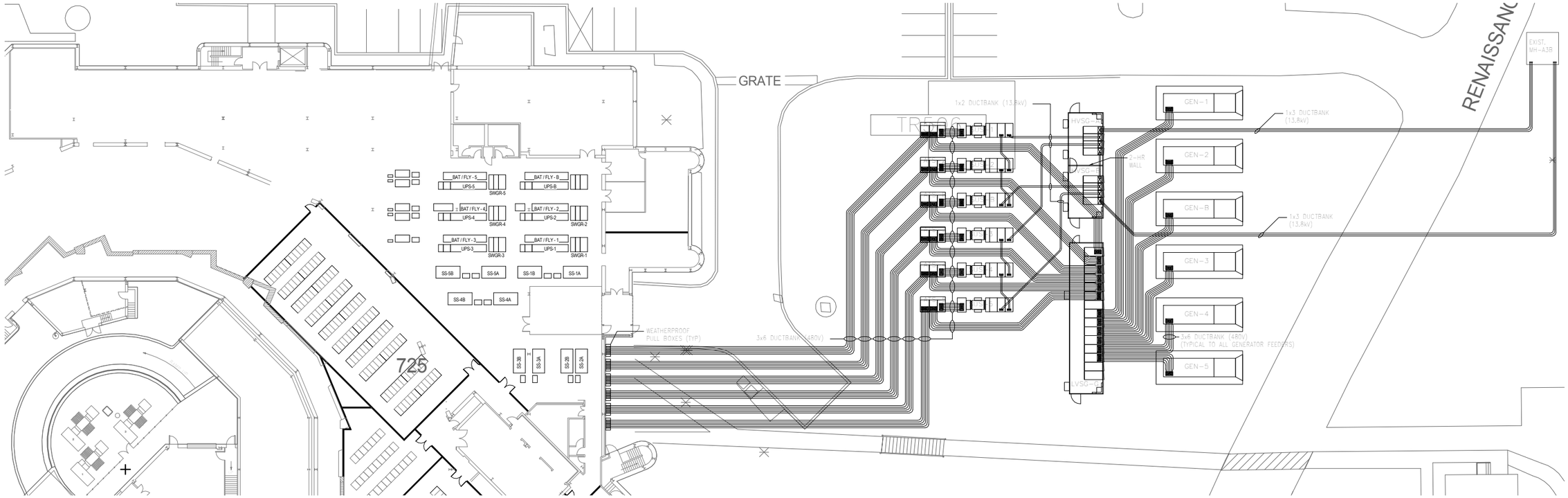

DATE:	1 JULY 2016
PROJECT:	CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE:	GENERATOR STUDY
SHEET:	GENERATOR OPTION #2

0 16' 32'

BROOKHAVEN NATIONAL LABORATORY

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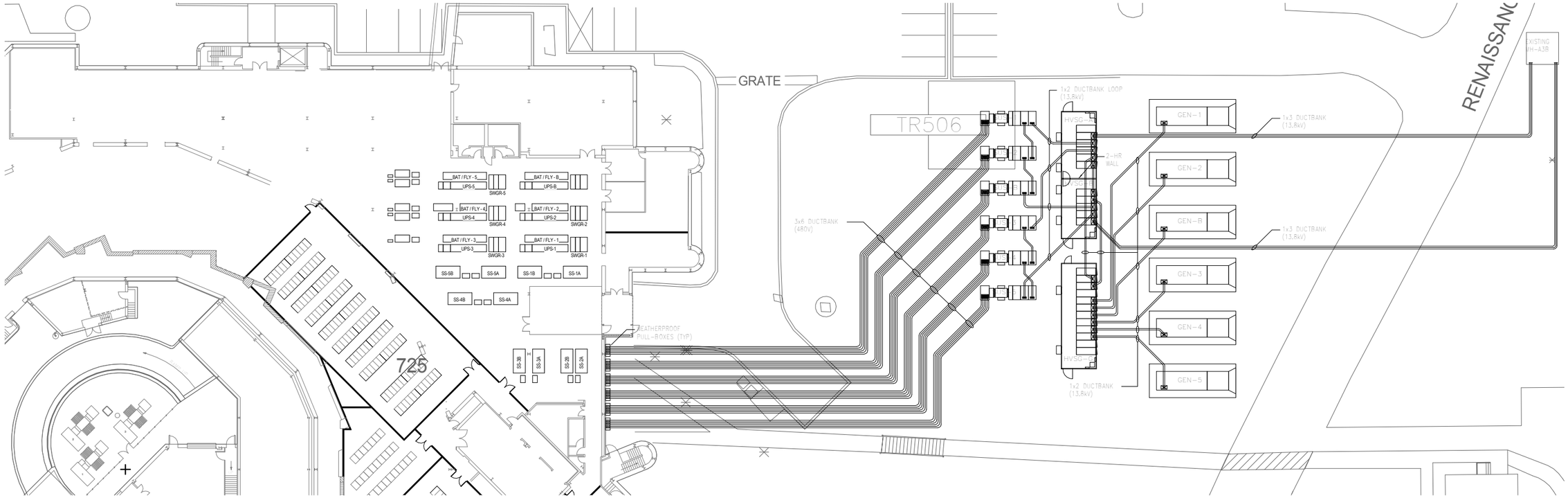

0 16' 32'

DATE:	1 JULY 2016
PROJECT:	CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE:	GENERATOR STUDY
SHEET:	GENERATOR OPTION #3

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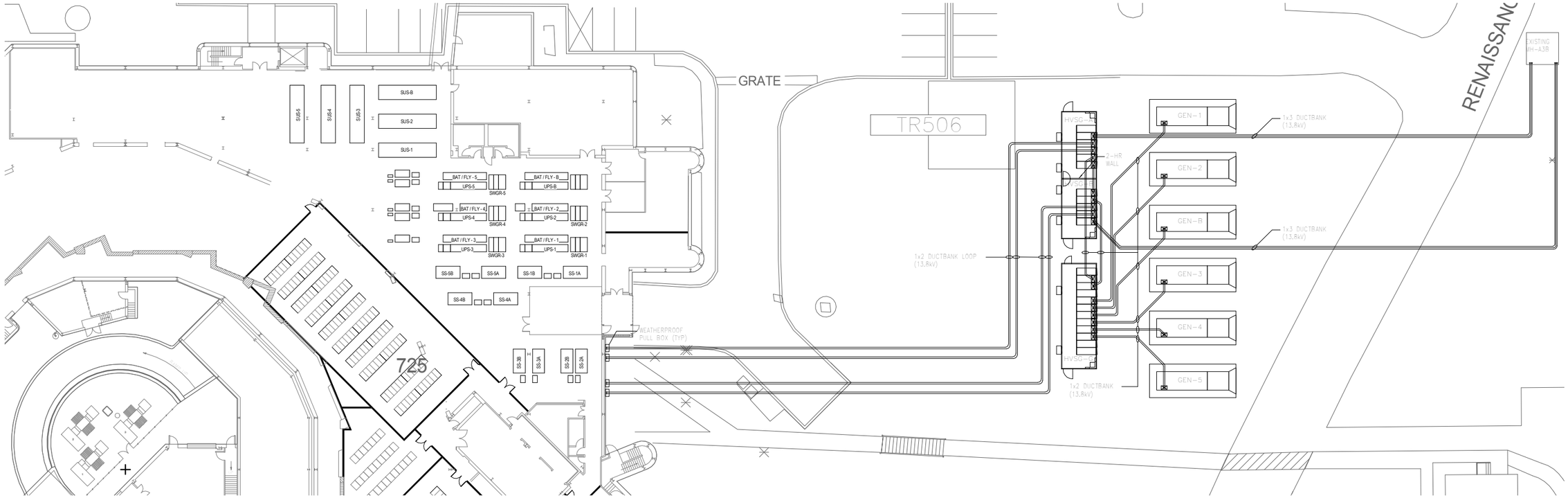

0 16' 32'

DATE:	1 JULY 2016
PROJECT:	CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE:	GENERATOR STUDY
SHEET:	GENERATOR OPTION #4

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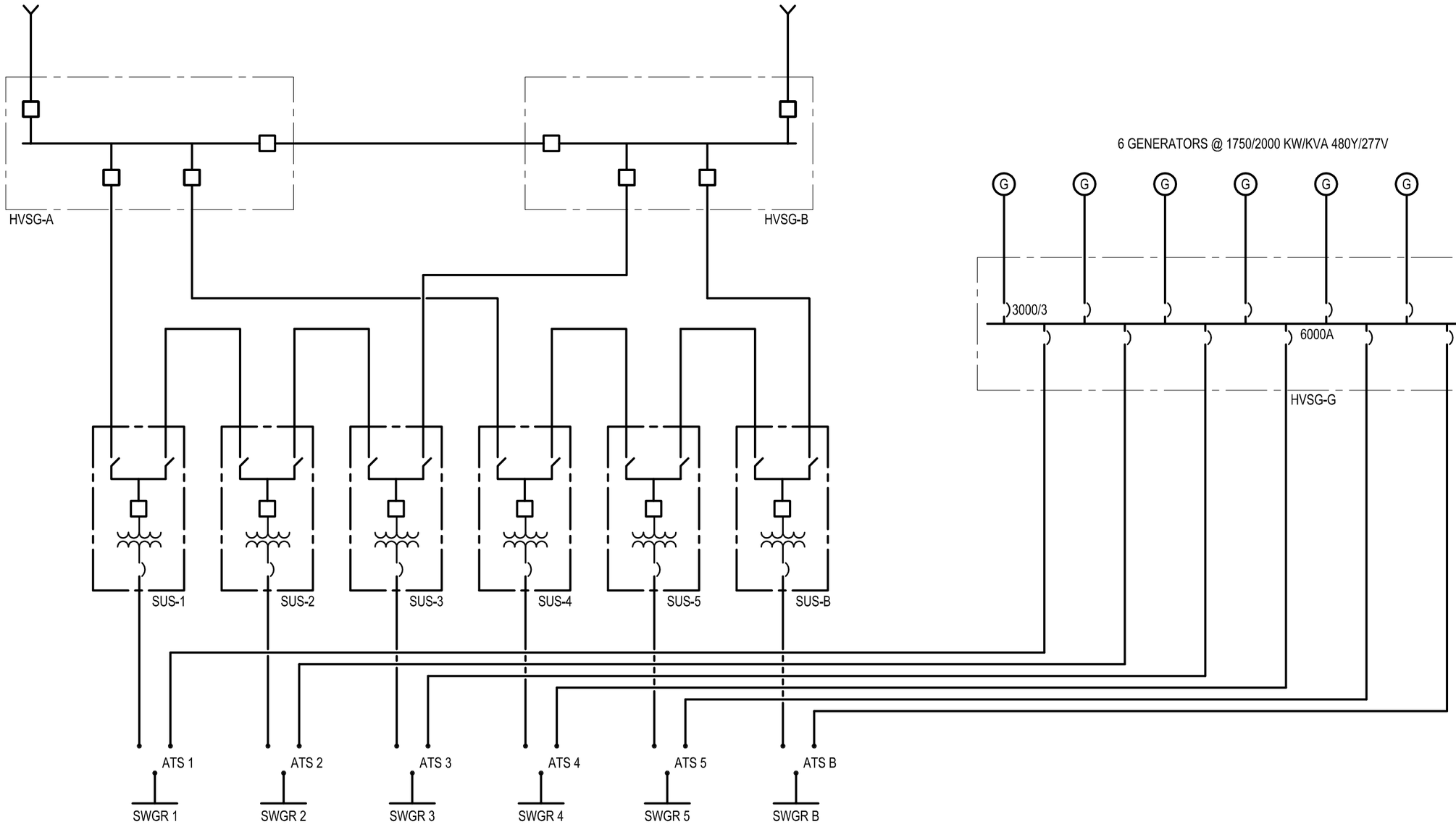

DATE:	1 JULY 2016
PROJECT:	CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE:	GENERATOR STUDY
SHEET:	ONE-LINE DIAGRAM
	OPTIONS: BASE, #1 & #2

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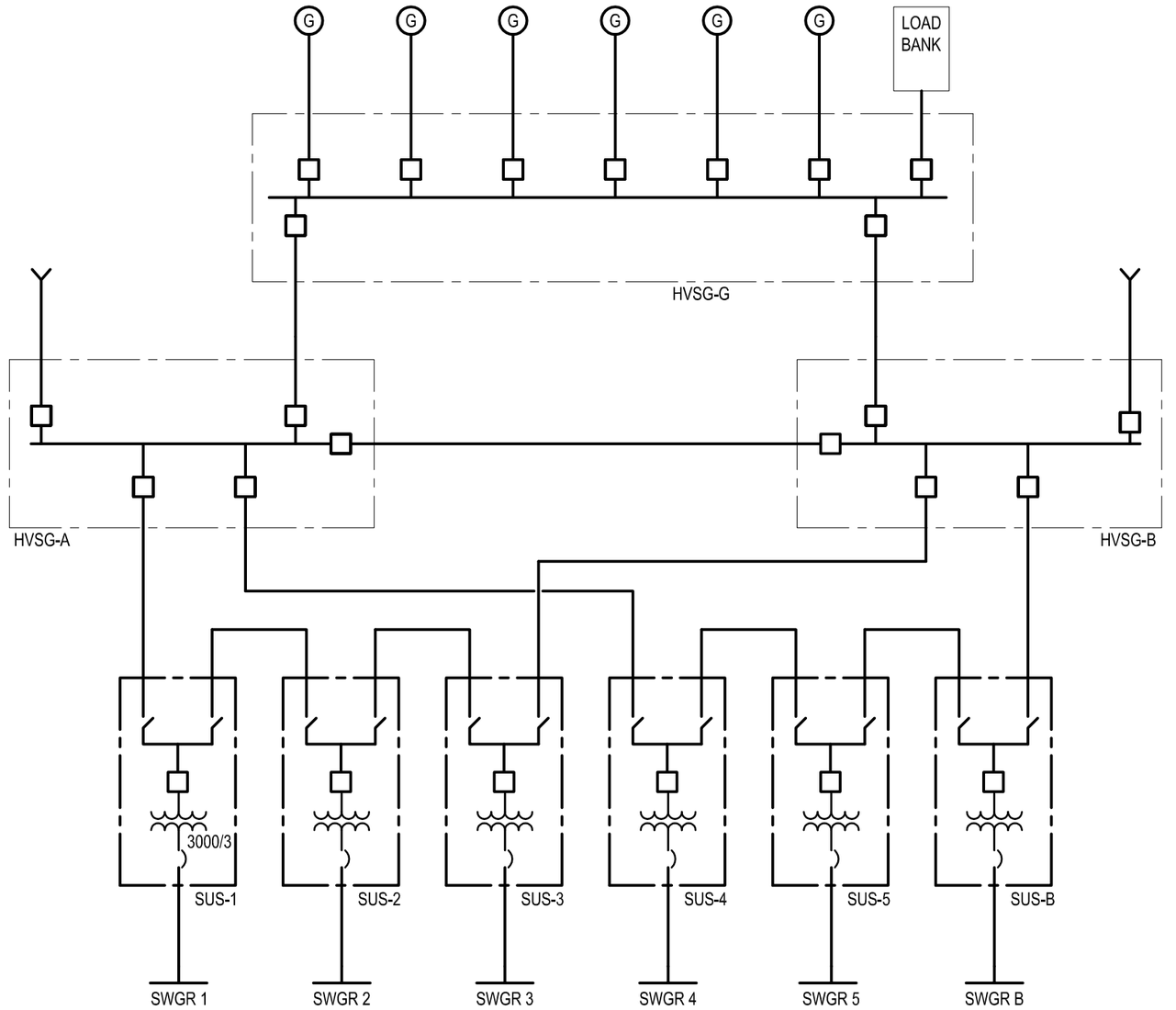
6 GENERATORS @ 1750/2000 KW/KVA 13,800 VOLT



DATE:	1 JULY 2016
PROJECT:	CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE:	GENERATOR STUDY
SHEET:	ONE-LINE DIAGRAM OPTIONS: #3 & #4

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GENERATOR PERFORMANCE CHARACTERISTICS

OPTIONS		MAINTENANCE	RADIATOR LOCATION	VENTILATION	SAFETY	FUEL, LUBE, COOLANT LEAKAGE	MAXIMUM DAY TANK CAPACITY	VIBRATION ISOLATION	SOUND TRANSMISSION	
BASE	INDOOR 480 VOLT GENERATOR INDOOR 15KV SWGR INDOOR SUS INDOOR ATS	out of the weather, removal route	remote radiator on roof (may require structural upgrade)	rooftop ventilator for combustion air and to cool radiated heat	NFPA 37 requirements: rated walls limited fuel storage	easier containment and clean up	660 gal (5 hours @ full load) (therefore, main storage tanks may be required)	cut slab (do not need to remove slab)	high STC rated walls	
1	INDOOR 480 VOLT GENERATOR OUTDOOR 15KV SWGR OUTDOOR SUS INDOOR ATS	see Base Option	see Base Option	see Base Option	see Base Option	see Base Option	see Base Option	see Base Option	see Base Option	
2	OUTDOOR 480 VOLT GENERATOR OUTDOOR 15KV SWGR OUTDOOR SUS OUTDOOR ATS	walk-in enclosure	generator mounted	outdoor not a issue	outdoor	soil contamination	no restrictions	remote units not a issue	walk-in enclosure	
3	OUTDOOR 13800 V GENERATOR OUTDOOR 15KV SWGR OUTDOOR SUS NO ATS	see Option 2	see Option 2	see Option 2	see Option 2	see Option 2	see Option 2	see Option 2	see Option 2	
4	OUTDOOR 13800 V GENERATOR OUTDOOR 15KV SWGR INDOOR SUS NO ATS	see Option 2	see Option 2	see Option 2	see Option 2	see Option 2	see Option 2	see Option 2	see Option 2	

DATE: 1 JULY 2016
PROJECT: CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE: GENERATOR STUDY
SHEET: PERFORMANCE CHARACTERISTICS

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GENERATOR COST COMPAIRISON DATA

OPTIONS		NORMAL 15 KV SWGR	SECONDARY UNIT SUBSTATION	GENERATOR	GENERATOR PARALLELING SWGR	ATS	LOSS OF NET USER SPACE EQ @ $200/SF	STR AND MECH UPGRADES OUTDOOR FUEL TANK AND PIPING	15kV AND 480V 3000A FEEDERS CHANGE FROM BASE OPTION	TOTAL INITIAL COST	TOTAL INITIAL COST WITHOUT THE COST FOR NET USER SPACE @ 200/SF
BASE	INDOOR 480 VOLT GENERATOR INDOOR 15KV SWGR INDOOR SUS INDOOR ATS	$450,000 2 @ $225,000	$1,920,000 6 @ $320,000	$3,900,000 6 @ $650,000	$860,000	$258,000 6 @ $43,000	$1,758,400	$300,000 6 @ $50,000	$0	$9,446,400	$7,688,000
1	INDOOR 480 VOLT GENERATOR OUTDOOR 15KV SWGR OUTDOOR SUS INDOOR ATS	$600,000 2 @ $300,000	$2,340,000 6 @ $390,000	$3,900,000 6 @ $650,000	$860,000	$258,000 6 @ $43,000	$1,080,800	$300,000 6 @ $50,000	$2,170,400	$11,509,200	$10,428,400
2	OUTDOOR 480 VOLT GENERATOR OUTDOOR 15KV SWGR OUTDOOR SUS OUTDOOR ATS	$600,000 2 @ $300,000	$2,340,000 6 @ $390,000	$4,698,000 6 @ $783,000	$984,000	$288,000 6 @ $48,000	$0	$0	$1,521,340	$10,431,340	$10,431,340
3	OUTDOOR 13800 V GENERATOR OUTDOOR 15KV SWGR OUTDOOR SUS NO ATS	$750,000 2 @ $375,000	$2,340,000 6 @ $390,000	$4,950,000 6 @ $825,000	$1,198,000	$0	$0	$0	$592,320	$9,830,320	$9,830,320
4	OUTDOOR 13800 V GENERATOR OUTDOOR 15KV SWGR INDOOR SUS NO ATS	$750,000 2 @ $375,000	$1,920,000 6 @ $320,000	$4,950,000 6 @ $825,000	$1,198,000	$0	$571,200	$0	-$281,300	$9,107,900	$8,536,700

DATE: 1 JULY 2016
PROJECT: CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE: GENERATOR STUDY
SHEET: COST COMPARISON

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9.6.2 UPS Energy Storage Study

BATTERY/FLYWHEEL PERFORMANCE CHARACTERISTICS

	design life years	expected life years	status of charge	footprint	location	temperature control	safety	sustainability	
5 minute 20 yr wet cell battery	20 yrs	12 - 18 yrs	unknown state of charge requires monitoring	**65' x 27"** 2 tier racks	**open racks in separate room**	tight tolerance	**hydrogen spill containment eye wash / shower**	**special handling and disposal**	
5 minute 10 yr VLRA battery	10 yrs	3 - 5 yrs	unknown state of charge requires monitoring	**28' x 33"**	**in matching UPS cabinets**	tight tolerance		recycling required	
5 minute 20 yr VLRA battery	20 yrs	12 - 15 yrs	unknown state of charge requires monitoring	**48' x 27"** 8 high stack	**open stackable**	tight tolerance		disposal issues	
5 minute 10 yr VLRA battery with 15 second flywheel	see 10 year VLRA and 30 second flywheel data for information (excepted battery life increases to 4 - 6 years because the flywheel carries the momentary outages) (excepted 15 second flywheel will be 14' x 3' based on 4 300kVA cabinets)								
30 second bearing-free flywheel	20 yrs	15+ yrs	**reliable state of charge**	24.5' x 33" (based on 7 300kVA cabinets)	**in matching UPS cabinets**	wide tolerance		**no hazardous or toxic materials**	
5 minute lithium battery	20 yrs	12 - 16 yrs	unknown state of charge requires monitoring	**14' x 33"**	**in matching UPS cabinets**	wide tolerance		disposal issues	

DATE: 1 JULY 2016
PROJECT: CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE: UPS ENERGY STORAGE STUDY
SHEET: PERFORMANCE CHARACTERISTICS

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BATTERY/FLYWHEEL COST COMPAIRISON DATA

1200kVA 1200kW static UPS system	initial cost	annual maintenance cost (today's dollars)	battery replacement cost (today's dollars)	years between battery replacements	flywheel major servicing cost (today's dollars)	years between major servicing	flywheel replacement cost (today's dollars)	years between flywheel replacements	30 year life cycle cost (today's dollars)
5 minute 20 yr wet cell battery	$195,000	$11,000	$168,000	12	NA	NA	NA	NA	$693,880
5 minute 10 yr VLRA battery	$138,000	$5,200	$103,000	4	NA	NA	NA	NA	$757,000
5 minute 20 yr VLRA battery	$244,000	$9,500	$286,000	12	NA	NA	NA	NA	$908,760
5 minute 10 yr VLRA battery with 15 second flywheel	$458,000	$16,800	$103,000	5	$64,000	7.5	$320,000	15	$1,801,840
30 second flywheel	$560,000	$20,300	NA	NA	$112,000	7.5	$560,000	15	$2,008,720
5 minute lithium battery	$350,000	$5,200	$300,000	15	NA	NA	NA	NA	$853,000

DATE: 1 JULY 2016
PROJECT: CORE FACILITY REVITALIZATION (CFR) BUILDING 725
DISCIPLINE: UPS ENERGY STORAGE STUDY
SHEET: COST COMPARISON

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Arlington, VA 22201
703.518.8500

hdrinc.com

We practice increased use of sustainable materials and reduction of material use.