Fermi National Accelerator Laboratory

Fermilab

PIP-II Site Preparation
Functional Requirements Specification

Document number: ED0006787, Rev. A

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Document Approval

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Revision History

Revision	Date of Release	Description of Change
Rev -	25 October 2017	Initial Release
Rev A	19 June 2018	Updated to Revised Format

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1. Purpose

An FRS describes the programmatic or project needs and/or requested behavior of a system or component. The document typically outlines what is needed by the end user as well as the requirements and requested properties of inputs and outputs. The FRS specifies the functions that a system or component must perform and establishes consensus among stakeholders on what the system is expected to provide.

2. Scope

This FRS addresses the functional requirements of the Site Preparation conventional construction including utility infrastructure, site work, roads and site restoration.

3. Acronyms

FESHM	Fermilab ES&H Manual
FRCM	Fermilab Radiological Control Manual
FRS	Functional Requirements Specification
L2	WBS Level 2
L3	WBS Level 3
PIP-II	Proton Improvement Plan II Project
SCD	System Configuration Document
SP	Site Preparation
TC	Teamcenter
WBS	Work Breakdown Structure

4. Reference

#	**Reference**	**Document #**
1	Conventional Facilities Engineering Process Document Management	ED0002857
2	Conventional Facilities System Configuration Document (SCD)	ED000xxxx
3	Fermilab Engineering Manual	NA
4	Fermilab Environmental Safety and Health Manual	NA
5	Fermilab Radiological Control Manual	NA
6	PIP-II Project Assumptions	PIP-II-doc-144
7	PIP-II – Fermilab Interface Document	PIP-II-doc-528

5. Key Assumptions

The assumptions for the Site Preparation (SP) work includes:

1. The PIP-II Project Assumption document (PIP-II-doc-144) contains the detailed list of the requirements for the SP work;

6. Functional Requirements

Requirement #	Requirement Statement
F-121.06.02-001	The SPshall provide a safe environment for employees and the public.
F-121.06.02-002	The SP shall provide and extension of the existing Fermilab utility infrastructure to the PIP-II site. This includes electrical, domestic water, industrial cooling water, sanitary sewer, chilled water and data/communication.
F-121.06.02-003	The SP shall provide an extension of the existing Fermilab road network.
F-121.06.02-004	The UPB shall comply with the overall character of the PIP-II campus.

7. Safety Requirements

The system shall abide by all Fermilab ES&H (FESHM) and all Fermilab Radiological Control Manual (FRCM) requirements including but not limited to:

Pressure and Cryogenic Safety
• FESHM Chapter 5031 Pressure Vessels
• FESHM Chapter 5031.1 Piping Systems
• FESHM Chapter 5031.5 Low Pressure Vessels and Fluid Containment
• FESHM Chapter 5031.6 Dressed Niobium SRF Cavity Pressure Safety
• FESHM Chapter 5032 Cryogenic System Review
• FESHM Chapter 5033 Vacuum Vessel Safety
Electrical Safety
• FESHM Chapter 9110 Electrical Utilization Equipment Safety
• FESHM Chapter 9160 Low Voltage, High Current Power Distribution Systems
• FESHM Chapter 9190 Grounding Requirements for Electrical Distribution and Utilization Equipment
Radiation Safety
• FRCM Chapter 8 ALARA Management of Accelerator Radiation Shielding

• FRCM Chapter 10 Radiation Safety Interlock Systems
• FRCM Chapter 11 Environmental Radiation Monitoring and Control
General Safety
• FESHM Chapter 2000 Planning for Safe Operations
Construction Safety
• FESHM Chapter 7010 ES&H Program for Construction
• FESHM Chapter 7030 Excavation
• FESHM Chapter 7060 Fall Protection
• FESHM Chapter 7070 Ladder & Scaffold Safety
Environmental Protection
• FESHM Chapter 8011 Groundwater Protection – Excavations and Wells
• FESHM Chapter 8012 Sedimentation and Erosion Control Planning
• FESHM Chapter 8025 Wastewater Discharge to Sanitary Sewers
• FESHM Chapter 8026 Surface Water Protection
• FESHM Chapter 8050 Domestic Water Protection

Any changes in the applicability or adherence to these standards and requirements require the approval and authorization of the PIP-II Technical Director or designee.

In addition, the following codes and standards in their latest edition shall be applied to the engineering, design, fabrication, assembly and tests of the given system:

ASME B31.3 Process Piping
ASME Boiler and Pressure Vessel Code (BPVC)
CGA S-1.3 Pressure Relief Standards
NFPA 70 – National Electrical Code
IEC Standards for Electrical Components

In cases where International Codes and Standards are used the system shall follow FESHM Chapter 2110 Ensuring Equivalent Safety Performance when Using International Codes and Standards and requires the approval and authorization of the PIP-II Technical Director or designee.

Additional Safety Requirements that are not listed in the general list above shall be included in the Requirements table in the Functional Requirements section.

Fermi National Accelerator Laboratory
P.O. Box 500 - Batavia, Illinois - 60510

Technical Requirement Specification
TRS Site Preparation
ED0006789, Rev. -

Prepared by: S. Dixon	FNAL	Extension x8501	Date 25 OCT 2017
Reviewed by:	FNAL	Extension x	Date
Reviewed by:	FNAL	Extension x	Date
Reviewed by:	FNAL	Extension x	Date
Reviewed by:	FNAL	Extension x	Date
Approved by:	FNAL	Extension x	Date
Approved by:	FNAL	Extension x	Date
Approved by:	FNAL	Extension x	Date

Revision control is managed via Fermilab Teamcenter Workflows.

Rev.	Date	Description	Originated By	Section No.	Approved By
-	25 OCT 2017	Initial release	*S. Dixon*	*ALL*	*As signed*
A					
B					
C					

Technical Requirements Specifications

Site Preparation

WBS 121.5.2

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Section 1 – Conventional Facilities Purpose

The PIP-II conventional facilities will house the accelerator components and support equipment required to install and operate the PIP-II linac and transfer line. The PIP-II conventional facilities scope includes the elements of work normally included in conventional construction such as earthwork, utilities, structural concrete, structural steel, architectural cladding, finishes, roofing, plumbing, process piping, heating ventilation and air conditioning (HVAC), fire protection, fire detection, lighting and electrical. This also includes the work required to extend the utilities to the project site, excavation associated with the below grade cast-in-place concrete enclosures, creation of a shielding berm and site restoration.

Section 2 – Scope

The Site Preparation work consists of the conventional construction required to extend the existing Fermilab infrastructure to the PIP-II site and prepare the site to support PIP-II accelerator installation, assembly and operation.

Section 3 – Requirements

3.1 – Spatial Requirements

The Site Preparation work will generally be located in the infield area of the Main Ring/Tevatron portion of the Fermilab site.

3.2 – Architectural Requirements

Not applicable

3.3 – Structural Requirements

The design of structural systems will include the following requirements:

- New roads will be designed to accommodate standard truck loading (H-20);
- All buried piping will have a minimum of five (5) feet of coverage

3.4– Mechanical Requirements

The design of mechanical systems will include the following requirements:

- All plumbing work to be designed in accordance with Illinois Plumbing Code and Standard Specifications for Water & Sewer Main Construction in Illinois.
- The following site utilities will be extended to or routed to the PIP-II site:
  - Industrial Cooling Water (ICW) capable of providing a minimum of 1,400 gallons per minute (GPM) will be extended from the existing site wide network in the vicinity of AZero;
  - The PIP-II ICW return discharge will be routed to the existing AZero pond;
  - A minimum of 250 tons of chilled water will be available for PIP-II use at the Central Utility Building (CUB). The PIP-II connection point will be in the vicinity of CUB;
  - Natural gas will be extended from the existing site wide distribution network in the vicinity of CUB;
  - Sanitary sewer for PIP-II will be discharged to the existing sanitary lift station in the vicinity of CUB;
  - Domestic Water Supply (DWS) will be extended from the existing sanitary lift station in the vicinity of CUB;

3.5 – Electrical Requirements

The design of electrical systems will include the following requirements:

- The Master Substation (MSS) will be used to provide electrical power utilizing six (6) new feeders;
- PIP-II will install new breakers in the existing MSS panels;
- PIP-II will utilize existing ductbanks from MSS to manhole P71;
- New ductbanks will comply with Fermilab electrical isolation standards;
- Feeder 46A, fed from Kuatz Road Substation (KRS) will be used to provide backup power for critical systems;
- Communication will be extended from the existing site wide network in the vicinity of the existing Transfer Gallery;
- Lighting to be LED based where possible.
- Lighting Levels as follows:
  - Exterior Spaces: 2 to 5 foot-candles.

3.6 – Fire Protection Requirements

The design of fire protection systems will include the following requirements:

- Fire hydrants will be served from the ICW system and located within 150 feet of each building. Two (2) hydrants will be provided for each building.

3.7 – Special Requirements

The design will include:

- Provisions to accommodate the existing AZero pond;
- Incorporation of landscaping restoration will utilize both native prairie plantings and wetland specific plantings to accommodate Fermilab's long range plans for managing the available areas of the site according to principles of ecosystem management and restoration.

Section 4 – Code Requirements

4.1 – Organizational Processes

Organizational Processes provide institutional requirements for the design, construction and operations of all projects built and operated at Fermilab. For the PIP-II conventional facilities these requirements are derived from the Policies and Procedures of the Fermilab Directorate, Accelerator Division (AD), and the PIP-II project. All applicable DOE orders and standards are included in these requirements. A selection of applicable standards is listed below:

- DOE Order 151.1C – Comprehensive Emergency Management System
- DOE Order 413.3B – Program and Project Management for the Acquisition of Capital Assets, Change 1 issued 11/29/10
- DOE Order 414.1C – Quality Assurance
- DOE Order 420.1B – Facility Safety
- DOE Order 430.1B – Real Property Asset Management (2/8/08)
- DOE Order 430.2B – Departmental Energy, Renewable Energy and Transportation Management
- DOE Order 450.1A – Environmental Protection Program (6/4/08)
- DOE STD-1066-99 – Fire Protection Design Criteria
- DOE STD-1073-2003 – Configuration Management
- DOE Guide 420.1-2 – Guide for the Mitigation of Natural Phenomena Hazards for DOE Nuclear Facilities

and Non-Nuclear Facilities
- 10 CFR 835 – Radiological Protection Program
- 10 CFR 851 – Worker Safety and Health Program
- 10 CRF 851.23 – Safety and Health Standards
- Internal Fermilab permits and work notifications as described in the Fermilab ES&H Manual (FESHM)
- Fermilab Director's Policy Manual (http://www.fnal.gov/directorate/Policy_Manual.html)
- Fermilab Engineering Manual (http://www.fnal.gov/directorate/documents/FNAL_Engineering_Manual.pdf)

4.2 – Enterprise Standards

Enterprise standards from regulatory agencies, code bodies and trade organizations also provide requirements for the design and construction of the PIP-II conventional facilities. The Fermilab Engineering Standards Manual provides a comprehensive listing of applicable and adopted building codes and design standards. The applicable standards are listed below:

- Codes, Standards, and Guidelines
- International Building Code (IBC) – 2009 Edition
- International Energy Conservation Code – 2009 Edition
- International Fire Code – 2009 Edition
- International Mechanical Code – 2009 Edition
- Minimum Design Loads for Buildings and Other Structures – ASCE 7-05
- Building Code Requirements for Structural Concrete – ACI 318-05
- Specification for Structural Steel Buildings – AISC 360-05
- Building Code Requirements for Structural Concrete and Commentary – ACI 318-08
- Building Code Requirements for Masonry – ACI 530-05
- Illinois Plumbing Code – 2004
- Illinois Department of Public Health Codes
- Illinois IEPA
- NFPA 101 Life Safety Code – 2009 Edition
- NFPA 13 – Standard for the Installation of Sprinkler Systems – 2010 Edition
- NFPA 24 – Standard for the Installation of Private Fire Service Mains and Their Appurtenances – 2010 Edition
- NFPA 30 – Flammable and Combustible Liquids Code – 2008 Edition
- NFPA 55 – Compressed Gases and Cryogenic Fluids Code – 2010 Edition
- NFPA 70 – National Electrical Code – 2008 Edition
- NFPA 70E – Standard for Electrical Safety in the Workplace – 2009 Edition
- NFPA 72 – National Fire Alarm Code – 2010 Edition
- NFPA 80 – Fire Doors and Fire Windows – 2010 Edition
- NFPA 90A – Standard for the Installation of Air-Conditioning and Ventilating Systems – 2009 Edition
- NFPA 90B – Standard for the Installation of Warm Air Heating and Air Conditioning Systems – 2009 Edition
- NFPA 92A – Standard for Smoke-Control Systems utilizing Barriers and Pressure Differences – 2009 Edition
- NFPA 92B – Standard for Smoke Management Systems in Malls, Atria, and Large Spaces – 2009 Edition
- NFPA 110 – Emergency and Standby Power Systems – 2010 Edition
- NFPA 115 – Standard for Laser Fire Protection – 2008 Edition
- NFPA 780 – Standard for the Installation of Lightning Protection Systems (and UL 96A) – 2008 Edition

- ASHRAE Standard 90.1-2004 Energy Standard for Buildings Except Low-Rise Residential Buildings
- ANSI/HFES 100-2007 – Human Factors Engineering of Computer Workstations
- ANSI 17.1 Safety Code for Elevators and Escalators
- ANSI/ASHRAE Standard 62.1-2004 Ventilation for Acceptable Indoor Air Quality
- ANSI/AIHA Z9.5-2003 Standards for Laboratory Ventilation
- ANSI/ASME B31.3 – Process Piping (2002)
- ANSI 31.9 – Building Services Piping (1996)
- Occupational Safety and Health Administration (OSHA)
- Underwriters Laboratory
- ICC/ANSI A117.1 – 2003 Standard for Accessible and Usable Buildings and Facilities Illinois Accessibility Code
- ADA Accessibility Guidelines for Buildings and Facilities (ADAAG) – 2004 will be used for those areas of facility not exempted by Fermilab policy
- Illinois Accessibility Code

Engineering Risk Assessment

Project: PIP-II Conventional Facilities - WBS 121.06.02 Site Preparation
Lead Engineer: S. Dixon
Department: PIP-II
Date: August 23, 2018

Chapter		Engineering Risk Element A	B	C	D	E	F	G	High Risk	Subtotal	Assessment
1	Requirements and Specifications	2	4				2		≥ 10	8	Standard Risk
3	Requirements and Specification Review	2	4		2	2	2		≥ 16	12	Standard Risk
4	System Design	2	4	2		2	2	1	≥ 19	13	Standard Risk
5	Engineering Design Review	2	4	2		2	2	1	≥ 19	13	Standard Risk
6	Procurement and Implementation		4		2	2	2	1	≥ 16	11	Standard Risk
7	Testing and Validation	2				2	2	1	≥ 13	7	Standard Risk
8	Release to Operations						2		≥ 4	2	Standard Risk
9	Final Documentation		4				2		≥ 7	6	Standard Risk

Project Risk Element H	I	J	K	L	M	N	O	High Risk	Subtotal	Assessment
2	2	3	2	1	4	1	4	≥ 25	19	Standard Risk

Engineering Risk Elements	
A	Technology
B	Environmental Impact
C	Vendor Issues
D	Resource Availability
E	Safety
F	Quality Requirements
G	Manufacturing Complexity

Project Risk Elements	
H	Schedule
I	Interfaces
J	Experience / Capability
K	Regulatory Requirements
L	Project Funding
M	Project Reporting Requirements
N	Public Impact
O	Project Cost

Engineering Risk Assessment

Project: PIP-II Conventional Facilities - WBS 121.06.02 Site Preparation
Lead Engineer: S. Dixon
Department: PIP-II
Date: August 23, 2018

Technology

Score	
2 - Low to Medium Risk	2

This defines the degree of technical complexity the Lead Engineer or engineering team will face in executing the project.

1 The project will use off-the-shelf technology.
3 Engineers will purchase and modify off-the-shelf technology.
5 The project will require the development of new technology.

Environmental Impact

4 - Medium to High Risk	4

This defines the potential level of environmental impact.

1 There will be no environmental impact.
3 The project may have some environmental impact but will not require an environmental assessment, as determined by FESHM.
5 The project will require an environmental impact statement.

Vendor Issues

2 - Low to Medium Risk	2

This defines the degree of complexity to be expected with vendors. Complicating factors may include long-lead-time items and issues with vendor qualification and reliability.

1 Vendors could cause minor issues.
3 Vendors could cause manageable complications.
5 Vendor issues could result in significant schedule delays or cost overruns or could otherwise jeopardize the successful completion of the project.

Resource Availability

2 - Low to Medium Risk	2

This defines the availability of internal and external resources to plan and execute the project.

1 Resources will be readily available.
3 Resources could be somewhat restricted.
5 The difficulty of obtaining resources puts the project schedule at high risk.

Quality Requirements

2 - Low to Medium Risk	2

This determines the effort required to achieve the quality level the customer assigns to the final product.

1 The quality requirements can be met easily with existing infrastructure.
3 The quality requirements are challenging but can be met with existing infrastructure.
5 The quality requirements are beyond the capability of existing infrastructure.

Safety

2 - Low to Medium Risk	2

This defines the safety issues the project team will encounter while completing the project.

1 The project will require standard safety considerations.

3 The project will require increased diligence due to its location, the configuration of the product or the type of work required. This includes work requiring review according to FESHM.

5 The project will require very restrictive safety considerations. This includes work requiring review and personnel safety systems.

Manufacturing Complexity

1 - Low Risk	1

This defines the degree of complexity to be expected when combining the elements of technology, operations and schedule in product manufacturing.

1 The manufacturing processes will be routine.

3 The project will require an existing technology that the manufacturer has not previously used.

5 The project will require new or complex manufacturing methods.

Schedule

2 - Low to Medium Risk	2

This defines how much time the Lead Engineer or engineering team will have to complete the schedule.

1 Time will be unlimited.

3 The schedule will be somewhat constrained.

5 The subproject will be on the overall project critical path and has no schedule contingency.

Interfaces

2 - Low to Medium Risk	2

This defines the risk associated with the complexity of integrating multiple subprojects.

1 One department at Fermilab will be involved with a standalone project.

3 Project success depends upon contributions from multiple departments at Fermilab.

5 Project success depends upon contributions from multiple institutions.

Experience/Capability

3 - Medium Risk	3

This defines the level of experience and capability project team members will have.

1 Only experts will participate.

3 A blend of experts and inexperienced personnel will participate.

5 Only inexperienced personnel will participate.

Regulatory Requirements

2 - Low to Medium Risk	2

This identifies the degree to which oversight by governmental or other regulatory agencies will impact the project.

1 Regulatory agencies will have minor to no involvement.

3 The Department of Energy, DOE, will have direct regulatory involvement.

5 DOE, as well as state or federal government, will have regulatory involvement.

Project Funding

1 - Low Risk	1

This defines the availability and approval status of project planning and execution funds.

1 A single source within Fermilab will fund the project.

3 A source outside of Fermilab will fund the project.

5 Multiple sources outside of Fermilab will fund the project.

Project Reporting Requirements

4 - Medium to High Risk	4

This indicates the level of reporting to the senior management the project requires.

1 Reports to senior management about the project will not be required.

3 The project will require quarterly performance reports.

5 The project will be highly visible. Top management or outside agencies will schedule visits and issue monthly performance reports.

Public Impact

1 - Low Risk	1

This indicates how much the project will affect the public or public opinion.

1 The public will not be affected.

3 The public may be somewhat affected and should be informed with news releases.

5 The project may have an impact on the public. The public should be involved through public forums and may participate in advisory councils.

Project Cost

4 - Medium to High Risk	4

This defines how much the project is projected to cost.

1 The project will be within the department operating budget.

3 The project will require divisional budget planning.

5 The project will require laboratory or DOE budget tracking and reporting.

Safety by Design (SbD) Hazard Risk Assessment

Date: **August 23, 2018**
System: **PIP-II Conventional Facilities**
WBS 121.06.02 - Site Preparation

Assessed By: **S. Dixon, R. Wielgos, E. Huedem**

Identifier	*Potential Hazard Description*	*Life Cycle Stage*	*Who is at risk?*	*What is at risk?*	*Pre-Mitigation Severity*	*Pre-Mitigation Probability*	*Pre-Mitigation Risk Score*	*Mitigations*	*Post-Mitigation Severity*	*Post-Mitigation Probability*	*Post-Mitigation Risk Score*	*Status of Mitigation Implementation*	*Comments*
SP-001	Electrocution while working in live manholes	Multiple	Workers	Property	High	C - Possible	2 - High	Design new ductbanks that can be accessed without live feeders	Minimal	D - Unlikely	5 - Negligible	Integrated into Design	The design of the ductbanks includes provisions for isolating feeders for inspection and maintenance
SP-002	Traffic Incident Due to Road Conditions	Operations	Workers	Property	Medium	C - Possible	3 - Moderate	Design roadways to a reasonable speed limit and post accordingly. Provide rowadway lighting	Low	C - Possible	3 - Moderate	Integrated into Design	The roadway design is based on a 25mph design speed. Roadway lighting is included in the project design
SP-003	Equipment damage during transportation	Installation		Property	Medium	C - Possible	3 - Moderate	Design roadways and access drives to accommodate semi-truck truck traffic	Low	D - Unlikely	4 - Low	Integrated into Design	The roadway and access road design has been test-fit for semi-truck traffic
SP-004	Personnel injury while walking to the project.	Multiple	Workers/Public		Medium	C - Possible	3 - Moderate	Design alternate path for pedestrian access seperated from the roadway	Medium	D - Unlikely	3 - Moderate	Integrated into Design	The design will include a walking path seperated from the roadway for the primary pedestrian access to the building from Wilson Hall
SP-005													

PIP-II
BASIS of ESTIMATE (BoE)
for
121.06.02 Conventional Facilities Site Preparation

Date of Estimate: August 21, 2018

Prepared by: S. Dixon

Contributing Authors: _____

Reviewed by:

Docdb #: 238

WBS number: 121.06.02	**Control Account:** __N/A_____	**WBS Title:** _____

WBS Dictionary Definition:

121.06.02 This WBS covers procurement and management for all contracted labor, materials, tools, equipment, and services needed for the construction of the Site Preparation work scope. It describes the labor resources, materials and services necessary for management, organization, planning, oversight and engineering, design, inspection and administration (EDIA).

Supporting Documents (including but not limited to):

- PIP-II-doc-238 for supporting documentation.;
- PIP-II-doc-144 for PIP-II Project Assumptions Document;
- PIP-II-doc-327 for EDIA Calculation assumptions;
- PIP-II-doc-318 for A/E Tasking Duration Assumptions;
- PIP-II-doc-321 for Construction Subcontract Procurement Duration Assumptions;
- PIP-II-doc-333 Construction Package Cost Estimate;
- PIP-II-doc-345 Contingency Rules for Basis of Estimates;
- PIP-II-doc-229 Project Management Basis of Estimate;
- PIP-II-doc-528 PIP-II Fermilab Interface Document;
- PIP-II-doc-581 Construction Package Schedule Estimate;

Assumptions:

- This Basis of Estimate starts on June 1, 2018;
- This WBS does not include any extraordinary technology requirements;
- The PIP-II Fermilab Memorandum of Understanding is in place;
- Costs listed are in 2018 dollars and do not include escalation;
- Costs listed do not include Indirect multipliers;
- One (1) full time equivalent (FTE) is based on 1,768 hours worked per year;
- FESS/Engineering hourly rate is based on $103.00/hour per FY18 Provisional Labor, Indirect and Shop Rates
- Final Design is assumed to begin after CD-2;
- Construction phase is assumed to begin after CD-3a is issued and be complete when Final Acceptance is achieved for the installed work;
- The construction subcontract is anticipated to be specified as a multi-year, phased funded procurement.

Details of the Base Estimate

Description

This work will consist of the detailed design, final design, procurement and construction phases for the Site Preparation construction package. The construction package will include the utilities (industrial cooling water, domestic water supply, sanitary sewer, electric, data/communication, natural gas), site work and related surface features and prepatory work needed to support construction and subsequent operation of the PIP-II facility.

The Detailed Design and Final Design phases approximates the Construction Document Phase as described by the American Institute of Architects (AIA) and tailored to meet specific Fermilab requirements. In this phase, the integrated project team will produce the drawings, Exhibit A and Exhibit B (specifications) that set forth the detailed requirements for the construction of the project.

Detailed Design activities will bring the design to approximately 90% complete. Final Design activities will begin after CD-2 and will complete the construction package documentation suitable for competitive, fixed price procurement.

The procurement phase of the work includes the activities required to support the selection of a construction subcontractor and construct the work package scope. For cost tracking purposes, this effort is included in the Construction phase calculations.

The Construction phase of the work will procure, fabricate, construct, install and deliver the work associated with the Site Preparation work package.

Deliverables

The deliverables for this WBS will include the following:

The Detailed Design phase deliverables will include construction documents (drawings, specifications and exhibits) ready to be issued for a lab-wide review.

The Final Design phase deliverables will include construction documents (drawings, specifications and exhibits) ready to be issued for a competitive, fixed price procurement.

The Construction Phase deliverables will include the installation of the Site Preparation work scope and supporting close out documentation typical for construction projects including shop drawings, operations and maintenance manuals and warranty information.

Cost Calculation

Listed below is the calculation for the ED&I, A and construction costs for this WBS.

$23,200,155	Estimated Construction Package Base Cost	
	See PIP-II-doc-333 for construction cost estimate	
-$930,000	Scope Adjustments (see description below)	
$22,270,155	**Total**	
Engineering Design and Inspection Multipliers		
7.0%	Design Phase A/E ED&I	See PIP-II-doc-327 for basis of EDI and A description and analysis of multipliers by phase
2.0%	Design Phase ED&I In-House	
7.9%	Construction Phase A/E Construction Administration	
3.1%	Construction Phase A/E Construction Coordination	
2.0%	Construction Phase ED&I In-House	

Detailed Design/Final Design Assumptions									
80.0%	Detailed Design Portion of Design Phase Total								
20.0%	Final Design Portion of Design Phase Total								

Cost Breakdown

		M&S					Labor	
		A/E		FESS/E		Construction	FTE	Hours
		Design		$	Hours			
Detailed Design		5.6%		1.6%				
		$1,285,916		$371,000	3,602		0.50	875
Subsurface Characterization		$83,900						
Final Design		1.4%		0.4%				
		$257,006		$93,000	903		0.06	97
		CA Support	CC Support					
Construction Phase Support		7.9%	3.1%	2.0%				
		$1,833,000	**$719,000**	$464,000	**4,505**		**2.10**	**3,713**
Construction	*Site Clearing*	*$99,000*	*$39,000*	*$25,000*	*243*	$1,200,000	*0.11*	*200*
	Electrical Feed	*$247,000*	*$97,000*	*$63,000*	*612*	$3,000,000	*0.28*	*500*
	Utility Corridor	*$411,000*	*$161,000*	*$104,000*	*1,010*	$5,000,000	*0.47*	*834*
	Site Work	*$911,000*	*$357,000*	*$230,000*	*2,233*	$11,070,155	*1.04*	*1,846*
	Site Restoration	*$165,000*	*$65,000*	*$42,000*	*408*	$2,000,000	*0.19*	*333*
	Totals	**$3,459,822**	**$719,000**	$928,000	**9,010**	**$9,200,000**	**2.65**	**4,685**
		*Figures in **red** indicate known costs*						

Materials and Supplies (M&S) Notes:
The M&S costs will consist of the following:

- Scope Adjustments from the Estimated Construction Package Base Cost include the following:
  - Reduction of $930,000 for wetland credits.
- Architect/Engineering (A/E) firm to provide Detailed Design, Final Design and Construction Phase Support services. This will be done utilizing task order agreements from a previously selected A/E firm;
- FESS/Engineering will provide support during the Detailed Design, Final Design and Construction phases;
- Emil Huedem of FESS/Engineering is assumed to be available as needed based on his level of mechanical expertise, history of project management knowledge and PIP-II conceptual design.
- The annual costs for the Deputy L2-CF (provided by FESS/Engineering) is included in the M&S costs;
- "CA Support" is the A/E construction administration cost to support the project during the construction phase.
- "CC Support" is the A/E construction coordination cost to provide field representatives during the construction phase.
- It is anticipated that the construction subcontracts will be specified as a multi-year, phased funded procurement;

Labor Notes:
The Labor estimate in the Cost Breakdown table includes the following:

- The labor costs above include support design coordination and integration effort.
- The annual labor cost for the L2 Manager for Conventional Facilities (L2-CF) management efforts is captured in CF Project Management and Coordination (see PIP-II-doc-229);

Uncertainty/Contingency Rules

This uncertainty for this WBS is based on the standard PIP-II guidance (PIP-II-doc-345) and is assumed to be:

Labor	Level of Effort Tasks	Support type activities that must be done to support other work activities or the entire project effort, where estimated effort is based on the duration of the activities it is supporting.	0%-20%	20	Based on level of design maturity
M&S	Preliminary	Items that can be readily estimated from a reasonably detailed but not completed design; items adapted from existing designs but with moderate modifications, which have documented costs from past projects. A recent vendor survey (e.g., budgetary quote, vendor RFI response) based on a preliminary design belongs here.	20%-40%	20	Based on purchase order issued for detailed and final design.
CF	Conceptual	10-15% design complete	20-40%	20	Based on current state of the design. Does not include risk based contingency

Durations

Listed below are the basis of the durations for this work scope:

	Work Days	Reference
Detailed Design		
A/E Tasking	30	*See PIP-II-doc-318*
Detailed Design Phase	132	*Planning Package*
Final Design		
A/E Tasking	30	*See PIP-II-doc-318*
Final Design Phase	44	*Planning Package*
Construction		
Procurement	107	*See PIP-II-doc-321*
Construction Phase	393	*Based on 19MAY17 A/E Estimate*
Notice To Proceed (NTP)	*0*	
Start Construction	*43*	*After NTP*
Beneficial Occupancy	*392*	*After NTP*
Final Acceptance	*393*	*After NTP*

Duration Notes:

- Planning packages are based on previous similar work scope.
- Construction durations are assumed to have a range of -10% to +20% based on the results of the 19MAY17 cost/schedule estimate (see PIP-II-doc-581).
- Duration estimates will be updated upon receipt of task order agreement from A/E firms and Construction Subcontractor.

Reviews

This WBS will include the following formal reviews:

- A Preliminary Design Review (PDR) at the ~60% complete point for the Detailed Design
- A Final Design Review (FDR) at the ~90% complete point for the Detailed Design
- A Production Readiness Review (PRR) at the 100% complete point of the Final Design.

Lessons Learned/Historic Data

The breakdown for EDIA costs is based on previous projects of similar scope and scale. The historic data and analysis is described in PIP-II-doc-327.

The A/E tasking durations is based on previous projects. The historic data and analysis is described in PIP-II-doc-318.

Relationships

Listed below are relationships for this WBS:

- WBS 121.06.01 Conventional Facilities Management and Coordination is a predecessor (PIP-II-doc-217)
- WBS 121.06.03 CF Cryo Plant Building is a successor (PIP-II-doc-244)
- WBS 121.06.04 CF Utility Building is a successor (PIP-II-doc-250)
- WBS 121.06.05 CF Linac Complex is a successor (PIP-II-doc-1515)
- WBS 121.06.06 CF Booster Connection is a successor (PIP-II-doc-265)

Change Log

Revision No.	Description of Change	Change Date
Rev. 0	Initial Release After Internal Review	08/14/17
Rev. 1	Updated cost based on Scope Reduction and change in APM-CF labor	08/23/17
Rev. 2	Updated costs based on review of cost reduction items	10/19/17
Rev. 3	Updated based on revised funding profile and added subsurface characterization and external independent cost/schedule estimate	11/29/17
Rev. 4	Updated A/E Construction Phase Support from 8% to 11% based on December 2017 IPR Recommendation	12/20/17
Rev. 5	Updated based on revised WBS structure and FY18 cost estimate	06/01/18
Rev. 6	Updated based on revised construction packages	08/21/18

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