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National Nuclear Security Administration

Engineering Assessment Report

Pu Pit Production Engineering Assessment

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Revision Summary

Rev. No.	Date	Change Description	Pages Affected
0	5 April 2018	Initial Submission	n/a
1	13 April 2018	Factual accuracy review edits, minor formatting changes, and other corrections	2-25; 2-36; 3-15&16; 3-18; E-2; Appendix I, J, K schedules
2	20 April 2018	Minor corrections to schedules	Appendix I, J, K, L schedules

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Acronyms

AoA	Analysis of Alternatives
BAP	Aqueous Polishing Building
BMP	Material Process Building
BSR	Shipping and Receiving Building
BTS	Technical Support Building
CAAS	criticality accident alarm system
CD	Critical Decision
CER	cost estimating relationship
CMRR	Chemical Metallurgy Research Replacement
CMRR-NF	Chemical Metallurgy Research Replacement – Nuclear Facility
CNC	computer numerical controlled
COA	conditions of approval
CSDR	Conceptual Safety Design Report
CT	computed tomography
CTE	critical technology element
CUB	Combined Utility Building
D&D	decommissioning and disposal
DG	diesel generator
DOE	Department of Energy
DSA	Documented Safety Analysis
EA	Engineering Assessment
EB	electron beam
ECF	Entry Control Facility
ECMS	Enterprise Construction Management Services
EG	Evaluation Guideline
EIS	environmental impact statement
ELD	equipment layout drawing
ES&H	environment, safety, and health
ETF	entry control facility
ft2	square foot
FTE	full-time equivalent
FY	fiscal year
FY	fiscal year
G	Guide
GA	general arrangement
GAO	Government Accountability Office
HC	Hazard Category
HEU	highly enriched uranium
HEUMF	Highly Enriched Uranium Manufacturing Facility
HVAC	heating, ventilation, and air conditioning
LANL	Los Alamos National Laboratory
LCC	life cycle cost
LCCE	life cycle cost estimate
LLNL	Lawrence Livermore National Laboratory
LLW	Low Level Waste
M&O	management and operating
MAR	material at risk
MC&A	material control and accountability
MEB	Mechanical and Electrical Building

MFFF	Mixed Oxide Fuel Fabrication Facility
MOX	mixed oxide
MPF	Modern Pit Facility
MPM	main process module
MR	management reserve
NA-10	Office of Defense Programs
NDC	NPH design category
NEPA	National Environmental Policy Act
NF	nuclear facility
NFPA	National Fire Protection Association
NNSA	National Nuclear Security Administration
NPH	natural phenomena hazard
NRC	Nuclear Regulatory Commission
O	Order
O&M	Operations and Maintenance
OMB	Office of Management and Budget
OST	Office of Secure Transportation
PC	Performance Category
PED	project engineering and design
PEI	PF-4 Equipment Installation
PF	Plutonium Facility
PIDAS	Perimeter Intrusion Detection and Assessment System
ppy	pits per year
PSM	Personnel Support Module
Pu	plutonium
PV	present value
RBA	radiological buffer area
REI	RLUOB equipment installation
RLUOB	Radiological Laboratory Utility Office Building
ROD	record of decision
ROM	rough order of magnitude
SC	Safety Class
SDC	Seismic Design Category
SDS	Safety Design Strategy
SME	subject matter expert
SNM	special nuclear material
SRNL	Savannah River National Laboratory
SRS	Savannah River Site
SS	Safety Significant
SSCs	structures, systems, and components
SWPF	Salt Waste Processing Facility
TA	Technical Area
TPC	total project cost
TRU	transuranic
TRUM	transuranic mixed (waste)
UPF	Uranium Processing Facility
UPS	uninterruptible power supply
WBS	work breakdown structure
WIPP	Waste Isolation Pilot Plant
WR	war reserve
WSB	Waste Solidification Building

Executive Summary

The U.S. Department of Energy (DOE) National Nuclear Security Administration's (NNSA) capability in plutonium (Pu) operations is a cornerstone of NNSA's stockpile stewardship mission. DOE/NNSA's ability to maintain Pu capabilities and increase production capacity will be increasingly vital to sustaining the nuclear weapons stockpile. DOE/NNSA's nuclear security enterprise needs facilities to meet mission requirements and support current and future national security requirements.

DOE/NNSA is reconfiguring existing facilities to support production of up to 30 pits per year (ppy) at Los Alamos National Laboratory (LANL) in Los Alamos, New Mexico[1]. DOE/NNSA's Office of Defense Programs (NA-10) recently completed a Plutonium Pit Production Analysis of Alternatives (AoA) to identify preferred alternatives for meeting the NNSA pit production capability gap. The AoA evaluated options for providing the required infrastructure to support the production of 80 ppy without compromising the ability to conduct all other required and enduring plutonium missions described in the Program Requirements Document (PRD). The AoA narrowed the Alternatives to two, construct a new pit production capability at LANL or repurpose the Mixed Oxide Fuel Fabrication Facility (MFFF) at the Savannah River Site (SRS) located near Aiken, South Carolina. Following the AoA, the NNSA Administrator requested an engineering analysis of these two alternatives for a 50 ppy capability by 2030 combined with an enduring 30 ppy capability being developed at the PF-4 facility at LANL for a total of 80 ppy by 2030.

DOE/NNSA tasked Parsons, under the Enterprise Construction Management Services (ECMS) contract to conduct this engineering assessment (EA) of a 50 ppy capability in support of pre-Critical Decision (CD)-1 activities to support decision making and conceptual design of preferred alternatives for enduring pit production and related plutonium operations.

Approach

The EA Team included subject matter experts from the ECMS Team and DOE/NNSA. The NNSA SMEs provided expertise in the areas of plutonium pit manufacturing, handling and storage of nuclear materials and waste, security, acquisition, and program management. The ECMS SMEs provided expertise in project management, construction, nuclear safety, scheduling, cost estimating, and risk analysis. The EA Team developed and evaluated equipment configuration layouts, preconceptual facility arrangements, schedules, cost estimates, and qualitative risks by conducting a series of five site visits, meetings, and workshops at LANL, DOE/NNSA Headquarters in Washington, DC, and at the Savannah River Site (SRS) in Aiken, South Carolina. The team visited LANL to discuss equipment requirements and preconceptual layouts, tour PF-4 and understand the utilities and support facilities available to support a new 50 ppy pit production facility. The team then met with the authors of the AoA to understand the model and assumptions used to establish the equipment requirements. The team visited the MFFF project at SRS to walk the spaces to assess the feasibility of repurposing the facility for a pit production mission. The equipment set was established, and preliminary equipment layout drawings were developed at a workshop in Aiken, South Carolina. For a more detailed trip report of these site visits, please see Appendix N.

[1] Production capacity beyond 30 ppy will require additional Hazard Category (HC) 2, Security Category (SC) 1 processing area(s) to support long-term increased capacity of plutonium operations.

Equipment layout drawing development and qualitative risk analysis activities were led by ECMS SMEs and performed collaboratively by the EA Team. Cost and schedule estimates were developed by ECMS SMEs with some input and data provided by the NNSA SMEs. The term EA Team is used throughout the document without distinguishing between the activities and organizations described above.

Major Assumptions

The EA Team used the following assumptions for the engineering assessment:

- Plutonium pit production capability will produce a minimum of 80 ppy by 2030.
- For Alternative 1, a congressional decision to terminate the Mixed Oxide Fuel Fabrication Facility (MFFF) project is made by the end of fiscal year 2018.
- The Chemistry and Metallurgical Research Replacement (CMRR) project and Plutonium Sustainment programs will be executed as planned, including the change to the Radiological Laboratory Utility Office Building (RLUOB) material-at-risk (MAR) limits. The resulting capabilities will provide sufficient analytical chemistry (AC) and materials characterization capabilities to support plutonium mission activities at LANL and the capacity to manufacture 30 ppy in PF-4.
- The baseline program will be a W87-like pit. The equipment and space needed to work on or produce small quantities of all seminal pit types were included.
- Pit reuse activities can be supported by the same capabilities as pit remanufacturing.
- Non-nuclear pit parts will be manufactured new. Production of these parts can continue at current locations (e.g., Kansas City National Security Campus near Kansas City, Missouri, and LANL).
- Future pits will continue to be cast, not wrought, and will use current processes and technology.
- Lawrence Livermore National Laboratory in Livermore, CA will continue to perform its current plutonium mission.
- Pit production must be performed in the United States in government-owned facilities and by approved management and operating partners.
- All four alternatives include adequate radiography when complete.

Alternatives Reviewed

The EA Team used the program requirements as defined and documented in the classified PRD to conduct the engineering assessment of four alternatives, including determining engineering feasibility (Section 2), developing schedule and cost estimate ranges (Section 3), and assessing qualitative risks (Section 4).

Alternative 1: Modify the Mixed Oxide Fuel Fabrication Facility with Production Modules

The MFFF structure at SRS has been designed and constructed to meet nuclear codes and standards for natural phenomena hazard (NPH) protection, for safeguards and security, and material control and accountability (MC&A). The MFFF has sufficient space to install the utility and process systems needed for pit processing. The process equipment supporting the 50 ppy mission that will be installed in MFFF is identified and included in the Engineering Feasibility Section (Section 2). Alternative 1 would repurpose the MFFF structure to meet the Pu mission by:

- Removing process equipment and utility commodities intended for fuel fabrication that had been previously installed in the existing MFFF building, followed by installation of pit processing and process support equipment and utilities.
- Modifying the existing Technical Support Building as required to provide the personnel support functions for the new Pu pit production mission.
- Installing an analytical chemistry laboratory in the MFFF.
- Installing fire water supply equipment and the emergency diesel generators in separate structures adjacent to the MFFF.
- The significant number of samples required to support a 50 ppy Pu pit mission in conjunction with other missions at SRNL may increase the MAR in A-Area facilities above the current safety basis limits. As a result, separate analytical laboratory capabilities will be constructed and located in the MFFF area which improves the efficiency of the movement of samples and turnaround time.

Alternative 2a: Construct a Module at LANL – Production Facility Outside PF-4

Alternative 2a involves construction of a new 50 ppy facility at LANL. Because of interdependencies with PF-4 and RLUOB, the new facility will be constructed in an area adjacent to these existing facilities. The new facility will include:

- A process module designed to nuclear codes and standards to protect process equipment and safety systems from NPH events. The process module will also provide the appropriate features needed for safeguard and security and for MC&A. The process equipment required to support the 50 ppy mission in both the new process module and in PF-4 is identified and included in the Engineering Feasibility Report (Section 2).
- A personnel support module that will provide personnel support capabilities and will be designed to commercial codes and standards.
- A Mechanical and Electrical Building (MEB) that will house non-safety utility systems.
- Other structures for the fire water supply equipment, emergency diesel generators, and other utility systems. The fire water supply system and the emergency diesel generators will be in separate structures adjacent to the process module.

Alternative 2b: Construct a Module at LANL – Production Capability Split with PF-4

In Alternative 2b, some of the pit processing operations that were to be performed in the new process module for Alternative 2a will be performed in PF-4.

- Because some of the pit production operations will be located in PF-4, the new process module for Alternative 2b will be smaller than the module planned for Alternative 2a.
- Pit production operations to be performed in PF-4 for Alternative 2b for the 50 ppy capability include disassembly, metal preparation, foundry, and to provide aqueous recovery of plutonium.
- The equipment to be installed in the new process module and in PF-4 is identified and included in the Engineering Feasibility Report (Section 2).
- As in Alternative 2a, a new personnel support module, mechanical and electrical building, and fire water supply and diesel generator buildings will be required for Alternative 2b.
- Because the new process module will not include all 50 ppy process areas, the size of the process module will be smaller than for Alternative 2a.

Alternative 2c: Use PF-4 as a Bridge Until Construction of Modules at LANL

Alternative 2c is a LANL preferred option of a two-phased approach to achieve 80 ppy in PF-4 by using two-shift operations followed by construction of new process modules.

- LANL provided layout drawings for the preferred option to support Alternative 2c, involving reconfiguration of PF-4 and construction of three modules to provide an overall production rate of 80 ppy.
- The EA Team evaluated a two-phased approach that starts with installation of new additional equipment in PF-4 to achieve an 80 ppy production rate using two-shift operations; two 10-hour shifts, four days a week.
- The initial phase is intended as a bridging strategy to achieve full production by 2030.
- The second phase includes constructing new processing modules to achieve an 80 ppy production rate using single-shift operations.
- It is uncertain whether the existing radiography capability in the PF-4 tunnel would be sufficient for 80 ppy. Therefore, it is possible that during the short-term 80 ppy operations in PF-4, some radiography would have to be performed at an offsite location, such as the Pantex Plant outside of Amarillo, TX.
- PF-4 reconfiguration for Alternative 2c involves installation of additional production equipment beyond the 30 ppy requirement as specified in the Plutonium Sustainment Plan.
- The process equipment to be installed in PF-4, RLUOB, and in the new process modules is identified and included in the Engineering Feasibility Section (Section 2).

Engineering Feasibility

The EA Team evaluated the engineering feasibility and developed preconceptual designs for Alternatives 1, 2a, and 2b. The EA Team used LANL-developed preconceptual design drawings to evaluate Alternative 2c.

Although the end states[2] of all four alternatives are feasible, the alternatives have some discrete differences in the design approach, safety strategy, constructability, operability, self-sustainability, and expandability. These differences are summarized in Table ES-1 and are discussed in more detail in the Engineering Feasibility Section (Section 2).

Table ES-1: Engineering Feasibility Summary

Engineering Feasibility Component	Alternative 1 Modify MFFF at SRS with Production Modules	Alternative 2a Construct a Module at LANL – Production Facility Outside PF-4	Alternative 2b Construct a Module at LANL – Production Capacity Split with PF-4	Alternative 2c Use PF-4 as a Bridge Until Construction of Modules at LANL
Design Approach	• Design includes minor modifications to facility; and equipment installation	• Includes new Hazard Category (HC) 2 process module	• Includes new HC-2 process module; equipment installation in PF-4	• Limited to equipment installation in PF-4 (first phase) • Includes new HC-2 process modules (second phase)
Safety Strategy	• Conservative MFFF safety strategy • Uncertainty with MFFF safety basis; constructed as a NRC-licensed facility and will transition to DOE safety regulations	• Conservative process module safety strategy • Uncertainty approval of material at risk increase for RLUOB may affect 50 ppy production	• Conservative process module safety strategy • Uncertainty[1] with PF-4 documented safety analysis and approval of material at risk increase for RLUOB may affect 50 ppy production	• Safety strategy for PF-4 is founded on existing DSA (first phase) • Safety strategy for process modules is non-conservative (second phase) • Uncertainty[1] concerning safety basis for PF-4 and RLUOB may affect 50 ppy production
Constructability	• Construction includes reconfiguring facility and equipment installation • Commodity routing in an existing facility is more challenging	• Includes new HC-2 process module and personnel support module (PSM) [non-nuclear facility] • Equipment and commodity installation is simplified by purpose-built design of new process module	• Includes new HC-2 process module, PSM, and installation of new process equipment in PF-4 • Equipment and commodity installation in new process module is simplified • Equipment installation in PF-4, an operating nuclear facility, is more challenging	• Construction limited to installation of new process equipment in PF-4; equipment installation in an operating nuclear facility is challenging (first phase) • Construction includes construction of new below-grade HC-2 process modules (second phase) • Below-grade design requires excavation and backfill (second phase) • Equipment installation is simplified by purpose-built design of modules (second phase) • Commodity installation is more challenging (second phase)
Operability	• Includes all capabilities to sustain 50 ppy production rate	• Manual transfer of oxides and samples to PF-4	• Manual transfer of oxides, samples and Pu material between PF-4 and process module	• Limited vault and shipping and receiving capacity may affect 50 ppy production • Lack of personnel support facilities for staff could limit production • Interruption of radiography capability

[2] The EA Team determined that the final configuration of Alternative 2c is feasible, but did not have sufficient data to determine the feasibility of two-shift operations in PF-4.

Engineering Feasibility Component	Alternative 1 Modify MFFF at SRS with Production Modules	Alternative 2a Construct a Module at LANL – Production Facility Outside PF-4	Alternative 2b Construct a Module at LANL – Production Capacity Split with PF-4	Alternative 2c Use PF-4 as a Bridge Until Construction of Modules at LANL
Self-Sustainability	• MFFF is fully independent	• Partial reliance on PF-4 • Fully reliant on RLUOB	• Complete inter-dependency between process module and PF-4 • Fully reliant on RLUOB	• Fully reliant on RLUOB • Significant reliance on PF-4 (Pu vault and shipping and receiving)
Expandability	• MFFF has sufficient space for 80 ppy	• Process module could be designed with space margin to allow future expansion	• Increased pit production rate would require installation of more process equipment in process module and PF-4	• Achieving 80 ppy in PF-4 requires two shift operations; higher pit production rate is not viable (first phase) • Additional module(s) could be added in the future (second phase)
1. Based on LANL SME input, plans are in place to adequately address the two bounding accidents that would have significant unmitigated off-site consequences. These are operational and post-seismic fires. Uncertainty remains because the work is not completed, which poses some risk.				

Schedule and Cost Estimate Ranges

The EA Team developed schedule and cost estimate ranges for the four alternatives. Individual areas addressed were capital costs, Life Cycle Cost Estimates (LCCE), and project schedules.

Estimates and schedules that have been developed for each alternative represent rough-order-of-magnitude estimates (Class 5 in accordance with DOE Cost Estimating Guide estimate classification) and are intended to provide a means of comparing relative costs of alternatives to support the decision-making process. Estimates and schedules are not intended for budgeting purposes.

Alternatives 2b and 1 have the lowest high-end range at $4.4 billion and 4.6 billion, respectively. Alternative 2c has the highest high-end range at $5.8 billion. Figure ES-1 summarizes the total project cost (TPC) estimate range. Table ES-2 summarizes the LCCEs. Figure ES-2 summarizes the schedule range. Supporting schedule and cost estimating details, including the approaches and methodologies used to develop the cost estimates and schedule, and the basis of estimates are included in Section 3.

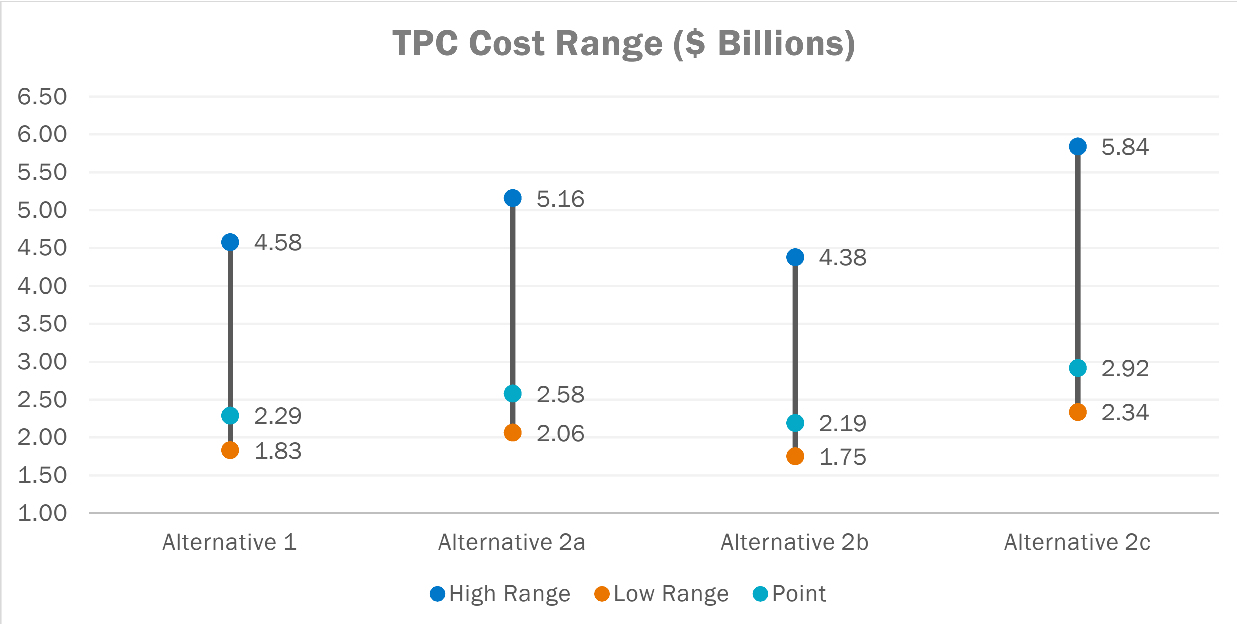

Figure ES-1: Total Project Cost (TPC) Estimate Range Summary

Table ES-2: Present Value of Life Cycle Costs for Alternatives ($B)

Cost Element	Alternative 1 Modify MFFF at SRS with Production Modules	Alternative 2a Construct a Module at LANL – Production Facility Outside PF-4	Alternative 2b Construct a Module at LANL – Production Capacity Split w/PF-4	Alternative 2c Use PF-4 as a Bridge until Construction of Modules at LANL
Capital Projects	1.74	1.93	1.68	1.94
Operations Costs	25.99	16.86	12.618	12.80
End-of-Life D&D	0.04	0.03	0.03	0.04
Total Life Cycle Cost	27.77	18.82	14.32	14.78

The below schedule ranges are for CD-4 milestone and do not include the time required for hot commissioning, development, process prove in, and qualification activities required to achieve war reserve (WR) production. For Alternative 1, seven years was analyzed to be required to achieve WR production (1 year for hot commissioning followed by 6 years for the remaining activities). For Alternatives 2a, 2b and 2c (phase 2), these activities were assessed to require five years. In addition to the above, each alternative will require additional time to ramp to the required 50 ppy capacity. This additional time extends Alternatives 1, 2a and 2b beyond the 2030 requirement date. Alternative 2c phase 1 includes installing equipment and adding a shift in PF-4 to achieve 80 ppy by 2030. The EA Team identified significant risks associated with this alternative. Details are provided in the Qualitative Risk Analysis section of this report (Section 4).

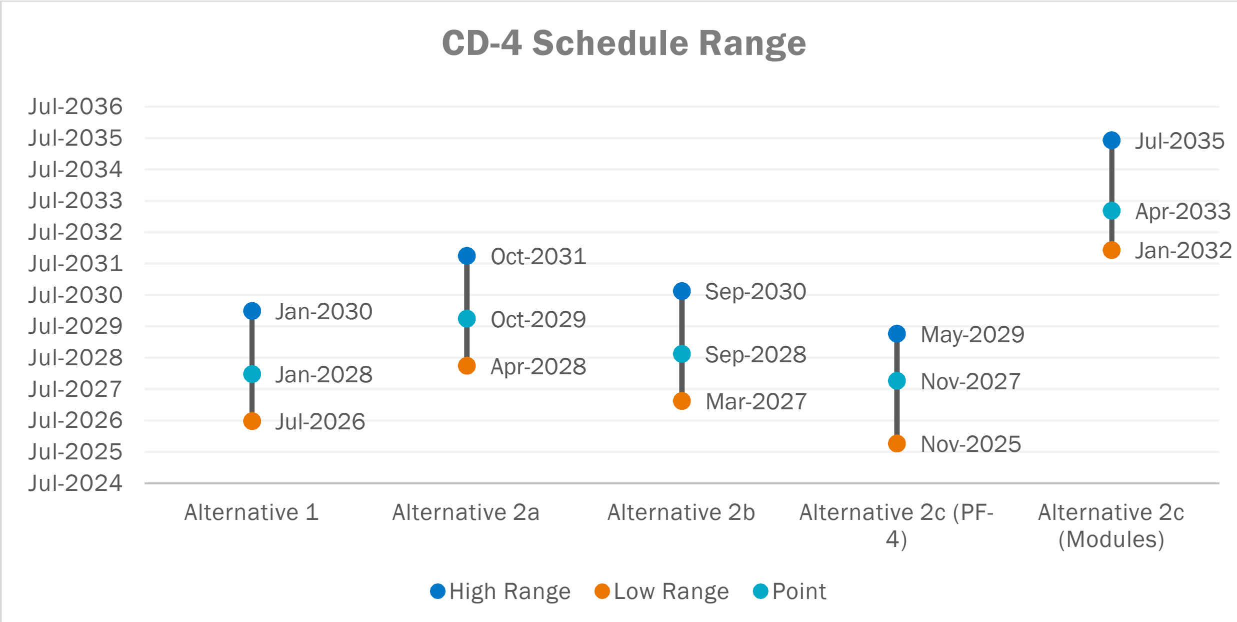

Figure ES-2: Schedule Range Summary

All four alternatives analyzed could meet the requirements for the production of 50 ppy using some of the following approaches: shift work, robust funding, enhanced collaboration between Design Agency and Production Agency, and detailed upfront planning in all phases of the project. Priority and focused leadership will be required to meet the 2030 requirement for 50 ppy.

Qualitative Risk Analysis

The qualitative risk analysis included identification of threats and opportunities applicable to all four alternatives in addition to specific threats and opportunities unique to individual alternatives. Individual threats and opportunities and the overall qualitative risk analysis are included in the Qualitative Risk Analysis section of the report. The report includes the following information:

- Risk assessment methodology used
- Description and the results of the risk analysis workshop and subsequent conferences, comments and resolutions, and additional discussions
- Major risks that discriminate between the alternatives
- Overall comparative risks of the alternatives
- Risk assessment conclusions, including a narrative assessment of the additional risk implications of double-shift operations
- Detailed risk registers with all results
- Risk assessment rationale developed during the risk analysis workshop

Figure ES-3 summarizes the residual threats and opportunities. Overall, Alternative 1 is summarized as low risk, Alternatives 2a and 2b are summarized as low to moderate risk, and Alternative 2c is summarized as moderate risk, with the first phase of Alternative 2c having the highest residual risk. Details on the qualitative risk analysis process used, including the risk register and the risk analysis rationale, are included in Appendix M.

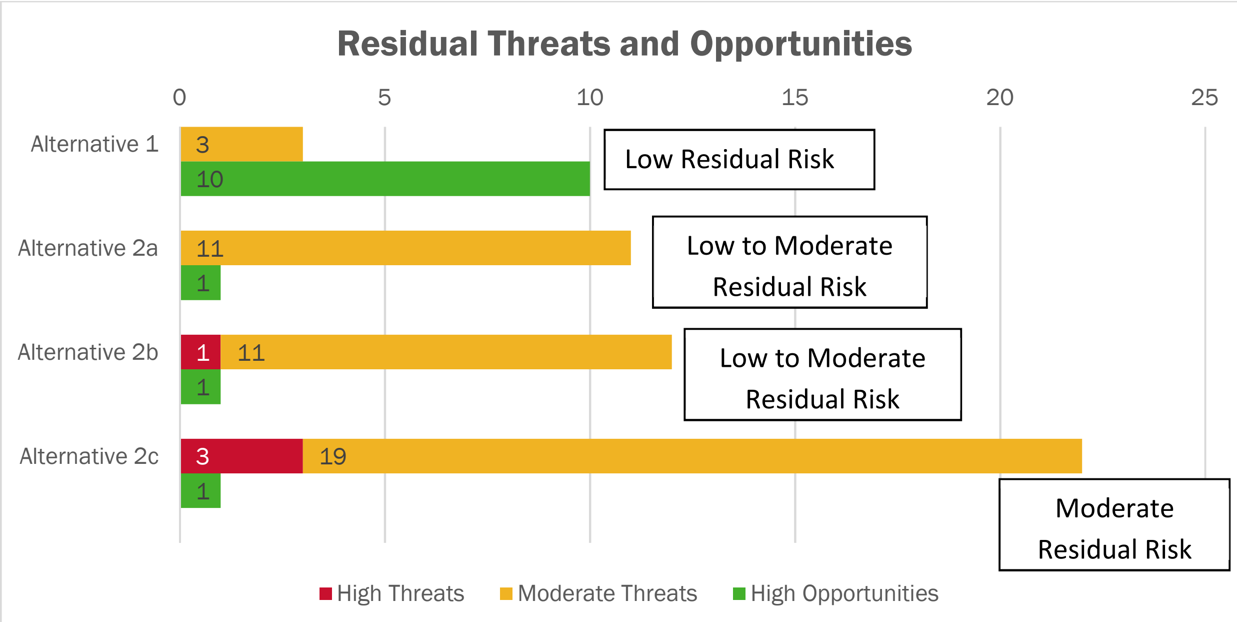

Figure ES-3: Qualitative Risk Analysis Summary

Summary Observations

The engineering assessment determined all four alternatives to be feasible to achieve 50 ppy. Each alternative includes varying schedule and cost estimate ranges and associated qualitative risks, with some notable distinguishing factors:

- Alternative 1 is entirely contingent on a congressional decision to terminate the MFFF project.
- Alternatives 2b and 2c's reliance on PF-4 represents a significant risk as a single point of failure if operations in PF-4 are shut down.
- Alternatives 2a, 2b, and 2c rely on approval of the increased MAR limit for the RLUOB to provide analytical chemistry services for PF-4 and any new pit production facilities.

The evaluations of the alternatives in this analysis should only be used to compare the alternatives and should not be used for budgeting or determining completion dates. Scheduling and costs for any of the alternatives could be affected by funding stream and choice in using shift work for construction, commissioning, or other functions. NNSA processes do not establish total project costs or baseline schedules until much later in the development of a single alternative. In addition, NNSA could pursue other opportunities for improving the schedule to achieve 80 ppy with high confidence by 2030. The analysis is intended only to inform decision-making on conceptual designs as DOE/NNSA nears CD-1.

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1 Introduction

1.1 Tasking

The U.S. Department of Energy (DOE), National Nuclear Security Administration (NNSA) tasked the Enterprise Construction Management Services (ECMS) Team under the awarded Call DO-89233118FNA000009 to conduct an engineering assessment (EA) in support of pre-Critical Decision (CD)-1 activities to support conceptual design of preferred alternatives for enduring pit production and related plutonium operations. The NNSA Office of Defense Programs (NA-10) recently completed a Plutonium Pit Production Analysis of Alternatives (AoA) to identify preferred alternatives for meeting the NNSA pit production capability gap. The AoA identified two preferred alternatives: (1) repurposing the Mixed Oxide Fuel Fabrication Facility (MFFF) at the Savannah River Site (SRS) in Aiken, South Carolina; and (2) new construction at Los Alamos National Laboratory (LANL) in Los Alamos, New Mexico.

1.2 Purpose

The purpose of the EA is to evaluate the technical feasibility, schedule, cost, and risks of the two preferred AoA alternatives, in addition to a variation of one of the alternatives and a fourth alternative proposed by LANL. The four alternatives evaluated are:

- Alternative 1: Modify MFFF at SRS with Production Modules
- Alternative 2a: Construct a Module at LANL – Production Facility Outside PF-4
- Alternative 2b: Construct a Module at LANL – Production Facility Split with PF-4
- Alternative 2c: Use PF-4 as a Bridge Until Construction of Modules at LANL

1.3 Scope

The scope of the EA includes an assessment of the following for each of the four alternatives:

- Engineering Feasibility (Section 2), including preconceptual equipment configuration layouts and facility arrangements[3] (Appendices A, B, C, and D)
- Schedule and cost estimate ranges (Section 3)
- Qualitative Risk Analysis (Section 4)

[3] Layouts and facility arrangements for Alternative 2c were provided by LANL. The EA Team reviewed these submissions for feasibility and reasonableness; The EA Team provided schedule and cost estimates and evaluated qualitative risks for comparison with Alternatives 1, 2a, and 2b.

1.4 Background

Maintaining capabilities in plutonium operations is a cornerstone of NNSA's stockpile stewardship mission. As NNSA conducts this mission, the ability to maintain plutonium capabilities and increasing production capacity will be increasingly vital to sustaining the nuclear weapons stockpile. The Nuclear Security Enterprise needs facilities to meet mission requirements and support current and future national security requirements related to the nation's nuclear deterrent.

NNSA is committed to continuity in plutonium operations; it is optimizing existing facilities to meet this commitment and plans to support production of up to 30 pits per year (ppy) at LANL. Production capacity beyond 30 ppy will require an additional Hazard Category (HC) 2, Security Category (SC) 1 processing area to support long-term increased capacity of plutonium operations.

Acquisition for the planned pit production mission achieved CD-0 on 25 November 2015. To ensure compliance with departmental project management best practices and policies, DOE Order 413.3B Change 3, and recent National Defense Authorization Act language, an AoA was conducted to examine viable options to meet the approved mission need. The AoA evaluated options for providing the required infrastructure to support the production of 80 ppy without compromising the ability to conduct all other required and enduring plutonium missions described in the Program Requirements Document (PRD).

1.5 Program Requirements

The EA Team used the program requirements as defined and documented in the classified PRD to conduct the engineering assessment of each of the four alternatives, including determining engineering feasibility, developing schedule and cost estimate ranges, and assessing qualitative risks.

1.6 Major Assumptions

Consistent with the PRD and the AoA, the EA Team used the following assumptions for the engineering assessment:

- Plutonium pit production capability will be able to produce a minimum of 80 ppy by 2030.
- For scheduling purposes, the EA Team assumes that a Congressional decision to terminate the MOX project is made by the end of fiscal year 2018 if Alternative 1 is selected.
- The Chemistry and Metallurgical Research Replacement (CMRR) project and Plutonium Sustainment programs will be executed as planned, including the change to the Radiological Laboratory Utility Office Building (RLUOB) material-at-risk (MAR) limits. The resultant capabilities will provide sufficient analytical chemistry (AC) and materials characterization capabilities to support plutonium mission activities at LANL and the capacity to manufacture 30 ppy in PF-4.

- The baseline program will be a W87-like pit. The equipment and space needed to work on or produce small quantities of all seminal pit types were included.
- Pit reuse activities can be supported by the same capabilities as pit remanufacturing.
- Non-nuclear pit parts will be manufactured new. Production of these parts can continue at their current locations (e.g., Kansas City National Security Campus and LANL).
- Future pits will continue to be cast, not wrought, and will use current processes and technology.
- Lawrence Livermore National Laboratory (LLNL) will continue to perform its current plutonium mission.
- Pit production must be performed in the United States in government-owned facilities and by approved management and operating partners.

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2 Engineering Feasibility Analysis

The EA Team evaluated the engineering feasibility of four plutonium pit production alternatives. Engineering feasibility was evaluated in terms of design approach, safety strategy, constructability, operability, self-sustainment, and expandability. The EA Team developed preconceptual designs for Alternatives 1, 2a, and 2b, and used LANL-developed preconceptual design drawings for Alternative 2c to determine engineering feasibility. The overall conclusion is that all four alternatives can, when completed, feasibly meet the objective of producing 50 pits per year (ppy); however, the EA team did not evaluate the feasibility of meeting 80 ppy by using two shifts in PF-4 as proposed for the first phase of Alternative 2c. There are discrete differences between each alternative, and these are summarized below and discussed in more detail in this Engineering Feasibility Analysis.

2.1 Alternative Descriptions

2.1.1 Alternative 1: Modify MFFF at SRS with Production Modules.

Alternative 1 provides a fully independent and self-contained 50 ppy capability within the existing Mixed Oxide Fuel Fabrication Facility (MFFF) at the Savannah River Site (SRS). The MFFF was designed and constructed to meet Nuclear Regulatory Commission (NRC) requirements for nuclear safety and DOE requirements for material control and accountability (MC&A) and for safeguards and security. The safety strategy for Alternative 1 is to conservatively assume that all the passive and active engineered controls credited in the Los Alamos National Laboratory (LANL) Plutonium Facility (PF-4) Documented Safety Analysis (DSA) would be required for accident mitigation in the MFFF. Safety documentation would be developed for the MFFF during the design of the 50 ppy project as required by DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets*.

Because the MFFF is an existing structure, design for the 50 ppy project would be limited to designing process and support systems and the minor modifications to the MFFF building. Similarly, the construction phase of the project would be limited to adding support equipment mezzanines, removing existing fuel manufacturing equipment, installing new pit production process, process support, and building utilities equipment, and routing commodities to connect the systems. However, Alternative 1 does include the addition of a significant and somewhat complex conveyance system. The MFFF's building size requires commodities to be routed over longer distances and requires more wall and floor penetrations than for other alternatives.

The process and process support areas and the building utility systems for pit production would be in the MFFF areas that provide the best fit. The EA Team developed detailed equipment layout drawings (ELDs) to verify that the process equipment needed for 50 ppy would fit within select MFFF areas. After a review of the MFFF general arrangement drawings and several walk-downs of the building, the EA Team concluded that the MFFF provided more than sufficient room for all process support areas and for building utility systems for production of 50 ppy.

No inherent design limitations are associated with Alternative 1 that would directly or indirectly affect the pit production capability. No dependencies on other process facilities could affect pit production. The existing Technical Support Building (BTS) has more than sufficient room to house the operational staff needed for production of 50 ppy. The BTS can provide the personnel support functions (e.g., entry control facility, office areas, conference rooms, restrooms, locker rooms, and lunch or break room) for a 50 ppy staff and allows efficient movement of staff between the BTS and the MFFF.

2.1.2 Alternative 2a: Construct a Module at LANL – Production Facility Outside PF-4.

Alternative 2a provides a new 50 ppy process module, a new personnel support module (PSM), and a mechanical and electrical building (MEB). The process module provides the process and process support areas needed for producing 50 ppy and would be a Hazard Category 2 (HC-2) nuclear facility due to the quantity of radioactive material at risk (MAR) and the potential for a criticality accident. The module's structure would have to meet the natural phenomena hazard (NPH) protection requirements to provide confinement functions to be determined by the hazard and accident analyses.

Similar to Alternative 1, the safety strategy for Alternative 2a is to conservatively assume that all passive and active engineered controls credited in the PF-4 DSA would be required for accident mitigation in the new process module. Safety documentation would be developed for the process module during the design of the 50 ppy project as required by DOE Order 413.3B.

Alternative 2a (and Alternatives 2b and 2c) relies on PF-4 to provide aqueous recovery of plutonium. The existing PF-4 tunnel will be connected to the process module to provide for manual material transfers between the process module to PF-4 to perform this ancillary operation. Once the process module is operational, the combined 80 ppy production process facilities will rely on the new high-energy radiography vault in the process module. During the time that existing radiography equipment is removed from the PF-4 end of the tunnel and the connection to the new process module is finished, material transfers between the two will have to occur using a different route. The interdependencies between the process module and PF-4 constitute an operational risk for Alternative 2a (and Alternatives 2b and 2c).

PF-4 was constructed in the 1970s; it meets SDC-3 seismic requirements for existing facilities. There are open questions regarding the seismic capacity of the PF-4 building structure and the ability to withstand a Performance Category 3 (PC-3) seismic event. Complex, nonlinear analyses are pending to address these questions. The outcome of these analyses may result in the need for structural upgrades and/or imposition of operational constraints on the facility. These seismic vulnerabilities of PF-4 represent a risk for Alternative 2a in that plutonium recovery may have to be accomplished using foundry equipment in the process module while the aqueous recovery capability in PF-4 is unavailable.

Alternative 2a (and Alternatives 2b and 2c) also requires that the Radiological Laboratory Utility Office Building (RLUOB) provide all sample splitting and analysis functions for pit production at LANL. To perform sample splitting operations in RLUOB, the facility Pu material at risk (MAR) limit must be increased. The increase in MAR will require that the facility be categorized as an HC-3 facility. This change in hazard category will require that a DSA be developed and approved. There is some risk that the safety analysis process will identify the need to modify the facility to provide safety significant safety controls, or the need for other operational restrictions.

The process module for Alternative 2a would be a two-story structure built at the existing grade of the site. The two-story concept decreases the footprint of the module, which allows more room for construction access. Equipment installation is simplified by using cranes to drop equipment in place through the roof opening during module construction. Commodity installation is also simplified in a purpose-built facility where penetrations are installed during walls and floor construction.

Alternative 2a (and Alternative 2b) includes constructing a non-nuclear PSM to house the operational staff needed for pit production at 50 ppy. The PSM will provide the personnel support functions for a 50 ppy staff and allows efficient movement of staff between the PSM and the process module. Because the PSM is a non-nuclear facility, it can be constructed prior to approval of Critical Decision 2/3 (CD-2/3) and the start of construction of the process module. The PSM could also be used as a construction support facility during the construction phase.

2.1.3 Alternative 2b: Construct a Module at LANL – Productivity Capacity Split with PF-4

Alternative 2b is based on a “split-flowsheet” concept: the processing equipment for the 50 ppy capability is in two facilities — a new process module and the existing PF-4 facility. PF-4 would be reconfigured to allow installation of the process equipment needed for the disassembly, metal preparation, and foundry operations. The new process module would house the process equipment needed for all other pit processing operations.

The design and construction of the process module is similar to Alternative 2a, except that the module is smaller because it does not provide all process equipment needed for pit production. Installation of the new process equipment in PF-4 is more challenging because PF-4 is an operating nuclear facility.

In addition to the manual transfer of oxides and samples, Alternative 2b also requires manual transfer of Pu materials from the PF-4 foundry to the process module. These transfer operations could create a bottleneck in the connecting corridor between the process module and PF-4 that potentially could impact the pit production rate.

Alternative 2b relies on PF-4 to provide aqueous recovery of plutonium and, because part of the pit production flowsheet remains in PF-4, more risk is associated with interdependencies between the process module and PF-4.

2.1.4 Alternative 2c: Use PF-4 as a Bridge until Construction of Modules at LANL.

The design and operational concept for Alternative 2c is to add process equipment in PF-4 to allow short-term operations at an 80 ppy production rate with two labor shifts. Two-shift operations are defined as two 10-hour shifts, four days per week. New modules would be constructed to provide the capability for long-term operation at “split production” operations with a single shift. The safety strategy for Alternative 2c is to build the modules below grade and credit only the passive confinement barriers to mitigate the off-site and co-located worker dose consequences due to radioactive material release accidents.

It is uncertain whether the existing radiography capability in the PF-4 tunnel would be sufficient for 80 ppy. It is therefore possible that, during the short-term 80 ppy operations in PF-4, some radiography would have to be performed at an offsite location, such as Pantex. This poses a risk of negative impact on productivity resulting from pits that must be shipped back and forth between the sites instead of generally flowing from LANL to Pantex.

The below-grade design concept for the new modules requires additional civil design and construction scope. The single-story design also requires a larger footprint on a relatively small construction site, which makes construction access more difficult. The operational concept for the process modules is to rely on PF-4 to provide ancillary process support operations and to provide Pu vault storage and shipping and receiving capabilities. The 80 ppy production process relies on use of the high-energy radiography vaults that will be relocated to the process modules. The manual transfer of material between facilities could result in bottlenecks that could affect the pit processing rate of both facilities.

Table 2-1 summarizes the design approach, safety strategy, constructability, operability, self-sufficiency, and expandability for each alternative.

Table 2-1: Engineering Feasibility Summary

Engineering Feasibility Component	Alternative 1 Modify MFFF at SRS with Production Modules	Alternative 2a Construct a Module at LANL – Production Facility Outside PF-4	Alternative 2b Construct a Module at LANL – Production Capacity Split with PF-4	Alternative 2c Use PF-4 as a Bridge Until Construction of Modules at LANL
Design Approach	• Design includes minor modifications to facility, and equipment installation	• Includes new Hazard Category (HC) 2 process module	• Includes new HC-2 process module; equipment installation in PF-4	• Limited to equipment installation in PF-4 (first phase) • Includes new HC-2 process modules (second phase)
Safety Strategy	• Conservative MFFF safety strategy • Uncertainty with MFFF safety basis; constructed as a NRC-licensed facility and will transition to DOE safety regulations	• Conservative process module safety strategy • Uncertainty with PF-4 documented safety analysis and approval of material at risk increase for RLUOB may affect 50 ppy production	• Conservative process module safety strategy • Uncertainty[1] with PF-4 documented safety analysis and approval of material at risk increase for RLUOB may affect 50 ppy production	• Safety strategy for PF-4 is founded on existing DSA (first phase) • Safety strategy for process modules is non-conservative (second phase) • Uncertainty[1] concerning safety basis for PF-4 and RLUOB may affect 50 ppy production
Constructability	• Construction includes reconfiguring facility and equipment installation • Commodity routing in an existing facility is more challenging	• Includes new HC-2 process module and personnel support module (PSM) [non-nuclear facility] • Equipment and commodity installation is simplified by purpose-built design of new process module	• Includes new HC-2 process module, PSM, and installation of new process equipment in PF-4 • Equipment and commodity installation in new process module is simplified • Equipment installation in PF-4, an operating nuclear facility, is more challenging	• Construction limited to installation of new process equipment in PF-4; equipment installation in an operating nuclear facility is challenging (first phase) • Additional material characterization equipment in RLUOB (first phase) • Construction includes construction of new below-grade HC-2 process modules (second phase) • Below-grade design requires excavation and backfill (second phase) • Equipment installation is simplified by purpose-built design of modules (second phase) • Commodity installation is more challenging (second phase)
Operability	• Includes all capabilities to sustain 50 ppy production rate	• Manual transfer of oxides and samples to PF-4	• Manual transfer of oxides, samples and Pu material to PF-4	• Limited vault and shipping and receiving capacity may affect 50 ppy production • Lack of personnel support facilities for staff could limit production • Interruption of radiography capability
Self-Sustainability	• MFFF is fully independent	• Partial reliance on PF-4 • Fully reliant on RLUOB	• Complete inter-dependency between process module and PF-4 • Fully reliant on RLUOB	• Fully reliant on RLUOB • Significant reliance on PF-4 (Pu vault and shipping and receiving; second phase)
Expandability	• MFFF has sufficient space for 80 ppy	• Process module could be designed with space margin for future expansion	• Increased pit production rate would require installation of more process equipment in process module and PF-4	• Achieving 80 ppy in PF-4 requires two shift operations; higher pit production rate is not viable (first phase) • Additional module(s) could be added in the future (second phase)

1 Based on LANL SME input, plans are in place to adequately address the two bounding accidents that would have significant unmitigated off-site consequences. These are operational and post-seismic fires. Uncertainty remains because the work is not completed, which poses some risk.

2.2 Process Equipment List

2.2.1 Throughput Modeling

The Plutonium Pit Production Analysis of Alternatives (AoA) Team performed detailed modeling of the process flowsheet provided by LANL to determine the number of process equipment items needed to achieve pit production rates of 30, 50, and 80 pits per year (ppy) at a high confidence level. The model used "isolated event simulation" to predict pit production process times, equipment failure rates, repair times, and part rejection rates for each process step. This was based on probability distributions informed by historic production efforts at PF-4, and SME input from LANL and former Rocky Flats Plant production managers supporting the AoA team.

The simulation runs identified "choke points" where the overall throughput was limited by equipment availability at specific process steps. The AoA Team added redundant equipment items to the model to eliminate choke points and to achieve the required throughput.

The equipment set was further adjusted to achieve 90% confidence that the required pit production capacity of 80 ppy could be maintained for the duration of the Pu pit production mission. The equipment sets needed to achieve this "high confidence level" of throughput are documented in Appendix H of the AoA Report.

The LANL staff independently developed a flowsheet model using different software to determine the equipment set needed in PF-4 to achieve the 30 ppy production requirement of the Pu Sustainment Program at 50% confidence. The AoA model was used to develop an equipment set under similar assumptions (30 ppy at 50% confidence), and the required equipment set was comparable to that developed independently by LANL. This was reviewed and confirmed by LANL, Lawrence Livermore National Laboratory (LLNL), and Rocky Flats subject matter experts (SMEs) in February–March 2017 and by the Plutonium Advisory Team in April 2017. The results of the AoA model and a summary of the model validation activities are provided in the AoA Report, Section 2.

2.2.2 Modeling Assumptions and Limitations

The flowsheet provided by LANL for use in development of the AoA model is for production of the base case pit type. The Program Requirements Document requires that the future Pu pit production facility be capable of manufacturing other pit types. There are minor differences in the process steps and equipment set needed for manufacturing these other pit types. Flowsheets have not been developed for these other pit types, and the AoA and LANL models have not been revised to account for the differences. The AoA Team reviewed the equipment set/equipment list for the base case pit type and added the additional equipment items to perform all process steps needed for manufacturing other pit types identified in the PRD.

The AoA and LANL single-shift throughput models assume that the pit manufacturing operations in the production facility are limited to one shift per day. It is assumed that surveillances, equipment calibrations, and preventive and corrective maintenance activities are performed on second shifts.

Other forced or planned facility level outages are assumed to occur throughout the year, which reduces the annual operating time for pit manufacturing operations to 1,645 hours. The equipment set used by the Engineering Assessment (EA) Team for the development of Alternatives 1, 2a, and 2b are based on the same assumptions. The equipment set developed by LANL for the first phase of Alternative 2c (80 ppy production in PF-4 with two shift operations) assumed that pit production operations in PF-4 would take place on two shifts.

2.2.3 Engineering Assessment Team Review of Throughput Modeling

The EA Team met with the AoA team in Washington, DC, on 29–30 November 2017 to review the AoA model and the model simulation results. The EA Team confirmed that AoA model was technically sound and, to the extent that the pit production data provided by LANL (with input from Rocky Flats SMEs) that was used in the model (e.g., process times, equipment failure rates, repair times, and part rejection rates) is accurate, the results are correct and provide a reasonable basis for the equipment set to be used for estimating process area space requirements. The pit production data from LANL is limited because PF-4 only operated in a limited production capacity (i.e., 10 ppy maximum).

The EA Team adjusted the equipment list developed by the AoA Team to provide redundancies needed to prevent single equipment failures from having significant negative impacts on the throughput. The specific changes that the EA Team made to the equipment list for the 50 ppy case in Table H-4 of the Final Report for the Plutonium Pit Production Analysis of Alternatives are described below:

- In-Line Radiography, Machining Area: A second in-line radiography unit is required for reliability. In-line radiography is a required operation in the machining process. Inability to perform this process step prevents moving the part to the next process step which over time shuts down all downstream operations.
- Electron Beam (EB) Welder, Assembly Area: A second welder is required for reliability. Inability to perform this process step prevents moving the part to the next process step which, over time, shuts down all downstream operations.
- Surface Preparation Station, Assembly Area: A second station is required for reliability. Although repair/replacement of mechanical cleaning equipment is simple, a second unit would prevent failure of one unit from impeding downstream assembly operations.
- Laser Gas Sampler, Assembly Area: A second gas sampler is required for reliability. This equipment is highly sophisticated. Repair/replacement is time consuming. Although this is a post-assembly operation, inability to perform this sampling operation, impedes downstream post-assembly operations.
- Gas Mass Spectrometer, Assembly Area: A second gas mass spectrometer is required for reliability. This equipment is highly sophisticated. Repair/replacement is time consuming.

Although this is a post-assembly operation, inability to perform this sampling operation, impedes downstream post-assembly operations.

- Manual Lathe: A second lathe is needed for reliability. The final assembly lathe is highly complex. Repair/replacement of this equipment would be time consuming. If only one lathe were provided for this operation, a single failure would impede downstream assembly operations.

The EA Team also reviewed the AoA equipment list to determine if additional equipment not specifically identified in the flowsheet or the throughput model that would be necessary to sustain long-term pit processing operations in a manufacturing mode. The Team determined that, in order to transition from manufacturing of one pit type to another, the equipment settings and procedures needed for the new pit type must be demonstrated on the equipment to be used in manufacturing. To avoid impacting the manufacturing operations for the current pit type, some redundant manufacturing equipment is needed to demonstrate readiness to manufacture the new pit type. The following additional manufacturing equipment would be needed:

- Casting furnace
- Lathe
- Milling machine
- Welders

The EA Team SMEs also determined the specific equipment types needed for demonstration of manufacturing readiness. The equipment items required for process development and for process qualification and surveillance testing were added to the equipment list.

The equipment types and the equipment count required for each alternative has been through numerous iterations with the NNSA SMEs and with LANL. Each new iteration has resulted in fewer changes than the previous iteration. Because engineering judgement was relied upon to determine the need for some equipment items, it is expected that the equipment lists will be further revised during the conceptual and preliminary design phases. However, given the level of review provided by the SMEs and the fact that the later iterations identified only minor changes in the equipment count, the equipment lists included in Tables 1-1 through 1-4, which are in alignment with LANL equipment lists, are complete and more accurate than normally associated with preconceptual design.

Tables 2-2 through 2-4 provide the equipment lists for Alternatives 1, 2a, and 2b, respectively. Table 2-5 identifies the equipment required for the two phases of Alternative 2c (80 ppy in PF-4 and 50 ppy in new process modules). These equipment lists identify the equipment items and the quantities of each equipment item that would be needed to provide the required production capability. The equipment lists also include square footage of the gloveboxes in which the equipment is located. For equipment items that do not require gloveboxes (some of the assembly equipment and all post-assembly equipment), the square footage of the working stations that the equipment would be located on top or within are provided. The glovebox and work station square footages were based on the design and configuration of the gloveboxes and work stations currently in use for pit production within PF-4.

Table 2-2: Alternative 1 Equipment List

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Table 2-3: Alternative 2a Equipment List

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Table 2-4: Alternative 2b Equipment List

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Table 2-5: Alternative 2c Equipment List

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(b)(3) UCNI

2.3 Equipment Layout Drawings

To translate the equipment lists into equipment layout drawings (ELDs) for Alternatives 1, 2a, and for the new process module for Alternative 2b, the EA Team identified the process flow for each major process operation (i.e., disassembly and metal preparation, foundry, machining [alternatively referred to as machining and inspection], subassembly and assembly, post-assembly, material characterization, and material management). The ELDs developed by LANL for the process operations performed in PF-4 and in the new process modules for Alternative 2c, used similar process flows. The ELDs that were developed for each of the major process operations or process lines formed the framework for sizing the process rooms for Alternatives 1, 2a, and for the new process module for Alternative 2b.

The process flows were used to arrange the gloveboxes and work stations in “process lines.” For Alternatives 1 and 2a, and for the new process module for Alternative 2b, the gloveboxes and work stations were arranged within the process line to minimize the space required and to maximize operational efficiency. LANL followed a similar process in laying out the process equipment in PF-4 for the second phase of Alternative 2c (new process modules). For the alternatives that required installation of process equipment into PF-4 (Alternative 2b and the first phase of Alternative 2c), the process lines and glovebox configurations were adjusted to fit within the space available within PF-4.

For the new construction alternatives, the EA Team established recommended working spaces around the gloveboxes and work stations and set-back distances to the walls to optimize operator access. To the extent practicable, the ELDs developed for the equipment installations in PF-4 and in the new process modules for Alternative 2c provided the same working space and set back distances.

The EA Team recommendation was to provide 5' working space around the gloveboxes and work stations. A setback distance of 10' was recommended on the side of the process room where the access doors were located. This space reserve would provide room for personnel contamination monitoring devices, a frisking station, and a step-off pad. A 7-foot setback distance was recommended for the other three sides of the process rooms to allow for placement of storage cabinets.

"Drop boxes" were added to the glovebox lines to connect the glovebox lines to the hot material conveyance system. Entry hoods were also added to the glovebox lines to allow for introduction of clean parts into the process line. Safes were also added to some of the process rooms to provide for in-process storage of Pu materials. The safes were added to the process rooms to improve operational efficiency and to minimize the size of the Vault.

For Alternative 1, the configuration of the Mixed Oxide Fuel Fabrication Facility (MFFF) required that the process lines be segmented into parts that would fit within rooms that were adjacent to each other. Using multiple rooms for each process line may not be optimal for process efficiency but provides greater flexibility during a contamination event. Other process areas could remain operational if another small area is experiencing a contamination event. The Alternative 1 ELDs are also less space efficient than those for Alternative 2a because of the constraints imposed by the arrangement of the rooms within the MFFF. Given the robustness of the MFFF structure, it should be possible to remove some or all of walls that separate the process lines. The footprint in the MFFF represents a relatively small proportion of the overall MFFF floor-space. Thus, the number of penetrations and/or structural modifications, if needed, will affect only a small proportion of the walls and floors of the MFFF facility. The EA review team discussed potential impacts of these types of modifications to the overall structural viability of the MFFF with structural SMEs (e.g. CJC & Associates) and it was concluded that potential modifications such as these would represent a minimal risk to the overall structural viability of the MFFF.

Appendices A, B, C, and D provide the ELDs for Alternatives 1, 2a, 2b, and 2c respectively.

2.4 General Arrangement Drawings and Site Plot Plans

The ELDs provided the space requirements for the process rooms for each alternative. To develop general arrangement (GA) drawings for Alternatives 1 and 2a, and for the new process module for Alternative 2b, the EA Team also had to determine the space requirements for operations support areas and for the process support and building utility systems. The space requirements for the operations support areas the EA Team considered the current space allocations for the same functions within PF-4 and the proposed space allocations for the Modern Pit Facility (MPF). The difference in the pit production levels for each facility were also considered. The space requirements for the process support and building utility systems were developed using parametric methods by comparing the space required for these systems against the space required for the process systems for other Pu and highly enriched uranium (HEU) processing facilities. Section 2.5 of this report provides the bases for the space requirements that were used in development of the GA drawings.

For Alternative 1, the EA Team determined the general areas where the aqueous recovery, the analytical laboratory, and the operations support and process and building utility systems would be located and verified that the space and configuration of these general areas was sufficient to satisfy the space requirements. The GA drawings for Alternative 1 identify the specific rooms within the MFFF that would be occupied by process equipment and identify the general areas within the building that are recommended to be used for aqueous recovery and the Analytical Laboratory, and for operations support and for the process support and building utility systems.

For Alternative 2a and for the new process module for Alternative 2b, the architectural engineers for the EA Team arranged the process rooms and the areas required for the operations support areas and for the process support and building utility system into a configuration that was both functional and space efficient. Internal building structural walls, personnel and material movement corridors, and stairways and elevators were also incorporated into the GA drawings.

The EA Team also developed site plot plans for Alternatives 1 and 2a, and for the new process module (and PSB) for Alternative 2b. These site plot plans identify the proposed location of other utility systems that are external to the MFFF (Alternative 1) or the process module (Alternatives 2a and 2b). These utilities included diesel generators, fire water tanks, fire water pump building, cooling towers, and the Mechanical and Electrical Building (MEB) (Alternatives 2a and 2b only). The Site Plot Plans also show the location of the new structures with respect to the construction site boundaries and the other existing structures adjacent to the site.

LANL developed GA drawings and a Site Plot Plan for the new process modules and associated structures too be built for Alternative 2c. The EA Team was not involved in the process used to develop these GA drawings or the Site Plot Plan. The team, did however evaluate the technical feasibility of the design concept for Alternative 2c using the information provided.

Appendices A, B, C, and D provide the GA drawings and Site Plot Plans for Alternatives 1, 2a, 2b, and 2c, respectively.

2.5 Space Requirements and Allocations

As described in Sections 2.2 and 2.3 of this report, the GA drawings for Alternatives, 1, 2a, and 2b were developed by the first established the space requirements for the pit processing equipment. The ELDs that were developed identified the location, size, and configuration of each of the process equipment items. The GA drawings for the process facilities were built around the locations selected for the process rooms as shown in the ELDs. The locations of the operations support areas and for the process support and building utility systems were driven by the location of process areas as shown in the ELDs. The space requirements for the operations support areas and for the process support and building utility systems were determined by evaluating the space allocated to these same functions in PF-4 and scaling based on the difference in processing rates.

GA drawings were also developed for the personnel support modules that were determined to be necessary for Alternatives 2a and 2b. These GA drawings were developed by evaluating the required functions and determining the size of the area needed for each function based on the size of the staff that would be located in the process module or in the personnel support module. The space requirements for the personnel support modules for Alternatives 2a and 2b were compared to the available space in the BTS to confirm that the BTS could adequately support the personnel support needs for Alternative 1.

The GA drawings developed by LANL that depict the new process modules for Alternative 2c include space allocations for the process rooms (as reflected in the ELDs) and for process support and building utility systems. In general, the GA drawings do not include space allocations for the operations support or the personnel support functions.

In development of the GA drawings, the EA Team grouped the functions according to the hazards involved in performing those functions or operations. High-hazard functions were assumed to be located in process modules, which would be designed and built to applicable nuclear safety, safeguards, and security requirements. Moderate- and low-hazard operations were assumed to be located in buildings that would be designed and constructed to appropriate codes and standards for the hazards involved.

In the case of Alternative 1, the high hazard functions were located in the MFFF and the personnel support functions were located in the BTS. Rather than locate non-safety utility systems in a separate MEB module as proposed for Alternatives 2a and 2b, these systems were located in the MFFF because the building was designed to include those systems.

Space estimates for the process support and building utility systems were developed by parametric methods. The EA Team determined the space allocations for the process support and building utility systems as a percentage of the space allocations for the process equipment for several nuclear processing facilities including PF-4, the MPF, and the Uranium Processing Facility (UPF). The average percentage was applied to the footprint of the process equipment areas as shown in the ELDs.

The space required for the exterior utilities is a function of the capacity of the utility systems. The initial utility supply needs and the utility system capacities will be determined in conceptual design. Utility equipment sizing calculations are typically developed in preliminary design. Because the utility system capacities and equipment sizing has not been determined, the EA Team scaled the size and cost of the exterior utilities based on the size of the process facilities. Because the UPF project had recent data on sizing of the MEB, diesel generators, and fire water supply systems, the size and cost for the exterior utilities for a 50 ppy facility was determined parametrically.

2.6 Process Area Sizing

The size of the process areas within the process modules was established principally by the ELDs. Because different subsets of process equipment may be located in existing facilities, the amount of space required to accommodate the process lines for 50 ppy is different in each case. The ELDs developed for Alternative 2a are based on an ideal unconstrained case with no limitations on room sizing or on the configuration of an existing building. These ELDs were used as a starting point in developing the ELDs for the process areas for Alternatives 1 and 2b.

2.6.1 Process Area Space Allocations for Alternative 1

The equipment layout drawings were developed for Alternatives 1 without any constraints imposed on space availability. For Alternative 1, the MFFF does not have rooms in the same part of the building that are large enough to accommodate the process rooms as sized for Alternatives 2a. To fit the process lines within the MFFF, the equipment items that would normally be located in a common process room had to be located in multiple adjacent rooms. This led to some inefficiencies in space utilization. However, an operational benefit to this arrangement is that an entire process line is less likely to succumb to a contamination event due to this physical separation. As a result, the sizes of the process areas within the MFFF are larger than those for Alternative 1. The equipment layout drawings for the MFFF are included in Appendix A.

Alternative 1 will also require process areas for aqueous recovery, sample preparation, analytical chemistry laboratory, and material characterization. ELDs were prepared for aqueous recovery and material characterization to show where the required equipment would be in the MFFF. An equipment list was not developed for sample preparation or for the analytical laboratory. The EA Team estimated the space required for these process areas by conservatively assuming that the same sample preparation and analytical laboratory equipment planned for installation in RLUOB under an existing line-item construction project would have to be provided for Alternative 1. The total size of the areas where the new sample preparation and analytical laboratory equipment will be installed in RLUOB under the RLUOB Equipment Installation (REI) 1 and 2 subprojects is 18,000 ft^2. This is a conservative estimate because the REI subprojects will be installing equipment to support missions not related to pit production. A location for sample preparation and analytical chemistry was chosen in MFFF that contained at least 18,000 ft^2.

The spaces allocated to the various process areas in the MFFF are provided in Table 2-6.

Table 2-6: Size of Process Areas for Alternative 1

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2.6.2 Process Area Space Allocations for Alternative 2a

The ELDs established the space requirements for the process rooms that would be used to house the process lines for each of these major process operations for Alternative 2a. The process room sizes as shown in the layout drawings are provided in Table 2-7.

Table 2-7: Size of Process Areas for Alternative 2a

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Except for the high-energy radiography vault, the dimension of the individual gloveboxes and work stations and of the glovebox lines dictated the size of the process rooms. The high-energy radiography vault has only one major equipment item. The size of the vault is driven by the shielding dimensions. The shielding design will be developed during the conceptual and detailed design phases. (b)(3) UCNI

Several process areas are not included in Table 2-7 that are needed for Alternative 2a. These process areas include aqueous recovery, analytical laboratory, sample preparation, and material characterization. An explanation as to why these process operations are not considered in the space estimates for Alternative 2a is provided below.

Aqueous recovery is used to recover Pu from the oxides that are generated in metal preparation. PF-4 has an existing aqueous recovery capability that could process the oxide materials from 30 ppy production. This capability could be expanded to process the waste streams from 80 ppy production by adding a second nitrate process line. This new nitrate process line is planned to be added in PF-4. All LANL alternatives assume that the Pu recovery from the oxide materials generated at LANL (either by PF-4 or a new pit production facility) would be performed in PF-4.

Alternative 2a (and Alternatives 2b and 2c) rely on the RLUOB (as modified by the Chemical Metallurgy Research Replacement [CMRR] subprojects) to analyze radioactive samples generated during pit processing. The RLUOB is an existing facility and is therefore not included in the space allocation estimates for the LANL alternatives.

To use RLUOB for analyzing samples from pit production operations, the safety basis will have to be revised to allow RLUOB to increase the material at risk (MAR) limit. Even with this change in the MAR limit, the samples must be diluted to reduce the Pu quantities sent to RLUOB. A sample dissolution and dilution capability must therefore be provided for all LANL alternatives.

PF-4 currently has the capability to perform material characterization. It is assumed that all LANL 50 ppy facilities will rely on PF-4 to perform material characterization services.

2.6.3 Process Area Space Allocations for Alternative 2b

For Alternative 2b, the disassembly and metal preparation and the foundry processes are performed in PF-4. LANL has provided ELDs to show the new equipment to be installed in PF-4 to perform these 50 ppy processes. For Alternative 2b, the remaining process operations will be performed in a new process module. The process area space allocation needed for these processes are the same as shown in Table 2-7.

2.6.4 Process Area Space Allocations for Alternative 2c

LANL provided ELDs for Alternative 2c that show the configuration of the pit processing equipment for all process areas for both operational phases. The ELDs for the first phase of Alternative 2c show the proposed process equipment layouts for PF-4 needed for achieving an interim 80 ppy capability with two shifts, including additional material characterization equipment in RLUOB. The ELDs for the second phase of Alternative 2c provide the process equipment layouts for the new process modules to be constructed.

As in the case of Alternatives 2a and 2b, the new process modules for Alternative 2c rely on PF-4 to perform the aqueous recovery and material characterization operations required for the 50 ppy process lines. Sample preparation and analytical laboratory functions for the new process modules will be performed by RLUOB.

The size of the process areas within the new process modules for 50 ppy are shown in Table 2-8. Sizes were approximated from the LANL provided ELDs (dated January 24, 2018) for the process modules.

Table 2-8: Size of Process Areas for Alternative 2c

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2.7 Operations Support Areas

Some Operations, Maintenance, and Radiological Control (Health Physics) functions are required to directly support pit processing. These functions are integral to pit processing and must be located within the same building. These support functions include:

- Waste Storage and Staging: Interim storage of low-level waste (LLW) and transuranic (TRU) solid waste drums
- Shipping and Receiving: Staging for shipment of pits and solid waste, receipt of pits, and shipment of pits and solid waste
- Vault: Storage of Pu metal containers
- Production Development
- Offices: Offices and cubicles for operations, radiological control, and design agency personnel assigned to work in the process areas
- Hot Calibration Checks
- Radiological Control Support: Radiological buffer area (RBA) control point, RBA personnel contamination monitoring, and personnel decontamination

To determine the space requirements for the operations support areas for Alternatives 1, 2a, and 2b, the EA Team reviewed design information from existing facilities and previous and current DOE projects that used glovebox process lines for Pu pit production or for manufacturing of highly enriched uranium (HEU) cores. These projects/facilities included the existing PF-4 facility, the former

Rocky Flats pit production facility, the Modern Pit Facility (MPF) project (discontinued), the Chemical Metallurgy Research Replacement (CMRR) project and associated subprojects, and the UPF project. The space allocations for the process support areas for PF-4 and the MPF were the most relevant.

The recommended space requirements for the operations support areas represent what the EA Team considers to be the minimum amount of space needed to support a 50 ppy production rate. The actual space that is available for these process support areas varies for each alternative.

For Alternative 1, the GA drawings identify the general areas within the MFFF that the EA Team has identified as feasible for the process support areas. The team confirmed that free and clear space within those general areas exceeded the recommended space requirements. For Alternatives 2a and 2b, the GA drawings for the process module identify areas allocated to each operations support function. These areas are sized to be at least as large as the recommended space requirements, but because of the arrangement of the rooms within the process module, the sizes of the areas allocated may marginally exceed the recommended space requirement.

The recommended space requirements developed by the EA Team for the operations support areas are provided in the following subsections.

2.7.1 Solid Waste Storage and Staging

The new pit production facility will require space for interim storage of solid mixed waste (MW), low-level waste (LLW), transuranic waste (TRU), and transuranic mixed waste (TRUM). To determine the amount of radioactive solid waste generated from pit production, LANL reviewed the solid waste records for the 2007 pit production campaign at PF-4.

During this period, approximately 10 drums of solid waste were generated for every pit produced. For a 50 ppy production rate, it is assumed that 500 drums of solid radioactive waste would be generated every year. It is assumed that solid radioactive waste will be held in interim storage at the waste generating facility for less than 90 days. If 500 drums were generated each year, then storage space should be provided for 125 drums.

To use the same shared walls for other process and process support areas, the space actually allocated in the new process module for Solid Waste Storage for Alternative 2a was 1,615 ft^2. The Solid Waste Storage area in the process module for Alternative 2b was similarly sized. For Alternative 1, the MFFF has a large general area on the first floor that had been reserved for shipping and receiving, a covered truck bay, and for solid radioactive waste storage. Allocating 1,500+ ft^2 in this general area for solid waste storage should not pose any problem.

Alternative 2c will rely on the existing space available within PF-4 for storage of radioactive solid waste. PF-4 does not have specific areas that were designated for storage of radioactive waste. Interim radioactive waste storage areas are established and permitted in PF-4 on an as-needed basis. It is therefore assumed that there will be sufficient space available for interim radioactive solid waste storage generated during pit production at 80 ppy.

The waste storage for Alternatives 1, 2a, 2b and 2c included considerations associated with Resource Conservation and Recovery Act compliance.

2.7.2 Shipping and Receiving

The new 50 ppy production facility will need a loading dock, airlock, area(s) for unloading and loading shipment containers, and area(s) for interim staging of containers. To determine the amount of space needed for the shipping and receiving area inside the process module (Alternatives 2a and 2b) or the MFFF (Alternative 1), the EA Team estimated the size of the materials to be shipped on a tractor trailer and the area needed for staging and offloading shipments, and the maneuvering room needed for forklifts.

The interior dimensions of a standard Wedge Trailer are 100 inches. Trailers range from 28 ft to 48 ft long. The trailers used for material shipments were assumed to be 48 ft long. Assuming that the shipped materials are not stacked, the footprint taken up by the material packages for shipment or receipt is 400 ft^2. To provide space for staging packages for shipment and off-loading, and for forklift access, approximately 1,500 ft^2 would be required.

The PF-4 shipping and receiving area is 1,772 ft^2. To ensure that the Shipping and Receiving area would be adequate to support a 50 ppy facility, the EA Team conservatively established a recommended space requirement of 2,500 ft^2. Because of the dimensions of adjacent walls and access corridors, the actual size of the spaces allocated for shipping and receiving for Alternatives 2a and 2b are 3,156 ft^2 and 2,633 ft^2, respectively. As discussed in the previous section, the MFFF has a large general area on the first floor that was previously reserved for shipping and receiving. The GA drawings for Alternative 1 identify a 5,700-ft^2 area within the larger general area that could be used for Shipping and Receiving.

Alternative 2c relies on the existing shipping and receiving area in PF-4 to handle the shipping and receiving functions for production of 80 ppy. The risk is that material shipments could be limited during the 80 ppy mission because of inadequate space in the shipping and receiving area. This could impact the pit production rate.

2.7.3 Pu Vault

To determine the space requirements for the Vault for the new 50 ppy mission, the EA Team developed an estimate based on current PF-4 vault space dedicated to pit manufacturing. In parallel with this, the initial set of ELDs were reviewed to determine to determine how to improve operational efficiency by locating safes in the process rooms.

The PF-4 vault is 4,500 ft^2. Data provided by LANL on the allocation of vault storage space indicates that approximately 50% of the vault space is currently being used for missions other than pit processing. LANL has indicated that most of the remaining 50% of the vault space will be needed for material storage for the 30 ppy mission.

The EA Team intentionally included additional safes within the process rooms that could be used for interim Pu storage. In consideration of this, and the vault storage usage information from LANL, the EA Team applied engineering judgement to establish the recommended space requirement of 3,000 ft^2 for a Pu vault to support 50 ppy.

The space actually identified in the ELDs for Alternatives 2a and 2b is 3,306 ft^2 and 3,000 ft^2, respectively. For Alternative 1, the EA Team determined that more than adequate room is available on the MFFF first floor to accommodate a 3,000-ft^2 Pu vault within the general area previously reserved for Shipping and Receiving on the first floor. The GA drawings for Alternative 1 show the area where a 3,800-ft^2 vault could be located.

Alternative 2c relies on the existing PF-4 vault to provide the material storage space needed for the 80 ppy mission. A lack of vault space in PF-4 could pose the risk of decreasing the pit processing rate.

2.7.4 Production Development

The ELDs for Alternatives 1, 2a, and 2b include process equipment that is necessary to qualify the production process for new pit types. The EA Team determined that an additional area was needed outside the process rooms to establish the recommended machine settings and operational procedures needed for producing new pit types, to identify and resolve problems with on-going operations. This production development would include select process equipment items that could perform the critical pit processing steps that occurred in the process lines. The recommended space requirements for this area were determined to be 1,000 ft^2.

For Alternative 1, the EA Team determined that the optimal location for Production Development was immediately adjacent to the other production process lines on the third floor of the MFFF. The space allocation reflected in the GA drawings is 1,071 ft^2. For Alternatives 2a and 2b, the size of the production development area in the GA drawings for the process module are 1,006 ft^2.

2.7.5 Offices

The EA Team and SMEs identified the need for having cubicles and offices for operations, radiological control, and technical support staff working in the process areas. The space allocation for these offices was based on the number of personnel and the average size of office spaces and cubicles.

The average size of a cubicle in an office environment is 36 ft^2. The average size of an enclosed office in an industrial setting is 120 ft^2. It is assumed that six supervisors and DA engineers will be in enclosed offices and that “turnaround” offices will be provided in a cubicle bay for 10 additional personnel. Allowing for corridors around the cubicles, the recommended space requirement for the office space area within the process modules or the MFFF was determined to be 1,200 ft^2.

The size of the Office Area space within the process modules for Alternatives 2a and 2b is 1,216 ft^2. For Alternative 1, the MFFF has several large general areas throughout the building that are currently reserved for offices. The EA Team and SMEs proposed to locate the office area for pit production in the area on the third floor identified as "Office and Control. This general area occupies 18,610 ft^2 and is adjacent to the areas to be used for the pit process lines.

Alternative 2c relies on existing space within PF-4 and other new space in TA-55 to provide office space for the personnel assigned to work in PF-4. The new process modules include space for several small offices – a health physics office of 177 ft^2 and an undefined office area of 385 ft^2. There is a risk that the limited office spaces in the new process modules could be inadequate to support efficient operations.

2.7.6 Hot Calibration Shop

The measurement devices that are used in the manufacturing process are calibrated prior to first use. Once the devices have been placed in service they become contaminated and cannot be sent to a commercial calibration laboratory for calibration. To ensure that the measurements that had been made with the measurement devices were accurate, the devices must be checked in a "hot" calibration laboratory.

The EA Team determined that the new 50 ppy production facility would need an area of 500 ft^2 for the equipment and working space needed to perform calibration checks on measurement devices used in the pit processing operations.

For Alternative 1, the available space in the general areas on the second and third floors that have been designated for "process" in the GA drawings are much larger than the space taken up by the process rooms. Many rooms in this area could be used for a hot calibration room.

Given the relatively small size of the area required for hot calibration, the EA Team built in space margin in the new process modules for Alternatives 2a and 2b. The GA drawings developed for Alternatives 2a and 2b included more space than was determined to be necessary for "Process Support" and for "Building Utilities." This was the result of the decision to locate the process rooms on the second floor which then required an equivalently sized first floor. The space margin in the process module GA drawings is on the order of 5,000 ft^2. Given the fact that the space margin was much larger than the space needed for the area in question, the EA Team did not identify a specific location for the hot calibration area for Alternatives 2a and 2b.

Alternative 2c does not include space specifically allocated to a hot calibration laboratory. It is assumed that unallocated space within the laboratory or basement areas within PF-4 would be used to perform this function. Because the amount of space required is relatively small, this should not pose any significant challenge.

2.7.7 Radiological Control Support

A radiological buffer area (RBA) control point will have to be established in the MFFF or in the process modules to allow for personnel contamination monitoring prior to exiting the radiological control area perimeter. The RBA control point should also include space for personnel decontamination showers and a radiological control support desk. To accommodate all RBA control point functions, the EA Team determined that the recommended space requirement should be 2,000 ft^2.

For Alternative 1, the RBA control point would be established in the MFFF immediately adjacent to the entry/exit portal in the Technical Support Building (BTS). The rooms within the MFFF in this general area comprise much more workable space than 2,000 ft^2. For Alternatives 2a and 2b, the process module GA drawings show a space allocation of 2,232 ft^2 for the RBA control point.

For Alternative 2c, PF-4 will operate on a two-shift basis to produce 80 ppy. During this period, the existing RBA control point within PF-4 will provide be used for personnel contamination monitoring for the staff working inside. Long term operations on a single shift basis will require an RBA control point immediately adjacent to personnel entry/exit point. The GA drawings developed by LANL identify an Entry Control Facility (ECF) and areas that connect from the ECF to the modules that would serve as an RBA control point. These areas include a “RAD CHECK” area and “Anti C Lockers.” The total size of these areas is 1,023 ft^2.

2.8 Process Support and Building Utility Systems

The process support systems are those systems that interface directly with the process systems and the safety systems needed for accident prevention and mitigation. The building utility systems include those systems that provide or rout electrical power, instrumentation and control signals, communications, and noncontaminated fluids. Active safety systems are also included within the scope of the building utility systems.

As discussed in Section 2.13.2, the safety strategy for Alternatives 1, 2a, and 2b is to include the same active safety systems for the 50 ppy facilities as are currently required for PF-4. These active safety systems include: emergency electrical power, uninterruptible power supplies (UPS), criticality accident alarm system (CAAS), seismic power shutoff system, paging system, instrument air, ventilation exhaust system, and fire suppression system.

For Alternatives 1, 2a, and 2b, the EA Team design concept was to locate the process support systems directly below the process rooms to allow the cable, piping, and ductwork to be routed vertically. The design concept for Alternative 2c is to build single story process modules. The process support systems are in rooms adjacent to the process rooms within the laboratory area of each module.

For Alternatives 2a and 2b, the non-safety utility systems that do not interface directly with the process equipment are in a mechanical and electrical building (MEB) that will be designed to commercial codes and standards. For Alternative 1, the MFFF has areas currently designated for non-safety utility systems. To avoid having to construct a MEB for Alternative 1, all non-safety utility systems will be in the MFFF. For the new process modules to be constructed for Alternative 2c, electrical vaults and a communication and data room are provided external to the process modules.

The size and configuration of the building utility systems depends on the system capacities (e.g., flow rates, heat transfer rates, etc.). This information is not developed until late in conceptual design. To estimate the space required for building utilities for purposes of determining the size of the process module, the EA Team used a parametric approach.

Equipment lists, and equipment layout drawings were not developed for the process support and building utility systems. The EA Team used a parametric approach to estimate the space requirements for these systems.

The size of the space allocations for existing nuclear processing facilities and for recent nuclear projects were evaluated to determine the amount of space occupied by the process support and building utility systems in comparison to the space occupied by the process equipment. The facilities and projects that were used for this effort included PF-4, the Salt Waste Processing Facility (SWPF), MPF, and UPF. The space allocation data from the UPF project was the most detailed and showed that the utility space allocation was 40% of the glovebox space allocation in the main process module (MPM). This data was in the same range as the space allocation data for the other facilities and projects that were reviewed.

As shown in Table 2-7, the size of the pit production process areas for Alternative 2a is approximately 26,000 ft^2. The amount of space needed for the building utilities was therefore estimated to be 10,400 ft^2 (40% of 26,000 ft^2).

For Alternative 1, the size of the pit process areas on the second and third floors of the MFFF is 46,600 ft^2. The required space allocations for the pit process areas in the MFFF is however not representative of the process services and utility systems that are required to support the process equipment. The fact that 46,600 ft^2 was required in the MFFF is a result of the smaller room sizes which required use of multiple rooms and revised process line arrangements that were inefficient in terms of space utilization. It is therefore more appropriate to use the process equipment space requirements for Alternative 2a to calculate the size of the process support and utility areas for Alternative 1.

For Alternative 2b, the disassembly and metal preparation and foundry process areas are located in PF-4. The size of the process areas within the new process module is 18,488 ft^2. The process support and utility space requirement should then be approximately 7,400 ft^2 (40% of 18,488 ft^2). For Alternative 2c, the process equipment is located within the areas within each module identified as “laboratory area.” The density of the process equipment located in these areas is higher than for the other alternatives. The size of each of these areas is approximately 5,000 ft^2.

The actual space that was reserved for the process support and building utility systems in the MFFF and in the process modules varied for Alternatives 1, 2a, and 2b. In all cases, the space allocations were greater than the calculated space requirement. For example, Alternatives 2a and 2b needed to locate the process equipment on the second floor required that the first floor be sized as large as the second floor which left more space available for the process support and building utility systems than was needed. Also, for Alternative 1, the glovebox process lines would be located on the third floor. To simplify commodity routing, the EA Team reserved space for process support systems on the second floor under each of the process areas. There were several large areas within the MFFF that were previously reserved for "Chillers" and "Utilities". The EA Team concluded that these utility areas were more than sufficient to house the building utilities.

The space which is available for the process support and building utility systems for Alternatives 2a and 2b are designated as process support, HVAC, and building utilities in the GA drawings. The total footprint of these spaces is 23,966 ft^2 for Alternative 2a and 19,462 ft^2 for Alternative 2b. The spaces that are available for process support and building utility systems for Alternative 1 are designated as process support, utilities, and chillers. The total footprint of these spaces is 39,725 ft^2.

The building arrangement drawings for Alternative 2c identify space allocations for electrical vaults (443 ft^2), electrical equipment, and motor control centers (668 ft^2), and communications and data (821 ft^2). The remaining HVAC and other process support and building utility systems are located within the process modules opposite of the laboratory areas. The size of these utility and process support equipment areas is approximately the same size as the process areas within the laboratory area (5,188 ft^2 per module). This is more space than the metrics would indicate to be needed but given the density of the process equipment in the Laboratory areas of the process modules, the space allocated for the process support and building utility systems is considered reasonably conservative.

2.9 External Utilities

The scope of the external utilities includes non-safety utility supplies to the MFFF or the process modules. In addition, because of the hazards involved, some utility safety systems cannot be located inside the modules that house the process equipment. These utility safety systems are also considered to be external utilities for determining space requirements.

The general service process support and utility systems include:

- HVAC supply to the process buildings
- Process cooling water supply system
- Cooling water system
- Cooling tower system
- Process gas system(s)
- Instrument air supply to non-safety systems
- High voltage transformers (13.8 kV/480 VAC)
- Normal electrical power and distribution systems

- Unclassified communications

The non-safety utility systems are “general service” from a quality assurance standpoint and will be designed and built to commercial codes and standards. For Alternatives 2a and 2b, the design concept is to locate these non-safety utility systems in an MEB that would be designed to commercial codes and standards. The cooling towers and the process gas storage tanks would also be located on separate foundations outside the MEB.

The size of the MEB was estimated based on the sizing of the MEB for UPF. The MEB for the UPF is 66,384 ft^2. This building provides utilities to the UPF process buildings (MPB and SAB). These buildings are much larger than the process modules for Alternatives 2a and 2b (and for the area of the MFFF being used for pit processing). Based on the difference in the size of the process buildings being served by the MEB for UPF, it was determined that the MEB for Alternatives 2a and 2b should be approximately 7,500 ft^2.

For Alternative 1, the existing MFFF building includes large utility areas that were designed to house all non-safety utilities. Because it would not be cost effective to construct a new MEB for Alternative 1, the utility systems needed for pit production would be installed in the MFFF in one or more of the areas identified in the GA drawings as chillers or utilities.

The safety systems that must be located outside of the MFFF or the process modules include diesel generators (DGs) and fire water supply systems. These systems are required by the safety strategy for Alternatives 1, 2a, and 2b. The size of the foundation pads for the required equipment items were estimated by applying scaling factors to the sizes specified for the UPF Project.

The DG foundation pad is 1,700 ft^2 and is sized for two DGs of 1.5 MW each. The DG capacities for the new pit production facility will not be required to carry the larger loads of the ventilation fans for the confinement exhaust system and should have much lower capacities. For purposes of the preconceptual design space estimates, 1,700 ft^2 is a reasonably conservative estimate.

The UPF project has one fire water tank and two diesel-driven fire water pumps that provide fire water to the process buildings. The fire water tank volume needed to provide fire water these process buildings is 180,000 gallons (50-ft diameter). The fire water pumps are 1,500 gpm each. The fire water pumps are in a Fire Water Pump Building of 3,100 ft^2. The size of the Process Building for Alternatives 2a and 2b is much smaller than the size of the process buildings for the UPF. The capacity of the fire water tank and the fire water pumps is estimated to be 33% of the capacities for UPF based on the differences in the process building dimensions. The footprint taken up by the fire water tank and the Fire Water Pump Building is estimated to be 1,700 ft^2 (33% of 3,100 ft^2 plus 625 ft^2 for a 25-ft diameter tank).

For Alternative 1, it is assumed that the fire codes will require that fire suppression be provided for the entire MFFF, including those areas not being used for pit production. The size of the MFFF is ~400,000 ft^2. The size of the UPF process buildings is 367,450 ft^2. The capacities of the fire water system for the MFFF should therefore be 9% larger than for UPF. The estimated size of the Fire Water Pump Building for the MFFF should then be 3,488 ft^2 (109% of 3,100 ft^2 plus 5,041 ft^2 for a 49-ft-diameter tank). The size of the tank and number of pumps is based on the National Fire Protection Association (NFPA) calculated flow required.

For Alternative 2c, fire water supply tanks will be located on a 3,000-ft^2 fire water tank foundation located adjacent to Module A. Because the safety strategy for Alternative 2c is to rely solely on passive confinement boundaries for accident mitigation, the fire water system does not provide a credited safety function. Therefore, a separate structure is not needed to provide natural phenomena hazard (NPH) protection for the fire water tanks or pumps. Emergency DGs are also not credited safety systems under the safety strategy for Alternative 2c and are therefore not identified in the GA drawings.

2.10 Personnel Support Areas

The EA Team identified the personnel support capabilities that should be provided for a 50 ppy production facility. It was determined that a personnel support facility, adjacent to the pit production facility, would be required to provide these personnel support capabilities. The EA Team estimated the space requirements for each of the personnel support areas by using parametric data and engineering judgement. Since the personnel support facility would be a commercial non-nuclear structure, and the facility cost is negligible compared to the Total Project Cost, the estimating methods used for determining the space requirements were considered to be adequate.

The EA Team initially developed the space requirements for the personnel support capabilities for Alternatives 1, 2a, and 2b based on an initial staffing estimate developed by NNSA. This initial staffing estimate indicated that 485 personnel were required to operate and maintain a 50 ppy facility. Since then, NNSA has revised the staffing analysis for the pit production alternatives. This staffing analysis shows that the total staff needed to operate and maintain a 50 ppy facility is different for each alternative.

The space requirements for the personnel support facility as described in this section are based on the initial staffing estimate of 485. Similarly, the GA drawings for Alternatives 2a and 2b that show the PSM sizing is based on the space requirements for 485 personnel. Although the cost estimates provided in this report include the life-cycle costs associated with the final NNSA staffing estimates, the EA Team has not developed new personnel support space requirements or resized the PSM Alternatives 2a and 2b to reflect the final staffing estimates.

For Alternative 1, the existing BTS should have adequate space to accommodate the number of personnel established in the final NNSA staffing estimate. The scope of the BTS modifications (e.g., new wall partitions) would not appreciably change, and no technical issues or risks are associated with these modifications.

For Alternatives 2a and 2b, a new PSM would be required to support the staff needed to operate and maintain the pit production equipment located in the new Process Module. The need for the PSM does not change as a result change in the NNSA staffing estimates. The PSM, would however, need to be resized based on the new staffing levels. Because the PSM is a non-nuclear commercial building, no technical issues or risks are associated with resizing the PSM.

Alternative 2c does not incorporate a personnel support facility in the design concept. Both the initial phase (interim operation of PF-4) and second phase (long term operation of new process modules and PF-4) for alternative 2c will be required to rely on the existing personnel support infrastructure within PF-4 and the TA-55 complex.

Because the design concept for providing the personnel support capabilities has not changed for any of the alternatives as a result of the change in staffing level, the conclusions regarding the technical viability of alternatives are unaltered.

The EA Team determined that the process support functions required for a pit production facility (note that in the context of this discussion, pit production "facility" refers to the building/module that houses the pit production process equipment) should include the following:

- Access control area with adjacent security offices to facilitate personnel movement between the pit production facility and the personnel support facility
- Operations control area including Shift Supervisor's Office and a shift briefing area
- Office spaces for the staff not working in the MFFF or process modules
- Conference rooms
- Locker rooms and restrooms to accommodate the full staff complement
- Break-room/lunch-room for staff briefings, seating area for bag-in lunches, and a kitchen and vending area
- Utility equipment rooms

For Alternative 1, the existing BTS was designed to provide all of the above functions for 50 ppy production facility.
The BTS is a two-story structure with 36,571 ft^2 per floor (total of 73,143 ft^2) and can be easily reconfigured to suit the personnel support needs for pit production in the MFFF.

For Alternatives 2a and 2b, the new PSM would be sized to provide all personnel support capabilities. The basis for the space requirements needed to provide the personnel support capabilities for Alternatives 2a and 2b for 50 ppy are provided below.

As previously mentioned, the space requirements described below are based on the initial NNSA staffing estimate of 485 for Alternatives 1, 2a, and 2b. The Architect-Engineer selected for Conceptual Design will have to revise the personnel support facility space requirements based on the final NNSA staffing estimates for each alternative. The conceptual design details for the BTS or PSM will then be developed to satisfy the revised space requirements.

To determine the space requirements for the access control area, the EA Team reviewed GA drawings for other nuclear process facilities to determine the space required for this function. Engineering judgement was used to account for differences in the process operations and staffing. To allow entry and exit of 225+ personnel to/from the pit production facility during shift change within a reasonable time, the space requirement for the access control area was determined to be 3,000 ft^2.

The operations control area provides space for a Shift Supervisor's Office and for a congregation area for shift briefings. The Shift Supervisor's Office in a nuclear facility typically includes a small meeting room, an enclosed private office, and a rest room. The size for these areas was estimated to be 1,000 ft^2. Assuming that the number of personnel assigned to a shift is approximately 250, the size of a general standing room meeting area for shift briefings is estimated t0 be 3,000 ft^2. This is based on a personal space of 10 ft^2 per person plus 500 ft^2 of margin. The total space requirement for the operations control area is then 1,000 ft^2 + 3,000 ft^2, or 4,000 ft^2 total.

To determine the space requirement for the offices, the EA Team estimated the area required for cubicles and enclosed offices for the number of personnel that would not be located inside the pit production facility. With a total staff contingent of 485 and 250 personnel assigned to work inside of the pit production facility, the number of personnel who needed office space in the personnel support facility would be 235. The following assumptions were made to estimate the required footprint for an office area to accommodate 235 personnel:

- Cubicles sizes are 6 × 6 ft (36 ft^2).
- Enclosed offices are 10 × 12 ft (120 ft^2).
- 25 offices are required for the supervisory staff and cubicles are provided for the remaining 210 personnel.

Using these assumptions, the footprint of the office spaces and cubicles (without consideration of spaces between cubicle rows and personnel corridors) would be 10,500 ft^2. To account for cubicle spacing and personnel corridors an additional 6,150 ft^2 (60% of 11,100 ft^2) was added to arrive at a recommended space requirement for personnel offices of 16,650.

The required size of the Conference Room areas was estimated to be 3,000 ft^2. This estimate was based on one 1,500 ft^2 conference room of capable of seating 60 and two 750 ft^2 conference rooms capable of seating 20 each.

A parametric data was used to estimate the space requirement for the locker room and restroom areas. This area, which was considered to be necessary by the EA Team, included a locker room/change area, showers, and restrooms to serve the full staff complement of 485.

Planning guidelines for educational institutions were used to estimate the size of a typical locker-room. These guidelines provide metrics for estimating the total size of a locker room based on the number of students. These metrics were used for estimating the size of the locker room needed for the personnel support facility since they include space for lockers, toilets, and sinks (water closets), and showers. The parametric values range from 7.5 to 15 ft^2 per student. Using the conservative value, the space requirement for a single-sex locker-room/rest-room would be 7,275. Since separate male and female locker rooms would be required for the personnel support facility, the total space requirement was increased to 10,000 ft^2 to account for space inefficiencies.

The space requirement for the break-room/lunch-room were determined by rough order of magnitude calculations. The required capabilities for this area included a combined break room/lunchroom seating area, a small kitchen, microwaves, and a vending area. It was assumed that approximately 250 personnel would use the break-room/lunch-room area at any one time. The space requirement for the break room/lunchroom seating area was estimated to be 8,500 ft^2. This was based on assuming 50 circular tables serving 5 each, table and seating areas of 100 ft^2, and 6-ft walking corridors between rows of tables. The space requirements for the kitchen and microwave area and the vending area were notionally estimated to be 1,000 ft^2 and 500 ft^2, respectively. The total space requirement for the break room/lunchroom

The space requirements for utility equipment rooms for the personnel support facility were estimated by identifying the utility equipment that would be housed inside the building and then applying engineering judgement to determine the size of the rooms needed to house this equipment.

The largest utility equipment serving a facility such as the personnel support facility would be the Air Handling Units, chillers, and HVAC exhaust fans. Consistent with standard commercial facility design, it is assumed that the HVAC equipment would be located on the roof of the personnel support facility. This equipment is therefore not included in the internal facility space requirements. The other utility equipment that would be required for the personnel support facility includes electrical distribution, IT servers and routers, and a fire water pump. The size of the rooms needed to house this equipment can be accurately determined after the system capacity calculations are completed during conceptual design. For purposes of the EA, the sizes of the rooms to house these equipment items were estimated to be 400 ft^2 each for a total space requirement of 1,200 ft^2.

A summary of the estimated space requirements for the personnel support facility (BTS for alternative 1, and PSM for alternatives 2a and 2b) are provided in Table 2-9. As noted in the above paragraphs, some of the space requirement estimates for the personnel support capabilities are based on parametric data and on engineering judgement. The actual space requirements for the BTS or PSM will be determined during conceptual design by using the methods identified in the appropriate commercial building codes.

Table 2-9: Space Requirements for Personnel Support Areas for Alternatives 1, 2a, and 2b

Personnel Support Area	Sizing (ft^2) for Staff of 485
Access Control Area	3,000
Operations Area	4,000
Office Spaces	16,650
Conference Rooms	3,000
Locker Rooms and Restrooms	10,000
Break-room/Lunch-room	10,000
Utility Rooms	1,200
Total	**47,850**

The building layout drawings for the new process modules for Alternative 2c identify an area for an access control area, change rooms, workroom, and mechanical support room inside an entry control facility (ECF). The size of these areas are as follows:

- Access Control Area: 1,219 ft^2
- Locker Rooms and Restrooms: 1,306 ft^2
- Office Spaces: 729 ft^2
- Utility Rooms: 314 ft^2

Alternative 2c relies primarily on the existing personnel support capabilities within PF-4 and in TA-55. The existing personnel support capabilities provided in PF-4 and other adjacent areas inside the PIDAS are maximized with current missions. Adding the staff needed for an 80-ppy mission will further exacerbate the problem. This poses a risk that the existing personnel support facilities will prove to be insufficient for the 80-ppy mission using two shifts in PF-4 and could reduce operational efficiency within PF-4 to a point that would affect pit production rates. It also poses a risk that additional personnel space within the ECF will prove to be insufficient for operation of the new process modules. This could impact operational efficiency and prevent meeting an 80-ppy mission for single-shift operations.

2.11 Summary of Space Requirements

Table 2-10 provides the EA Team space estimates for all process modules that would be needed for a new 50-ppy production facility at either SRS within the MOX complex, or at LANL. Space estimates from the AoA are also provided for comparison.

There is a clear difference between the requirements for Alternative 1 compared with the three LANL Alternatives, and this is driven by the reuse of space that has already been constructed. In new construction, the space can be designed to fit the planned equipment and room sizes can be optimized to some degree, whereas fitting equipment into predetermined spaces results in inefficiencies. The MFFF layouts adjusted glovebox spacing and step-off areas as necessary to reasonably fit into existing rooms. Existing walls in process areas will remain.

Within Alternative 1 there is also a difference between the identification of non-process spaces, such as Analytical Labs, Process Support, and Utilities, and process spaces like Disassembly and Metal Preparation, Foundry, and Machining. The EA Team laid equipment out for the process areas to demonstrate that there was not only adequate physical space in MFFF, but also that it could be installed without removing walls. For the non-process spaces, the EA Team identified locations that are available and that have adequate area but did not, in keeping with the preconceptual nature of the layouts, attempt to further design or optimize these areas.

Finally, areas of the BSR and BMP not identified for specific uses are assumed to be the responsibility of the project and will need to meet minimum life safety and security requirements. These areas are included in the gross square footage for Alternative 1.

Area calculations for Alternative 2c process areas were scaled electronically from LANL PMA Site Development, Arch: Preconceptual Design, 3-Module Floor Plan, Sheet A-1001, 3 of 7 dated 30 January 2018. All other Alternative 2c area measurements were taken from the table "Gross and Net Square Footage" on LANL PMA Site Development, Arch: Preconceptual Design, Area Square Footages, Sheet A-1001, 3 of 3, dated 30 January 2018.

Table 2-10: Alternative 1, 2a, 2b and 2c Process Module Space Allocations

(b)(3) UCNI

(b)(3) UCNI

2.12 Scope of Structures, Systems, and Components

This section provides the engineering bases for the design concepts that were used to define the scope of each alternative. This design basis information was also used to establish the scope of the cost estimate and to guide the development of the schedule estimates and the Risk Analysis.

2.12.1 Pit Processing Areas

The preconceptual design for the process areas for each alternative was developed from the ground up by first defining the process equipment items needed for each pit processing step and then configuring these equipment items into process lines which are reflected in the ELDs. For Alternative 1, the EA Team identified specific locations for the operations support areas and the general areas where the process support and utility systems could be in the existing MFFF building. For the new construction alternatives (Alternative 2a and 2b and the second phase of Alternative 2c), the process module structures were designed using the ELDs as the framework. The modules were sized to include operations support areas and internal process support and building utility systems. For the alternatives that used PF-4 to perform some or all the major pit production process operations (Alternatives 2b and 2c), it was assumed that the existing operations support areas and process support and building utility systems would be used as is with only minor modifications.

The ELDs and GA drawings for both phases of Alternative 2c were developed by LANL. The EA Team reviewed these drawings and the responses to requests for information to develop an understanding of the scope of the reconfigurations to be made to PF-4 and the scope of the new process module complex. Because the EA Team did not have direct involvement in the development of the preconceptual design for this alternative, this section describes the structures, systems, and components (SSCs) that comprise the alternative but does not endeavor to provide the basis for the selection of these SSCs.

2.12.1.1 Alternative 1

The MFFF was selected for installation of the pit processing equipment for Alternative 1. The MFFF was designed and constructed to meet the Nuclear Regulatory Commission (NRC) requirements for nuclear safety confinement and to meet the applicable DOE requirements for safeguards and security and material control and accountability (MC&A). The existing MFFF building structure is robust from an NPH protection standpoint and has been previously evaluated for compliance with DOE requirements for safeguards and security and for MC&A. There should therefore be no significant technical issues that would preclude using this facility for Pu pit production.

The Waste Solidification Building (WSB) was evaluated as a possible candidate for installation of some pit processing equipment but was rejected for several reasons. The part of the WSB that was designed to withstand the design base NPH events is too small (approximately 18,000 ft^2 on each of the two floors) to accommodate all the process rooms and process support and safety SSCs needed for a 50 ppy facility. In contrast Alternative 2a, which provides a purpose-built structure, requires 85,000 ft^2.

The WSB is also fully equipped for liquid waste processing operations. The demolition work required to remove the large process vessels and specialized waste solidification equipment in the WSB and to then reinstall liquid waste processing equipment in the MFFF would add to the overall project cost, and schedule. Finally, the WSB was not designed to meet the applicable Security Category 1 requirements for Pu pit production.

The configuration and dimensions of the process lines were overlaid onto the existing GA drawings for the MFFF to determine what areas and rooms provided the best fit. In determining the appropriate location for the process areas, the EA Team had to ensure that space was available directly below the process rooms for installation of the process support systems. Because of the constraints imposed by the existing walls within the MFFF, the process lines required more space than was available within one area on any single floor

The third floor of the MFFF was selected for installation of the glovebox process lines (disassembly and metal preparation, foundry, machining, and parts of subassembly and assembly) because the existing rooms were large enough in most cases to provide the recommended working space distances around the gloveboxes and work stations and the stand-off distances to the walls. Another consideration for certain areas was due to the original building designs already including process ventilation. The gloveboxes and work stations for the subassembly, assembly, and post-assembly process lines were located on the second floor.

Alternative 1 provides a self-sufficient 50 ppy processing capability. Process areas are therefore required for aqueous recovery and material characterization. The proposed design solution for Alternative 1 is to use space in the second floor of the MFFF to locate the aqueous recovery process line. The material characterization process line would be in other rooms on the second floor that are near the aqueous recovery and the subassembly and assembly areas.

Due to the relatively small size of the existing rooms within the MFFF, the process lines for each major process operation could not be located within the same rooms. As a result, the process lines are not contiguous and will require operator entry into multiple rooms to move materials through a single process line. This may have a minor effect on operator productivity; it is not expected to affect the pit production rate. Additionally, a potential operational benefit could be realized should a contamination event occur. Due to the segmentation of process lines, if one smaller room were to become contaminated other areas on the same process line could potentially continue operations.

The segmentation of the process lines and the location of process lines and other operations support areas on multiple floors will require that the material conveyance lines to go up and over walls within and between the process lines, and through the floor slabs. The conveyance system will have to connect all process areas and the operations support areas including the high-energy radiography vault, the Pu vault, and shipping and receiving. With a modern conveyance system, there should not be any significant effect on the material movement efficiency.

The design concept for Alternative 1 included installing an Analytical Laboratory in the MFFF to perform the sample analysis capabilities needed for pit production. The proposed location for the Analytical Laboratory is on the first floor of the MFFF. The material conveyance line will connect the other process areas with the Analytical Laboratory area. The basis for including an Analytical Laboratory within the scope of Alternative 1 is described below.

The current SRS Strategic Plan for the Savannah River National Laboratory (SRNL) consolidates the F/H-Area analytical laboratory capabilities to the SRNL A-Area facilities, which are located near the site boundary. The plan also refurbishes the nuclear infrastructure for the A-Area facilities and relocates the low/no risk mission facilities outside the protected/limited area or off-site (ref: *Savannah River National Laboratory 2018 – 2022 Strategic and Institution Plan*, September 22, 2017); and the *SRNL 10 Year Infrastructure Plan*, September 2016).

The significant number of samples required to support a 50 ppy plutonium pit mission in conjunction with the other missions at SRNL could increase the material at risk in the A-Area facilities above the current safety basis limits. With the facility located near the site boundary, additional or enhanced safety systems and controls may be required to handle the increased MAR. Another consideration for locating the analytical lab capabilities within the MOX facility complex is that the turnaround time and movement of the lab samples would be far more efficient if co-located at or near the facility in lieu of shipping the samples 8 miles to SRNL in A-Area.

2.12.1.2 Alternative 2a

A new process module is proposed for Alternative 2a to house all 50 ppy process lines. This module would be designed and constructed to meet all nuclear safety confinement requirements and the applicable security and MC&A requirements. This building would be designed to satisfy the applicable requirements in DOE Order 420.1, *Facility Safety* and in DOE Order 470.4, *Safeguards and Security Program.* The specific design requirements will be identified as part of the initial hazards and safety analyses and security vulnerability assessments during conceptual design.

The new process module for Alternative 2a will include all process lines required for production of 50 ppy. The ancillary process operations for aqueous recovery, material characterization, and sample preparation will be performed in PF-4. The oxide materials and process samples that will be sent to PF-4 will have to bagged and transported manually. To facilitate movement of these materials from the process module to PF-4, a connecting corridor will be built to connect the process module to the PF-4 Tunnel. To allow for these material transfers, the existing high-energy radiography vault in the PF-4 tunnel may have to be shut down. In that case, PF-4 may send pits to the process module to be radiographed. This would involve the same bagging and manual transfer process.

2.12.1.3 Alternative 2b

The same process room equipment layout drawings that were developed for Alternative 1 were used to develop the general arrangement drawings for the new process module for Alternative 2b. The difference is that only the Machining, Subassembly and Assembly, and Post-Assembly process rooms will be in the process module for Alternative 2b. The process equipment required for Disassembly and Metal Preparation and Foundry will be installed in existing rooms in PF-4.

Alternative 2b required the movement of Pu metal from the Foundry process area in PF-4 to the new process module. In addition, the ancillary operations for material characterization and sample preparation will be performed in PF-4 which will require the transfer of samples from the process module to PF-4. A connecting corridor will be required to connect the process module to the PF-4 Tunnel to allow for these material transfers. As previously discussed for Alternative 2a, materials to be transferred would have to be bagged and carried by hand cart. The frequent material transfers may require that the existing high-energy radiography vault in the PF-4 tunnel be shut down. Pits produced in PF-4 would then be bagged and transferred by cart to the process module to be radiographed.

2.12.1.4 Alternative 2c

The operational concept for Alternative 2c involves two operational phases. In the first phase, PF-4 would operate on a two-shift basis to produce 80 ppy on an interim basis. In the second phase, new process modules would be constructed to provide a long-term 50 ppy production rate operating on a single-shift basis. In this long-term phase PF-4 would revert to single shift operations and, in conjunction with the new modules, would produce 80 ppy.

The first phase for Alternative 2c will require some reconfiguration of the first-floor laboratory areas within PF-4 and installation of new process equipment to allow a short-term production rate of 80 ppy when operated on a two-shift basis. The ELDs provided by LANL identify the changes in the process room configurations and showed the specific locations of each of the required equipment items needed to increase production from 30 ppy (single shift) to 80 ppy (two shifts). Once operating at two shifts, high-energy radiography would be performed both in the PF-4 tunnel and at Pantex to meet the 80 ppy mission.

In the second phase of Alternative 2c, a new process module complex would be constructed to supplement the pit production capabilities in PF-4. The new modules will include:

- 3 Process modules (A, B, and C)
- 2 Radiography bays
- Fire water tank foundation
- Connecting tunnel to PF-4
- Connecting tunnel to RLUOB
- Entry control facility (ECF) with change rooms that connect to the process modules

The ELDs and GA drawings provided by LANL identify the configuration of the process rooms and the locations for process support and utility systems. The module complex has no operations support areas for LLW or TRU waste storage, nor does it have a Pu vault or a shipping and receiving area. The EA team did not evaluate whether these existing facilities are adequate.

The design concept for the modular complex is to construct the modules below grade. A tunnel would connect the material transfer corridor in the module complex to the PF-4 Tunnel. A second tunnel would connect the ECF to the RLUOB.

In the second phase of Alternative 2c, the module complex relies on the existing Pu vault and Shipping and Receiving areas within PF-4. The ancillary operations for aqueous processing, material characterization, and sample preparation needed to support the module operations will also be performed in PF-4. In addition, PF-4 will rely on the high-energy radiography vaults in the new module complex to perform the radiography operations for the pits produced in PF-4.

2.12.2 Processing Modules/Structures

2.12.2.1 Design Requirements

The Pu pit processing areas will need to be housed in a building(s) that will provide confinement for design base accidents. The MAR that would be present in any of the major pit processing areas would exceed the threshold for a Hazard Category 2 (HC-2) facility as specified in DOE Standard 1027. The facilities housing the Pu processing operations and MAR must therefore be categorized as HC-2 and designed and constructed to meet the appropriate confinement and criticality control requirements specified in the facility nuclear safety and criticality analyses.

The Pu-239 equivalent used in pit production operations requires MC&A controls. The quantity and forms of the special nuclear material (SNM) that would be present in the pit processing/manufacturing and in the vault storage and shipping and receiving areas require that the building housing these areas be designed to meet Security Category 1 requirements.

2.12.2.2 Description of the MFFF and Process Modules

For Alternative 1, the pit processing/manufacturing areas and the process support equipment and building utilities will be located within the MFFF. The location of the equipment is constrained by the wall locations, room sizes, and the free clear height of the rooms. Given the constraint imposed by the walls within the MFFF, the equipment within each process lines had to be in multiple rooms that were adjacent to each other. The area required to accommodate all the process lines parts of the second and third floors were used. All disassembly and metal preparation, foundry, machining, subassembly, and some of the assembly areas are located on the third floor and the remainder of the assembly and post-assembly, aqueous processing, and material characterization areas are located on the second floor. The high-energy radiography vault, the Pu vault, and the solid waste storage and shipping and receiving areas are located on the first floor.

The segregation of the process lines and need to move materials between multiple rooms and floors within the MFFF will require a longer conveyance line(s). It may be possible to reduce the segregation of the process lines by removing some of the walls in the rooms used for the same process line. An earlier analysis performed by the EA Team demonstrated that all the pit processing/manufacturing areas could fit on the third floor with more working space by eliminating only a few walls. To be conservative, the ELDs for Alternative 1 are based on the existing wall configuration.

Because of the need for material transfer between the new process modules and PF-4 for all LANL alternatives, the new process modules will have to be located on a site that would allow construction of a material transfer corridor or tunnel that could connect to PF-4. The only available area that is adjacent to PF-4 is the site previously reserved and partially excavated for the CMRR-NF project. The process modules for Alternatives 2a, 2b, and 2c are located on this site. The process modules would be connected to PF-4 via a connecting corridor or tunnel. To prevent having to provide a new PIDAS entry for the process modules, a connecting corridor or tunnel would be constructed between the process modules and RLUOB.

For Alternatives 2a and 2b, a single process module was considered to be the most cost and schedule effective solution. To make the most effective use of the available space on the construction site, a two-story process module was proposed for these alternatives. These process modules would be designed in accordance with the requirements for a new HC-2 facility. The safety strategy for all the LANL alternatives is to design the process modules to provide confinement of radioactive releases due to accidents. It is assumed that the hazard and accident analysis will require that the module structures withstand all NPH design categories (NDC)-3 events.

The design concept for the process module for Alternatives 2a and 2b is to locate the active safety systems (e.g., confinement exhaust, essential electrical power distribution, facility monitoring and control system, etc.) on the first floor. This eliminates seismic amplification concerns at higher elevations and simplifies seismic qualification of the safety systems. By locating the active safety systems on the first floor, the glovebox process areas were located on the second floor.

The process modules for Alternatives 2a and 2b provide all operations support functions for production of 50 ppy. These functions include interim storage and staging of LLW, TRU, and TRUM solid waste, Pu vault storage, and Shipping and Receiving. These areas are located on the first floor of the process module. The process modules for these alternatives also provide space for the process support and building utility systems. Process support areas are located beneath the process areas where required to simplify the connections between the process support equipment and the glovebox process lines.

Alternative 2a requires that the metal oxides and samples generated in the process modules be bagged and transferred by hand cart to PF-4. Alternative 2b is based on a “split-flowsheet” where pit processing operations are shared between the new process module and PF-4. Under this alternative Pu metal from the PF-4 Foundry would most likely be bagged and transferred by hand cart to the process module.

Alternative 2c proposes to construct three single story process modules below grade. The structures would provide passive confinement for radioactive releases and would be designed to meet NDC-3 requirements. An ECF and tunnel would facilitate personnel access between the RLUOB and the process modules. Another tunnel would connect the process modules to PF-4 to allow for material movement.

The process modules for Alternative 2c would house some process lines needed for split flowsheet production of 80 ppy. Space is also provided in the modules for process support and building utility systems. The modules do not provide space for solid waste storage, Pu vault storage or shipping and receiving.

2.12.3 Safety Class and Safety Significant Systems

For purposes of the EA, the scope of the safety systems that were assumed to be required is a function of the safety strategy for each alternative. The safety basis documentation to be developed for the 50 ppy facility will ultimately establish the required engineered controls and the functional classification (i.e., classification as SC, SS, or Defense in Depth) of those controls.

The safety strategy for Alternatives 1, 2a, and 2b, conservatively assumes that active safety systems will be required. For the cost and schedule estimates, the scope of these alternatives includes these active safety systems. The safety strategy for the second phase of Alternative 2c is to rely solely on the passive confinement capability of the process modules for accident mitigation and assumes that no active safety systems will be required.

For Alternative 2c, the new process modules are located below grade for reducing the leak path factor and take more credit for mitigating the radioactive material releases from a seismic event. It is assumed that if the mitigated accident consequences are below the Evaluation Guideline (EG) of 25 Rem, that the safety basis documentation can justify not providing active safety systems for additional accident mitigation. If this strategy is not approved by the Safety Basis Approval Authority, the concept of locating the modules below grade would have to be reconsidered because the added cost of the excavation, shoring, and backfill would provide no offsetting benefit.

The location to the site boundary and the MAR determine the unmitigated dose consequences to the public, which then determines the need for SC controls. The new process modules for the LANL alternatives are located approximately the same distance to the site boundary as PF-4. The MAR for the process modules is expected to be on the order of one magnitude less than that for PF-4. Given that the unmitigated dose to the public due to a seismic event at PF-4 is one order of magnitude above the EG, there is a high probability that SC controls will be required for the process modules for all LANL 50 ppy alternatives.

The threshold for SS controls are lower than for SC controls. The DSA for PF-4 identifies the need for multiple active safety systems for protection of the public and the co-located worker. For a new HC-2 facility, the thresholds for designating SSCs as SC or SS are more conservative than they were when the DSA was approved for PF-4. It is therefore expected that additional active safety systems will have to be classified as SS for the process modules for the LANL alternatives.

2.12.3.1 Scope of Active Safety Systems for Alternatives 1, 2a, and 2b

For Alternatives 1, 2a, and 2b, it is assumed that the same active safety systems that are identified in the DSA for PF-4 will be required for the MFFF or the process module. For Alternative 1, these building utilities will be in the MFFF, generally in the same areas previously reserved for the same purposes. For Alternatives 2a and 2b, these active safety systems will be located on the first floor of the process module. However, MFFF was designed as a NRC-licensed facility and the transition to compliance with DOE safety regulations may present additional risks and complexities associated with the scope of active safety systems for Alternative 1.

The safety basis documents needed for all alternatives will address all hazards associated with the MFFF or the process modules. Alternative 2b and 2c require installation of new process equipment items in the PF-4 facility. DOE Standard 1189 requires that a “major modification” determination be performed to establish whether this scope of work would constitute a major modification and whether the existing DSA would have to be revised to address the hazards involved in the new or revised mission.

The 2016 DSA identified conditions of approval (COA) for upgrades to select safety SSCs. The risk is that the DSA revision for PF-4 may not be approved, or that new COAs for upgrades to PF-4 may be specified.

There are also questions concerning the adequacy of the seismic design of the PF-4 structure. Although it meets SDC-3 requirements, it may not withstand a PC-3 seismic event. Ongoing analyses are addressing these questions. The results of these analyses could require additional seismic upgrades to PF-4 or impose operational restrictions. This represents a risk to all LANL alternatives that depend on PF-4 to perform some of the process or process support functions for the process modules.

The LANL alternatives also depend on the RLUOB to analyze samples from the 50 ppy process lines. To optimize RLUOB's ability to analyze samples for plutonium operations, the NNSA is pursuing an increase in RLUOB's MAR limit. Increasing RLUOB's MAR limit allows analytical chemistry sample preparation activities to occur in RLUOB rather than PF-4, improving operational efficiency by collocating sample preparation with analysis and preserving space in PF-4 to support pit production. Sample preparation activities must occur under all LANL alternatives and each alternative assumes these activities will take place in RLUOB as an HC-3 facility with a limit off 400g of Pu-239 equivalent MAR.

To change the MAR limit for RLUOB will make the facility HC-3, which will then drive the need to prepare safety basis documentation in accordance with the requirements of DOE Order 413.3B and DOE Standard 1189. The risk is that the safety basis for RLUOB will not be approved without upgrades to the safety SSCs.

2.12.3.2 Scope of Engineered Controls for Alternative 2c

LANL has assumed that the nuclear safety analysis can demonstrate that the passive confinement provided by the structures alone are sufficient and no active safety controls will be required. It will not be possible to determine if this safety strategy is viable until the Safety Design Strategy and the Conceptual Safety Design Report have been approved by DOE. The risk is that the DOE Safety Basis Approval Authority will require that the new process modules include active safety systems that are not currently within the scope of Alternative 2c. This would require reevaluation of the design approach for the proposed module complex because there would no longer be any benefit to locating the modules below grade.

Similar to Alternatives 2a and 2b, Alternative 2c also relies on PF-4 and RLUOB to perform some essential functions (i.e., Pu vault storage and shipping and receiving at PF-4 and sample preparation and analysis at RLUOB). As discussed in the previous section, risks are associated with the safety bases for both facilities.

2.12.4 Operations Support Areas

The MFFF and process modules for Alternatives 1, 2a, and 2b have allocated space for all operations support areas that are necessary for production of 50 ppy. These areas include hot calibration; shipping & receiving; solid waste interim storage; vault; operations offices, radiological control offices, and personnel contamination monitoring at the RBA control point. The support functions that need to be adjacent to the process rooms or that needed for material transfers (e.g., solid waste storage, shipping and receiving, and RBA control point) are located on the first floor. Other support functions (e.g., operations staff offices) will be located on the third floor of the MFFF or the second floor of the process modules.

For Alternative 2c, the existing operations support infrastructure within PF-4 (vault storage and shipping and receiving), will be relied upon to support the 50 ppy production operations within the process modules. The risk is that the space available within PF-4 to provide these operations support functions will prove to be inadequate. Inadequate space within the vault and shipping and receiving could result in a backup in material transfers, which could result in a reduction in throughput.

2.12.5 PSM (BTS) Scope

The staffing plan prepared by LANL shows that 485 production staff are required to operate and maintain a 50 ppy production facility. For all alternatives, approximately half of the staff will be required to either work in the MFFF or process module, and the other half should be in a location immediately adjacent to the MFFF or process modules. For Alternative 1, the existing BTS will be used as the control point for entry/exit to/from the MFFF and will also provide office spaces and other facilities for the support staff not located in the MFFF. Alternatives 2a and 2b require construction of a new PSM, which would provide the same functions as the BTS.

The personnel support functions for all alternatives include entry/exit portals into the MFFF or process modules, operations and security staff working areas, offices for technical and other support staff, restrooms/locker rooms, and a lunchroom/kitchen area. The recommended space requirements for the PSM for the new staffing levels are provided in Section 2.10.

The process module for Alternative 2b will not perform all of the same pit processing functions as are required for Alternatives 1 and 2a. In specific, the disassembly and metal preparation and foundry operations will be located in PF-4. To size the PSM, the personnel staffing required to produce 80 ppy total is assumed to be the same, irrespective of which operations are performed in PF-4 or in the new process module. The scope of Alternative 2b therefore includes construction of the same size PSM as planned for Alternative 2a.

As part of the planning for Alternative 2c, LANL has provided information on plans to complete upgrades to PF-4 and to other facilities to provide some of the personnel support functions needed for an 80 ppy mission. The plan for providing office spaces for LANL is described in a presentation that summarized the results of a requirements and alternative analysis. The options for new office buildings ranged from a 150-person to 450-person building. None of the options involved locating an office building in the PIDAS or adjacent to the new process modules. The plan recommended that the CMRR project fund the recommended alternative (Option 3, a 375-person office). At present, the CMRR subproject associated with this scope has not been baselined.

The new module construction scope for Alternative 2c includes space within the new ECF area for relatively small change rooms (1,306 ft^2 total). No other space is provided as part of the module construction for technical support office areas, lunch/break room, restrooms, or operations or security control areas as were required for Alternatives 1, 2a, and 2b.

If Alternative 2c is selected, a detailed review of the approved capital and expense funded projects for upgrades to PF-4 and the PF-4 support infrastructure should be performed during the conceptual design phase. This review should evaluate the scope of the upgrades for operations and security offices, technical support staff offices, change rooms, rest rooms, and lunch and break rooms. If these upgrades are inadequate to support an 80 ppy mission within PF-4 and the associated modules, then the module design should be revised to include these capabilities.

2.12.6 Safety Systems Located Outside Process Module

As discussed in Section 2.13.2, Alternatives 1, 2a, and 2b are based on conservative safety basis assumptions. These alternatives assume that passive and active SC and SS engineered controls will be required for accident prevention and mitigation. Most of the active safety systems are located within the MFFF or process module. The safety systems that are located outside the MFFF or the process module include the SC fire water supply and emergency DG systems. The large equipment items associated with these SC systems include:

- Fire water tank(s).
- Redundant fire water pumps.
- Redundant diesel generators.

To avoid the need for providing SC electrical power to the fire water supply pumps, the fire water supply pumps are assumed to be diesel driven. Because the SC systems and components will have to be designed to survive NPH events, the weather protection enclosures will also be designed and constructed to withstand the design basis NPH events.

Although the scope of Alternative 2c includes fire water supply and emergency electrical power systems, these systems and components will not be designed, procured, or installed to nuclear codes and standards. The Alternative 2c drawings show a “Fire Water Tank Foundation” adjacent to Module A. Although not shown on the building general arrangement drawings, it is assumed that the scope of Alternative 2c includes fire water tanks and fire water pumps. The drawings do not identify diesel generators, but because most of the utility supplies for the modules are provided by the Combined Utility Building (CUB), it is assumed that Alternative 2c proposes to rely on the diesel generators located in the CUB.

2.12.7 Non-safety Utility Systems

The non-safety utility systems that will be required for all alternatives include:

- Electrical switchgear

- Medium- and low-voltage normal power distribution
- Instrument air system (service to non-safety systems)
- Breathing air system
- Cooling towers
- Chillers and cooling water pumps
- Process cooling water system
- Communications and IT systems

All non-safety utility systems, as well as the utility support building, will be designed and constructed to commercial codes and standards. For Alternative 1, the MFFF has space previously reserved for non-safety utilities, and the utility systems needed to support pit production would be located in these same areas.

To avoid driving up the size (and cost) of the new process modules, Alternatives 2a and 2b propose locating the non-safety utility systems inside an MEB; a separate building would be also designed to commercial codes and standards. Alternative 2b will include an MEB to provide the utility and process support systems that will serve the new process module. Because the process module for Alternative 2b only includes the process lines for machining, subassembly and assembly, post assembly, and material characterization, the utility and process support capacities will be lower than for Alternative 2a. The required capacities for these systems will be determined in the conceptual and preliminary design phases.

The drawings for Alternative 2c identify several areas for electrical and communications utilities, but no areas specifically identified for mechanical utilities. The electrical and communication utility areas include two electrical vaults (443 ft^2 total), an electrical equipment and motor control center room (210 ft^2), and a communications and data room (821 ft^2). Because the drawings do not identify any mechanical support equipment items or utility spaces, it is assumed that Alternative 2c relies on the CUB to provide chilled water, potable water, instrument and breathing air, and other mechanical utilities to the process modules. If Alternative 2c is selected it is recommended that the Combined Utility Building (CUB) utility capacities be evaluated and compared to the utility demands for the new process modules. The process module design could then be revised as necessary to include additional space for utility supply systems, if required.

2.12.8 Site Interfaces

For Alternative 1, the EA Team confirmed that the E-Area can disposition all LLW, TRU, and TRUM solid waste that would be generated by a 50 ppy facility. The EA Team also concluded that the necessary analytical laboratory and liquid TRU and LLW processing capabilities needed for pit production are limited at the SRS site. These limitations are described below.

- The F Area analytical chemistry laboratory is the only existing facility at SRS that could analyze samples from a new 50 ppy facility at MOX. The current Savannah River Site strategic plan for the Savannah River National Laboratory (SRNL) consolidates the F/H analytical laboratory capabilities to the SRNL A-Area facilities, located at the site boundary. The plan also refurbishes the nuclear infrastructure for the A-Area facilities and relocates the low/no risk mission facilities outside the protected/limited area or off-site. (ref: *Savannah River National Laboratory 2018 – 2022 Strategic and Institution Plan*, September 22, 2017; and the *SRNL 10-year infrastructure Plan*, Sept 2016) and will not be available for analyzing actinide samples after that.

- The significant number of samples required to support a 50 ppy plutonium pit mission in conjunction with the other missions at SRNL, could increase the material at risk in the A-Area facilities above the current safety basis limits. With the facility located at the site boundary, additional or enhanced safety systems and controls may be required to handle the increased MAR. Another consideration for locating the analytical lab capabilities within the MOX facility complex is that the turnaround time and movement of the lab samples would be far more efficient if co-located at or near the facility in lieu of shipping the samples eight miles to SRNL in A-Area.
- The WSB was designed and built to process liquid TRU and LLW from the MFFF. Although this facility can process the liquid waste that would be generated by a 50 ppy production facility, the WSB systems and components have not been tested and are not being maintained.

To address these infrastructure limitations, the scope of Alternative 1 includes:

- Design and procurement of analytical chemistry equipment, and installation and commissioning of this equipment in the MFFF.
- Alternative 1 scope will include testing and repairing or replacing the existing equipment in the WSB and commissioning the facility.

The EA Team also evaluated the LANL infrastructure for analytical laboratory and liquid and solid radioactive waste processing to determine if this infrastructure could process the samples and waste streams generated by both PF-4 (operating at a 30 ppy production rate) and by the processing modules (operating at 50 ppy).

The EA Team concluded that the capabilities of the existing LANL facilities for solid waste disposition and liquid LLW processing were adequate for handling the waste streams that will be generated from pit production at 80 ppy.

The MAR limit for RLUOB must be increased to allow analytical chemistry sample preparation and analysis capabilities in RLUOB and preserve space in PF-4 for pit production. The change in MAR will require that the facility be re-categorized as an HC-3 facility. This change in hazard category will require that safety basis documentation be prepared. If the hazard or accident analyses identify safety vulnerabilities, it is possible the safety upgrades may be required for RLUOB.

The TLW facility (Room 60) is an aging facility. The project that would construct a new replacement facility is currently on hold. There is some risk that the existing TLW facility could shut down as a result of equipment failures and not be available to process the TRU liquid waste generated by the 50 ppy facility.

2.13 Engineering Feasibility Conclusions

The EA Team evaluated the technical merits associated with each alternative. The overall conclusion is that the preconceptual design concept for each alternative can be executed, but each alternative offers different benefits and technical challenges. To provide a better understanding of these benefits and challenges, the EA Team evaluated the alternatives in terms of the following factors:

- Design approach: Scope of the design effort, complexity of the design, and technical issues and challenges
- Safety strategy: Scope of safety SSCs, challenges associated with approval of safety basis documentation for the new 50 ppy facility and other support facilities
- Constructability: Scope of construction or facility modification/reconfiguration, complexity of construction/modification/reconfiguration activities, construction/modification/reconfiguration sequencing, and construction site access
- Operability: Operator productivity, material movement between process areas and between facilities, operator access to the process facility, and ability to accommodate the staff required to operate and maintain the 50 ppy facility
- Self-sustainment: Reliance on other facilities to provide essential pit processing functions and ancillary operations and challenges associated with interdependencies
- Expandability: Ability to add additional pit production capability

2.13.1 Design Approach

The scope and complexity of the design effort that would be required to translate the preconceptual design concept into a workable design has a bearing on the design execution challenges. The EA Team has assumed that no new technologies or new critical technology elements (CTEs) will be required for any of the alternatives. The scope of the design does not include any technology development activities. In general, the design execution challenges are directly related to scope of the design and the complexity of the individual SSCs.

2.13.1.1 Alternative 1

Alternative 1 will repurpose existing structures within the MOX complex (MFFF and BTS). The design scope for alternative does not include construction of a new HC-2 facility as would be required for all other alternatives. The design scope is limited to the design of the internal process systems and the process support and building utility systems.

Because Alternative 1 does not rely on any other facility, other than the WSB for waste handling, to perform pit processing or process support operations, the MFFF must provide all functions that would be provided by PF-4 or RLUOB for the other LANL alternatives. The scope of the design of the process systems must therefore include aqueous recovery, material characterization, sample preparation, and an analytical laboratory.

Locating and routing the necessary commodities to the process equipment will be constrained by the arrangement, configuration, and sizes of the rooms in the MFFF. The building utility systems will be required to serve the entire MFFF building and will therefore require larger capacity systems and longer and more complex commodity routing. The design of the automated material conveyance system will also involve more complex routing because of the segregation of the process lines and the movement of materials between multiple floors. The structural design is limited to adding mezzanines to the second floor of the MFFF to install process support equipment, design of new penetrations for commodity routing and confirmation of the adequacy of the NPH design of the MFFF structure.

The MOX complex is under construction and the as-built records for the MFFF may not be complete at the time that the facility is made available for conversion to a pit production mission. Design records are available, but they are not updated to reflect design changes during construction. Most of the construction work packages for the MFFF structure are complete and closed. No significant quality assurance or quality control issues are associated with the geotechnical or structural design that have been identified by the NRC or DOE. Because most of the equipment currently installed in the MFFF will be removed or abandoned in place, the inadequacies of the as-built drawings and design records for this equipment do not pose a technical challenge.

Although the cost and schedule estimates for Alternative 1 assume that all existing equipment will be removed or abandoned in place in order to preserve the option to reuse the building utility equipment, the design scope of work also includes evaluation of the existing technical baseline documents for the MFFF. The design scope also includes development of the design changes and deconstruction plans for removal of existing equipment and utility systems within the MFFF.

The BTS as currently designed and constructed can provide, after adding an ECF, all personnel support functions needed for the required staff of a 50 ppy facility. The scope of the design changes for the BTS would be limited to adding an ECF, reconfiguring partition walls, and adding communications drops to the offices and cubicles.

Except for the structures to house the DGs and the fire water tank and pumps, the scope of the design for Alternative 1 does not include design of new structures. Structural design is a sequential element of the design process (i.e., it follows process design and precedes final electrical and instrumentation and control design) and adds time to the overall design schedule. The duration of the preliminary and final design phases for Alternative 1 is therefore shorter than for any of the other alternatives.

2.13.1.2 Alternative 2a

The design scope for Alternative 2a includes design of a new process module, the process systems and the process support and building utility systems. Additional structures and systems include a new PSM, a Mechanical and Electrical Equipment Building (MEB), and external utility systems. Connecting corridors will also be required between the process module and the PF-4 facility and between the PSM and the RLUOB.

The process module will be “purpose built” and will be designed to simplify the layout of the process equipment and build in the necessary penetrations to simplify commodity routing. With the process line configurations optimized, the material conveyance system design will also be simplified. It should be noted however, that although the material routing within the process module can be optimized in the design of the process module, the alternative will require the material transfer of materials to PF-4 through the connecting corridor.

To make the final connection between the connecting corridor to PF-4, the PF-4 tunnel walls will be breached. This will affect the operability of the PF-4 confinement SSCs and could require a short-term shutdown of PF-4, as well as temporary loss of high-energy radiography capability. The connecting corridor must include design features that will limit the effect on the PF-4 confinement barriers.

The design effort for Alternative 2a includes the design of the new building structures for the process module, PSM, an MEB, and new external structures for NPH protection of the fire water supply and DGs. In contrast, Alternative 1 relies on existing structures that will require minimal changes to the structural design. Because the scope of the design work for Alternative 2a includes the design of a HC-2 nuclear structure and other non-nuclear structures, the preliminary and final design phases will take longer to complete than for Alternative 1.

2.13.1.3 Alternative 2b

For Alternative 2b, the disassembly and metal preparation, and the foundry process lines will be installed in PF-4. The new process module will include the other process lines needed for production of 50 ppy. Separate designs will have to be developed for the PF-4 reconfigurations and for the new process module.

The difference in the design code of record between PF-4 and the new facility will add to the design complexity. The PF-4 reconfigurations will require revisions to existing design drawings, calculations, and other technical baseline documents. This will require interfaces between the design agent and the PF-4 engineering staff. Work planning documents will also be required for the PF-4 reconfigurations. These work plans will have to incorporate the appropriate integrated safety management system controls for performing work in an operating facility.

Similar to Alternative 2a, the design for Alternative 2b must also include design features to facilitate the tie-in of the connecting corridor to PF-4. This could require a short-term shutdown of PF-4, as well as temporary loss of high-energy radiography capability.

In addition, the reconfigurations to PF-4 will require an evaluation of the effect of the proposed reconfiguration on the safety basis. A "major modification" determination will be required to determine if the PF-4 safety basis documentation (i.e., TA-55 DSA) will have to be revised. If the PF-4 safety basis documents must be revised, the design modifications might have to include additional engineered safety controls.

The scope of the design for the new process module will be less than that required for Alternative 2a because some of the 50 ppy process operations will be performed in PF-4. The design efforts for the new process module can proceed in parallel with the PF-4 design modifications. Although this parallel design approach has some schedule benefits, it poses a higher level of design execution risk.

2.13.1.4 Alternative 2c

Similar to Alternative 2b, Alternative 2c also requires parallel design efforts to modify PF-4 and to design a new process module complex. This entails the same design execution challenge as discussed in the previous section. The different design approach for the new process modules (i.e., below-grade design) adds to the design scope of work and complexity.

Designing below-grade modules requires a significant civil design effort. The civil design will have to account for excavation, shoring the excavated area, dewatering the construction area, and backfill. The civil and structural design will also have to include design features that will simplify the construction effort.

In addition to design features for tying in the connecting tunnel to the PF-4 tunnel, the design must also include design features that would allow for commissioning the new process modules and transitioning from pit production in PF-4 to the new modules without affecting the pit production rate.

2.13.2 Safety Strategy

2.13.2.1 Alternative 1

The safety strategy for Alternative 1 assumes that the safety systems required for PF-4 will also be required for the MFFF. The Safety Design Strategy (SDS) and the Conceptual Safety Design Report (CSDR) will provide more definitive guidance as to what safety systems will be required and what their functional classification will be.

The estimated dose consequences to the public and to the co-located worker will determine which safety SSCs are required. The dose consequences to the public dictate the need for SC controls. The dose consequences to the public are directly related to the distance to the off-site boundary. The distance from MOX to the site boundary is approximately 7 miles, whereas the distance from PF-4 to the site boundary is less than 1 mile. There is an opportunity that the MFFF will not require the same level of safety controls as PF-4.

Alternative 1 does not rely on any other facilities for any pit processing or process support functions. Unlike the LANL options, no nuclear safety vulnerabilities are associated with other existing facilities that could affect pit production at the MFFF.

2.13.2.2 Alternatives 2a and 2b

As is the case for Alternative 1, the safety strategy for Alternatives 2a and 2b assume that the safety systems required for PF-4 will also be required for the process module. The SDS and the CSDR will provide more definitive guidance as to what safety systems will be required and what their functional classification will be.

All LANL alternatives rely to a certain extent (some more than others) on PF-4 to perform direct pit processing functions or ancillary support functions. Vulnerabilities are associated with the safety basis for PF-4, which could pose a challenge to pit production under all LANL alternatives. Long-standing questions are associated with the seismic capacity of the decades-old PF-4 structural design with respect to local probabilistic seismic hazard analysis information. Complex nonlinear structural analyses are pending to address these questions. The results of these analyses may require that additional seismic upgrades be made to PF-4 or that operational constraints be imposed on future operations.

The extent to which the PF-4 safety basis vulnerabilities may impact each alternative depends on the extent to which each alternative depends on PF-4. A summary of the PF-4 dependencies for each alternative is provided below:

- Alternative 2a provides a new process module that is minimally dependent on PF-4. The new process module relies on PF-4 to perform some ancillary support functions, including aqueous recovery and MC&A. These functions could be incorporated into the design of the process module to further reduce dependencies with a minimal increase in building size.
- Alternative 2b is fully dependent on PF-4. In addition to some ancillary functions, PF-4 will perform all disassembly, metal preparation, and foundry operations, which are the first steps in pit production.
- The new process modules proposed for Alternative 2c do not include a Pu storage vault or a shipping and receiving area. The new process modules rely on PF-4 to provide these capabilities. Lack of a vault would result in material bottlenecks that would affect the pit production rate in the new process modules. Lack of a shipping and receiving capability would preclude pit delivery.

All LANL alternatives are fully reliant on RLUOB to perform sample preparation and radiochemical analysis of samples. NNSA has proposed to transfer pit processing sample preparation operations to RLUOB, which will increase available space in PF-4 for other functions and enable greater operational efficiency by collocating sample preparation and analysis. This will require an increase in the MAR limit for RLUOB, which will then require that the facility be recategorized as an HC-3 nuclear facility. The change in hazard category will require that safety documentation be prepared as required by DOE Order 413.3B and DOE Standard 1189. The risk is that the underlying safety analyses will identify safety vulnerabilities that will require upgrades to RLUOB.

The safety strategy for Alternative 2b is to assume that all safety systems currently required for PF-4 will also be required for the new process module.

The new process module for Alternative 2b is fully reliant on PF-4. If the PF-4 seismic risk is realized, the only available mitigation would be to redesign the process module to perform all essential pit processing operations, which is in effect the same design as for the process module for Alternative 2a.

2.13.2.3 Alternative 2c

Alternative 2c assumes that no active safety systems will be required for the new modules. It is assumed that by locating the modules below grade, the nuclear safety analysis will allow crediting only the passive confinement capabilities without relying on any active safety systems. The EA Team believes that this is a non-conservative strategy and that there is a risk that DOE will require that the module design include active safety controls. If this risk is realized, the design for the modules would have to be revised because there would be no benefit in locating the modules below grade.

The safety strategy for Alternative 2c is to rely on the passive confinement provided by the process module structure for mitigation of the design basis seismic-induced fire and spill accident and to classify the fire suppression and active confinement ventilation systems as defense in depth (DiD). DOE Standard 1189 requires that the design of nuclear facilities be founded on conservative safety controls, particularly during the early design phases. A conservative approach for the preconceptual design of a new HC-2 nuclear facility would be to classify the fire suppression and active confinement systems as SC or SS until the preliminary hazards and accident analysis processes have been completed. Because the safety strategy for Alternative 2c presumes that the hazards and accident analysis results will support the initial assumption that active safety controls are not required, the EA Team considers this strategy to be non-conservative.

Recent revisions to DOE Order 420.1C and Standards 1020, 1189, and 3009 (DOE O 420.1C, Change 3; DOE-STD-1189-2016; DOE-STD-1020-2016; and DOE-STD-3009-2014) require more rigorous hazards and accident analysis methodology and have lowered the threshold for classification of engineered controls as SC and SS and as Seismic Design Category 3 (SDC-3). The material at risk (MAR) for a 50 ppy production facility is expected to be approximately one order of magnitude less than that of PF-4. Given that the unmitigated accident consequences for PF-4 exceeded the threshold for active SC (and SDC-3) controls, it is reasonable to conclude that, at a minimum, active SS (and SDC-2) engineering would be required for a new 50 ppy production facility. The assumption that no active safety controls will be required in the early stages of design could result in design rework if the hazards and accident analysis results later demonstrate the need for such controls.

The new process modules for Alternative 2c are also fully reliant on PF-4.

2.13.3 Constructability

Modification or construction of an HC-2 nuclear facility involves inherent challenges. This section does not discuss these challenges unless they are unique to one or more of the alternatives. This section focuses on differences in the construction scope of work and differences in construction sequences or the size of the construction footprint compared to the construction site.

2.13.3.1 Alternative 1

For Alternative 1, the scope of the construction effort includes:

- Removing the existing equipment previously installed in the areas of that MFFF that are being used for pit production
- Installation of a mezzanines on the second floor of the MFFF for locating process support equipment
- Installation of process equipment
- Installation of process support and building utility systems
- Commodity routing and final system connections
- Construction and equipment installation in the DG buildings and the Fire Water Tank and Pump-house
- Testing and repairing or replacing the existing equipment in the WSB
- Modifications to the BTS

The process gloveboxes will be installed through existing construction openings in the sides of the MFFF. Due to the size of the MFFF, this will require moving the gloveboxes long distances and through multiple rooms to reach their final location. This adds to the equipment placement time. Because of the large size of the MFFF, there are multiple construction access routes to the process areas. This allows use of multiple work crews in the same general area to mount and connect the gloveboxes to a glovebox line. The overall result is that the process equipment installation effort takes approximately the same time as for Alternatives 2a and 2c.

There is an opportunity to reevaluate the need for retaining all structural walls in the MFFF during the design phase. Removing some select walls on the third floor of the MFFF would improve construction access and could further reduce the equipment installation time.

The large size of the MFFF allows the new systems and components for pit production to be located in different parts of the building. This improves construction flexibility by allowing the construction craft to work in multiple work fronts in parallel.

In addition, the commodities for the process support and utility systems will have to be in the areas where sufficient space is available. Although the MFFF has an overabundance of space to accommodate the process support and utility systems, the available areas are separated by large distances. The increase in the commodity routing distances will result in the need for more wall and floor penetrations and support hangers.

2.13.3.2 Alternative 2a

The scope of the construction effort for the process module for Alternative 2a includes:

- Construction of a PSM
- Construction of the process module shell
- Construction of the connecting corridors to PF-4 and RLUOB
- Installation of process equipment
- Installation of process support and building utility systems
- Installation of aqueous recovery line in PF-4
- Installation of additional capacity in RLUOB
- Commodity routing and final system connections
- Construction and equipment installation in the DG buildings and the fire water tank and pump house

The PSM is a non-nuclear facility and could be constructed prior to CD-2/3 approval for the process module. The PSM could then be used for construction support offices during construction of the process module.

The process module for Alternative 2a is a two-story building. This minimizes the building footprint and maximizes the space available for construction access. The process module and all other required structures will be built on the existing grade elevation. The site will be excavated down to the depth where competent soil exists and will be backfilled with engineered fill.

The large equipment items on the first floor will be installed by crane after the first-floor walls have been erected. The process gloveboxes will be installed by crane after the second-floor slab is in place. Vertical installation of large equipment items by crane simplifies the construction process.

The process module is a purpose-built building and will be designed to optimize commodity routing. Preinstallation of penetration blockouts and grid steel for commodity supports will further simplify commodity routing.

The construction of the connecting corridor to PF-4 is expected to require close coordination between the construction organization and the PF-4 operations staff. The tie-in to PF-4 will ultimately have to breach the wall of the PF-4 tunnel, which could affect the ability to maintain a negative pressure for confinement. The tie-in will have to be sequenced to minimize the impact on PF-4 operations.

2.13.3.3 Alternative 2b

The construction scope and sequencing for the new PSM and process module and the other new buildings is identical to Alternative 2a. The new process module will have a smaller footprint, which reduces construction congestion at the site.

PF-4 is an operating facility; the new process lines for disassembly and metal preparation and foundry will have to be installed without affecting the other ongoing missions. Moving large equipment items through the building and moving construction craft throughout the building could disrupt the other ongoing missions. In the worst case, failure to maintain the isolation boundaries for lockouts and tagouts could result in injury to workers or inadvertent facility shutdown.

The complications involved in modifying an active facility will limit construction flexibility. The installation of new equipment or modifications to existing systems will have to be completed in a prescribed sequence to avoid impacting other facility missions. The productivity of the construction craft will also be negatively affected by having to perform work inside PIDAS and in potentially contaminated areas.

The additional work controls for worker safety and for minimizing the impact to the ongoing missions will complicate construction planning for the PF-4 reconfiguration. These complications, in addition to the inherent challenges involved in installing new equipment into an existing building, are construction risks that are unique to Alternatives 2b and 2c.

2.13.3.4 Alternative 2c

The construction considerations for the PF-4 reconfiguration for Alternative 2c are identical to those described for Alternative 2b.

The design concept for the new modules involves locating three process modules and an ECF below grade. This will require excavation and shoring a relatively large area. Working below grade to install the foundations and walls for the new modules and the connecting tunnels to PF-4 and RLUOB will also be less efficient than working at grade. After the structures for the process modules and the ECF are in place, a relatively large quantity of soil will have to be brought back to the site for backfill.

The gloveboxes and process support and building utility equipment will be installed by crane after the walls for the modules have been placed. Commodity installation would be more difficult because both the process support and process gloveboxes are on the same floor. This will require routing commodities in the overhead areas in the process rooms.

The footprint of the module complex for Alternative 2c is approximately 80,000+ ft^2 vs. 40,000 ft^2 for Alternative 2a. The area remaining on the construction site will be more congested, which will affect construction efficiency.

The tie-in of the connecting tunnel to PF-4 involves the same complications as for Alternatives 2a and 2b.

2.13.4 Operability

The design concepts for the alternatives drive the equipment layouts and the building arrangements, which affect material movement and operator access to the process equipment. The design concepts also provide different levels of personnel support capabilities. The material movement, operator access, and the personnel support capabilities all affect operations efficiency. Where operational efficiency is significantly reduced, the risk is that the facility will not be able to achieve or sustain the required pit production rate.

2.13.4.1 Alternative 1

To fit the process equipment into the MFFF, Alternative 1 requires that the process lines be split between multiple rooms. This requires that operators move between rooms to access the equipment needed for the next process step(s) in the process line. The net effect is that operator productivity will be somewhat reduced. Offsetting this, the segregation of the process lines would confine radioactive contamination to smaller areas that would be easier to decontaminate and return to service.

The segmentation of the process lines also requires that the hot material conveyor line be routed above and through walls in the same process line. Although this adds to the cost to procure and install the conveyor system, it should not affect process line efficiency and throughput. A modern conveyor system will allow rapid material movement, and the additional distances traversed should have a negligible effect on process times.

The rooms to be used for housing each process line were selected to provide the best use of space; however, it was not always possible to satisfy the recommended working space and standoff distances. Some process rooms provide less than recommended working space around the gloveboxes and working stations, as well as standoff distances to the walls.

There is an opportunity to evaluate the option to remove structural walls to simplify the process line configurations during the design phase. Eliminating select walls could improve operator access to the process lines and allow for better construction access during equipment installation.

Alternative 1 uses the existing BTS to provide personnel support for pit production in the MFFF. The BTS is a 73,480-ft^2 office building that was designed to provide personnel support functions. Because the BTS was designed to support a larger staff than that required for a 50 ppy facility, the available space is more than adequate to provide personnel support for the 50 ppy mission in the MFFF.

2.13.4.2 Alternative 2a

Alternative 2a allows locating the pit process lines in a new facility that is purpose-built to house them. The process lines can therefore be sized and configured to maximize operator access to the process lines and to the process equipment.

Alternative 2a relies on PF-4 to perform ancillary operations support functions. These functions include aqueous recovery, material characterization, and sample processing. This will require transfer of metal oxides and process samples to PF-4, which will require bagging the materials and transferring them by handcart to PF-4. The bagging and manual transfer operations will affect operating efficiency to some extent, but they would not affect pit production rates.

Alternative 2a also includes a new PSM to provide the personnel support functions. The PSM is proposed to be a two-story non-nuclear facility to accommodate the necessary staff. The staffing estimate developed by LANL identified a production staff of 485 to operate and maintain a 50 ppy facility.

2.13.4.3 Alternative 2b

Alternative 2b involves production of 50 ppy on a “split flowsheet,” which means that the required process lines are split between two facilities — PF-4 and a new process module. New equipment would be installed in PF-4 to perform the disassembly, metal preparation, and foundry process operations. The remaining process operations would be performed in a new process module.

The ELDs developed by Parsons to install the new glovebox lines for Alternative 2b are generally consistent with the working space recommendations provided in Section 2.6. The new process module would also include a high-energy radiography vault; a Pu vault; a shipping and receiving area; LLW, TRU, and TRUM solid waste storage; an RBA control point; and operations offices. These areas were conservatively sized to match the space allocations for Alternative 2a. Because the process module for Alternative 2b is purpose-built to provide the process and operations support functions, the internal material movement operations and the operator access to the process areas will be optimized.

The split flowsheet for Alternative 2b will require the movement of Pu metal from the PF-4 foundry to the new process module. The process module also relies on PF-4 to perform material characterization and sample processing. This will require transfer of samples to PF-4. All transfers will require bagging the materials and transferring them by handcart through the connecting corridor to/from PF-4, which will have some effect on operational efficiency. Taking metal out of the conveyor system and packaging it for contamination control and then moving it to another building adds more inefficiency than just packaging up residues for aqueous processing. It is also possible that bottlenecks could occur in the transfer routes, which could reduce the pit production rate.

The design concept for Alternative 2b also includes a new PSM. The PSM was sized to be the same as for Alternative 2a. The concept assumed that the same number of personnel would be needed to operate the 50 ppy process lines even though some personnel would be located in PF-4. It was further assumed that the personnel in PF-4 could use the facilities in the PSM.

2.13.4.4 Alternative 2c

Alternative 2c proposes to modify PF-4 to provide an interim 80 ppy capability operating on a two-shift basis. A new process module complex would be built to provide a long-term capability to produce 50 ppy operating on a single-shift basis.

The proposed ELDs for the PF-4 process line configuration were developed by LANL. In general, these ELDs reflect the working space recommendations. The process modules for Alternative 2c will include a split flowsheet for pit production operations, similar to Alternative 2b. Because the modules are new structures, the process equipment was configured to provide for the efficient movement of material and facilitate operator access to the process rooms. The process line configurations and sizing used by LANL in developing the ELDs for the modules are generally consistent with the recommended working space and stand-off distance recommendations. The operational efficiency of the process line configurations within the modules is therefore not significantly different from that for Alternative 2a.

The process modules will rely on the Pu vault and the shipping and receiving area within PF-4. The process modules will also rely on PF-4 to perform ancillary operations, including aqueous processing, material characterization, and sample preparation. Moving materials between the process modules and PF-4 will require bagging of the materials and manual transfer by handcart.

The rate of the manual material transfers through the connecting tunnel to PF-4 and through the PF-4 processing areas could result in material flow bottlenecks that could affect the pit production rate for Alternative 2c. The size of the existing PF-4 Pu vault and shipping and receiving area may be inadequate and could also result in material flow bottlenecks.

Personnel access to the modules is controlled through the RLUOB tunnel to the ECF or through the PF-4 tunnel. Personnel assigned to work in the modules are assumed to enter or exit the module complex through RLUOB, the RLUOB tunnel, the ECF, and the rad check area. The sizes of the entry control area within the ECF and the rad check area within the RBA are relatively small and may create bottlenecks for personnel access and egress to/from the process module complex.

The design concept for Alternative 2c provides 1,624 ft^2 of space within the ECF for locker/change rooms. No space is provided within the ECF for a lunchroom/break room, restrooms, or technical support offices. Personnel assigned to work in the module complex will have to exit the PIDAS area to access restrooms and lunchroom facilities. The technical support staff will also have to be located outside PIDAS, which limits direct communications with the operations staff in the module complex. The lack of personnel support facilities close to the module complex will reduce productivity but might not affect the pit production rate. Housing the technical support staff farther from the production staff could have an indirect effect on productivity and it may also affect the ability to recognize and solve operational problems, which could indirectly affect the pit production rate.

2.13.5 Self-Sustainability

The EA Team also evaluated the self-sustainability of each of the four alternatives in terms of the reliance on other facilities to provide essential pit processing functions and ancillary operations and challenges associated with interdependencies.

2.13.5.1 Alternative 1

Alternative 1 is fully independent of LANL and of all other facilities at SRS except for the radioactive solid waste facility in E-Area.

2.13.5.2 Alternative 2a

Alternative 2a relies on PF-4 and RLUOB for some limited ancillary functions (aqueous recovery, material characterization, and sample preparation). The process module could operate for at least several months if PF-4 could not perform these operations. The new process module for Alternative 2a is fully reliant on RLUOB to perform sample preparation and analysis.

2.13.5.3 Alternative 2b

Alternative 2b is fully reliant on PF-4 to perform all disassembly and metal preparation, and foundry operations. In addition, the process module will rely on PF-4 and RLUOB to perform some ancillary functions, including material characterization and sample preparation. The new process module for Alternative 2b is fully reliant on RLUOB to perform sample preparation and analysis.

2.13.5.4 Alternative 2c

Alternative 2c is fully reliant on PF-4 to provide interim storage of Pu materials in the vault and to ship and receive materials. The process modules also rely on PF-4 and RLUOB to perform some ancillary support functions, including aqueous recovery, material characterization, and sample preparation. The new process modules for Alternative 2c are fully reliant on RLUOB to perform sample preparation and analysis.

Alternative 2c does not provide any new personnel support facilities. The existing personnel support capabilities within TA-55 are currently strained. LANL has proposed to construct a new 375-person office building that would accommodate the increased staff to support pit production at 80 ppy. At present, the CMRR subproject associated with this scope has not been baselined. The new office building is also outside PIDAS and could not support a new 50 ppy process module(s).

The staffing analysis performed by NNSA shows that a staff of 485 would be required to operate and maintain a 50 ppy facility. Approximately half of this complement would be in the process modules at any one time. Alternative 2c does not provide the capability to house the remaining staff, nor does it provide the ability for the operating staff in the modules to use restroom facilities or a breakroom without exiting PIDAS. The lack of a personnel support facility represents a risk to pit production under the process module concept for Alternative 2c.

2.13.6 Expandability

The ability to add additional pit production capability or expandability was also evaluated for each of the four alternatives.

2.13.6.1 Alternative 1

The MFFF has sufficient space to add or expand the process lines in the MFFF to provide an 80 ppy capability. The EA Team developed ELDs to show how the process equipment would be laid out in the MFFF. The GA drawings identify specific locations where the other operations support functions would occur. The GA drawings only identified general areas where the process support and building utility systems could be located. These general areas were much larger than the recommended space requirements. The GA drawings therefore represent more space than would actually be required for a 50 ppy facility.

Even if the equipment required for a 50 ppy capability did take up all of the space identified in the GA drawings, many large areas that are not highlighted in the GAs could be used to add process equipment. The number of process equipment items needed to produce 80 ppy is also only marginally larger than the number required for 50 ppy. It is therefore reasonable to assume that the additional equipment items needed to expand the mission from 50 ppy to 80 ppy could easily be added MFFF.

2.13.6.2 Alternative 2a

The process module for Alternative 2a is sized for 50 ppy. Although conservatism in the space calculations for the process areas has likely created surplus space in the proposed process module, this space may not be ideal for future equipment installations. If there is a high likelihood that the facility mission will increase over time, it would be prudent to design and construct the module with an area specifically reserved for additional process equipment. This was the approach taken for the MPB for the UPF project: throughout final design, a space blockout was maintained for special casting.

2.13.6.3 Alternative 2b

Increasing the capacity for Alternative 2b would require increasing the capacity in both the process module and in PF-4. PF-4 is not likely to have enough unallocated space available in the future for any increase in mission if it is not built into the current space allocation planning. Capacity could be increased at PF-4 using multiple labor shifts, similar to the first phase of Alternative 2c.

2.13.6.4 Alternative 2c

Alternative 2c relies on the vault storage and shipping and receiving capability in PF-4. The risk is that the existing vault and shipping and receiving areas may not be adequate to support the new process modules operating at 50 ppy. To increase the pit production rate for the new process modules, one or more additional modules would have to be constructed to provide space for a Pu vault and to add the additional processing equipment. Because the proposed module complex for 50 ppy takes up a large area on the CMRR-NF site, adding modules would be difficult. Also, excavation around the existing modules could affect the soil structure interaction analysis that was performed to demonstrate seismic capacity.

3 Cost and Schedule Analysis

This section documents the cost and schedule estimates developed for four alternatives in support of the Engineering Assessment (EA). The approaches and methodologies used to develop the cost estimates and schedules are described, and the resultant estimates and schedule are presented and discussed. The basis of estimate is also provided in Appendices E, F, G, and H.

The capital cost and life-cycle cost estimates (LCCE), and project schedules that have been developed for each alternative represent rough-order-of-magnitude estimates (Class 5 in accordance with DOE Cost Estimating Guide estimate classification). These estimates and schedules are therefore intended only to provide a means of comparing relative costs of alternatives to support the decision-making process; they are not intended for budgeting purposes.

Table 3-1 shows the estimated total project cost (TPC) range for the capital projects needed for each alternative evaluated in the EA. The TPC encompasses all project-related costs incurred from conceptual design through approval of Critical Decision 4 (CD-4), but it excludes the costs for hot commissioning and transition to operations. The TPC range is shown in dollars escalated to the time of the planned expenditure.

Table 3-1: Total Project Cost Ranges ($B)

Alternative 1 Modify MFFF at SRS with Production Modules	Alternative 2a Construct a Module at LANL – Production Facility Outside PF-4	Alternative 2b Construct a Module at LANL – Production Capacity Split w/PF-4	Alternative 2c Use PF-4 as a Bridge until Construction of Modules at LANL
$1.8 to $4.46	$2.1 to $5.2	$1.8 to $4.44	$2.3 to $5.8

As shown above, the differences in the estimated cost of the initial capital projects for Alternatives 1, 2a, and 2b are minimal. Alternative 2c, however, is estimated to cost considerably more in terms of capital investment.

Table 3-2 shows the estimated schedule range for the capital projects needed for each alternative evaluated by the EA. It is assumed that opportunities are available for schedule acceleration and compression. If no significant threats affect the schedule, each alternative can be completed approximately 18 months earlier than currently scheduled. Conversely, if threats are realized and schedules cannot be optimized, all alternative schedules may be 24 months longer than currently scheduled.

Table 3-2: Schedule Ranges (CD-4 Date)

Alternative 1 Modify MFFF at SRS with Production Modules	Alternative 2a Construct a Module at LANL – Production Facility Outside PF-4	Alternative 2b Construct a Module at LANL – Production Capacity Split w/PF-4	Alternative 2c Use PF-4 as a Bridge until Construction of Modules at LANL
Jul 2026 to Jan 2030	Apr 2028 to Oct 2031	Mar 2027 to Sept 2030	PF-4: Nov 2025 to May 2029 Modules: Jan 2032 to Jul 2035

Note that a period of hot commissioning and transition to operations activities will follow CD-4 and needs to be completed successfully before full production levels can be achieved and maintained. Expected durations for those activities have been included in each alternative schedule but are not captured in the above schedule ranges.

The present value (PV) of the LCCE was calculated for each alternative using the expected expenditures by year for the proposed capital projects, the estimated annual operations phase costs over a 50-year operating life, and end-of-life decommissioning and disposal (D&D). The resultant LCCEs are summarized in Table 3-3. The PV calculation used the Office of Management and Budget (OMB) Real Discount Rate applied to un-escalated annual expenditures.

Table 3-3: Present Value of Life Cycle Costs for Alternatives ($B)

Cost Element	Alternative 1 Modify MFFF at SRS with Production Modules	Alternative 2a Construct a Module at LANL – Production Facility Outside PF-4	Alternative 2b Construct a Module at LANL – Production Capacity Split w/PF-4	Alternative 2c Use PF-4 as a Bridge until Construction of Modules at LANL
Capital Projects	1.74	1.93	1.68	1.94
Operations Costs	25.99	16.86	12.618	12.80
End-of-Life D&D	0.04	0.03	0.03	0.04
Total Life Cycle Cost	27.77	18.82	14.32	14.78

As shown above, the estimated PV LCC of Alternative 1 is considerably more than for the other three alternatives. This is due to the need for a full level of staffing for the pit production operations at SRS using MFFF, as compared to the lesser incremental staffing that would need to be added to accomplish the added 50 ppy production at LANL for the other alternatives. The ongoing labor study (being conducted outside this EA) could significantly affect the cost data presented in the EA. Section 3.6 provides a sensitivity analysis of those impacts.

3.1 Approach and Methodology

Rough order of magnitude (ROM) cost estimates and project schedules have been developed to compare relative costs of identified alternatives and to support the critical decision and conceptual design planning processes. These estimates are not intended for budgeting purposes.

3.1.1 Overview of Approach

In general, estimates are based on previous estimates developed as part of the Analysis of Alternatives (AoA) for the Plutonium (Pu) Pit Production project, with additional detailed analysis and revised estimate bases applied as appropriate. Estimates are Class 5 as defined in DOE Guide 413.3-21 and have generally been developed using parametric techniques and factoring. To the maximum practical extent, estimates have been normalized to avoid favoring a particular alternative. Whenever possible, estimated costs have been compared to historical analogous projects, and actual data and prior estimates have been used when possible.

Table 3-4 presents the work breakdown structure (WBS) used for estimate development and the general approaches to be used to estimate those WBS elements for each alternative. Each alternative has its own set of assumed subprojects, as shown in Table 3-5.

Table 3-4: Estimate WBS and Estimating Approach

WBS	Description	Estimate Approach
1	Capital Project	
1.1	Subproject (as many as appropriate for a specific alternative)	
1.1.1	Project Management/Support	% of Other Project Costs
1.1.2	Engineering/Design	% of Procurement + Construction
1.1.3	Site Preparation/decommissioning and disposal (D&D)	Parametric Estimate/Cost Estimating Relationship (CER)
1.1.4	Equipment Procurement	Analogy Estimate or Parametric/CER
1.1.5	Construction/Installation	Analogy Estimate or Parametric/CER
1.1.6	Startup/Commissioning	% of Procurement + Construction
1.1.7	Contingency	Based on Uncertainty/Risk Analysis
1.2	Subproject (as many as appropriate for a specific alternative)	
1.2.1	Project Management/Support	% of Other Project Costs
1.2.2	Engineering/Design	% of Procurement + Construction
1.2.3	Site Preparation/D&D	Parametric Estimate/CER
1.2.4	Equipment Procurement	Analogy Estimate or Parametric/CER
1.2.5	Construction/Installation	Analogy Estimate or Parametric/CER
1.2.6	Startup/Commissioning	% of Procurement + Construction
1.2.7	Contingency	Based on Uncertainty/Risk Analysis
1.x	Other Project Costs	
1.x.1	Conceptual Design	ROM Estimate
1.x.2	Environment, Safety, and Health (ES&H; incl. NEPA)	ROM Estimate
1.x.3	Spare Parts	% of Equipment Procurements
1.x.4	Management and operations (M&O) (or Owner Agent) Oversight	% of all above costs
2.0	Operations Period Costs	
2.1	Facility Operations and Maintenance	ROM Estimate
2.2	Operations Staffing and Expenses	ROM Estimate
2.3	Security Related Costs	ROM Estimate
2.4	Waste Transportation and Disposal)	ROM Estimate
2.5	Periodic Major Upgrades	% of Initial Capital Costs
3.0	End-of-Life D&D	CER

Table 3-5: Alternative Subprojects

Alternative 1 Modify MFFF at SRS with Production Modules	Alternative 2a Construct a Module at LANL – Production Facility Outside PF-4	Alternative 2b Construct a Module at LANL – Production Capacity Split w/PF-4	Alternative 2c Use PF-4 as a Bridge until Construction of Modules at LANL
MFFF readiness and modifications	New process module for pit production	New process module for pit production	PF-4 additional equipment
Pit production equipment/installation	Personnel support module	Personnel support module	Laboratory modules
Analytical laboratory equipment/systems	Pit production equipment/installation	Pit production equipment/installation	Radiography bays
Technical support building modifications	Support facilities/systems (incl. MEB)	Support facilities/systems (incl. MEB)	Other TA-55 construction/ modifications
WSB readiness and reactivation	TA-55 PIDAS extension/modification	PF-4 modifications	TA-55 PIDAS extension/modification
MFFF security upgrades (incl. PIDAS)	Other project costs	TA-55 PIDAS extension/modification	Other project costs
Other project costs	–	Other project costs	–

MEB = Mechanical and Electrical Building
MFFF = Mixed Oxide Fuel Fabrication Facility
PF = Plutonium Facility
PIDAS = perimeter intrusion detection and assessment system
RLUOB = Radiological Laboratory Utility Office Building
TA = Technical Area
WSB = Waste Solidification Building

3.1.2 Capital Project Cost Estimate Development

This section describes the methodology used to develop the project cost estimates at a summary level. The cost estimate results are summarized in Section 3.3 of this report; the supporting detailed estimate bases and estimates can be found in Appendices E, F, G and H, for Alternatives 1, 2a, 2b, and 2c, respectively.

3.1.2.1 Facility Construction Costs

New facilities have been estimated parametrically using a cost per square foot of floor area. The parameters are like those used for the Pit Production AoA and are based on historical DOE/NNSA project actual costs and recent estimates for comparable facilities.

The cost for deconstruction and modification activities needed to refurbish the Mixed Oxide Fuel Fabrication Facility (MFFF) have been estimated using inventories of installed materials and equipment, photos of current conditions, and EA Team assessments of the degree of difficulty and level of effort required to accomplish the assumed scope.

3.1.2.2 Equipment and Systems Costs

The estimated costs for pit production equipment and associated gloveboxes are developed using the equipment lists produced by the Engineering Assessment (EA) team. Unit costs are based on analogies to previous NNSA projects, recent estimates for comparable projects, and EA Team opinion. Although equipment procurement unit costs are assumed to be identical for each alternative, equipment installation unit costs have been varied, as appropriate, based on location and complexity of installation (e.g., new facility vs. Plutonium Facility 4 [PF-4]).

Although the EA Team assumed that all alternatives would be outfitted with the same equipment as currently installed in PF-4, it may be that some equipment will no longer be available necessitating new versions of the same equipment. This applies equally to all alternatives and is not a differentiator, so no attempt was made to quantify this.

Utilities, support systems, and equipment have been estimated using analogies to other DOE/NNSA projects with appropriate factoring based on sizes and capacities.

3.1.2.3 Design, Project Management, and Other Project Costs

The estimated costs for engineering and design, project management and support, and startup and commissioning have been estimated parametrically by applying appropriate percentages to the estimated procurement and construction costs for each subproject. The percentages used are based on and are consistent with historical DOE/NNSA performance on comparable projects.

- Engineering and design costs cover preliminary and final design and related activities such as safety basis development, procurement specifications/bid evaluations, etc.
- Project management and support costs include all management oversight, plans, project controls, administrative support, and associated activities from the beginning of conceptual design through Critical Decision 4 (CD-4) approval.
- Startup and commissioning costs include all startup and transition to operations planning, system and integrated testing, operational readiness reviews by a contractor and the DOE, addressing corrective actions, and preparation of the CD-4 package.

Allowances have also been included for conceptual design; environmental, safety, and health (ES&H) activities (including National Environmental Policy Act [NEPA]), and spare parts. These represent ROM estimates based on past DOE/NNSA project estimates and actual experience, as well as EA Team opinion.

The alternative cost estimates assume no specific acquisition strategy, but they have been developed conservatively with appropriate adders included for construction management and management and operating (M&O) contractor or owner's agent oversight of the project.

3.1.2.4 Management Reserve and Contingency Allowances

A contingency reserve has been included in the point estimates to reflect the degree of estimate uncertainty and project risk identified by the EA team. The various specific contingency allowances included are described in the alternative bases of estimates presented in Appendices E, F, G, and H.

3.1.3 Capital Project Schedule Development

Project schedules have been developed for each alternative. The project schedule durations have been determined using EA Team judgment and are consistent with the alternative cost estimates, as well as historical DOE/NNSA experience. This is consistent with Government Accountability Office (GAO) best practices for schedule assessments and commensurate with the early stages of project definition and scope.

3.1.4 Project Cost and Schedule Range Development

Cost and schedule ranges have been developed for the capital project needed for each alternative. The project estimates are calculated using assumed cost profiles derived from applying the estimated costs to the schedule durations and include allowances for cost escalation over time. The project cost and schedule ranges are then determined based on assumed levels of cost and schedule estimate uncertainty and the qualitative risk analysis completed by the EA team.

The total project cost (TPC) range for each alternative was determined by assuming that the cost estimate for each alternative had an uncertainty range of from –20% to +100%, consistent with DOE/NNSA expectations for a Class 5 estimate of a complex nuclear project. The uncertainty range is believed to be adequate to also address potential risk impacts (threats and opportunities).

For the schedule range, the EA team applied judgment based on the assumptions, duration uncertainties, risks, and other factors considered during estimate and schedule development to provide a range for CD-4 around the point determined by the project schedules for each alternative. Due to the preconceptual nature of these schedules, the same size schedule ranges have been assumed for all alternatives.

3.1.5 Life-Cycle Cost Estimate Development

Life-cycle cost estimates (LCCE) have been developed for each alternative by spreading the project costs over time and then applying estimated un-escalated annual costs over the assumed operating lifespan of 50 years from the start of operations. The present values (PVs) of those LCCEs, calculated using the Office of Management and Budget (OMB) real discount rate, are used to compare the alternatives from a cost perspective.

3.1.5.1 Annual O&M Costs

Annual O&M costs have been included in the LCCE for each alternative, based on estimates of the staffing needed to accomplish 50 ppy production level. It is assumed that the LANL staff and other costs needed to produce 30 ppy is the same for all alternatives and thus is not included in the LCCEs for the EA alternatives.

Staffing estimates were provided by SMEs supporting the EA team and were used as the basis to estimate annual operations and maintenance (O&M) costs for each alternative. Staffing estimates were identified separately for production (i.e., operations), support (i.e., facility O&M), and security personnel. These estimates were developed based on LANL staffing estimates for 30 ppy production by developing ratios of production staff to pieces of equipment for each alternative. A ratio of operations, support, and maintenance staff to production staff, based on current PF-4 experience and LANL estimates, was also used. Security staffing numbers are based on SME estimates extrapolated from current TA-55 staffing. The estimated staffing for each alternative are shown in Table 3-6.

Table 3-6: Estimated Staffing Levels for Alternatives

Staff Category	Alternative 1 Modify MFFF at SRS with Production Modules	Alternative 2a Construct a Module at LANL – Production Facility Outside PF-4	Alternative 2b Construct a Module at LANL – Production Capacity Split w/PF-4	Alternative 2c Use PF-4 as a Bridge until Construction of Modules at LANL
Production Staff	722	489	347	363
Operations and Maintenance Staff	886	587	426	445
Security Staff	200	80	60	60
Total Staff	1807	1156	833	868

In addition, for Alternative 2c, an estimate of the incremental staff needed to produce 50 ppy using double shift operations has also been incorporated into the life cycle cost estimate.

An assumed average annual cost per full-time equivalent (FTE) personnel was applied and an allowance was included for supplies and other direct costs. Additional information regarding these estimates for each alternative can be found in Appendices E, F, G, and H.

For the operations (i.e., production) staff, it was assumed that staff would be hired, cleared, trained, and certified over a period of years. Accordingly, a ramp-up of the operations staffing costs was applied for each alternative as follows:

- CD-4 minus 4 years 20%
- CD-4 minus 3 years 35%
- CD-4 minus 2 years 60%
- CD-4 minus 1 year 75%
- CD-4 year 90%

3.1.5.2 Waste Transportation and Disposal Costs

Estimated volumes of transuranic (TRU), low-level (LLW), and nonhazardous waste were calculated for 50 pits per year (ppy) production levels using the cost estimating relationship (CER) developed and used for the Pit Production AoA. The cost values used for disposal of the LLW and nonhazardous waste are the same as used for that AoA.

For TRU waste, the number of annual shipments to the Waste Isolation Pilot Plant (WIPP) was calculated based on estimated waste volume. The cost for each WIPP shipment from either Los Alamos National Laboratory (LANL) or the Savannah River Site (SRS) was calculated using the unit cost of shipments from those sites provided by the Carlsbad Field Office to the Surplus Plutonium Disposition AoA team. The costs to process waste prior to shipment, and the cost of disposal at WIPP, have not been included in the LCC as these would be the same for all alternatives. Thus, only differential transportation costs have been considered and included in the LCCE for this EA.

3.1.5.3 Periodic Major Upgrades

An allowance was included for major upgrades of the pit production facilities and equipment for each alternative. The allowance is over and above the allowance for annual maintenance and repair included in the O&M estimate. This cost is estimated as a percentage of the initial capital investment. Major upgrades are included for new facilities as well as for production and support equipment.

Two major upgrades for each alternative are assumed to occur over the 50-year life of the facilities.

3.1.5.4 End-of-Life D&D

All facilities needed for each alternative to complete the pit production mission, either constructed or modified for use, will have to be decommissioned and disposed of at the end of the production operations. The cost included in the LCCE for this effort is based on a benchmark developed by the DOE Office of Project Management based on an analysis of historical DOE D&D experience. The parameter used is ($111,000 per $ft^2)^{0.45}$ (to recognize economy of scale for D&D costs).

3.2 Assumptions and Exclusions

This section discusses the key assumptions used to develop the cost and schedule estimates. Also identified are those elements excluded from the EA cost and schedule estimates.

3.2.1 Cost Estimate Assumptions

Assumptions are as follows:

- Point estimates for capital projects include all costs to be incurred beginning with conceptual design and concluding with CD-4 prior to the start of hot commissioning, except as noted in Section 3.2.5.
- EA estimates do not include any cost differentials between the sites due to differing wage rates, salaries, market conditions, M&O overheads/burdens, etc.[4] It may be appropriate to consider such differentials and reassess these cost estimates (see Section 3.6, Sensitivity Analysis, for further discussion of this issue).
- Glovebox and equipment installation base hours were derived from average rates being experienced at PF-4 for the PF-4 Equipment Installation (PEI) project and are also consistent with the Uranium Processing Facility (UPF) estimates. Although these rates reflect work in an

[4] The EA Team's understanding is that site-driven cost differentials are being studied as part of a labor analysis being performed by others.

operating nuclear facility, they were also conservatively applied for the installations in the new process module. However, productivity is assumed to vary by location as follows due to access and site logistical challenges:

- LANL new construction base case assumes optimal construction execution.
- SRS – work inside MFFF 20% more to reflect access and logistical issues.
- LANL – work inside PF-4 40% more to reflect working in operating facility and logistics. (recognizing the base hours already are consistent with PF-4 experience but also reflecting that it will be higher than needed in a new facility).

- Equipment procurement costs, on a unit or average cost basis, are assumed to be the same for each alternative. These costs will not be a key discriminator between alternatives, except as the amount of equipment varies. Therefore, ROM cost estimates for equipment costs are adequate for establishing the approximate TPC ranges for the projects. The EA team has attempted to identify approximate costs for each glovebox and piece of identified equipment, based on similar equipment previously costs incurred for the PEI project at LANL and estimated costs for the Uranium Processing Facility (UPF).
- Transportation of TRU waste to the WIPP is included for each alternative and is based on a calculated average rate over the estimated operational duration for each alternative. Unit costs were provided by Carlsbad Field Office based on TRU waste shipments to WIPP: $18,700 for SRS and $4,300 for LANL.
- The LCCEs for each alternative encompass 50 years beginning in the year following CD-4. This includes a period for hot commissioning, followed by transition to operations activities, before full production levels are reached. The estimate assumes the same level of staffing and associated costs for facility O&M, operations, and security over that time span. The estimated cost for waste transportation and disposal are assumed to ramp up over the hot commissioning and transition to operations phase before reaching a steady-state cost over the remaining operational period.
- Costs for staff to support project and operations have been estimated using a single, average, fully burdened annual cost per FTE with no difference between sites reflected in the resultant cost estimates.
- No allowance for growth of facility maintenance over the operating period was included, as it has been assumed that cost is captured in the periodic major upgrade estimates that have been included in the LCCE.
- End-of-Life D&D is assumed to occur over a 3-year schedule beginning in the year after operations are assumed to end.

3.2.2 Schedule Assumptions

Assumptions are as follows:

- The LANL alternatives require an environmental impact statement (EIS). The EIS process will culminate with a record of decision after a 3-year process. For the MFFF alternative, it is assumed that a full EIS process is not required, but the process is anticipated to last 1 year.
- The schedules are not resource loaded.
- Alternative selection decision will be made by 1 June 2018, although CD-1 will not be approved until conceptual design is completed. Conceptual design will start on 1 October 2018 (start of fiscal year [FY] 2019). Adequate funding will be available to support the conceptual design effort in FY 2019.
- Project engineering and design (PED) funding will be available beginning in FY 2020 to start preliminary design work for the selected alternative.
- Schedules will not be affected by constrained or inadequate levels of funding.
- Construction schedules for new facilities assume maximum possible use of prefabrication of equipment and bulk commodity modules and ability to install those from above before floors and roofs are closed.
- Waste Isolation Pilot plant will be able to receive all TRU or TRU-mixed waste for each year, as well as the entire 50-year pit production operation.

3.2.3 Time Value of Money Assumptions

Assumptions are as follows:

- Base year for point estimates: FY 2018.
  - Prior year estimates, when used, have been escalated to this base period using appropriate rates or cost indices.
- Escalation Rates:
  - Capital costs, including all construction costs and other project costs: escalated 4% per year (compounded) applied to an expected spend plan to calculate the capital project TPC range for each alternative.
  - O&M costs and other operations costs: not escalated, as real rate present value (PV) is calculated.
  - End-of-life D&D costs: not escalated, as real rate PV is calculated.
- Discount Rate: 0.6% per year (OMB A-94 Real Rate [30 years])[5].

3.2.4 Alternative-Specific Estimate and Schedule Assumptions

This section discusses alternative specific assumptions used to develop the cost and schedule estimates for each alternative.

[5] This is the 2018 rate published in February 2018.

3.2.4.1 Alternative 1: Modify MFFF at SRS with Production Modules

Assumptions are as follows:

- Building sizes are as shown on EA drawings.
- MFFF clean-out work will be authorized by a CD-3A.
- The condition of specific rooms/spaces within the MFFF is approximately as documented in "DCS-DOE-005560 Phase 1 Response Extent of Condition Summary" and photos provided to the EA team.
- Necessary work to bring the WSB back to operational condition is as described in "SRNS-T8000-2014-00176, Waste Solidification (WSB) Reactivation Cost Analysis."
- No existing materials and bulk commodities now installed or available at MFFF will be reused for this alternative (this is discussed as a potential opportunity in the Risk Analysis Report Section).
- The cost estimate to provide a full analytical laboratory within MFFF has been factored from the cost to outfit the RLUOB at LANL, using historical costs made available to the EA team.
- PIDAS costs are estimated using the latest proposed MFFF layout developed by the EA team.
- No portion of the Aqueous Polishing Building (BAP) will be used, and the pit production project and mission will not be responsible for previously installed commodities or equipment therein.
- The project will seal off all penetrations greater than 96 in^2 between the Manufacturing Process Building (BMP) and BAP.
- No additional costs will be required to maintain the BAP.
- The WSB will be used to treat pit production liquid waste; it will have to be reactivated and brought back to operational condition, which will include replacing some equipment, and it will require startup and commissioning.
- New utility systems will be installed in the BMP to support the pit production mission.
- The estimate includes the cost for a mezzanine to be installed over the process areas on the second floor of the BMP.
- The Technical Support Building (BTS) will be modified to provide the needed entry control facility, as well as office and support space for the pit production mission.
- The LCCE includes the cost to D&D the portion of the MFFF used for pit production, as well as the WSB and the space used in the BTS.

3.2.4.2 Alternative 2a: Construct a Module at LANL – Production Facility Outside PF-4

Assumptions are as follows:

- Building sizes are as shown on EA drawings.
- Mechanical and Electrical Building (MEB) is a 7,500-ft^2, one-floor structure.

- Because pit production in the new process module will depend on having available analytical chemistry capabilities available in RLUOB, the current Chemistry and Metallurgy Research Replacement Facility (CMRR) project must be completed prior to CD-4 for this alternative.
- A second nitrate line will be added in PF-4 to support the added 50 ppy production.
- PIDAS length is as shown on EA drawings and includes a barrier wall along Pajarito Road, as shown in LANL plans.
- End-of-life D&D responsibilities for this program do not include full D&D of PF-4 but will return used space (Room 401) to clean condition.

3.2.4.3 Alternative 2b Construct a Module at LANL – Production Capacity Split w/PF-4

Assumptions are as follows:

- Building sizes are as shown on EA drawings.
- MEB is a 7,500-ft^2, one-floor structure. The Alternative 2b MEB is assumed to be the same size as the Alternative 2a MEB, and the system requirements and sizes must be evaluated and confirmed during conceptual design if this alternative is selected.
- The estimate includes an allowance to prepare spaces to be used in PF-4 by removing equipment and making any necessary reconfiguration, which are assumed to be minimal.
- Because pit production in the new process module will depend on having available analytical chemistry capabilities available in RLUOB, the current CMRR project will need to be completed prior to CD-4 for this alternative.
- A second nitrate line will be added in PF-4 to support the added 50 ppy production.
- PIDAS length is as shown on EA drawings and includes a barrier wall along Pajarito Road, as shown in LANL plans.
- End-of-life D&D responsibilities for this program do not include full D&D of PF-4 but will return used spaces to clean condition.

3.2.4.4 Alternative 2c Use PF-4 as Bridge Until Construction of Modules at LANL

Assumptions are as follows:

- Components included in the estimate are as provided by LANL and described as Option 1C. Facility sizes are as summarized on Drawing A-1001, sheet 3 of 3, dated 30 January 2018.
- The estimate includes an allowance to prepare spaces to be used in PF-4 by removing equipment and making any necessary reconfiguration. which are assumed to be minimal.
- No significant utility or process support equipment/system upgrades will be required in PF-4 to accommodate the new equipment to be added therein.
- Operations phase staffing includes the LANL proposal of double-shift staffing (with shift differentials included) from the time at which the PF-4 reconfiguration and equipment installations are complete and CD-4 is approved, through three years after CD-4 for the new

modules is approved during ramp-up of production in the new facilities. Two-shift operations are defined as two 10-hour shifts, four days per week. At that point, the staffing levels become single-shift and continue for a period such that the total of the PF-4 double shift operations and the new module operations totals 50 years. This is consistent with the total operational period considered for the other alternatives.

- The LCCE includes an estimate of incremental operations phase staffing to be needed during start-up and commissioning of the new modules and equipment.
- PIDAS length is as shown on EA drawings and includes a barrier wall along Pajarito Road, as shown in LANL plans.
- End-of-life D&D responsibilities for this program do not include full D&D of PF-4 but will return used spaces to clean condition.

3.2.5 Exclusions and Qualifications

3.2.5.1 Cost Estimate Exclusions

Assumptions are as follows:

- Costs associated with Design Agency certification of plutonium pit production facilities located at different sites are not included in the EA scope.
- Program management costs are assumed to remain the same for all alternatives being considered and are not included in the LCCE.
- Costs incurred for operation of existing site infrastructure needed and used to support the pit production mission are not captured in the LCCE. This includes the cost to operate the Waste Solidification Building for Alternative 1.
- The LCCE does not include any utility charges (electrical supply, water, etc.) that may be incurred during production operations.
- The costs to be incurred to produce 30 ppy at PF-4 are not included in the LCCE for any of the EA alternatives.
- The LCCE for Alternatives 2a, 2b, and 2c do not include any costs for PF-4 life extension or major upgrades over the remaining facility life. Only the major upgrades to the new equipment being installed for 50 ppy alternatives are captured in the LCCE.
- Transportation costs covered by Office of Secure Transportation (OST) (for shipments of pits into and out of sites) are not included in the cost estimates. These costs are assumed to fall within the ongoing budget for OST operations.
- Costs to prepare TRU waste shipments and to dispose of TRU waste at WIPP are not included in the LCCE for the EA alternatives.

3.2.5.2 Schedule Exclusions

Assumptions are as follows:

- Schedules include nominal durations to complete hot commissioning and transition to operations but do not capture activities to ramp up to 50 ppy production level.

3.2.5.3 Cost and Schedule Estimate Qualifications

LCCEs and schedules have been developed for each alternative identified for pit production. These ROM estimates are intended as a means of comparing relative costs of alternatives to support the decision-making process; they are not intended for budgeting purposes.

3.3 Project Cost Estimate Results

Table 3-7 shows the estimated total project cost (TPC) range for the capital projects needed for each alternative evaluated by the EA.

Table 3-7: Total Project Cost Ranges ($B)

Alternative 1 Modify MFFF at SRS with Production Modules	Alternative 2a Construct a Module at LANL – Production Facility Outside PF-4	Alternative 2b Construct a Module at LANL – Production Capacity Split w/PF-4	Alternative 2c Use PF-4 as a Bridge until Construction of Modules at LANL
$1.8 to $4.6	$2.1 to $5.2	$1.8 to $4.4	$2.3 to $5.8

As can be seen above, there is not much difference in the estimated cost of the initial capital projects for Alternatives 1, 2a, and 2b. Alternative 2c, however, is estimated to cost more in terms of capital investment. The above ranges represent a –20% to +100% range around the point estimates developed for each alternative, consistent with DOE guidance for a Class 5 estimate.

Tables 3-8 through 3-12 summarize the capital project point estimate results for each alternative. The estimates are further broken down and the bases of estimates are presented in Appendices E, F, G, and H, for Alternatives 1, 2a, 2b and 2c, respectively.

Table 3-8: Capital Project Cost Summary by Alternative (as-spent $M)

Cost Element	Alternative 1 Modify MFFF at SRS with Production Modules	Alternative 2a Construct a Module at LANL – Production Facility Outside PF-4	Alternative 2b Construct a Module at LANL – Production Capacity Split w/PF-4	Alternative 2c Use PF-4 as a Bridge Until Construction of Modules at LANL
Project Management/Support	263.4	308.6	272.6	360.2
Engineering/Design	252.0	320.9	284.7	318.7
Site Preparation/D&D	15.9	22.2	18.5	12.8
Equipment Procurement	258.4	214.4	179.6	118.5
Construction/Installation	563.9	841.1	686.3	962.5
Startup/Commissioning	194.9	206.6	169.9	275.7
Mgmt. Reserve/Contingency	589.4	472.5	405.2	654.6
Other Project Costs	157.1	191.2	173.5	215.0
Total Point Estimate	2294.8	2577.4	2190.3	2918.0

Table 3-9: Alternative 1 – Modify MFFF at SRS with Production Modules

WBS	Description	Estimate (FY18 $M)
1.1	MFFF Readiness/Modification	556.4
1.2	Pit Production Equipment/Installation	829.9
1.3	Analytical Laboratory Equipment/Systems	102.3
1.4	Technical Support Building Modifications	28.1
1.5	WSB Readiness/Reactivation	14.3
1.6	MFFF Security Upgrades (including PIDAS)	143.5
1.7	Other Project Costs	127.1
	Subtotal	1,801.6
	Escalation	493.2
	Point Estimate (as-spent $M)	2,294.8

Table 3-10: Alternative 2a – Construct a Module at LANL – Production Facility Outside PF-4 – Estimated Capital Cost

WBS	Description	Estimate (FY18 $M)
1.1	New Facility for Pit Production	1,036.6
1.2	Personnel Support Module	46.8
1.3	Pit Production Equipment/Installation	623.1
1.4	Support Facilities/Systems (incl. MEB)	95.4
1.5	TA-55 PIDAS Extension/Modification	24.0
1.6	Other Project Costs	158.4
	Subtotal	1,984.3
	Escalation	593.1
	Point Estimate (as-spent $M)	2,577.4

Table 3-11: Alternative 2b – Construct a Module at LANL – Production Capacity Split w/ PF-4 – Estimated Capital Cost

WBS	Description	Estimate (FY18 $M)
1.1	New Facility for Pit Production	904.3
1.2	Personnel Support Module	46.8
1.3	Pit Production Equipment/Installation	498.3
1.4	Support Facilities/Systems (incl. MEB)	92.0
1.5	PF-4 Modifications	29.6
1.6	TA-55 PIDAS Extension/Modification	24.0
1.7	Other Project Costs	145.8
	Subtotal	1,740.8
	Escalation	449.5
	Point Estimate (as-spent $M)	2,190.3

Table 3-12: Alternative 2c – Use PF-4 as a Bridge Until Construction of Modules at LANL – Estimated Capital Cost

WBS	Description	Estimate (FY18 $M)
1.1	PF-4 Additional Equipment	118.7
1.3	Laboratory Modules (3)	1,110.1
1.4	Radiography Bays (2)	134.7
1.5	Other TA-55 Construction/Additions	601.0
1.6	TA-55 PIDAS Extension/Modification	24.0
1.7	Other Project Costs	165.4
	Subtotal	2,153.9
	Escalation	764.1
	Point Estimate (as-spent $M)	2,918.0

For comparison to other known DOE/NNSA projects, it should be noted that the all-inclusive capital project cost, in FY 2018 dollars, is approximately $14,000 per square foot of facility size for Alternatives 2a and 2b, including the 50,000 ft^2 Personnel Support Module that represents conventional construction. The estimate for Alternative 2c represents a value of approximately $19,000 per square foot, reflecting the smaller modules, buried construction, and equipment to be installed in currently operating facilities. The Alternative 1 estimated cost is just over $7,000 per square foot because the structure being used already exists.

3.4 Project Schedule Results

Table 3-13 shows the estimated schedule range for the capital projects needed for each alternative evaluated by the EA. It is assumed that opportunities may be available for schedule acceleration and compression, and that, if no significant threats affect the schedule, each alternative can be completed in approximately 18 months earlier than currently scheduled. Conversely, if threats are realized and schedule cannot be optimized, the schedules may be 24 months longer than currently scheduled.

Table 3-13: Schedule Ranges (CD-4 Date)

Alternative 1 Modify MFFF at SRS with Production Modules	Alternative 2a Construct a Module at LANL – Production Facility Outside PF-4	Alternative 2b Construct a Module at LANL – Production Capacity Split w/PF-4	Alternative 2c Use PF-4 as a Bridge until Construction of Modules at LANL
Jul 2026 to Jan 2030	Apr 2028 to Oct 2031	Mar 2027 to Sep 2030	PF-4: Nov 2025 to May 2029 Modules: Jan 2032 to Jul 2035

It should be noted that a period of hot commissioning and transition to operations activities will follow CD-4 and must be completed successfully before full production levels can be achieved and maintained. Those activities also have inherent risks and uncertainties and a resultant duration range associated with them. That range has not been assessed and quantified by the EA team.

Table 3-14 presents the key milestone dates for each alternative, based on the schedules developed by the EA team. The full schedules for each alternative can be found in Appendices I, J, K, and L for Alternatives 1, 2a, 2b, and 2c, respectively.

Table 3-14: Alternative Milestones

Milestone	Alternative 1 Modify MFFF at SRS with Production Modules	Alternative 2a Construct a Module at LANL – Production Facility Outside PF-4	Alternative 2b Construct a Module at LANL – Production Capacity Split w/PF-4	Alternative 2c Use PF-4 as a Bridge until Construction of Modules at LANL
Start Conceptual Design	Oct 2018	Oct 2018	Oct 2018	Oct 2018
CD-1 Approval	Dec 2019	Dec 2019	Dec 2019	Dec 2019
CD-3A Approval	Feb 2021	Jul 2020	Jul 2020	Jul 2020
CD-2/3 Approval (nuclear facility)	Sep 2022	Sep 2023	Jul 2023	PF-4: Jan 2023 Modules: Aug 2023
Construction Completion*	Jul 2025	Jul 2027	Jul 2026	PF-4: Aug 2025 Modules: Jul 2030
CD-4 Approval	Jan 2028	Oct 2029	Sept 2028	PF-4: Nov 2027 Modules: Apr 2033

Startup, testing, and other commissioning activities are accomplished following construction completion and end with CD-4 approval to start operations. The approximate expenditure profile for each alternative was assessed by spreading estimated costs over the scheduled activities. The resultant profile, assuming the high end of the cost range, is shown in Table 3-15 and Figure 3-1.

Table 3-15: Alternative Expenditure Profiles (High End of Cost Range $M)

Fiscal Year	Alternative 1 Modify MFFF at SRS with Production Modules	Alternative 2a Construct a Module at LANL – Production Facility Outside PF-4	Alternative 2b Construct a Module at LANL – Production Capacity Split w/ PF-4	Alternative 2c Use PF-4 as a Bridge until Construction of Modules at LANL
2019	61	72	71	73
2020	239	254	254	225
2021	347	367	337	258
2022	495	480	449	335
2023	674	732	925	467
2024	656	739	669	348
2025	570	667	458	344
2026	480	587	482	303
2027	551	519	330	305
2028	490	370	406	353
2029	26	265	0	521
2030	0	101	0	569
2031	0	0	0	532
2032	0	0	0	586
2033	0	0	0	618
Total	4,590	5,155	4,381	5,836

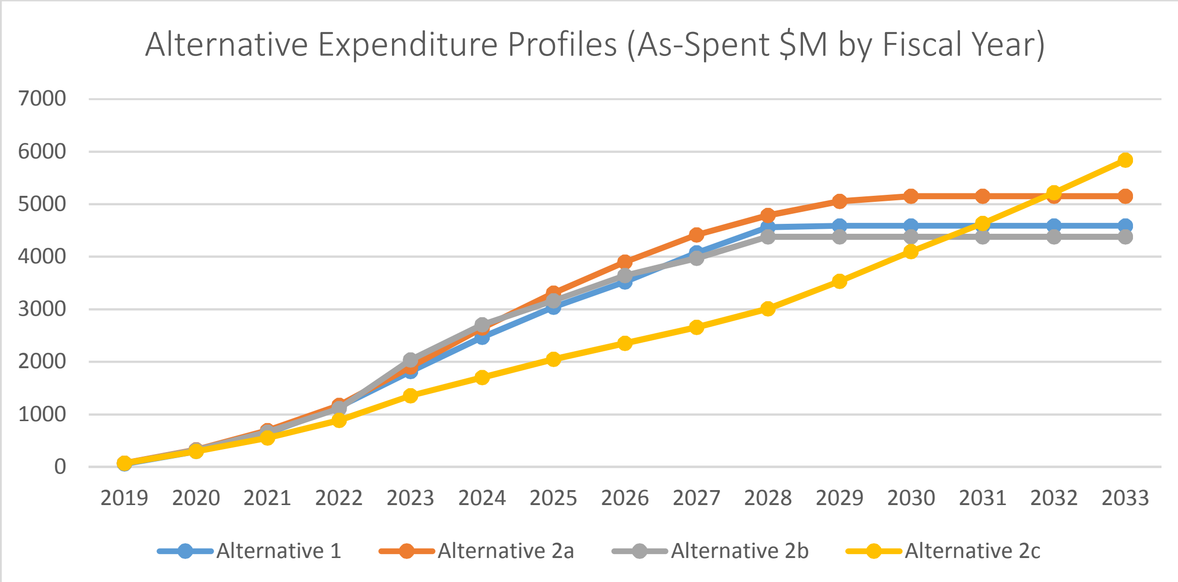

Figure 3-1: Alternative Expenditure Profiles (High End of Cost Range $M)

3.5 Life Cycle Cost Comparison

The PV of the LCCE was calculated for each alternative using the expected expenditures by year for the proposed capital projects, the estimated annual operations phase costs over a 50 -year operating life, and end-of-life D&D. Costs were not escalated, and the PV calculation used the OMB real discount rate as identified in Section 3.2.3. The LCCE does not include the full life cycle costs for 80 ppy production, but rather the incremental costs for adding 50 ppy production to a 30 ppy production operation at PF-4 at LANL.

The resultant LCCEs are summarized in Table 3-16.

Table 3-16: Present Value of Life Cycle Costs for Alternatives ($B)

Cost Element	Alternative 1 Modify MFFF at SRS with Production Modules	Alternative 2a Construct a Module at LANL – Production Facility Outside PF-4	Alternative 2b Construct a Module at LANL – Production Capacity Split w/ PF-4	Alternative 2c Use PF-4 as a Bridge until Construction of Modules at LANL
Capital Projects	1.74	1.93	1.68	1.94
Operations Costs	25.99	16.86	12.61	12.80
End-of-Life D&D	0.04	0.03	0.03	0.04
Total Life Cycle Cost	27.77	18.82	14.32	14.78

As shown above, the estimated PV LCC of Alternative 1 is considerably more than for the other three alternatives. This is due to the need for a full level of staffing for the pit production operations at SRS using MFFF, as compared to the lesser incremental staffing that would need to be added to accomplish the added 50 ppy production at LANL for the other alternatives.

3.6 Sensitivity Analysis

This section describes the potential impact if key assumptions or estimate variables are adjusted. Because most variations in assumptions and estimate bases are accommodated by the Class 5 estimate ranges that have been assumed (–20% to +100%), only one sensitivity was assessed.

- Cost Differential by Site: The base estimates have not assumed any difference between craft or operations staff labor rates (base rates, overhead and other burdens, etc.) between the SRS and LANL sites. If the labor analysis effort (now under way by others) finds that a difference that must be considered, alternative comparisons would vary as follows:
  - If LANL costs are higher than SRS costs, the estimated TPCs for Alternatives 2a, 2b, and 2c would increase. Approximately 50% of the estimated costs represent labor that would be impacted by differential rates or burdens.
  - TPC ranking of alternatives would only change in the case of higher costs (labor rates, burdens) being expected at SRS than at LANL. Only if SRS rates are 10% higher does Alternative 1 cost become slightly more than the estimated cost for Alternative 2b, and it is still lower than the estimated cost for Alternative 2a.
  - The impact on life-cycle cost (LCC) PV is similar to that experienced for TPC if labor rates are different for each site. Approximately 70% of the LCC represents labor costs, so higher LANL rates will increase the LCC PV for Alternatives 2a, 2b and 2c, thus making the PV LCC for Alternative 1 at SRS the lowest.
  - Due to the higher staffing numbers used for the SRS option, the PV LCC for Alternative 1 will be higher than the PV LCC for Alternatives 2a, 2b, and 2c unless the costs at LANL are approximately 70% higher than those for SRS, in which case Alternative 2a becomes a higher cost alternative. Only if the LANL costs are approximately 125% higher than SRS do the LCCs for Alternatives 2b and 2c become higher than for Alternative 1.

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4 Qualitative Risk Analysis

This section is prepared as a tailored and preliminary qualitative risk analysis (QRA) for the four alternatives. This section is organized to address the following topics:

- Section 4.1 introduces the risk analysis, along with the risk analysis methodology.
- Section 4.2 provides the description and the results of the risk analysis workshop and subsequent conferences, comments and resolutions, and additional discussions.
- Section 4.3 discusses the major risks that discriminate between the alternatives.
- Section 4.4 provides the overall comparative risks of the alternatives and the risk analysis conclusions, including a narrative assessment of the additional risk implications of double-shift operations.
- Appendix 0provides the detailed risk register with all results, and the Risk Analysis Rationale developed during the risk analysis workshop.

The overall conclusions of the qualitative risk analysis are listed below:

- All alternatives considered are viable from a risk perspective, with only a few high and multiple moderate residual threats remaining after reasonable mitigations.
- Alternative 1, Modify MFFF at SRS with Production Modules, is considered to have a low risk level and has the least residual threats of the alternatives after reasonable mitigations.
- Alternative 2a, Construct a Module at LANL – Production Facility Outside PF-4, is considered to have a low to moderate risk level and has the second-lowest residual threats of the alternatives after reasonable mitigations.
- Alternative 2b, Construct a Module at LANL – Production Capacity Split with PF-4, is considered to have a low to moderate risk level and has the third lowest residual threats of the alternatives after reasonable mitigations.
- Alternative 2c, Use PF-4 as a Bridge by FY 2030 Until Construction of Modules at LANL, is considered to have a moderate risk level and has the highest residual threats of the alternatives after reasonable mitigation.

Figure 4-1 shows a graphical comparison of the residual risks and opportunities of the alternatives.

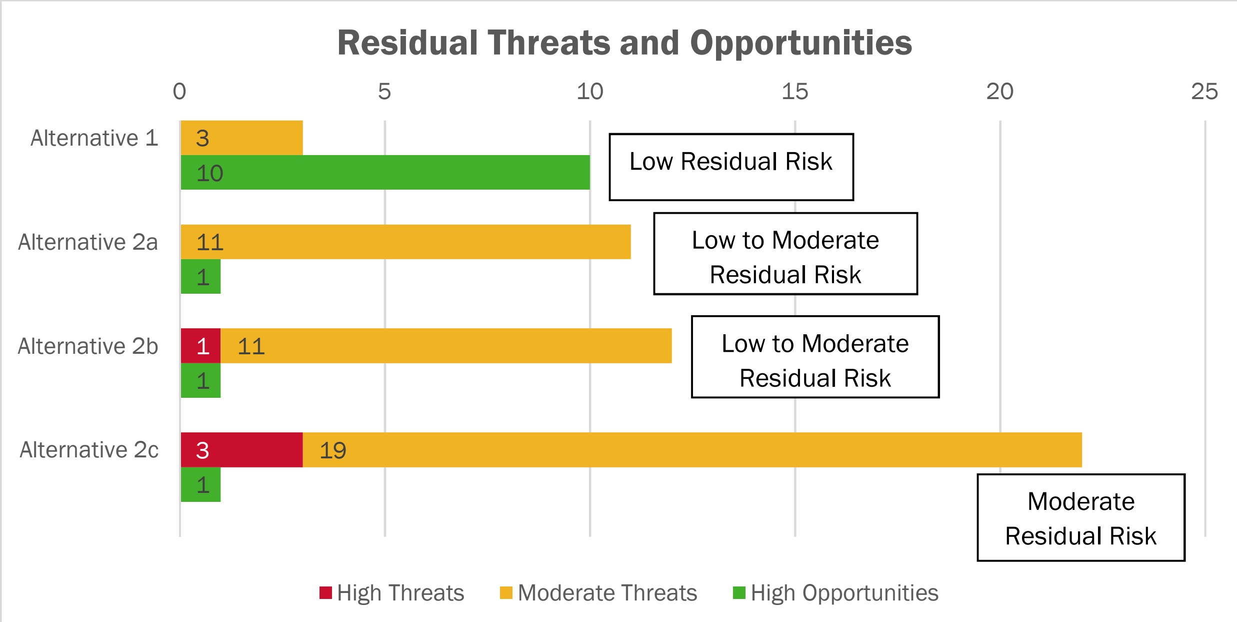

Figure 4-1: Alternative Qualitative Risk Comparison

4.1 Introduction

The purpose of the EA qualitative risk analysis was to identify and evaluate threats and opportunities applicable to each of the following four alternatives:

- **Alternative 1:** Modify the Mixed Oxide Fuel Fabrication Facility (MFFF) at SRS with Production Modules.
- **Alternative 2a:** Construct a Module at LANL – Production Facility Outside PF-4.
- **Alternative 2b:** Construct a Module at LANL – Production Capacity Split with PF-4.
- **Alternative 2c:** Use PF-4 as a Bridge by FY 2030 Until Construction of Modules at LANL.

4.1.1 Risk Analysis Process

The qualitative EA risk analysis process follows the requirements of DOE Order (O) 413.3B, “Program and Project Management for the Acquisition of Capital Assets,” and the nonmandatory recommendations provided by DOE Guide (G) 413.3-7A, “Risk Management Guide.” A workshop was established to brainstorm and characterize threats and opportunities for the alternatives, with a focus on the risks that discriminate between the alternatives. Many of the identified threats are similar for all the alternatives, and the risk levels for those threats are important for bounding the margins that should be included in cost and schedule ranges, but they do not discriminate between the alternatives.

The workshop reached consensus to use three levels of risk rather than the five levels that have been considered for other projects, because the development of the alternatives is preconceptual and further risk refinement is not warranted at this stage of project definition. A qualitative assessment of the likelihood (probability) of the threats coupled with the potential impacts (consequences) leads to the assessed risk level of high, moderate, or low, as shown in Table 4-1.

Similarly, a qualitative assessment of the likelihood (probability) of the opportunity coupled with the potential impacts (consequences) leads to the assessed opportunity level: high, moderate, or low, as shown in Table 4-2.

Table 4-1: Qualitative Threat Risk Evaluation Matrix

Cost/Schedule Consequence		Negligible	Marginal	Significant	Critical	Crisis
Cost		Minimal or no consequence to project objectives, negligible impact to project cost.	Small decrease in meeting project objectives, marginally increases costs.	Significant degradation in meeting objectives or significantly increases project costs.	Project objectives are not achievable, additional funding is required, 10% – 20% negative cost impact.	Project stopped, funding withdrawn, or severe contractor cost performance issues.
Schedule		Minimal or no consequence to project objectives, negligible impact to project schedule.	Small decrease in meeting project objectives, marginally increases project schedule.	Significant degradation in meeting objectives or significantly increases project schedule.	Project objectives are not achievable, additional time is required, 10% - 20% negative schedule impact.	Project stopped, scope withdrawn, greater than 20% negative schedule impact.
Probability	Very High: > 90%	Low	Moderate	High	High	High
	High: 75% – 90%	Low	Moderate	Moderate	High	High
	Moderate: 26% – 74%	Low	Low	Moderate	Moderate	High
	Low: 10% – 25%	Low	Low	Low	Moderate	Moderate
	Very Low < 10%	Low	Low	Low	Low	Moderate

Threats and opportunities were characterized as follows:

- **Program Risk:** A threat or opportunity that is governed by conditions outside the project and cannot be managed within the project funding.
- **Project Risk:** A threat or opportunity that is within the project baseline but is generally beyond the control of the executing contractor.
- **Execution Risk:** A threat or opportunity that generally falls within the control and contractual responsibility of the execution contractor.

Table 4-2: Qualitative Opportunity Risk Evaluation Matrix

Cost/Schedule Consequence		Negligible	Marginal	Significant	Efficient	Optimal
Cost		Minimal or no consequence to project objectives, negligible impact to project cost.	Small increase in meeting project objectives, marginally increases costs.	Significant improvement in meeting objectives or significantly reduces costs.	10% – 20% positive cost impact while meeting project objectives.	Greater than 20% positive cost impact while meeting project objectives.
Schedule		Minimal or no consequence to project objectives, negligible impact to project schedule.	Small increase in meeting project objectives, marginally improves project schedule.	Significant improvement in meeting objectives or significantly improves project schedule.	10% - 20% positive schedule impact while meeting project objectives.	Greater than 20% positive schedule impact while meeting project objectives.
Probability	Very High: > 90%	Low	Moderate	High	High	High
	High: 75% – 90%	Low	Moderate	Moderate	High	High
	Moderate: 26% – 74%	Low	Low	Moderate	Moderate	High
	Low: 10% – 25%	Low	Low	Low	Moderate	Moderate
	Very Low < 10%	Low	Low	Low	Low	Moderate

Potential mitigation strategies were identified on a preliminary basis for threats with High and Moderate risk levels (as appropriate), along with the impact of those strategies on the risk level. Threats with High risk levels should have a reasonable mitigation strategy that reduces the risk level to at least Moderate. Where the risk levels differ among alternatives, those risks were noted as *discriminators*. The discriminators are highlighted in the EA and in this QRA. Following the workshop, additional conferences, comments and resolutions, and subsequent discussions helped to refine the risks and to identify several additional threats and opportunities for inclusion in this risk analysis.

4.1.2 Risk Analysis Team

The EA Risk Analysis Team consisted of DOE/NNSA, Laboratory, and ECMS subject matter experts (SMEs) in Pu pit production, project management, construction, procurement, startup, risks, scheduling, and costs associated with large complex and nuclear projects.

4.1.3 Report Organization

Section 4 is organized to address the following topics:

- Section 4.2 provides the description and the results of the risk analysis workshop and subsequent conferences, comments and resolutions, and additional discussions.
- Section 4.3 discusses the major risks and opportunities that discriminate among the alternatives.

- Section 4.4 provides the overall comparative risks of the alternatives and the risk analysis conclusions, including a narrative assessment of the additional risk implications of double-shift operations.
- Appendix M provides the detailed risk register with all results and the risk analysis rationale developed during the risk analysis workshop.

4.1.4 Limitations

Within the time available, the EA Team has made all reasonable efforts to develop and obtain data deemed necessary for a preconceptual risk analysis of the preferred alternatives. The risk analysis compiled in section 4 are the result of the best effort of the ECMS Team in conjunction with NNSA and designated SMEs.

4.2 Risk Analysis Workshop

A preliminary set of risks for the alternatives was developed in advance to stimulate brainstorming and discussion (some risks do not apply to all alternatives, and qualitative risk levels may vary among alternatives). These preliminary risks were categorized as program risks, project risks, or execution risks as defined in Section 4.1. The alternatives are further defined elsewhere in the EA; for the risk analysis, they are identified as follows:

- Alternative 1: Modify MFFF at SRS with Production Modules
- Alternative 2a: Construct a Module at LANL – Production Facility Outside PF-4
- Alternative 2b: Construct a Module at LANL – Production Capacity Split with PF-4
- Alternative 2c: Use PF-4 as a Bridge by FY 2030 Until Construction of Modules at LANL

The discussions considered each preliminary risk topic and discussed the risk implications for each alternative. Additional risks were also identified during the discussion and subsequent conferences, comments and resolutions, and discussions. The results are detailed in the risk register and the workshop risk analysis rationale, both of which are included in Appendix M. Section 4.3 discusses the major risks that discriminate between the alternatives. The overall comparative risks of the alternatives and the conclusions of the qualitative risk analysis are presented in Section 4.4.

Threats with a high-risk level should have a reasonable mitigation strategy (when available) to reduce the risk to at least moderate. Threats with a moderate risk level may have a reasonable mitigation strategy to reduce the risk, or the risk may be accepted as routine for the engineering and construction industry and/or for nuclear operations.

Before the workshop, 24 initial threats were identified, along with four initial opportunities. Additional threats and opportunities beyond the preliminary set of risks were also identified and discussed during the workshop. After the workshop, additional conferences, comments and resolutions, and subsequent discussions helped to refine the risks and to identify several additional threats and opportunities for inclusion in this risk analysis. Some threats were identified as "not to be evaluated" as a part of the risk analysis. The threats and opportunities discussed, along with a summary of the rationale and the risk analysiss, and the reasonable mitigation strategies are identified in the following subsections.

4.2.1 Common Threats and Opportunities for All Alternatives

4.2.1.1 Threats

The following threats that are common for all alternatives were reviewed and discussed, with an emphasis on understanding any discriminators between the alternatives:

- **National Environmental Policy Act (NEPA) compliance is delayed.** The risk level was assessed to be low for Alternative 1 because only a NEPA review is required. The risk level was assessed to be moderate and nearly the same for all other alternatives. However, the impact for Alternative 2c during the double-shift interim operations of PF-4 has a very low likelihood of occurrence (due to current NEPA approval and prior evaluations for up to 120 ppy), but a higher consequence of affecting the ongoing Pu pit development, surveillance, and other Pu programs in PF-4. Early pursuit of NEPA approvals would reduce the likelihood of this threat and would reduce the risk level to low in all cases.
- **Pit production capacity cannot be realized due to conveyance system issues.** The likelihood was assessed to be higher for Alternatives 2b and 2c due to extended use of the existing trolley. The consequence was high for Alternative 2c due to significant increase in operational use with double-shift operations, resulting in a moderate risk level. LANL noted that upgrade projects are planned for the existing trolley systems, reducing the risk level to low in all cases.
- **Assumptions about the scope and scale with existing facilities (PF-4, MFFF) are not realized.** The likelihood was similar for the existing facilities, but the consequence for Alternative 1 was higher due to the uncertainty of information, resulting in a moderate risk level. A reasonable mitigation strategy for that alternative would include an early detailed engineering study and characterization of the existing facility, reducing the likelihood to a low risk level.
- Site infrastructure (outside the perimeter intrusion detection and assessment system [PIDAS]) capacity does not support pit production throughput. The likelihood and consequences were similar for all alternatives, with an assessed low risk level.
- **Process and personnel support capabilities (inside PIDAS) do not support pit production throughput.** The risk level was assessed to be similar for most alternatives; however, Alternative 2c was considered to have a higher likelihood and a higher consequence of impact due to double-shift interim operations with existing systems, resulting in a moderate risk level. A reasonable mitigation strategy for that alternative was deemed unavailable.
- **Availability and cost of craft labor for construction.** The likelihood and consequence were similar for all alternatives, with an assessed low risk level.
- **Increased complexity and inefficiency for the movement of nuclear materials in and between facilities.** The risk level was assessed to be similar for most alternatives; however, Alternative 2c

was considered to have a higher likelihood and a critical consequence due to double-shift operations with existing systems, resulting in a high-risk level. This threat must be mitigated by increased focus during design to ensure simplified and efficient operations. That strategy would reduce the consequence to significant and would reduce the risk level to moderate.

- **Site operations or other facility operations disrupt pit production.** The likelihood and consequence were similar for all alternatives, with a low risk level.
- **Excessive vibration for critical equipment (e.g., lathe) impacts pit production.** The risk level was similar for most alternatives; however, Alternative 1 has an increased likelihood due to the current lack of a vibration study for the existing facility, resulting in a moderate risk level. A reasonable mitigation strategy for that alternative would be early completion of an engineering vibration study, resulting in a lower likelihood and a low risk level.
- **Availability of skilled production personnel.** This threat was not assessed but poses a risk for all alternatives. The risk may be more significant for Alternative 1 resulting from operation two pit production facilities concurrently. The availability and risk of skilled personnel will be addressed in a separate labor study (to be completed by others).
- **Availability of capacity or certification for Waste Isolation Pilot Plant (WIPP) affects production.** The likelihood is the same for all alternatives, but the consequence was assessed to be lower for Alternative 1 due to a larger interim storage capacity, resulting in a low risk level versus a moderate risk level for other alternatives. A reasonable mitigation strategy for those alternatives was deemed unavailable.
- **Training of personnel for 50 ppy mission affects 30 ppy mission at PF-4.** This threat was not assessed. The training requirements and risk will be addressed by a separate labor study (to be completed by others).
- **Construction records and as-built drawings are incomplete for existing facilities.** The risk level was similar for most alternatives; however, because MFFF is under construction, some records are more mature than others. The MFFF geotechnical and concrete structural data are the most mature and have no major documented Nuclear Regulatory Commission (NRC) or DOE quality issues, so little risk is associated with the as-built condition and record status for the concrete structure. MFFF purchased equipment and materials that have been received and accepted by the project have a similarly low risk profile. However, Alternative 1 construction records associated with mostly incomplete work such as process facility supports, mechanical, electrical, miscellaneous structural steel (stairways/platforms), and instrumentation and controls have incomplete records, resulting in a high-risk level. A reasonable mitigation would be an early and detailed engineering evaluation and walk-down of the facilities to update the as-built drawings and to reduce both the likelihood and the consequence, which would result in a moderate risk level, depending upon the potential use of the MFFF and installed mechanical, electrical, and structural components and materials.
- **Technical Baseline and Design Code of Record for existing facilities are inadequate.** The risk level is low for Alternatives 2a, 2b, and 2c; however, Alternative 1 has higher likelihood and

consequence due to the NRC baseline versus DOE/NNSA baseline, resulting in a moderate risk level. A reasonable mitigation strategy for that alternative would be an early and detailed engineering review of the Technical Baseline and Code of Record to identify and implement corrective actions. That strategy would reduce both the likelihood and the consequence, resulting in a low risk level.

- Dispersed production areas and equipment layout results in more complex logistics and operating costs. The likelihood and consequence were similar for all alternatives, with a low risk level.
- **Facility configuration results in increased safety and security requirements and associated life cycle costs.** The risk level is low for Alternatives 2a, 2b, and 2c; however, Alternative 1 has higher likelihood and consequence due to the size of the facility and the location of equipment in separate rooms, resulting in a moderate risk level. A reasonable mitigation strategy for that alternative was deemed unavailable.
- **Implementation of the alternative does not meet the 2030 objective for 80 ppy.** The EA developed pre-CD-1 schedules for the alternatives. CD-4 dates for each alternative are as follows:
  - Alternative 1: January 2028
  - Alternative 2a: October 2029
  - Alternative 2b: September 2028
  - Alternative 2c: August 2027
- The CD-4 date is availability of plutonium operations and excludes the ramp up period to achieve production rate. The risk level is moderate for all four alternatives with a slightly lower likelihood for Alternative 2c.
- **Availability or personnel for criticality studies impacts planned project costs and schedules.** The risk level is low for Alternatives 2a, 2b, and 2c; however, Alternative 1 has higher likelihood due to the necessary development of additional resources at SRS, resulting in a moderate risk level. A reasonable mitigation strategy for that alternative would include early recruiting, training, and retention incentives for qualified plutonium criticality analyst personnel, reducing the likelihood to a low risk level.
- **Potential requirement for computed tomography (CT) inspection of partial and completed products.** The likelihood of this threat is the same for all alternatives, but the consequence is lower for Alternative 1 due to excess available space. The new requirement would be implemented through a new project or a project change. Reasonable mitigation of this threat for the LANL alternatives was deemed unavailable.
- **Potential requirement for new process technology is identified.** The risk level is low for most alternatives, but the higher consequence for Alternative 2c results in a moderate risk level due to the constraints of the existing PF-4. The new requirement would be implemented through a new project or a project change, resulting in a low risk level for all alternatives.

- **Additional engineering controls based on the Safety Design Strategy and the Conceptual Design Safety Report.** This threat results in a low risk level except for Alternative 2c, which has a higher likelihood and consequence due to a higher source in PF-4 and proximity to the site boundary. A reasonable mitigation for this threat was deemed unavailable.
- **Unplanned active Safety Class controls are required by the Safety Basis Approval Authority.** This threat results in a low risk level for Alternatives 1 and 2a, where active Safety Class controls are planned. Plans are in place for PF-4 to address the two bounding accidents that have significant unmitigated off-site consequences, i.e., are operational and post-seismic fires. Because these plans are not complete, the risk level is moderate for Alternative 2b; and Safety Class controls are not planned for Alternative 2c, resulting in a high-risk level. Some reconfiguration PF-4 or a waiver by the Safety Basis Approval Authority would be required for Alternative 2b. Significant reconfiguration of PF-4 or a waiver by the Safety Basis Approval Authority would be required for Alternative 2c. Reasonable mitigation strategies for the current state of these alternatives were deemed unavailable.
- **Post-assembly high-energy radiography is not performed at the 50 ppy facility,** which could result in returned parts for rework, thus affecting the pit production rate. The risk level is low for most alternatives with planned radiography capabilities in new facilities, but Alternative 2c would have a high likelihood due to double-shift operations prior to the new facilities because radiography would only be available at Pantex. A reasonable mitigation for this risk was deemed unavailable.

4.2.1.2 Opportunities

The following opportunities that are common for all alternatives were reviewed and discussed, with an emphasis on understanding any discriminators between the alternatives:

- **Existing infrastructure and analytical facilities can be leveraged to minimize capital costs and schedule.** The opportunity level is high for Alternatives 2a, 2b, and 2c; however, Alternative 1 has less opportunity based on the use of only the existing buildings for analytical facilities, resulting in a moderate opportunity level.
- **Off-site consequences can be minimized by production sites located further from site boundaries, reducing Safety Class equipment.** The opportunity level is high for Alternative 1 due to increased distance to the site boundary; the other alternatives were considered to have a lesser opportunity due to proximity to the site boundary, resulting in a moderate opportunity level.
- **Shared infrastructure and site resources could minimize overall costs.** The opportunity level was assessed to be high for all alternatives.
- **Potential requirement for new technology is identified to improve process operations.** The opportunity level is moderate for Alternatives 2a, 2b, and 2c, but high for Alternative 1 due to additional available facility space.

4.2.2 Common Threats Not Evaluated

The Pu pit production Risk Analysis team identified several common threats that that were not separately evaluated because the team consensus was that there would be no real, measurable, or discernable difference between each of the four Pu pit production alternatives. The following common threats were identified but not evaluated:

- Site fire or natural phenomena (storm, earthquake, flood, tornado) disrupts production
- Funding constraints
- Delay in CD Strategy or Critical Decisions
- Changes in codes of record, orders, standards, or safety requirements
- Co-location of design agency and production agency affects the focus on production
- Over-the-road transportation puts material at risk
- The Pu pit production equipment model has not been fully validated due to limited history in current operations

4.2.3 Specific Threats and Opportunities for Alternative 1

4.2.3.1 Threats

The following threats specific to Alternative 1 were reviewed and discussed:

- **MFFF ongoing construction leads to increased costs for modifications or facility retrofit.** This threat was assessed to have a high likelihood of occurrence until Congressional halt and/or contract direction, and a significant consequence, resulting in a moderate risk level. A reasonable mitigation strategy was deemed unavailable.
- **Failure to obtain Congressional support to terminate the MOX project and contract.** Although originally discussed as a threat to Alternative 1, it was determined that the EA would assume that Congress acts to terminate the MOX project and contract; therefore, this is not a threat for the purpose of the EA.
- **Difficulties closing out the MOX project and contract result in schedule delays.** This threat was assessed to have a moderate likelihood of occurrence and a critical consequence, resulting in a moderate risk level. A reasonable mitigation strategy was deemed unavailable.
- **Siting pit production in a high humidity environment affects product quality.** This threat was assessed to have a low likelihood of occurrence and a crisis consequence because the impact could preclude product qualification, resulting in a moderate risk level. A reasonable mitigation strategy would be to pursue early testing in a high-humidity environment, reducing the likelihood and the consequence to installation of environmental controls as needed, and resulting in a low risk level.
- **Two production entities increase certification, qualification, and surveillance of product quality.** This threat was assessed to have a very high likelihood of occurrence because duplicate

functions would be required at both sites, with a significant consequence, resulting in a high-risk level. A reasonable mitigation strategy would include early recruiting, training, and retention incentives for qualified certification, qualification, and surveillance personnel, resulting in reduced likelihood and a low risk level.

4.2.3.2 Opportunities

The following opportunities specific to Alternative 1 were reviewed and discussed:

- **Some work required for pit production at MFFF can be completed as part of MFFF closeout.** This opportunity was assessed to have a high likelihood of occurrence for early start on some construction activities, and a significant consequence resulting in a moderate opportunity level. A reasonable implementation strategy would include early identification of activities that could be completed during MFFF closeout to advance the project.
- **Analytical capabilities will be located in existing Hazard Category 2, Security Category 1 space.** This opportunity was assessed to have a high likelihood of occurrence and a significant consequence resulting in a moderate opportunity level. An implementation strategy was determined to not be required.
- **Improve operational efficiency using lessons learned and best practices with SMEs from separate sites.** This opportunity was assessed to have a high likelihood of occurrence and an efficient consequence with shared experiences for continuous improvements, resulting in a high opportunity level. An implementation strategy could include early establishment of an SME working group to share lessons and best practices.
- **Separate sites each with production capabilities can ensure continuing mission support.** This opportunity was assessed to have a high likelihood of occurrence with an optimal consequence resulting in a high opportunity level. An implementation strategy was determined to not be required.
- **Additional Hazard Category 2 space is available to support other NNSA programs.** This opportunity was assessed to have a high likelihood and an optimal consequence, resulting in a high opportunity level. An implementation strategy was determined to not be required.
- **Opportunity to make use of purchased and stored commodities from the MOX project.** This opportunity was assessed to have a high likelihood and an efficient consequence, resulting in a high opportunity level. More than $800 million of equipment and commodities are currently available. An implementation strategy could include detailed assessment of stored equipment and commodities during design.
- **Remove walls for construction and operations.** This opportunity was assessed to have a high likelihood and an efficient consequence, resulting is a high opportunity level. The opportunity has the potential to improve constructability and operational efficiency.
- **The BMP would not have to be safety class due to distance from the site boundary.** This opportunity was assessed to have a high likelihood and an efficient consequence, resulting is a

high opportunity level. The dose consequences to the public dictate the need for SC controls. The dose consequences to the public are directly related to the distance to the off-site boundary. The distance from MOX to the site boundary is approximately 7 miles.

- **Potential to use F/H analytical laboratory.** This opportunity was assessed to have a moderate likelihood and a significant consequence for an overall moderate opportunity. This opportunity may reduce overall construction costs

4.2.4 Specific Threats and Opportunities for Alternative 2a

4.2.4.1 Threats

The following threats specific to Alternative 2a were reviewed and discussed:

- **Inadequate parking for the increased production workforce.** This is a known issue for the constrained site, with a high likelihood of occurrence and a significant consequence, resulting in a moderate risk level. A reasonable mitigation strategy was deemed unavailable.
- **Inadequate local warehousing, laydown areas, and/or working space to support fabrication for construction.** This is a known issue for the constrained site, with a high likelihood of occurrence and a significant consequence, resulting in a moderate risk level. A reasonable mitigation strategy was deemed unavailable.
- **Inadequate office/training space to support operations.** This is a known issue for the constrained site, with a high likelihood of occurrence and a significant consequence, resulting in a moderate risk level. A reasonable mitigation strategy was deemed unavailable.
- **Implementation of 50 ppy mission disrupts 30 ppy mission at PF-4.** The reconfiguration required within PF-4 for this alternative were assessed to have a low likelihood of occurrence but a critical consequence, resulting in a moderate risk level. A reasonable mitigation strategy was deemed unavailable.
- **Increased 400-g material at risk (MAR) limit at RLUOB is not approved, creating need for alternate analytical chemistry and material characterization facilities.** This threat was assessed to have a low likelihood of occurrence but a critical consequence, resulting in a moderate risk level. A reasonable mitigation strategy was deemed unavailable.
- **Unexpected underground site conditions.** This threat was assessed to have a low likelihood of occurrence within the existing TA boundary, and a significant consequence, resulting in a low risk level.
- **Facility upgrades are needed to extend the operational life of PF-4 to 50 years.** This threat was assessed to have a high likelihood and a significant consequence, resulting in a moderate risk level. New projects will be needed for future life extension of PF-4. A reasonable mitigation strategy was deemed unavailable.
- **PF-4 has potential vulnerability to seismic risks.** This threat was assessed to have a high likelihood and a significant consequence, resulting in a moderate risk level. A reasonable

mitigation strategy would be to identify and include upgrade requirements during the design phase and prior to CD-2/3, but the residual risk level is moderate.

- **Limited operational flexibility for future expansion to accommodate increases in mission requirements.** This threat was assessed to have a moderate likelihood, and a marginal consequence, resulting in a low risk level.
- **Operational, safety, or equipment failures result in shutdown of PF-4, which affects its ability to meet the mission.** This threat was assessed to have a high likelihood and a significant consequence, resulting in a moderate risk level. Life cycle planning for PF-4 should include additional maintenance, repair, and replacement to maintain production rates. For this alternative, PF-4 represents a single point failure for aqueous operations needed for the 50 ppy mission, resulting in extended liquid waste storage. The residual risk level was assessed to be moderate.
- **Construction/equipment installation disrupts ongoing site or facility operations.** This threat was assessed to result in a low risk level.
- **Ongoing site or facility operations disrupts construction/equipment installation.** This threat was assessed to have a low risk level.
- **Construction of new 50 ppy facilities at LANL and tunnel connection to PF-4 could affect high-energy radiography for plutonium operations at PF-4.** This threat was assessed to have a high likelihood and a significant consequence, resulting in a moderate risk level. Mitigation may include evaluation of construction sequence and methods to minimize impact and verify capacity and obtain authorization to use radiography at Pantex during construction, but the threat continued to have an assessed moderate risk level.

4.2.4.2 Opportunities

The following opportunity specific to Alternative 2a was reviewed and discussed:

- **Separate facilities (within a site) each with production capabilities can ensure continuing mission support.** This opportunity was assessed to have a very high likelihood with dual production capacity, with an efficient consequence to result in a high opportunity level. An implementation strategy was determined to not be required for this opportunity.
- **The NEPA process can be shortened.** The scheduled duration for NEPA can be reduced by leveraging current LANL NEPA actions and conducting NEPA determination in parallel with construction work.

4.2.5 Specific Threats and Opportunities for Alternative 2b

4.2.5.1 Threats

The following threats specific to Alternative 2b were reviewed and discussed:

- **Inadequate parking for the increased production workforce.** This is a known issue for the constrained site, with a high likelihood of occurrence and a significant consequence, resulting in a moderate risk level. A reasonable mitigation strategy was deemed unavailable.
- **Inadequate local warehousing, laydown areas, and/or working space to support fabrication for construction.** This is a known issue for the constrained site, with a high likelihood of occurrence and a significant consequence, resulting in a moderate risk level. A reasonable mitigation strategy was deemed unavailable.
- **Inadequate office/training space to support operations.** This is a known issue for the constrained site, with a high likelihood of occurrence and a significant consequence, resulting in a moderate risk level. A reasonable mitigation strategy was deemed unavailable.
- **Implementation of 50 ppy mission disrupts 30 ppy mission at PF-4.** The reconfiguration required within PF-4 for this alternative were assessed to have a high likelihood of occurrence and a critical consequence, resulting in a high-risk level. A reasonable mitigation strategy for the required reconfiguration within PF-4 would include an early engineering assessment to minimize the impacts, resulting in a moderate risk level.
- **Increased 400-g MAR limit at RLUOB is not approved, creating need for alternate analytical chemistry and material characterization facilities.** This threat was assessed to have a low likelihood of occurrence but a critical consequence, resulting in a moderate risk level. A reasonable mitigation strategy was deemed unavailable.
- **Unexpected underground site conditions.** This threat was assessed to have a low likelihood of occurrence within the existing TA boundary, and a significant consequence, resulting in a low risk level.
- **Facility upgrades are needed to extend the operational life of PF-4 to 50 years.** This threat was assessed to have a high likelihood and a significant consequence, resulting in a moderate risk level. New projects will be needed for future life extension of PF-4. A reasonable mitigation strategy was deemed unavailable.
- **PF-4 has potential vulnerability to seismic risks.** This threat was assessed to have a high likelihood and a significant consequence, resulting in a moderate risk level. A reasonable mitigation strategy would be to identify and include upgrade requirements during the design phase and prior to CD-2/3, but the residual risk level is moderate.
- **Limited operational flexibility for future expansion to accommodate increases in mission requirements.** This threat was assessed to have a moderate likelihood, and a significant consequence, resulting in a moderate risk level. The new facility provides some operational flexibility, resulting in a low residual risk level.
- **Operational, safety, or equipment failures result in shutdown of PF-4 that affects its ability to meet the mission.** This threat was assessed to have a high likelihood and a critical consequence, resulting in a high-risk level. Life cycle planning for PF-4 should include additional maintenance, repair, and replacement to maintain production rates. But for this alternative PF-4 represents a

single point failure needed for the 50 ppy mission. The residual risk level was assessed to be high.

- **Construction/equipment installation disrupts ongoing site or facility operations.** This threat was assessed to result in a low risk level.
- **Ongoing site or facility operations disrupts construction/equipment installation.** This threat was assessed to have a high likelihood and a significant consequence, resulting in a moderate risk level. A reasonable mitigation strategy was deemed unavailable.
- **Construction of new 50 ppy facilities at LANL and tunnel connection to PF-4 could affect high-energy radiography for plutonium operations at PF-4.** This threat was assessed to have a high likelihood and a significant consequence, resulting in a moderate risk level. Mitigation may include evaluation of construction sequence and methods to minimize impact and verify capacity and obtain authorization to use radiography at Pantex during construction, but the threat continued to have an assessed moderate risk level.

4.2.5.2 Opportunities

The following opportunity specific to Alternative 2b was reviewed and discussed:

- **Separate facilities (within a site) each with production capabilities can ensure continuing mission support.** This opportunity was assessed to have a very high likelihood with significant redundancy for production capacity, with an efficient consequence to result in a high opportunity level. An implementation strategy was determined to not be required.
- **The NEPA process can be shortened.** The scheduled duration for NEPA can be reduced by leveraging current LANL NEPA actions and conducting NEPA determination in parallel with construction work.

4.2.6 Specific Threats and Opportunities for Alternative 2c

4.2.6.1 Threats

The following threats specific to Alternative 2c were reviewed and discussed:

- **Inadequate parking for the increased production workforce.** This is a known issue for the constrained site, with a high likelihood of occurrence and a significant consequence, resulting in a moderate risk level. A reasonable mitigation strategy was deemed unavailable.
- **Inadequate local warehousing, laydown areas, and/or working space to support fabrication for construction.** This is a known issue for the constrained site, with a high likelihood of occurrence and a significant consequence, resulting in a moderate risk level. A reasonable mitigation strategy was deemed unavailable.
- **Inadequate office/training space to support operations.** This is a known issue for the constrained site, with a high likelihood of occurrence and a significant consequence, resulting in a moderate risk level. A reasonable mitigation strategy was deemed unavailable.

- **The vault does not have the capacity to support pit production throughput.** This threat was assessed to have a high likelihood and a critical consequence, resulting in a high-risk level. A reasonable mitigation strategy would be to include expanded vault capacity with potential cost and schedule impacts, resulting in a moderate risk level.
- **Inadequate shipping and receiving capability to achieve pit production throughput.** This threat was assessed to have a high likelihood and a critical consequence, resulting in a high-risk level. A reasonable mitigation strategy would be to include expanded shipping and receiving capability with potential cost and schedule impacts, resulting in a moderate risk level.
- **Implementation of 50 ppy mission disrupts 30 ppy mission at PF-4.** The reconfiguration required within PF-4 for this alternative were assessed to have a high likelihood of occurrence and a critical consequence, resulting in a high-risk level. A reasonable mitigation strategy for the required reconfiguration within PF-4 would include an early engineering assessment to minimize the impacts, resulting in a moderate risk level.
- **Increased 400-g MAR limit at RLUOB is not approved, creating need for alternate analytical chemistry and material characterization facilities.** This threat was assessed to have a low likelihood of occurrence but a critical consequence, resulting in a moderate risk level. A reasonable mitigation strategy was deemed unavailable.
- **Unexpected underground site conditions.** This threat was assessed to have a low likelihood of occurrence within the existing TA boundary, and a significant consequence, resulting in a low risk level.
- **Operational mishaps or equipment failures due to double-shift operations in PF-4 affects production capacity and completion of the mission.** This threat was assessed to have a high likelihood and a critical consequence, resulting in a high-risk level. Life cycle planning for PF-4 should include additional maintenance, repair, and replacement to maintain production rates. But for this alternative, PF-4 represents a single point failure during double-shift operations prior to new modules being available in the second phase. The residual risk level was assessed to be high.
- **Facility upgrades are needed to extend the operational life of PF-4 to 50 years.** This threat was assessed to have a high likelihood and a significant consequence, resulting in a moderate risk level. New projects will be required for future life extension of PF-4. A reasonable mitigation strategy was deemed unavailable.
- **PF-4 has potential vulnerability to seismic risks.** This threat was assessed to have a high likelihood and a significant consequence, resulting in a moderate risk level. A reasonable mitigation strategy would be to identify and include upgrade requirements during the design phase and prior to CD-2/3, but the residual risk level is moderate.
- **Transition to module operations during the bridge from PF-4 may result in disruption of 80 ppy capabilities.** This threat was assessed to have a high likelihood and a significant consequence,

resulting in a moderate risk level. Transition planning will strive to minimize the disruption, but a reasonable mitigation strategy was deemed unavailable.

- **Limited operational flexibility for future expansion to accommodate increases in mission requirements.** This threat was assessed to have a moderate likelihood, and a significant consequence, resulting in a moderate risk level. New modules will provide some operational flexibility, but the residual risk level was assessed to be moderate during double-shift operations.
- **Construction/equipment installation disrupts ongoing site or facility operations.** This threat was assessed to result in a moderate risk level for equipment installation during 30 ppy production. A reasonable mitigation strategy was deemed unavailable.
- **Operational, safety, or equipment failures result in shutdown of PF-4 that impacts ability to meet the mission.** This threat was assessed to have a high likelihood and a critical consequence, resulting in a high-risk level. Life cycle planning for PF-4 should include additional maintenance, repair, and replacement to maintain production rates. But for this alternative, PF-4 represents a single point failure during double-shift operations prior to new modules. The residual risk level was assessed to be high.
- **Ongoing site or facility operations disrupts construction/equipment installation.** This threat was assessed to have a high likelihood and a significant consequence, resulting in a moderate risk level for equipment installation during 30 ppy production. A reasonable mitigation strategy was deemed unavailable.
- **Construction of new 50 ppy facilities at LANL and tunnel connection to PF-4 could affect high-energy radiography for plutonium operations at PF-4.** This threat was assessed to have a high likelihood and a critical consequence, resulting in a high-risk level. Mitigation may include starting radiography operations in the modules before the tie-in is complete resulting in no interruption in radiography capability, evaluation of construction sequence and methods to minimize impact and verify capacity and obtain authorization to use radiography at Pantex during double-shift operations and during construction, resulting in an assessed moderate risk level.
- **Personnel support facilities are inadequate for PF-4 double-shift operations, and unplanned for new facilities.** This threat was assessed to have a high likelihood and a significant consequence, resulting in a moderate risk level. Potential mitigation may be available through staggered shifts, but additional support space may be required, and the residual risk level was assessed to be moderate.

4.2.6.2 Opportunities

The following opportunity specific to Alternative 2c was reviewed and discussed:

- **Separate facilities (within a site) each with production capabilities can ensure continuing mission support.** This opportunity was assessed to have a moderate likelihood with a significant consequence to result in a moderate opportunity level after new modules are completed. An implementation strategy was determined to not be required.

- **The NEPA process can be shortened.** The scheduled duration for NEPA can be reduced by leveraging current LANL NEPA actions and conducting NEPA determination in parallel with construction work.

4.3 Discriminating Risks

Several qualitative risks were determined to be discriminators among the alternatives. These are risk topics where, after any identified and recommended mitigations, the residual risk levels vary among the alternatives. The discriminating risks are described below, organized by program, project, and execution, and are listed in order of severity or opportunity.

4.3.1 Program Risks

Program threats and opportunities that discriminate among the alternatives are shown in Table 4-3.

Table 4-3: Discriminating Program Threats and Opportunities After Mitigation

Discriminating Program Threats

Brief Threat Description	Alternative 1	Alternative 2a	Alternative 2b	Alternative 2c
Mishaps or failures shut down PF-4		Moderate	High	High
PF-4 equipment failures due to double-shift				High
Inadequate parking for workforce		Moderate	Moderate	Moderate
Inadequate local warehousing and laydown		Moderate	Moderate	Moderate
Inadequate office/training space		Moderate	Moderate	Moderate
50 ppy mission disrupts 30 ppy mission at PF-4		Moderate	Moderate	Moderate
400-g MAR limit at RLUOB not approved		Moderate	Moderate	Moderate
Upgrades needed to extend facility life of PF-4		Moderate	Moderate	Moderate
Facility layout impacts safety and security	Moderate	Low	Low	Low
Alternative does not meet the 2030 objective	Low	Moderate	Low	Low
Radiography rework affects production rate	Low	Low	Low	Moderate
Ongoing MFFF construction impacts costs	Moderate			
Difficulty closing out MFFF results in delay	Moderate			
The vault does not have capacity for production				Moderate
Inadequate shipping and receiving				Moderate
Transition to modules disrupts 80 ppy production				Moderate

Discriminating Program Threats

Brief Threat Description	Alternative 1	Alternative 2a	Alternative 2b	Alternative 2c
Limited operational flexibility for expansion		Low	Low	Low
Pit production in a high-humidity environment	Low			

Two production entities increase qualification, certification, and surveillance	Low			

Discriminating Program Opportunities

Brief Opportunity Description	Alternative 1	Alternative 2a	Alternative 2b	Alternative 2c
Improved operational efficiency/lessons learned	High			
Separate sites can ensure continuing mission	High			
Additional Hazard Category (HC) 2 space is available	High			
Analytical capability in existing HC-2 space	Moderate			

4.3.2 Project Risks

Project threats and opportunities that discriminate among alternatives are shown in Table 4-4.

Table 4-4: Discriminating Project Threats and Opportunities After Mitigation

Discriminating Project Threats

Brief Threat Description	Alternative 1	Alternative 2a	Alternative 2b	Alternative 2c
Active Safety Class controls are required.	Low	Low	Moderate	High
Potential requirement for CT inspection	Low	Moderate	Moderate	Moderate
PF-4 vulnerable to seismic risks		Moderate	Moderate	Moderate
Tunnel connection affects radiography		Moderate	Moderate	Moderate
Ongoing operations disrupt construction		Low	Moderate	Moderate
Complex movement of nuclear materials	Low	Low	Low	Moderate
Engineering controls based on safety	Low	Low	Low	Moderate
Construction disrupts ongoing operations		Low	Low	Moderate
Construction impacts radiography at PF-4				Moderate
Support facilities inadequate for double-shift				Moderate

Discriminating Project Opportunities

Brief Opportunity Description	Alternative 1	Alternative 2a	Alternative 2b	Alternative 2c
Existing infrastructure can be leveraged	Moderate	High	High	High
Off-site consequences reduce Safety Class	High	Moderate	Moderate	Moderate
Potential requirements for new technology	High	Moderate	Moderate	Moderate
Work can be completed during MOX closeout	High			
Use MOX purchased commodities	High			
Remove walls to improve construction/operations	High			
BMP would not be safety class	High			

4.3.3 Execution Risks

Execution threats and opportunities that discriminate between alternatives are shown in Table 4-5.

Table 4-5: Discriminating Execution Threats and Opportunities After Mitigation

Discriminating Execution Threats

Brief Threat Description	Alternative 1	Alternative 2a	Alternative 2b	Alternative 2c
Unexpected underground site conditions		Low	Low	Low

Discriminating Project Opportunities

Brief Opportunity Description	Alternative 1	Alternative 2a	Alternative 2b	Alternative 2c
Remove walls for construction and operations	High			

4.4 Alternative Comparisons and Risk Analysis Conclusions

4.4.1 General

The overall residual risk of the four alternatives is discussed below, along with discriminators and the risk analysis conclusions.

4.4.2 Alternative 1: Modify MFFF at SRS with Modules

The overall qualitative risk level of Alternative 1, Modified MOX Facilities at SRS, is considered to be low, with only a few residual moderate threats. The following moderate threats and high opportunities discriminate this alternative from others:

- **Threat:** Facility configuration impacts safety and security.
- **Threat:** Ongoing MFFF construction impacts costs.
- **Threat:** Difficulties closing out MOX results in delay.
- **High Opportunity:** Improved operational efficiency/lessons learned.

- **High Opportunity:** Separate sites can ensure continuing mission.
- **High Opportunity:** Additional HC-2 space is available.
- **High Opportunity:** Off-site consequences can reduce Safety Class equipment.
- **High Opportunity:** Potential requirements for new technologies.
- **High Opportunity:** Some work can be completed during MOX closeout.
- **High Opportunity:** Use MOX purchased commodities.
- **High Opportunity:** Remove walls for construction and operations.
- **High Opportunity:** BMP does not have to be safety class.

4.4.3 Alternative 2a: Construct a Module at LANL – Production Facility Outside PF-4

The overall qualitative risk level of Alternative 2a, Construct a Module at LANL – Production Facility Outside PF-4, is considered to be low to moderate, with several residual moderate threats and a single high opportunity. The following moderate threats and high opportunities discriminate this alternative from others:

- **Threat:** Mishaps or failures shut down PF-4.
- **Threat:** Inadequate parking for workforce.
- **Threat:** Inadequate local warehousing and laydown.
- **Threat:** Inadequate office/training space.
- **Threat:** 50 ppy mission disrupts 30 ppy mission at PF-4.
- **Threat:** 400-g MAR limit at RLUOB is not approved.
- **Threat:** Upgrades needed to extend facility life of PF-4.
- **Threat:** Alternative does not meet the 2030 objective.
- **Threat:** Potential for CT inspection.
- **Threat:** PF-4 vulnerable to seismic risks.
- **Threat:** Tunnel connection impacts radiography.
- **High Opportunity:** Existing infrastructure can be leveraged.

4.4.4 Alternative 2b: Construct a Module at LANL – Production Capacity Split with PF-4

The overall qualitative risk level of Alternative 2b, Construct a Module at LANL – Production Capacity Split with PF-4, is considered to be low to moderate, with a single residual high threat, several residual moderate threats, and a single high opportunity. The following high and moderate threats and high opportunities discriminate this alternative from others:

- **High Threat:** Mishaps or failures shut down PF-4.
- **Threat:** Inadequate parking for workforce.
- **Threat:** Inadequate local warehousing and laydown.

- **Threat:** Inadequate office/training space.
- **Threat:** 50 ppy mission disrupts 30 ppy mission at PF-4.
- **Threat:** 400-g MAR limit at RLUOB is not approved.
- **Threat:** Upgrades needed to extend facility life of PF-4.
- **Threat:** Active Safety Class controls are required.
- **Threat:** Potential for CT inspection.
- **Threat:** PF-4 vulnerable to seismic risks.
- **Threat:** Tunnel connection affects radiography.
- **Threat:** Ongoing operations disrupt construction.
- **High Opportunity:** Existing infrastructure can be leveraged.

4.4.5 Alternative 2c: Use PF-4 as a Bridge by FY 2030 Until Construction of Modules at LANL

The overall qualitative risk level of Alternative 2c, Use PF-4 as a Bridge by 2030 Until Construction of Modules at LANL, is considered to be moderate, with three residual high threats, many residual moderate threats, and a single high opportunity. The following high and moderate threats and high opportunities discriminate this alternative from others:

- **High Threat:** Mishaps or failures shut down PF-4.
- **High Threat:** PF-4 equipment failures due to double-shift.
- **High Threat:** Active Safety Class controls are required.
- **Threat:** Inadequate parking for workforce.
- **Threat:** Inadequate local warehousing and laydown.
- **Threat:** Inadequate office/training space.
- **Threat:** 50 ppy mission disrupts 30 ppy mission at PF-4.
- **Threat:** 400-g MAR limit at RLUOB is not approved.
- **Threat:** Upgrades needed to extend facility life of PF-4.
- **Threat:** Radiography rework impacts production rate.
- **Threat:** The vault does not have capacity for production.
- **Threat:** Inadequate shipping and receiving.
- **Threat:** Transition to modules disrupts 80 ppy mission.
- **Threat:** Potential requirement for CT inspection.
- **Threat:** PF-4 vulnerable to seismic risk.
- **Threat:** Tunnel connection impacts radiography.
- **Threat:** Ongoing operations disrupt construction.
- **Threat:** Construction impacts radiography at PF-4.

- **Threat:** Support facilities inadequate for double-shift.
- **High Opportunity:** Existing infrastructure can be leveraged.

4.4.6 Risk Analysis Conclusions

The overall conclusions of the qualitative risk analysis are listed below:

- **All alternatives considered are viable from a risk perspective**, with only a few high and multiple moderate residual threats remaining after reasonable mitigations.
- **Alternative 1**, Modify MFFF at SRS with Production Modules, is considered to have a **low risk level** and has the least residual threats of the alternatives after reasonable mitigations.
- **Alternative 2a**, Construct a Module at LANL – Production Facility Outside PF-4, is considered to have a **low to moderate risk level** and has the second lowest residual threats of the alternatives after reasonable mitigations.
- **Alternative 2b**, Construct a Module at LANL – Production Capacity Split with PF-4, is considered to have a **low to moderate risk level** and has the third lowest residual threats of the alternatives after reasonable mitigations.
- **Alternative 2c**, Use PF-4 as a Bridge by FY 2030 Until Construction of Modules at LANL, is considered to have a **moderate risk level** and has the highest residual threats of the alternatives after reasonable mitigation.

4.4.7 Risk Implications of Double-Shift Operations

The EA also includes a qualitative assessment of the potential impact of double-shift operations. Except for Alternative 2c, each alternative is conceived to achieve 50 ppy using single-shift operations. Alternative 2c will use double-shift operations to achieve 80 ppy by FY 2030 in PF-4 and will subsequently reconfigure PF-4 and add construction modules to later achieve the total production throughput with a single shift.

Double-shift operations have the following general impacts:

- Increased threat to LCCs due to shift labor premiums, duplication of support and administrative staffing, increased power and utilities, and increased maintenance, repair, and replacement frequency for equipment.
- Increased threat to training and qualifications for operations, surveillance, safety, and supervisory personnel.
- Increased opportunity to ensure meeting the 50 ppy production throughput.
- Increased opportunity to incrementally increase production throughput beyond 50 ppy with limited lead time.

Alternative 2c would realize the same general threats during early double-shift operations starting in FY 2030 in PF-4, and until reconfiguration and new construction modules are subsequently operational. Thereafter, Alternative 2c would have threats and opportunities similar to the other alternatives if double-shift operations were subsequently required.

4.4.8 Comparison of Residual Risks

Figure 4-2 compares the residual threats and opportunities of the alternatives.

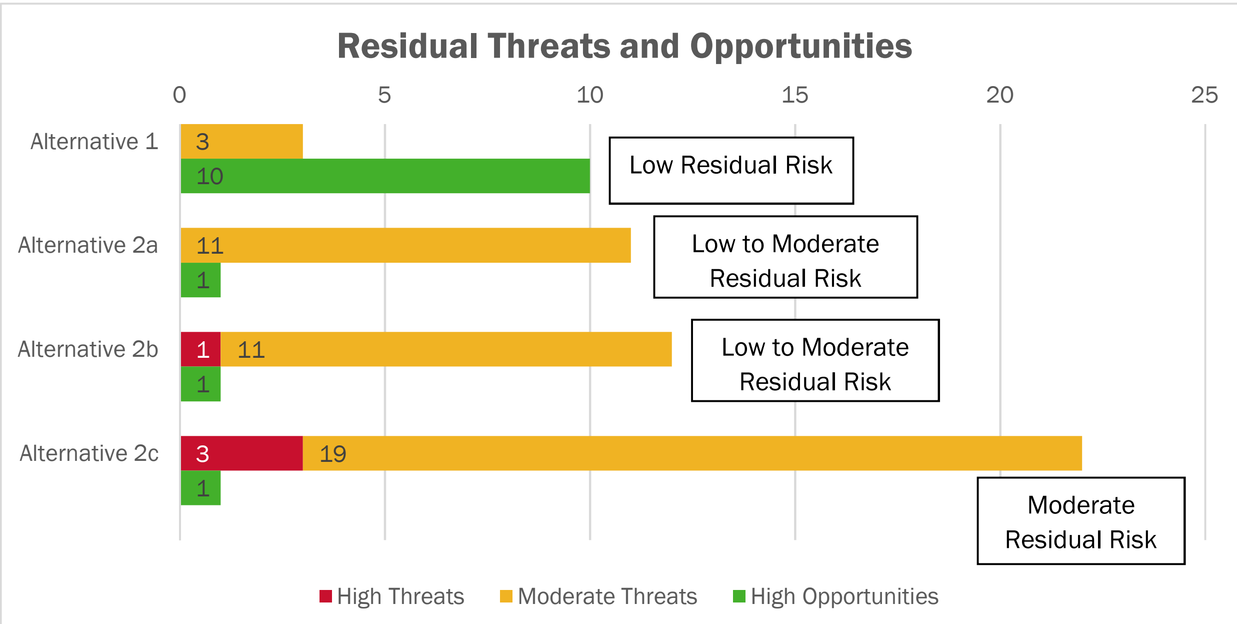

Figure 4-2: Alternative Qualitative Risk Comparison

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Appendix A Alternative 1 Preconceptual Site Plan, Equipment Layout Drawings, and General Arrangements

Page A-3 shows the location of the MFFF and BTS at SRS.

Pages A-4, A-5, and A-6 are the general arrangements of the first, second, and third floors of the BMP and BSR areas of the MFFF. Shaded areas indicate areas identified for specific functions; unshaded areas are not specifically designated for use. Process areas with significant equipment and gloveboxes have been sized by fitting equipment into existing rooms with appropriate spacing and clearances and therefore represent a reasonably accurate space requirement for this stage of project planning. Equipment layouts for these areas are detailed on pages A-7 and A-8. Other areas have been fit into appropriate available space but have not been optimized. Office space, for example, is significantly greater than what is expected to be required. Refinement of the space requirements would be accomplished during conceptual design.

Note that CAD drawings were not provided for MFFF. The EA team used PDF versions of the BMP and BSR General Arrangements. Alternative 1 layouts include room numbers, equipment, and other drawing objects that are part of the MOX scope and not required for plutonium pit production.

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Appendix B Alternative 2a Preconceptual Site Plan, Equipment Layout Drawings, and General Arrangements

Page B-3 shows the location of the process and process support modules and their positions relative to PF-4 and RLUOB.

Pages B-5 through B-10 are equipment layout drawings depicting equipment and gloveboxes with appropriate spacing and clearances. The ELDs established the minimum space requirements for the process areas. The actual areas in the general arrangements (page B-4) may be larger than required because the process module floor plan was laid out as a rectangle to avoid an irregular footprint. Process support areas meet at least the minimum sizes determined by the EA team and are otherwise driven by building configuration and available space.

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Appendix C Alternative 2b Preconceptual Site Plan, Equipment Layout Drawings, and General Arrangements

Page C-3 shows the location of the process and process support modules and their positions relative to PF-4 and RLUOB. Unlike Alternative 2a, the Alternative 2b process module does not include process and support areas for disassembly, metal preparation, and foundry. These functions are performed with shared space and equipment for the Plutonium Sustainment Program in PF-4. Process area ELDs for machining, subassembly and assembly, post assembly, and material characterization are the same for Alternatives 2a and 2b and are presented in Appendix B, pages B-5 through B-8.

Page C-8 is the GA drawing. Note that although the process module is smaller for Alternative 2b, the process support modules for Alternatives 2a and 2b are identical.

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Appendix D Alternative 2c Preconceptual Site Plan, Equipment Layout Drawings, and General Arrangements

All drawings for Alternative 2c were provided by LANL. Pages D-3 through D-6 Show the three-module approach to create additional processing, radiography, and support spaces to produce 80 ppy using both new construction and space in PF-4. Reconfiguration of PF-4 and RLUOB required to produce 80 ppy by 2030 on two shifts and without additional footprint are shown on pages D-7 and D-8. The final configuration, with production in both PF-4 and modules on a single shift, is shown on pages D-9 and D-10

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Appendix E Cost Estimate for Alternative 1

The estimate for Alternative 1 is organized into seven subprojects, as described below, along with the basis of estimate for each work breakdown structure (WBS) element.

E.1 MFFF Readiness/Modifications

Table E-1: MFFF Readiness/Modifications - Alternative 1

WBS	Description	Estimate (FY18 $k)
1.1	MFFF Readiness/Modifications	
1.1.1	Project Management/Support	61,800
1.1.2	Engineering/Design	80,300
1.1.3	Site Preparation/D&D	14,100
1.1.4	Equipment Procurement	50,300
1.1.5	Construction/Installation	136,400
1.1.6	Startup/Commissioning	28,000
1.1.7	Contingency	185,500
	Total Point Estimate	556,400

The decommissioning and disposal (D&D) estimate was developed by estimating the effort that will be needed to remove all equipment and commodities (piping, ductwork, electrical raceway) that is installed in the various rooms planned to be used for pit production and supporting processes. The basis of estimate was a combination of the layout drawings developed for this EA, inventory data provided by the Mixed Oxide (MOX) project team, and photos of the rooms as they now exist. Based on an assessment of difficulty levels, crew size and duration were estimated. For rooms without photos, the average hours per square foot estimated for other rooms was applied. The total calculated crew hours were then costed using an all-inclusive, fully burdened labor rate of $140 per hour. An additional allowance of 25% for construction indirect costs (including equipment) and an allowance of 20% for engineering support and construction management were also included for this estimate.

The construction cost includes an estimate for construction of a 4,000-ft^2 radiography vault at $2,000/ft^2, mezzanines over the second-floor process areas at $1,000/ft^2, and an allowance for the repair of construction openings and other miscellaneous work including sealing openings to unused areas ($25 million), based on EA Team judgment. It was assumed that 10% of this construction cost may represent procurements in advance of construction.

To make the Mixed Oxide Fuel Fabrication Facility (MFFF) useable for pit production, the estimate includes the cost to procure and install new utilities and miscellaneous commodities and equipment in the spaces inside the Manufacturing Process Building (BMP) to be used for the pit production mission. These costs were estimated as shown below, but they do not include the processing equipment and gloveboxes, which are separately estimated. The $/ft² rates used represent EA Team judgment and include procurement and installation of bulk commodities and, when appropriate, required equipment. It was assumed that 30% of these costs may represent procurements in advance of construction.

Space	Size (sf)	$/ft²	Estimated Cost (FY18 $)
Analytical Chemistry Area	19,960	300	5,988,000
All Process Areas	54,830	500	27,415,000
All Utilities Areas	39,635	1,000	39,635,000
Process Support Area	15,640	500	7,820,000
Aqueous Recovery Area	7,140	500	3,570,000
Control Room	4,860	1,000	4,860,000
Shipping/Receiving/Storage	7,755	300	2,326,500
Office Area	18,610	100	1,861,000
		Subtotal	93,475,500
Allowance for Other Areas/Connections		20%	17,280,080
		Total	112,170,600

The other elements needed to make the MFFF an operating pit production facility are the external utilities and systems shown below.

Item	Assumption	Cost, $
Transformers	Assumed ½ cost of UPF (1/3 size)	5,700,000
SC Fire Water Tanks	Assumed ½ cost of UPF (1/3 size)	5,974,000
Fire Water Pumphouse	1,024 ft² at $1,000/sf	1,024,000
Fire Water Pumps/System	Included with tank costs used	
SC Diesel Generators	Assumed ½ cost of UPF (1/3 size)	2,925,000
DG Enclosure	1700 ft² at $1,000/ft²	1,700,000
Gas Tank Pad	4800 ft² at $200/ft²	960,000
Gas System	Covered by utility area $/ft²	
Cooling Towers	Assumed ½ cost of UPF (1/3 size)	4,612,000
Chilled Water System	Assumed ½ cost of UPF (1/3 size)	
	Total	22,895,000

DG = Diesel Generator
SC = Safety Class
UPF = Uranium Processing Facility

Engineering and design was estimated as 40% of the total procurement and construction costs for the reconfiguration of MFFF for pit production, representative of historical DOE/NNSA experience for new nuclear facilities.

Facility startup and commissioning is estimated to be 15% of the procurement and construction costs based on EA Team judgment. Process equipment startup was estimated separately as discussed below.

Costs to be incurred for project management and support are estimated at 20% of all other costs (excluding contingency), consistent with DOE/NNSA experience.

A contingency/management reserve (MR) allowance of 50% was added to account for the high degree estimate uncertainty associated with cleaning out and reusing the MFFF for pit production. The scope of this effort has not been fully defined and has been estimated by component element; thus, it has a higher contingency level than has been used for construction of facilities for which a total $/ft^2 value is used.

E.2 Pit Production Equipment/Installation

Table E-2: Pit Production Equipment/Installation – Alternative 1

WBS	Description	Estimate (FY18 $k)
1.2	Pit Production Equipment/Installation	
1.2.1	Project Management/Support	106,400
1.2.2	Engineering/Design	103,000
1.2.3	Site Preparation/D&D	0
1.2.4	Equipment Procurement	133,600
1.2.5	Construction/Installation	209,600
1.2.6	Startup/Commissioning	85,800
1.2.7	Contingency	191,500
	Total Point Estimate	829,900

The equipment list developed for the EA formed the basis of estimated costs for procurement and installation of the pit production equipment. Costs were estimated using an average cost per glovebox (depending on size) derived from recent actual costs provided by Los Alamos National Laboratory (LANL) and cost estimates recently developed for the Uranium Processing Facility (UPF) project. Costs for equipment were included based on analogies to recent LANL purchases and UPF estimates when possible and augmented by rough order of magnitude (ROM) estimates and EA Team applied allowances.

The average estimates for procurement and installation of gloveboxes used for the EA estimate are as follows:

Item	Procurement Cost, $	Installation Hours
Smaller Gloveboxes (less than 50 ft^2)	500,000	3,000
Mid-Size Gloveboxes (50 ft^2 to 100 ft^2)	1,000,000	6,000
Larger Gloveboxes (greater than 100 ft^2)	1,500,000	6,000

The estimate includes the process equipment that will be installed in the BMP, including equipment for aqueous recovery. Although the same unit cost basis was used for the aqueous recovery equipment to be consistent with the estimates for all alternatives, it is likely this equipment will be simpler and less costly; the estimate can therefore be considered conservative.

Installation costs were calculated by applying an average, fully burdened labor rate consistent with ongoing LANL construction. An allowance was included for construction indirects (equipment, support facilities, etc.) and for Title III engineering and construction management oversight.

Below is a breakdown of the costs included in this WBS element:

Description	Cost, $
Procurement of Gloveboxes	75,000,000
Procurement of Equipment	6,755,000
Procurement of Aqueous Recovery Equipment	16,845,000
Procurement of Conveyance System	30,000,000
Procurement of Communications/Control Systems	5,000,000
Total Procurement Cost	133,600,000
Equipment and Glovebox Installation	159,894,000
Installation of Conveyance System	10,000,000
Installation of Aqueous Recovery Equipment	39,690,000
Total Installation Cost	209,584,000

Engineering and design was estimated as 30% of the total procurement and construction costs for the gloveboxes and equipment, representative of historical DOE/NNSA experience for new nuclear facilities, reduced to reflect the inclusion of vendor engineering in the procurement cost.

Startup and commissioning is estimated to be 25% of the procurement and construction costs based on EA Team judgment and DOE/NNSA experience for complex nuclear facilities.

Costs to be incurred for project management and support are estimated at 20% of all other costs (excluding contingency), consistent with DOE/NNSA experience.

A contingency/MR allowance of 30% was added for estimate uncertainty (both pricing and scope) for the pit production equipment.

E.3 Analytical Laboratory Equipment/Systems

Table E-3: Analytical Laboratory Equipment/Systems – Alternative 1

WBS	Description	Estimate (FY18 $k)
1.3	Analytical Laboratory Equipment/Systems	
1.3.1	Project Management/Support	13,100
1.3.2	Engineering/Design	12,700
1.3.3	Site Preparation/D&D	0
1.3.4	Equipment Procurement	6,100
1.3.5	Construction/Installation	36,200
1.3.6	Startup/Commissioning	10,600
1.3.7	Contingency	23,600
	Total Point Estimate	102,300

This subproject includes the cost to equip and analytical laboratory within the BMP area at the MFFF. The basis pf estimate is the actual procurement and installation cost incurred for the Radiological Laboratory Utility Office Building (RLUOB) Equipment Installation project, escalated to FY 2018 dollars.

Engineering and design was estimated at 30% of the total procurement and construction costs for the gloveboxes and equipment, representative of historical DOE/NNSA experience for new nuclear facilities, reduced to reflect the inclusion of vendor engineering in the procurement cost.

Startup and commissioning is estimated at 25% of the procurement and construction costs based on EA Team judgment and DOE/NNSA experience for complex nuclear facilities.

Costs to be incurred for project management and support are estimated at 20% of all other costs (excluding contingency), consistent with DOE/NNSA experience.

A contingency/MR allowance of 30% was added for estimate uncertainty (both pricing and scope).

E.4 Technical Support Building Modifications

Table E-4: Technical Support Building Modifications – Alternative 1

WBS	Description	Estimate (FY18 $k)
1.4	Technical Support Building Modifications	
1.4.1	Project Management/Support	3,900
1.4.2	Engineering/Design	3,000
1.4.3	Site Preparation/D&D	0
1.4.4	Equipment Procurement	0
1.4.5	Construction/Installation	15,000
1.4.6	Startup/Commissioning	1,500
1.4.7	Contingency	4,700
	Total Point Estimate	28,100

It is assumed that the existing Technical Support Building at the MFFF will be used to house offices and other personnel support functions, including an entry control facility, for pit production. The cost to modify, if necessary, furnish and equip this space was estimated at $200/ft^2 based on EA Team judgment. This value was applied to the entire TSF (75,000 ft^2) to be conservative.

Engineering and design was estimated as 20% of the total procurement and construction costs for the new process module, representative of historical DOE/NNSA experience for conventional facilities.

Startup and commissioning is estimated at 10% of the procurement and construction costs based on EA Team judgment.

Costs to be incurred for project management and support are estimated at 20% of all other costs (excluding contingency), consistent with DOE/NNSA experience.

A contingency/MR allowance of 20% was added for estimate uncertainty.

E.5 WSB Readiness/Reactivation

Table E-5: WSB Readiness/Reactivation – Alternative 1

WBS	Description	Estimate (FY18 $k)
1.5	WSB Readiness/Reactivation	
1.5.1	Project Management/Support	1,600
1.5.2	Engineering/Design	2,300
1.5.3	Site Preparation/D&D	0
1.5.4	Equipment Procurement	1,500
1.5.5	Construction/Installation	2,600
1.5.6	Startup/Commissioning	1,500
1.5.7	Contingency	4,800
	Total Point Estimate	**14,300**

The cost to make the Waste Solidification Building ready and available to support the pit production mission was based on an SRNS estimate developed in 2014 ("Waste Solidification Building Reactivation Cost Analysis," SRNS-T8000-2014-00176, 19 August 2014). The costs were used as shown below and escalated to FY 2018 assuming 3%/year escalation since 2014. For each activity identified, an assumed amount was deemed applicable for this project based on the limited equipment set and capability that will be used to process pit production liquid waste.

Activity/Element	2014 $	Applied %	Engineering	Procurement	Construction
Process System Cleaning	250,000	25			70,300
Instrumentation Calibration	400,000	25			112,600
Relief Valves	100,000	25			28,100
Restoration from Lay-up	1,000,000	25			281,400
Laboratory Equipment	1,000,000	0			
Equipment Refurbishment					
Standby Diesel Generator	250,000	100		291,400	
Instrument & Breathing Air	150,000	100			168,800
Steam Boiler	50,000	100			56,300
Cooling Tower	20,000	100		22,500	
Drum Handling	20,000	50		11,300	
HVAC System	20,000	100			22,500
Process Cooling Water	20,000	100			22,500
Radiological Monitoring Equipment	50,000	100		56,300	
LIMS Interface	50,000	0			
GB Compliance & Testing	1,200,000	25			337,700
Equipment Failure Recovery	500,000	100			562,800
Drums for Water Run Test	300,000	50		168,800	
Operational Spares	500,000	25		140,700	
Process Sewer Tie-In	100,000	100			112,600
MOX FO Communications	20,000	0			
STUs Required for Operations	90,000	0			
Waste Cert Update	400,000	25	112,600		
Process Lab Certification	500,000	0			
Air Monitoring Study & Report	100,000	100	112,600		
Updating Code of Record	200,000	100	225,100		
Cement. Equipment Refurbishing	1,200,000	25		337,700	
DSA Upgrade	1,375,000	100	1,547,600		
Process Tank Cleaning	1,000,000	25			281,400
Allowance for Tie-in to MFFF for Pit Production			300,000	500,000	500,000
		Totals	2,297,900	1,518,700	2,557,000

DSA = Documented Safety Analysis
FO = fiber optic
GB = glovebox
MOX = mixed oxide
LIMS = laboratory information management system
STU = secure telecommunications unit

In addition to the above activities, an estimate for startup and commissioning was included based on 10 full-time equivalents (FTEs) for 6 months at an average annual rate of $300,000.

Costs to be incurred for project management and support are estimated at 20% of all other costs (excluding contingency), consistent with DOE/NNSA experience.

A contingency/MR allowance of 50% was added to account for the high degree estimate uncertainty associated with making the WSB ready to support pit production.

E.6 MFFF Security Upgrades (including PIDAS)

Table E-6: MFFF Security Upgrades (incl. PIDAS) – Alternative 1

WBS	Description	Estimate (FY18 $k)
1.6	MFFF Security Upgrades (incl. PIDAS)	
1.6.1	Project Management/Support	19,100
1.6.2	Engineering/Design	19,800
1.6.3	Site Preparation/D&D	0
1.6.4	Equipment Procurement	20,100
1.6.5	Construction/Installation	45,900
1.6.6	Startup/Commissioning	9,900
1.6.7	Contingency	28,700
	Total Point Estimate	143,500

An estimated 6,100-ft PIDAS will be needed at the MFFF. The cost of the PIDAS is estimated at $10,000/ft, a parameter derived from historical NNSA experience and recent cost estimates.

It was assumed that approximately one-third of the estimated cost would represent elements to be procured in advance of installation, with the remainder being construction phase expenditures.

Engineering and design was estimated as 30% of the total procurement and construction costs, representative of historical DOE/NNSA experience and EA Team judgment.

Startup and commissioning is estimated as 15% of the procurement and construction costs based on EA Team judgment and DOE/NNSA experience.

Costs to be incurred for project management and support are estimated at 20% of all other costs (excluding contingency), consistent with DOE/NNSA experience.

A contingency/MR allowance of 25% was added for estimate uncertainty (both pricing and scope).

E.7 Other Project Costs

Table E-7: Other Project Costs – Alternative 1

WBS	Description	Estimate (FY18 $k)
1.7	Other Project Costs	
1.7.1	Conceptual Design	30,000
1.7.2	ES&H (incl. NEPA)	6,000
1.7.3	Spare Parts	6,700
1.7.4	M&O (or Owner Agent) Oversight	84,400
	Total Point Estimate	127,100

Conceptual design phase costs were estimated by assuming that a staff of 100 FTEs would work for 1 year at an average rate of $300,000 per FTE.

The environment, safety, and health (ES&H) costs assume that 6 FTES would be working for a 2-year period (including the NEPA review phase) and then a total of 4 FTEs for two additional years to process the various permits and accomplish the other ES&H activities before construction starts. An average of $300,000 per year per FTE was used to calculate the estimated cost.

Spare parts allowance is calculated as 5% of the equipment procurement value for the pit production equipment.

An allowance for M&O contractor or other Owner's Agent oversight of the total project is estimated at 5% of all other project costs.

E.8 Operations Costs and End-of-Life D&D

Table E-8: Operations Costs and End-of-Life D&D– Alternative 1

WBS	Description	Estimate (FY18 $k)
2.0	Operations Costs	
2.1	Facility Operations and Maintenance	292,300 per year
2.2	Operations Staffing and Expenses	238,200 per year
2.3	Security Related Costs	66,000 per year
2.4	Waste Transportation and Disposal	18,400 per year
2.5	Periodic Major Upgrades	283,100 twice over life
3.0	End-of-Life D&D	46,400

Staffing levels are based on input from SMEs supporting the EA team, based on existing staffing levels at PF-4 and LANL estimates of future staffing needs for pit production.

For facility operations and maintenance (O&M), 886 FTEs are assumed. The estimated cost is calculated by applying an average cost of $300,000 per FTE per year and adding a 10% allowance for supplies and other direct costs.

Operations staffing and expenses is calculated by applying an average cost of $300,000 per FTE per year for a staff of 722 FTEs and adding a 10% allowance for supplies and other direct costs.

Security-related cost is calculated by applying an average cost of $300,000 per FTE per year for a staff of 200 FTEs and adding a 10% allowance for supplies and other direct costs.

Waste transportation and disposal is the sum of the cost of 40 shipments of transuranic (TRU) waste to the Waste Isolation Pilot Plant (WIPP) per year at $18,700 per shipment, the disposal of 1,300 cubic meters of low-level waste (LLW) at $384 per cubic foot (from the Analysis of Alternatives [AoA]), and 6,200 cubic meters of nonhazardous waste at $0.185 per cubic foot (from AoA) per year.

Periodic major upgrades were estimated to occur twice over the 50-year life of these facilities. The estimated cost was estimated to be 25% of the initial capital project cost for the production and support equipment and systems. An additional allowance of $50 million was added for any needed MFFF, WSB, or PIDAS modifications as part of each major upgrade project.

End-of-life D&D costs have been estimated using the DOE cost estimating relationship (CER) based on historical data (see Section 3.1.5.4), as follows:

Facility	Facility Size (ft^2)	Estimated Cost (FY18 $)
MFFF (full facility)	325,000	33,548,000
WSB	40000	13,069,000
BTS (full facility)	75000	17,342,000
Total		63,959,000

Appendix F Cost Estimate for Alternative 2a

The estimate for Alternative 2a is organized into six subprojects, as described below, along with the basis of estimate for each WBS element.

F.1 New Facility for Pit Production

Table F-1: New Facility for Pit Production - Alternative 2a

WBS	Description	Estimate (FY18 $k)
1.1	New Facility for Pit Production	
1.1.1	Project Management/Support	141,100
1.1.2	Engineering/Design	182,100
1.1.3	Site Preparation/D&D	17,000
1.1.4	Equipment Procurement	43,200
1.1.5	Construction/Installation	412,100
1.1.6	Startup/Commissioning	68,300
1.1.7	Contingency	172,800
	Total Point Estimate	1,036,600

A new Hazard Category 2 process module of 85,086 ft^2 has been estimated to cost $5,000/$ft^2$ to construct. This cost includes utility systems inside the building but excludes the process equipment. The cost factor used is based on the actual costs incurred to construct previous NNSA facilities. Specific references used were the larger Highly Enriched Uranium Manufacturing Facility (HEUMF) that cost approximately $3,000/$ft^2$, and the smaller Waste Solidification Building (WSB) that cost approximately $4,765/$ft^2$. A higher value was used to reflect the need for safety class utility systems for the process module. A portion of this cost is assumed to represent items that will be procured in advance of construction and shown under the "Equipment Procurement" WBS.

The cost for process support equipment was added to the building construction cost. An allowance of $500/$ft^2$ was applied to the space to be used for this equipment (12,494 ft^2) based on EA Team judgment.

The construction cost includes an estimate for construction of a 2,000-ft^2 enclosed truck bay and dock at $500/$ft^2$. as well as a connecting corridor/tunnel to Plutonium Facility 4 (PF-4) and connection to the Radiological Laboratory Utility Office Building (RLUOB), estimated at $2,000/$ft^2$ (11,290 ft^2).

An allowance of $200/$ft^2$ was used to estimate site preparation and final site grading/landscaping costs, and this has been applied to the approximately 85,000-ft^2 site to be used within Technical Area 55 (TA-55).

Engineering and design was estimated as 40% of the total procurement and construction costs for the new process module, which is representative of historical DOE/NNSA experience for new nuclear facilities.

Facility startup and commissioning is estimated to be 15% of the procurement and construction costs based on EA Team judgment. Startup and commissioning of process equipment was estimated separately, as described below.

Costs to be incurred for project management and support are estimated at 20% of all other costs (excluding contingency), consistent with DOE/NNSA experience.

A contingency/management reserve (MR) allowance of 20% was added for estimate uncertainty for the new nuclear facility, based on the extensive use of all-inclusive parameters to develop the cost estimate.

F.2 Personnel Support Module

Table F-2: Personnel Support Module – Alternative 2a

WBS	Description	Estimate (FY18 $k)
1.2	Personnel Support Module	
1.2.1	Project Management/Support	6,500
1.2.2	Engineering/Design	5,000
1.2.3	Site Preparation/D&D	0
1.2.4	Equipment Procurement	0
1.2.5	Construction/Installation	25,000
1.2.6	Startup/Commissioning	2,500
1.2.7	Contingency	7,800
	Total Point Estimate	**46,800**

The cost of a 50,000-ft^2 Personnel Support Module was estimated using historical average costs for nonhazardous type conventional construction for DOE/NNSA projects. The value used was $500/$ft^2$ and represents the total construction costs for this building.

Engineering and design was estimated as 20% of the total procurement and construction costs for the new process module, representative of historical DOE/NNSA experience for conventional facilities.

Startup and commissioning is estimated to be 10% of the procurement and construction costs based on EA Team judgment.

Costs to be incurred for project management and support are estimated at 20% of all other costs (excluding contingency), consistent with DOE/NNSA experience.

A contingency/MR allowance of 20% was added for estimate uncertainty for the new nuclear facility, based on the extensive use of all-inclusive parameters to develop the cost estimate.

F.3 Pit Production Equipment/Installation

Table F-3: Pit Production Equipment/Installation – Alternative 2a

WBS	Description	Estimate (FY18 $k)
1.3	Pit Production Equipment/Installation	
1.3.1	Project Management/Support	79,900
1.3.2	Engineering/Design	77,300
1.3.3	Site Preparation/D&D	0
1.3.4	Equipment Procurement	105,800
1.3.5	Construction/Installation	151,900
1.3.6	Startup/Commissioning	64,400
1.3.7	Contingency	143,800
	Total Point Estimate	623,100

The equipment list developed for the EA formed the basis of estimated costs for procurement and installation of the pit production equipment. Costs were estimated using an average cost per glovebox (depending on size) derived from recent actual costs provided by LANL and cost estimates recently developed for the Uranium Processing Facility (UPF) project. Costs for equipment were included based on analogies to recent LANL purchases and UPF estimates when possible and augmented by rough order of magnitude (ROM) estimates and EA Team applied allowances.

The average estimates for procurement and installation of gloveboxes used for the EA estimate are as follows:

	Procurement Cost, $	Installation Hours
Smaller Gloveboxes – less than 50 ft^2	500,000	3,000
Mid-Size Gloveboxes – 50 ft^2 to 100 ft^2	1,000,000	6,000
Larger Gloveboxes – more than 50 ft^2	1,500,000	6,000

The estimate includes the equipment that will be installed in the new process module, as well as equipment to be added to PF-4. The installation effort in PF-4 includes an additional productivity adjustment over the unit rates used for installation in the new facility to reflect the access and logistical issues that would be faced during installation in an operating and congested facility. An allowance for preparation of the space to be used in PF-4 for the additional nitrate line is also included in this estimate and is captured in the construction cost shown above.

Installation costs were calculated by applying an average, fully burdened labor rate (consistent with ongoing LANL construction). An allowance was included for construction indirects (equipment, support facilities, etc.) and for Title 3 engineering and construction management oversight.

Below is a breakdown of the costs included in this WBS element.

Procurement of Gloveboxes	75,000,000
Procurement of Equipment	6,755,000
Procurement of Conveyance System	15,000,000
Procurement of Communications/Control Systems	5,000,000
Additional PF-4 Equipment Procurement	4,040,000
Total Procurement Cost	105,795,000,000
Equipment and Glovebox Installation – new Process Building	133,245,000
Installation of Conveyance System	5,000,000
Installation of Additional PF-4 Equipment	10,584,000
Room 401 Modifications	3,100,000
Total Installation Cost	151,929,000

Engineering and design was estimated as 30% of the total procurement and construction costs for the gloveboxes and equipment, representative of historical DOE/NNSA experience for new nuclear facilities, reduced to reflect the inclusion of vendor engineering in the procurement cost.

Startup and commissioning is estimated at 25% of the procurement and construction costs based on EA Team judgment and DOE/NNSA experience for complex nuclear facilities.

Costs to be incurred for project management and support are estimated at 20% of all other costs (excluding contingency), consistent with DOE/NNSA experience.

A contingency/MR allowance of 30% was added for estimate uncertainty (both pricing and scope) for the pit production equipment.

F.4 Support Facilities/Systems (incl. MEB)

Table F-4: Support Facilities/Systems – Alternative 2a

WBS	Description	Estimate (FY18 $k)
1.4	Support Facilities/Systems (incl. MEB)	
1.4.1	Project Management/Support	12,700
1.4.2	Engineering/Design	11,400
1.4.3	Site Preparation/D&D	0
1.4.4	Equipment Procurement	22,700
1.4.5	Construction/Installation	22,700
1.4.6	Startup/Commissioning	6,800
1.4.7	Contingency	19,100
	Total Point Estimate	95,400

This subproject includes the cost to construct a mechanical/electrical building (MEB) estimated at 7,500 ft². A cost of $2,000/ft² was used based on DOE/NNSA historical experience for constructing a nonhazardous building for these purposes. For comparison, the estimated cost for the MEB at the

UPF project is estimated at $2,900/ft², including equipment and escalation, but that cost includes the cost of equipment at a somewhat lower parameter was used for this estimate.

Below is a breakdown of the other elements included in this cost estimate and the basis for those estimates.

Transformers	Assumed ½ cost of UPF (1/3 size)	5,700,000
SC Fire Water Tanks	Assumed ½ cost of UPF (1/3 size)	5,974,000
Fire Water Pumphouse	1,024 ft² at $1,000/sf	1,024,000
Fire Water Pumps/System	Included with Tank costs used	
SC Diesel Generators	Assumed ½ cost of UPF (1/3 size)	2,925,000
DG Enclosure	1,700 ft² at $1000/sf	1,700,000
Gas Tank Pad	4,800 ft² at $200/sf	960,000
Gas System	Assumed 2/3 cost of UPF (1/2 size)	3,324,000
Cooling Towers	Assumed ½ cost of UPF (1/3 size)	4,612,000
Chilled Water System	Assumed ½ cost of UPF (1/3 size)	4,229,000
	Total	$30,448,000

The above values represent total cost estimates, including construction indirects. It was assumed that approximately half of the above estimated costs would represent items that would be procured in advance of construction, with the remaining costs being construction phase costs.

Engineering and design was estimated as 25% of the total procurement and construction costs, representative of historical DOE/NNSA experience and EA Team judgment.

Startup and commissioning is estimated to be 10% of the procurement and construction costs based on EA Team judgment and DOE/NNSA experience for conventional facilities.

Costs to be incurred for project management and support are estimated at 20% of all other costs (excluding contingency), consistent with DOE/NNSA experience.

A contingency/MR allowance of 25% was added for estimate uncertainty (both pricing and scope).

F.5 TA-55 PIDAS Extension/Modification

Table F-5: TA-55 PIDAS Extension/Modification - Alternative 2a

WBS	Description	Estimate (FY18 $k)
1.5	TA-55 PIDAS Extension/Modification	
1.5.1	Project Management/Support	3,200
1.5.2	Engineering/Design	3,300
1.5.3	Site Preparation/D&D	0
1.5.4	Equipment Procurement	3,600
1.5.5	Construction/Installation	7,400
1.5.6	Startup/Commissioning	1,700
1.5.7	Contingency	4,800
	Total Point Estimate	24,000

An estimated 900-ft PIDAS extension will be needed after the new facilities are constructed. A portion of the existing PIDAS will then be removed. The cost to accomplish this work is estimated to be $10,000/ft, a parameter derived from historical NNSA experience and recent cost estimates.

An additional $2,000,000 allowance was included to cover the wall component along Pajarito Road, as shown in the LANL layout drawings.

It was assumed that approximately one-third of the estimated cost would represent elements to be procured in advance of installation, with the remainder being construction phase expenditures.

Engineering and design was estimated as 30% of the total procurement and construction costs, representative of historical DOE/NNSA experience and EA Team judgment.

Startup and commissioning is estimated to be 15% of the procurement and construction costs based on EA Team judgment and DOE/NNSA experience.

Costs to be incurred for project management and support are estimated at 20% of all other costs (excluding contingency), consistent with DOE/NNSA experience.

A contingency/MR allowance of 25% was added for estimate uncertainty (both pricing and scope).

F.6 Other Project Costs

Table F-6: Other Project Costs – Alternative 2a

WBS	Description	Estimate (FY18 $k)
1.6	Other Project Costs	
1.6.1	Conceptual Design	30,000
1.6.2	ES&H (incl. NEPA)	30,000
1.6.3	Spare Parts	5,300
1.6.4	M&O (or Owner Agent) Oversight	93,100
	Total Point Estimate	158,400

Conceptual design phase costs were estimated by assuming that a staff of 100 FTEs would work for 1 year at an average rate of $300,000 per FTE.

The ES&H costs assume that 20 FTEs would be working for a 4-year period (including the EIS phase) and then a total of 10 FTEs would work for 2 additional years to process the various permits and accomplish the other needed ES&H activities before construction starts. An average of $300,000/year per FTE was used to calculate the estimated cost.

Spare parts allowance is calculated as 5% of the equipment procurement value for the pit production equipment.

An allowance for M&O contractor or other Owner's Agent oversight of the total project is estimated at 5% of all other project costs.

F.7 Operations Costs and End-of-Life D&D

Table F-7: Operations Costs and End-of-Life D&D – Alternative 2a

WBS	Description	Estimate (FY18 $k)
2.0	Operations Costs	
2.1	Facility Operations and Maintenance	194,300 per year
2.2	Operations Staffing and Expenses	161,400 per year
2.3	Security Related Costs	26,400 per year
2.4	Waste Transportation and Disposal	17,800 per year
2.5	Periodic Major Upgrades	290,400 twice over life
3.0	End-of-Life D&D	42,900

Staffing levels are based on input from SMEs for 50 ppy production level and represent the incremental staffing that would need to be added at LANL over the staff in place to produce 30 ppy in PF-4.

Facility O&M cost is calculated by applying an average cost of $300,000 per FTE per year for an additional staff of 587 FTEs and adding a 10% allowance for supplies and other direct costs.

Operations staffing and expenses are calculated by applying an average cost of $300,000 per FTE per year for an additional staff of 489 FTEs and adding a 10% allowance for supplies and other direct costs.

Security related cost is calculated by applying an average cost of $300,000 per FTE per year for an additional staff of 80 FTEs and adding a 10% allowance for supplies and other direct costs.

Waste transportation and disposal is the sum of the cost of 40 shipments of TRU waste to WIPP per year at $4,300 per shipment, the disposal of 1,300 cubic meters of LLW at $384 per cubic foot (from AoA), and 6,200 cubic meters of nonhazardous waste at $0.185 per cubic foot (from AoA) per year.

Periodic major upgrades were estimated to occur twice over the 50-year life of these facilities. The estimated cost was estimated to be 10% of the initial capital project cost for new facilities and PIDAS, and 25% of the initial capital project cost for the production and support equipment and systems.

End-of-life D&D costs have been estimated using the DOE cost estimating relationship (CER) based on historical data (see Section 3.1.5.4), as follows:

Facility	Facility Size (sf)	Estimated Cost (FY18 $)
Process Module	95,000	19,289,000
Personnel Support Module	50,000	14,450,000
Area used in PF-4	1,550	3,027,000
MEB	7,500	6,153,000
Total		42,919,000

Appendix G Cost Estimate for Alternative 2b

The estimate for Alternative 2b is organized into seven subprojects, as described below, along with the basis of estimate for each WBS element.

G.1 New Facilities for Pit Production

Table G-1: New Facility for Pit Production – Alternative 2b

WBS	Description	Estimate (FY18 $k)
1.1	New Facility for Pit Production	
1.1.1	Project Management/Support	125,600
1.1.2	Engineering/Design	162,700
1.1.3	Site Preparation/D&D	16,000
1.1.4	Equipment Procurement	36,600
1.1.5	Construction/Installation	354,100
1.1.6	Startup/Commissioning	58,600
1.1.7	Contingency	150,700
	Total Point Estimate	904,300

A new Hazard Category 2 process module of 72,046 ft^2 has been estimated at \$5,000/ft^2 to construct. This cost includes utility systems inside the building but excludes the process equipment. The cost factor used is based on the actual costs incurred to construct previous NNSA facilities. Specific references used were the larger Highly Enriched Uranium Manufacturing Facility (HEUMF) that cost approximately \$3,000/ft^2, and the smaller Waste Solidification Building (WSB) that cost approximately \$4,765/ft^2. A higher value was used to reflect the need for safety class utility systems for the process module. A portion of this cost is assumed to represent items that will be procured in advance of construction and shown under the “Equipment Procurement” WBS.

The cost for process support equipment was added to the building construction cost. An allowance of \$500/ft^2 was applied to the space to be used for this equipment (11,217 ft^2) based on EA Team judgment.

The construction cost includes an estimate for construction of a 2,000-ft^2 enclosed truck bay and dock at \$500/ft^2, as well as a connecting corridor and tunnel to PF-4 and connection to RLUOB, estimated to cost \$2,000/ft^2 (11,930 ft^2).

An allowance of \$200/ft^2 was used to estimate site preparation and final site grading and landscaping costs, which has been applied to the approximately 80,000-ft^2 site to be used within TA-55.

Engineering and design was estimated as 40% of the total procurement and construction costs for the new process module, representative of historical DOE/NNSA experience for new nuclear facilities.

Facility startup and commissioning is estimated to be 15% of the procurement and construction costs based on EA Team judgment. Process equipment was estimated separately, as discussed below.

Costs to be incurred for project management and support are estimated at 20% of all other costs (excluding contingency), consistent with DOE/NNSA experience.

A contingency/MR allowance of 20% was added for estimate uncertainty for the new nuclear facility, based on the extensive use of all-inclusive parameters to develop the cost estimate.

G.2 Personnel Support Module

Table G-2: Personnel Support Module – Alternative 2b

WBS	Description	Estimate (FY18 $k)
1.2	Personnel Support Module	
1.2.1	Project Management/Support	6,500
1.2.2	Engineering/Design	5,000
1.2.3	Site Preparation/D&D	0
1.2.4	Equipment Procurement	0
1.2.5	Construction/Installation	25,000
1.2.6	Startup/Commissioning	2,500
1.2.7	Contingency	7,800
	Total Point Estimate	46,800

The cost of a 50,000- ft^2 Personnel Support Module was estimated using historical average costs for nonhazardous type conventional construction for DOE/NNSA projects. The value used was $500/$ft^2$ and represents the total construction costs for this building.

Engineering and design was estimated as 20% of the total procurement and construction costs for the new process module, representative of historical DOE/NNSA experience for conventional facilities.

Startup and commissioning is estimated to be 10% of the procurement and construction costs based on EA Team judgment.

Costs to be incurred for project management and support are estimated at 20% of all other costs (excluding contingency), consistent with DOE/NNSA experience.

A contingency/MR allowance of 20% was added for estimate uncertainty for the new nuclear facility, based on the extensive use of all-inclusive parameters to develop the cost estimate.

G.3 Pit Production Equipment/Installation

Table G-3: Pit Production Equipment/Installation – Alternative 2b

WBS	Description	Estimate (FY18 $k)
1.3	Pit Production Equipment/Installation	
1.3.1	Project Management/Support	63,900
1.3.2	Engineering/Design	62,000
1.3.3	Site Preparation/D&D	0
1.3.4	Equipment Procurement	86,700
1.3.5	Construction/Installation	119,200
1.3.6	Startup/Commissioning	51,500
1.3.7	Contingency	115,000
	Total Point Estimate	498,300

The equipment list developed for the EA formed the basis of estimated costs for procurement and installation of the pit production equipment. Costs were estimated using an average cost per glovebox (depending on size) derived from recent actual costs provided by LANL, and cost estimates recently developed for the Uranium Processing Facility (UPF) project. Costs for equipment were included based on analogies to recent LANL purchases and UPF estimates when possible and augmented by ROM estimates and EA Team applied allowances.

The average estimates for procurement and installation of gloveboxes used for the EA estimate are as follows:

	Procurement Cost	Installation Hours
Smaller Gloveboxes – less than 50 ft^2	$500,000	3,000
Mid-Size Gloveboxes – 50 $ft^2$to 100 ft^2	$1,000,000	6,000
Larger Gloveboxes – more than 50 ft^2	$1,500,000	6,000

The estimate includes the equipment that will be installed in the new process module, as well as equipment to be added to PF-4. The installation effort in PF-4 includes an additional productivity adjustment over the unit rates used for installation in the new facility to reflect the access and logistical issues that would be faced during installation in an operating and congested facility.

Installation costs were calculated by applying an average, fully-burdened labor rate, consistent with ongoing LANL construction. An allowance was included for construction indirects (equipment, support facilities, etc.) and for Title III engineering and construction management oversight.

Below is a breakdown of the costs included in this WBS element:

Procurement of Gloveboxes	56,500,000
Procurement of Equipment	6,160,500
Procurement of Conveyance System	15,000,000
Procurement of Communications/Control Systems	5,000,000
Additional PF-4 Equipment Procurement	4,040,000
Total Procurement Cost	86,700,500
Equipment and GB Installation - new Process Bldg.	85,050,000
Installation of Conveyance System	5,000,000
Installation of PF-4 Equipment	10,584,000
Total Installation Cost	119,156,000

Engineering and design was estimated as 30% of the total procurement and construction costs for the gloveboxes and equipment, representative of historical DOE/NNSA experience for new nuclear facilities, reduced to reflect the inclusion of vendor engineering in the procurement cost.

Startup and commissioning is estimated to be 25% of the procurement and construction costs based on EA Team judgment and DOE/NNSA experience for complex nuclear facilities.

Costs to be incurred for project management and support are estimated at 20% of all other costs (excluding contingency), consistent with DOE/NNSA experience.

A contingency/MR allowance of 30% was added for estimate uncertainty (both pricing and scope) for the pit production equipment.

G.4 Support Facilities/Systems (including MEB)

Table G-4: Support Facilities/Systems – Alternative 2b

WBS	Description	Estimate (FY18 $k)
1.4	Support Facilities/Systems (incl. MEB)	
1.4.1	Project Management/Support	12,300
1.4.2	Engineering/Design	11,400
1.4.3	Site Preparation/D&D	0
1.4.4	Equipment Procurement	22,700
1.4.5	Construction/Installation	22,700
1.4.6	Startup/Commissioning	4,500
1.4.7	Contingency	18,400
	Total Point Estimate	92,000

This subproject includes the cost to construct an MEB estimated at 7,500 ft^2. A cost of $2,000/$ft^2$ was used based on DOE/NNSA historical experience for constructing a nonhazardous building for these purposes. For comparison, the estimated cost for the MEB at the UPF project is estimated to cost $2,900/$ft^2$, including equipment and escalation but that cost also included equipment costs.

Below is a breakdown of the other elements included in this cost estimate and the basis for those estimates.

Transformers	Assumed ½ cost of UPF (1/3 size)	5,700,000
SC Fire Water Tanks	Assumed ½ cost of UPF (1/3 size)	5,974,000
Fire Water Pumphouse	1,024 ft² at $1,000/ft²	1,024,000
Fire Water Pumps/System	Included with tank costs used	
SC Diesel Generators	Assumed ½ cost of UPF (1/3 size)	2,925,000
DG Enclosure	1,700 ft² at $1,000/ft²	1,700,000
Gas Tank Pad	4,800 ft² at $200/ft²	960,000
Gas System	Assumed 2/3 cost of UPF (1/2 size)	3,324,000
Cooling Towers	Assumed ½ cost of UPF (1/3 size)	4,612,000
Chilled Water System	Assumed ½ cost of UPF (1/3 size)	4,229,000
	Total	30,448,000

The above values represent total cost estimates, including construction indirects. It was assumed that approximately half of the above estimated costs would represent items that would be procured in advance of construction, with the remaining costs being construction phase costs.

Engineering and design was estimated as 25% of the total procurement and construction costs, representative of historical DOE/NNSA experience and EA Team judgment.

Startup and commissioning is estimated to be 10% of the procurement and construction costs based on EA Team judgment and DOE/NNSA experience for conventional facilities.

Costs to be incurred for project management and support are estimated at 20% of all other costs (excluding contingency), consistent with DOE/NNSA experience.

A contingency/MR allowance of 25% was added for estimate uncertainty (both pricing and scope).

G.5 PF-4 Reconfiguration

Table G-5: PF-4 Reconfiguration – Alternative 2b

WBS	Description	Estimate (FY18 $k)
1.5	PF-4 Reconfiguration (excl. Equipment)	
1.5.1	Project Management/Support	3,300
1.5.2	Engineering/Design	4,200
1.5.3	Site Preparation/D&D	0
1.5.4	Equipment Procurement	0
1.5.5	Construction/Installation	10,600
1.5.6	Startup/Commissioning	1,600
1.5.7	Contingency	9,900
	Total Point Estimates	29,600

An allowance has been included for any needed equipment removals or reconfiguration in the spaces within PF-4 that will be used to support the additional 50 ppy pit production. The disassembly and metal preparation functions will be located within PF-4 for this alternative. It is assumed that approximately 50% of the space allocated for those functions in the new process module for Alternative 1 will be needed and used in PF-4. This is in addition to the use of Room 401 for the second nitrate line. The total area assumed needed is 5,275 ft^2. An estimated cost allowance of $2000/$ft^2$ was used to develop the construction cost estimate for this effort, consistent with recent PF-4 experience.

Engineering and design was estimated as 40% of the total procurement and construction costs for the PF-4 reconfiguration, representative of historical DOE/NNSA experience for new nuclear facilities.

Facility startup and commissioning is estimated to be 15% of the procurement and construction costs based on EA Team judgment. Process equipment was estimated separately, as discussed above.

Costs to be incurred for project management and support are estimated at 20% of all other costs (excluding contingency), consistent with DOE/NNSA experience.

A contingency/MR allowance of 50% was added for estimate uncertainty for the PF-4 reconfiguration.

G.6 TA-55 PIDAS Extension/Modification

Table G-6: TA-55 PIDAS Extension/Modification – Alternative 2b

WBS	Description	Estimate (FY18 $k)
1.6	TA-55 PIDAS Extension/Modification	
1.6.1	Project Management/Support	3,200
1.6.2	Engineering/Design	3,300
1.6.3	Site Preparation/D&D	0
1.6.4	Equipment Procurement	3,600
1.6.5	Construction/Installation	7,400
1.6.6	Startup/Commissioning	1,700
1.6.7	Contingency	4,800
	Total Point Estimate	24,000

An estimated 900-ft PIDAS extension will be needed after the new facilities are constructed. A portion of the existing PIDAS will then be removed. The cost to accomplish this work is estimated to be $10,000/ft, a parameter derived from historical NNSA experience and recent cost estimates.

An additional $2,000,000 allowance was included to cover the wall component along Pajarito Road, shown in the LANL layout drawings.

It was assumed that approximately one-third of the estimated cost would represent elements to be procured in advance of installation, with the remainder being construction phase expenditures.

Engineering and design was estimated as 30% of the total procurement and construction costs, representative of historical DOE/NNSA experience and EA Team judgment.

Startup and commissioning is estimated to be 15% of the procurement and construction costs based on EA Team judgment and DOE/NNSA experience.

Costs to be incurred for project management and support are estimated at 20% of all other costs (excluding contingency), consistent with DOE/NNSA experience.

A contingency/MR allowance of 25% was added for estimate uncertainty (both pricing and scope).

G.7 Other Project Costs

Table G-7: Other Project Costs – Alternative 2b

WBS	Description	Estimate (FY18 $k)
1.7	Other Project Costs	
1.7.1	Conceptual Design	30,000
1.7.2	ES&H (incl. NEPA)	30,000
1.7.3	Spare Parts	4,300
1.7.4	M&O (or Owner Agent) Oversight	81,500
	Total Point Estimate	145,800

Conceptual design phase costs were estimated by assuming a staff of 100 FTEs would work for 1 year at an average rate of $300,000 per FTE.

The ES&H costs assume that 20 FTEs would be working for a 4-year period (including the EIS phase) and then a total of 10 FTEs would work for two additional years to process the various permits and accomplish the other needed ES&H activities before construction starts. An average of $300,000 per year per FTE was used to calculate the estimated cost.

The spare parts allowance is calculated as 5% of the equipment procurement value for the pit production equipment.

An allowance for M&O contractor or other owner's agent oversight of the total project is estimated at 5% of all other project costs.

G.8 Operations Costs and End-of-Life D&D

Table G-8: Operations Costs and End-of-Life D&D – Alternative 2b

WBS	Description	Estimate (FY18 $k)
2.0	**Operations Costs**	
2.1	Facility Operations and Maintenance	144,100 per year
2.2	Operations Staffing and Expenses	114,500 per year
2.3	Security Related Costs	19,800 per year
2.4	Waste Transportation and Disposal	17,800 per year
2.5	Periodic Major Upgrades	248,000 twice over life
3.0	**End-of-Life D&D**	**45,400**

Staffing levels are based on input from SMEs for 50-ppy production level and represent the incremental staffing that would need to be added at LANL over the staff in place to produce 30 ppy in PF-4.

Facility O&M cost is calculated by applying an average cost of $300,000 per FTE per year for an additional staff of 426 FTEs and adding a 10% allowance for supplies and other direct costs.

In addition, the charge for the space to be used in PF-4 that would be allocated to the pit production program was included under facility O&M. The rate used ($391/ft^2) was derived by escalating a cost previously provided for the Surplus Plutonium Disposition AoA.

Operations staffing and expenses are calculated by applying an average cost of $300,000 per FTE per year for an additional staff of 347 FTEs and adding a 10% allowance for supplies and other direct costs.

Security related cost is calculated by applying an average cost of $300,000 per FTE per year for an additional staff of 60 FTEs and adding a 10% allowance for supplies and other direct costs.

Waste transportation and disposal is the sum of the cost of 40 shipments of TRU waste to WIPP per year at $4,300 per shipment, the disposal of 1,300 cubic meters of LLW at $384 per cubic foot (from AoA), and 6,200 cubic meters of nonhazardous waste at $0.185 per cubic foot (from AoA) per year.

Periodic major upgrades were estimated to occur twice over the 50-year life of these facilities. The cost was estimated to be 10% of the initial capital project cost for new facilities and PIDAS, and 25% of the initial capital project cost for the production and support equipment and systems.

End-of-life D&D costs have been estimated using the DOE CER based on historical data (see Section 3.1.5.4), as follows:

Facility	Facility Size (ft^2)	Estimated Cost (FY18 $)
Process Module	83,000	18,151,000
Personnel Support Module	50,000	14,450,000
Area used in PF-4	9,000	6,679,000
MEB	7,500	6,153,000
Total		45,433,000

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Appendix H Cost Estimate for Alternative 2c

The estimate for Alternative 2c is organized into seven subprojects, as described below, along with the basis of estimate for each WBS element.

H.1 PF-4 Additional Equipment

Table H-1: PF-4 Additional Equipment – Alternative 2c

WBS	Description	Estimate (FY18 $k)
1.1	PF-4 Additional Equipment	
1.1.1	Project Management/Support	15,200
1.1.2	Engineering/Design	15,200
1.1.3	Site Preparation/D&D	10,500
1.1.4	Equipment Procurement	11,200
1.1.5	Construction/Installation	29,100
1.1.6	Startup/Commissioning	10,100
1.1.7	Contingency	27,400
	Total Point Estimate	118,700

The site preparation estimate covers potential modifications and removal of existing equipment in the spaces to be used in PF-4 under the LANL proposed plan. The space estimates are as shown below, and the effort was estimated assuming $2,000/ft^2.

Room	Size (ft2)
317	500
319	1,050
327	650
400	1,550
429	900
58	600
Total	5,250

The cost to procure and install new gloveboxes and equipment was estimated using the same unit costs as used for the other alternatives and applied to the list of equipment provided in LANL's proposed plan.

Engineering and design was estimated as 30% of the total procurement and construction costs for the gloveboxes and equipment, representative of historical DOE/NNSA experience for new nuclear facilities, reduced to reflect the inclusion of vendor engineering in the procurement cost.

Startup and commissioning is estimated to be 25% of the procurement and construction costs based on EA Team judgment and DOE/NNSA experience for complex nuclear facilities.

Costs to be incurred for project management and support are estimated at 20% of all other costs (excluding contingency), consistent with DOE/NNSA experience.

A contingency/MR allowance of 30% was added for estimate uncertainty (both pricing and scope) for the pit production equipment.

H.2 Laboratory Modules

Table H-2: Laboratory Modules – Alternative 2c

WBS	Description	Estimate (FY18 $k)
1.2	Laboratory Modules	
1.2.1	Project Management/Support	142,300
1.2.2	Engineering/Design	172,500
1.2.3	Site Preparation/D&D	0
12.4	Equipment Procurement	69,800
1.2.5	Construction/Installation	361,500
1.2.6	Startup/Commissioning	107,800
1.2.7	Contingency	256,200
	Total Point Estimate	1,110,100

The cost to construct each of the three laboratory modules was estimated at $6,000/ft^2$. This cost includes utility systems inside the building, but excludes the process equipment. The cost factor used is based on the actual costs incurred to construct previous NNSA facilities. This value is reflective of the smaller size of a module as compared to the new process module in Alternatives 2a and 2b and the anticipated site logistical challenges, including the buried structures. Construction of the three laboratory modules is estimated at $237.8 million.

To prepare the site for the laboratory modules and all other new construction for this alternative, a 100,000-ft^2 site was assumed to cost $300/$ft^2$ due to the amount of excavation and fill that will be required.

This subproject also includes the cost to procure and install the equipment identified in LANL's proposed plan for these modules. The cost to procure and install new gloveboxes and equipment was estimated using the same unit costs as used for the other alternatives.

Engineering and design was estimated as 40% of the total procurement and construction costs for the laboratory modules and equipment therein, representative of historical DOE/NNSA experience for new nuclear facilities.

Startup and commissioning is estimated to be 25% of the procurement and construction costs based on EA Team judgment and DOE/NNSA experience for complex nuclear facilities.

Costs to be incurred for project management and support are estimated at 20% of all other costs (excluding contingency), consistent with DOE/NNSA experience.

A contingency/MR allowance of 30% was added for estimate uncertainty for the laboratory modules and the equipment to be installed therein.

H.3 Radiography Bays

Table H-3: Radiography Bays – Alternative 2c

WBS	Description	Estimate (FY18 $k)
1.3	Radiography Bays	
1. 3.1	Project Management/Support	17,300
1.3.2	Engineering/Design	20,900
1.3.3	Site Preparation/D&D	0
1.3.4	Equipment Procurement	5,000
1.3.5	Construction/Installation	47,300
1.3.6	Startup/Commissioning	13,100
1.3.7	Contingency	31,100
	Total Point Estimate	**134,700**

The cost to construct each of the two radiography bays was estimated at $7,500/ft^2$. This cost includes utility systems inside the building but excludes the process equipment. The cost factor used is based on the actual costs incurred to construct previous NNSA facilities. This value reflects the smaller size of the bays, the high level of shielding expected for these facilities, and the anticipated site logistical challenges. Construction of the two radiography bays is estimated at $46.8 million.

This subproject also includes an allowance for equipment to be procured ($5,000,000) and installed ($500,000) in the radiography bays.

Engineering and design was estimated as 40% of the total procurement and construction costs for the laboratory modules and equipment therein, representative of historical DOE/NNSA experience for new nuclear facilities.

Startup and commissioning is estimated to be 25% of the procurement and construction costs based on EA Team judgment and DOE/NNSA experience for complex nuclear facilities.

Costs to be incurred for project management and support are estimated at 20% of all other costs (excluding contingency), consistent with DOE/NNSA experience.

A contingency/MR allowance of 30% was added for estimate uncertainty for the laboratory modules and the equipment to be installed therein.

H.4 Other TA-55 Construction/Additions

Table H-4: Other TA-55 Construction/Additions – Alternative 2c

WBS	Description	Estimate (FY18 $k)
1.43	Other TA-55 Construction/Additions	
1.4.1	Project Management/Support	83,500
1.4.2	Engineering/Design	64,300
1.4.3	Site Preparation/D&D	112,500
1.4.4	Equipment Procurement	7,000
1.4.5	Construction/Installation	202,100
1.4.6	Startup/Commissioning	31,400
1.4.7	Contingency	100,200
	Total Point Estimate	601,000

The site that houses the laboratory modules, radiography bays, and facilities listed below is estimated at 225,000 ft^2. Excavation, foundation walls and slabs, and backfill will be required to execute the LANL proposed plan. This cost was estimated using a parameter of $500/$ft^2$, which represents a conservative EA Team judgment as to the approximate cost of this work.

The other construction costs estimated within this subproject are shown below. The $/$ft^2$ parameters used represent EA Team judgment and are consistent with DOE/NNSA historical costs and the parameters used throughout this EA. When appropriate, the values include procurement and installation of equipment as well as the facility construction cost (as indicated by an asterisk [*]).

	Element	Gross Square Feet	$/$ft^2$	Construction Cost
HC-2	Ramp to PF-4	8,079	4,000	32,316,000
	Other Support Areas	27,317	5,000	136,585,000
Non-HC-2 Below Grade	Tunnel to RLUOB	3,546	1,000	3,546,000
	Mechanical Support	393	2,000*	796,000
	Change Room Overflow	282	1,000	282,000
	Women's Change Room	626	1,000	626,000
	Men's Change Room	626	1,000	626,000
	Entry Control Facility	1,633	1,500*	2,449,500
	EFC Office	466	1,000	466,000
	EFC Work Room	460	1,000	460,000
	Air Lock	628	1,500*	942,000
	Sally Port	320	1,500*	480,000
	Freight Elevator Vestibule	730	1,000	730,000
	Freight Elevator	654	1,500*	981,000
Non-HC-2 Above Grade	Auxiliary Building	9,600	2,000*	19,200,000
	Support Building	2,020	500	1,010,000
	Fire Water Base	3,000	200	600,000
	Total Construction			202,085,500

In addition, allowances were included in the estimate for the procurement of the fire water tank and pumps ($5,974,000, same as for Alternative 1) and the freight elevator ($1,000,000).

Engineering and design was estimated as 20% of the total procurement and construction costs.

Startup and commissioning is estimated to be 25% of the procurement and construction costs based on EA Team judgment.

Costs to be incurred for project management and support are estimated at 20% of all other costs (excluding contingency), consistent with DOE/NNSA experience.

A contingency/MR allowance of 20% was added for estimate uncertainty.

H.5 TA-55 PIDAS Extension/Modification

Table H-5: TA-55 PIDAS Extension/Modification – Alternative 2c

WBS	Description	Estimate (FY18 $k)
1.5	TA-55 PIDAS Extension/Modification	
1.5.1	Project Management/Support	3,200
1.5.2	Engineering/Design	3,300
1.5.3	Site Preparation/D&D	0
15.4	Equipment Procurement	3,600
1.5.5	Construction/Installation	7,400
1.5.6	Startup/Commissioning	1,700
1.5.7	Contingency	4,800
	Total Point Estimate	**24,000**

An estimated 900-ft PIDAS extension will be needed after the new facilities are constructed. A portion of the existing PIDAS will then be removed. The cost to accomplish this work is estimated to be $10,000/ft, a parameter derived from historical NNSA experience and recent cost estimates.

An additional $2,000,000 allowance was included to cover the wall component along Pajarito Road, as shown in the LANL layout drawings.

It was assumed that approximately one-third of the estimated cost would represent elements to be procured in advance of installation, with the remainder being construction phase expenditures.

Engineering and design was estimated as 30% of the total procurement and construction costs, representative of historical DOE/NNSA experience and EA Team judgment.

Startup and commissioning is estimated to be 15% of the procurement and construction costs based on EA Team judgment and DOE/NNSA experience.

Costs to be incurred for project management and support are estimated at 20% of all other costs (excluding Contingency), consistent with DOE/NNSA experience.

A contingency/MR allowance of 25% was added for estimate uncertainty (both pricing and scope).

H.6 Other Project Costs

Table H-6: Other Project Costs – Alternative 2c

WBS	Description	Estimate (FY18 $k)
1.7	Other Project Costs	
1.7.1	Conceptual Design	30,000
1.7.2	ES&H (incl. NEPA)	30,000
1.7.3	Spare Parts	4,300
1.7.4	M&O (or Owner Agent) Oversight	101,100
	Total Point Estimate	165,400

Conceptual design phase costs were estimated by assuming a staff of 100 FTEs would work for 1 year at an average rate of $300,000 per FTE.

The ES&H costs assume that 20 FTEs would be working for a 4-year period (including the EIS phase) and then a total of 10 FTEs would work for two additional years to process the various permits and accomplish the other needed ES&H activities before construction starts. An average of $300,000 per year per FTE was used to calculate the estimated cost.

Spare parts allowance is calculated as 5% of the equipment procurement value for the pit production equipment.

An allowance for M&O contractor or other Owner's Agent oversight of the total project is estimated at 5% of all other project costs.

H.7 Operations Costs and End-of-Life D&D

Table H-7: Operations Costs and End-of-Life D&D– Alternative 2c

WBS	Description	Estimate (FY18 $k)
2.0	Operations Costs	
2.1	Facility Operations and Maintenance	149,000 per year
2.2	Operations Staffing and Expenses	119,700 per year
2.3	Security Related Costs	23,400 per year
2.4	Waste Transportation and Disposal	19,800 per year
2.5	Periodic Major Upgrades	308,000 twice over life
3.0	End-of-Life D&D	61,900

Staffing levels are based on input from SMEs for 50 ppy production level and represent the incremental staffing that would need to be added at LANL over the staff in place to produce 30 ppy in PF-4.

Facility O&M cost is calculated by applying an average cost of $300,000 per FTE per year for an additional staff of 445 FTEs and adding a 10% allowance for supplies and other direct costs.

In addition, the charge for the space to be used in PF-4 that would be allocated to the pit production program was included under facility O&M. The rate used ($391/ft^2) was derived by escalating a cost previously provided for the Surplus Plutonium Disposition AoA.

Operations staffing and expenses are calculated by applying an average cost of $300,000 per FTE per year for an additional staff of 363 FTEs and adding a 10% allowance for supplies and other direct costs.

Security related cost is calculated by applying an average cost of $300,000 per FTE per year for an additional staff of 60 FTEs and adding a 10% allowance for supplies and other direct costs.

Waste transportation and disposal is the sum of the cost of 40 shipments of TRU waste to WIPP per year at $4,300 per shipment, the disposal of 1,300 cubic meters of LLW at $384 per cubic foot (from AoA), and 6,200 cubic meters of nonhazardous waste at $0.185 per cubic foot (from AoA) per year.

Periodic major upgrades were estimated to occur twice over the 50-year life of these facilities. The estimated cost was estimated to be 10% of the initial capital project cost for miscellaneous facilities and PIDAS, and 18% of the initial capital project cost for the new modules and equipment.

In addition to the annual costs shown above, which apply during the period after the new laboratory modules and radiography bays become operational, LANL proposes to operate using two labor shifts to attain the 80 ppy production levels earlier. During that time, the incremental estimated costs are as shown below, based on SME input. The labor costs include a 20% shift premium.

	FTEs	Total Annual Cost[1]
Support Personnel	163	$66,600,000 per year
Security Personnel	13	$5,100,000 per year
Production Personnel	232	$91,900,000 per year
[1]Includes supplies, other direct costs, and shift premium.		

The above annual costs are assumed to begin after PF-4 CD-4 is approved and continue through three years after the CD-4 for the new modules is approved, during the ramp-up to full operations of the new facilities. From that point forward, the operational phase costs discussed earlier (and which are the same as used for the other alternatives) continues until a total of 50 years of operations have been achieved (combining both operational periods).

There is also an allowance for added staffing to support the start-up and commissioning of the new modules, while double shift operations continue at PF-4. That estimated staffing (also based on SME input) is 25 support personnel, 5 added security personnel, and 92 additional operational staff.

End-of-life D&D costs have been estimated using the DOE CER based on historical data (see Section 3.1.5.4), as follows:

Facility	Facility Size (ft^2)	Estimated Cost (FY18 $)
Laboratory Module A	13,118	7,913,000
Laboratory Module B	13,118	7,913,000
Laboratory Module C	13,989	7,987,000
Radiography 1	3,318	4,263,000
Radiography 2	2,927	4,029,000
Auxiliary Building	9,600	6,876,000
Support Building	2,020	3,410,000
Other Areas	48,760	14,287,000
Areas used in PF-4	5,250	5,241,000
Total		61,919,000

Appendix I Schedule for Alternative 1

Both the Critical Path Schedule and Full Schedule for Alternative 1 are below. The Critical Path Schedule is on Page I-3. The Full Schedule begins on Page I-5.

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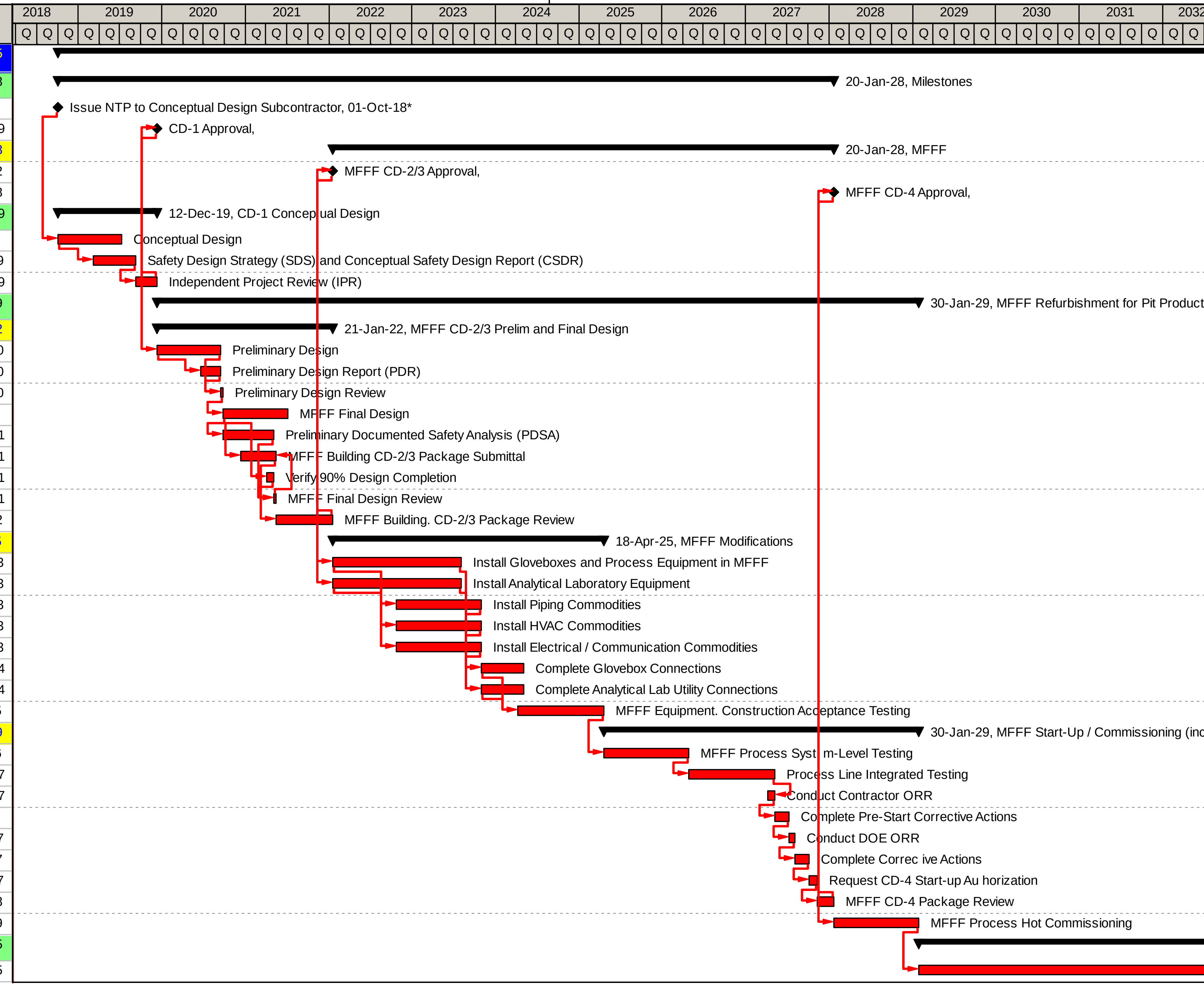
Pu Pit Production Engineering Assessment

Alternative 1 - Modfy MFFF at SRS with Production Modules

19-Apr-2018
Critical Path Schedule

Activity ID	Activity Name	Original Duration	Start	Finish
Alternative 1 - Modify MFFF at SRS with Production Module		190m	01-Oct-18	04-Jan-35
Milestones		109m	01-Oct-18	20-Jan-28
MS20	Issue NTP to Conceptual Design Subcontractor	0m	01-Oct-18*	
MS04	CD-1 Approval	0m		12-Dec-19
MFFF		70m	21-Jan-22	20-Jan-28
MS10	MFFF CD-2/3 Approval	0m		21-Jan-22
MS13	MFFF CD-4 Approval	0m		20-Jan-28
CD-1 Conceptual Design		14m	01-Oct-18	12-Dec-19
MFFF110	Conceptual Design	9m	01-Oct-18	10-Jul-19
MFFF145	Safety Design Strategy (SDS) and Conceptual Safety Design Repor	6m	08-Mar-19	10-Sep-19
MFFF150	Independent Project Review (IPR)	3m	10-Sep-19	12-Dec-19
MFFF Refurbishment for Pit Production		107m	12-Dec-19	30-Jan-29
MFFF CD-2/3 Prelim and Final Design		25m	12-Dec-19	21-Jan-22
MFFF175	Preliminary Design	9m	12-Dec-19	17-Sep-20
MFFF190	Preliminary Design Report (PDR)	3m	17-Jun-20	17-Sep-20
MFFF195	Preliminary Design Review	0m	17-Sep-20	24-Sep-20
A330	MFFF Final Design	9m	24-Sep-20	05-Jul-21
A360	Preliminary Documented Safety Analysis (PDSA)	7m	24-Sep-20	04-May-21
A375	MFFF Building CD-2/3 Package Submittal	5m	11-Dec-20	18-May-21
A355	Verify 90% Design Completion	1m	02-Apr-21	04-May-21
A370	MFFF Final Design Review	0m	04-May-21	18-May-21
A380	MFFF Building. CD-2/3 Package Review	8m	18-May-21	21-Jan-22
MFFF Modifications		38m	21-Jan-22	18-Apr-25
A35	Install Gloveboxes and Process Equipment in MFFF	18m	21-Jan-22	02-Aug-23
A595	Install Analytical Laboratory Equipment	18m	21-Jan-22	02-Aug-23
A65	Install Piping Commodities	12m	26-Oct-22	02-Nov-23
A70	Install HVAC Commodities	12m	26-Oct-22	02-Nov-23
A75	Install Electrical / Communication Commodities	12m	26-Oct-22	02-Nov-23
A76	Complete Glovebox Connec ions	6m	02-Nov-23	06-May-24
A77	Complete Analytical Lab Utility Connections	6m	02-Nov-23	06-May-24
A80	MFFF Equipment. Construc ion Acceptance Testing	12m	09-Apr-24	18-Apr-25
MFFF Start-Up / Commissioning (incl. ORR)		44m	18-Apr-25	30-Jan-29
A615	MFFF Process System-Level Testing	12m	18-Apr-25	29-Apr-26
A650	Process Line Integrated Testing	12m	29-Apr-26	07-May-27
A655	Conduct Contractor ORR	1m	07-Apr-27	07-May-27
A660	Complete Pre-Start Corrective Actions	2m	07-May-27	08-Jul-27
A670	Conduct DOE ORR	1m	08-Jul-27	06-Aug-27
A680	Complete Corrective Actions	2m	06-Aug-27	07-Oct-27
A665	Request CD-4 Start-up Authorization	1m	07-Oct-27	09-Nov-27
A675	MFFF CD-4 Package Review	2m	09-Nov-27	20-Jan-28
A715	MFFF Process Hot Commissioning	12m	20-Jan-28	30-Jan-29
Transition to War Reserve (WR) Production		72m	30-Jan-29	04-Jan-35
A720	Transition to WR Production	72m	30-Jan-29	04-Jan-35



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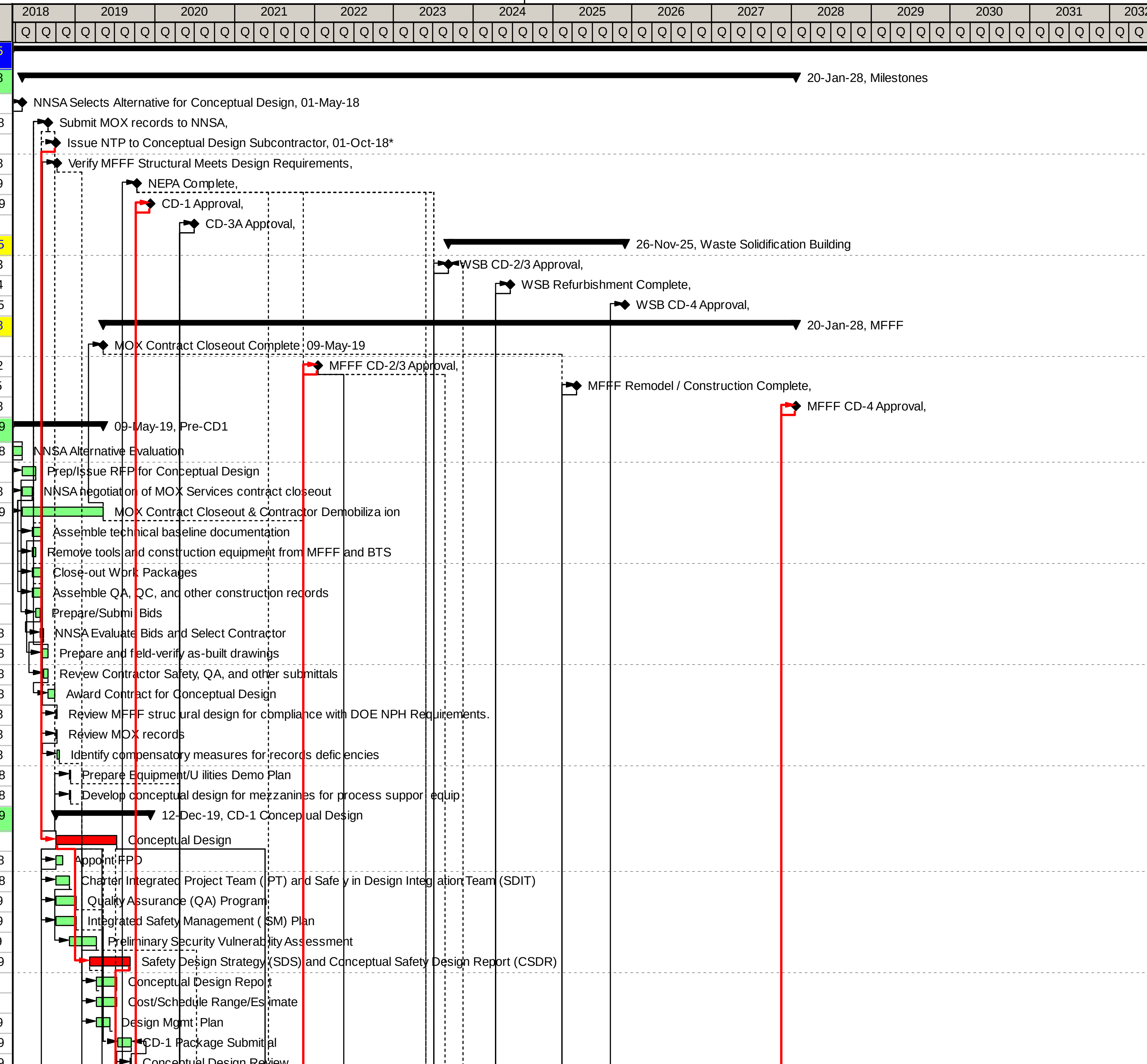
Activity ID	Activity Name	Original Duration	Start	Finish
Alternative 1 - Modfy MFFF at SRS with Production Module		197m	16-Mar-18	04-Jan-35
Milestones		114m	01-May-18	20-Jan-28
MS01	NNSA Selects Alternative for Conceptual Design	0m	01-May-18	
MS02	Submit MOX records to NNSA	0m		29-Aug-18
MS20	Issue NTP to Conceptual Design Subcontractor	0m	01-Oct-18*	
MS03	Verify MFFF Structural Meets Design Requirements	0m		09-Oct-18
MS06	NEPA Complete	0m		09-Oct-19
MS04	CD-1 Approval	0m		12-Dec-19
MS05	CD-3A Approval	0m		01-Jul-20
Waste Solidification Building		26m	11-Sep-23	26-Nov-25
MS07	WSB CD-2/3 Approval	0m		11-Sep-23
MS08	WSB Refurbishment Complete	0m		18-Jun-24
MS09	WSB CD-4 Approval	0m		26-Nov-25
MFFF		102m	09-May-19	20-Jan-28
MS11	MOX Contract Closeout Complete	0m	09-May-19	
MS10	MFFF CD-2/3 Approval	0m		21-Jan-22
MS12	MFFF Remodel / Construction Complete	0m		18-Apr-25
MS13	MFFF CD-4 Approval	0m		20-Jan-28
Pre-CD1		14m	16-Mar-18	09-May-19
MFFF10	NNSA Alternative Evaluation	2m	16-Mar-18	01-May-18
MFFF15	Prep/Issue RFP for Conceptual Design	2m	01-May-18	02-Jul-18
MFFF25	NNSA negotiation of MOX Services contract closeout	1m	01-May-18	14-Jun-18
A710	MOX Contract Closeout & Contractor Demobilization	12m	01-May-18	09-May-19
MFFF40	Assemble technical baseline documentation	1m	14-Jun-18	30-Jul-18
MFFF35	Remove tools and construction equipment from MFFF and BTS	1m	14-Jun-18	03-Jul-18
MFFF45	Close-out Work Packages	1m	14-Jun-18	30-Jul-18
MFFF50	Assemble QA, QC, and other construction records	1m	14-Jun-18	30-Jul-18
MFFF20	Prepare/Submit Bids	1m	02-Jul-18	24-Jul-18
MFFF30	NNSA Evaluate Bids and Select Contractor	0m	24-Jul-18	07-Aug-18
MFFF60	Prepare and field-verify as-built drawings	1m	30-Jul-18	29-Aug-18
MFFF55	Review Contractor Safety, QA, and other submittals	1m	07-Aug-18	28-Aug-18
MFFF65	Award Contract for Conceptual Design	1m	28-Aug-18	26-Sep-18
MFFF70	Review MFFF structural design for compliance with DOE NPH Req	0m	01-Oct-18	09-Oct-18
MFFF75	Review MOX records	0m	01-Oct-18	09-Oct-18
MFFF80	Identify compensatory measures for records deficiencies	0m	09-Oct-18	16-Oct-18
MFFF85	Prepare Equipment/Utilities Demo Plan	0m	03-Dec-18	10-Dec-18
MFFF90	Develop conceptual design for mezzanines for process support equ	0m	03-Dec-18	10-Dec-18
CD-1 Conceptual Design		14m	01-Oct-18	12-Dec-19
MFFF110	Conceptual Design	9m	01-Oct-18	10-Jul-19
MFFF115	Appoint FPD	1m	01-Oct-18	01-Nov-18
MFFF140	Charter Integrated Project Team (IPT) and Safety in Design Integra	2m	01-Oct-18	03-Dec-18
MFFF100	Quality Assurance (QA) Program	3m	01-Oct-18	04-Jan-19
MFFF105	Integrated Safety Management (ISM) Plan	3m	01-Oct-18	04-Jan-19
MFFF185	Preliminary Security Vulnerability Assessment	4m	03-Dec-18	08-Apr-19
MFFF145	Safety Design Strategy (SDS) and Conceptual Safety Design Repor	6m	08-Mar-19	10-Sep-19
MFFF120	Conceptual Design Report	3m	08-Apr-19	10-Jul-19
MFFF125	Cost/Schedule Range/Estimate	3m	08-Apr-19	10-Jul-19
MFFF130	Design Mgmt. Plan	2m	08-Apr-19	07-Jun-19
MFFF160	CD-1 Package Submittal	2m	16-Jul-19	16-Sep-19
MFFF155	Conceptual Design Review	0m	10-Sep-19	16-Sep-19



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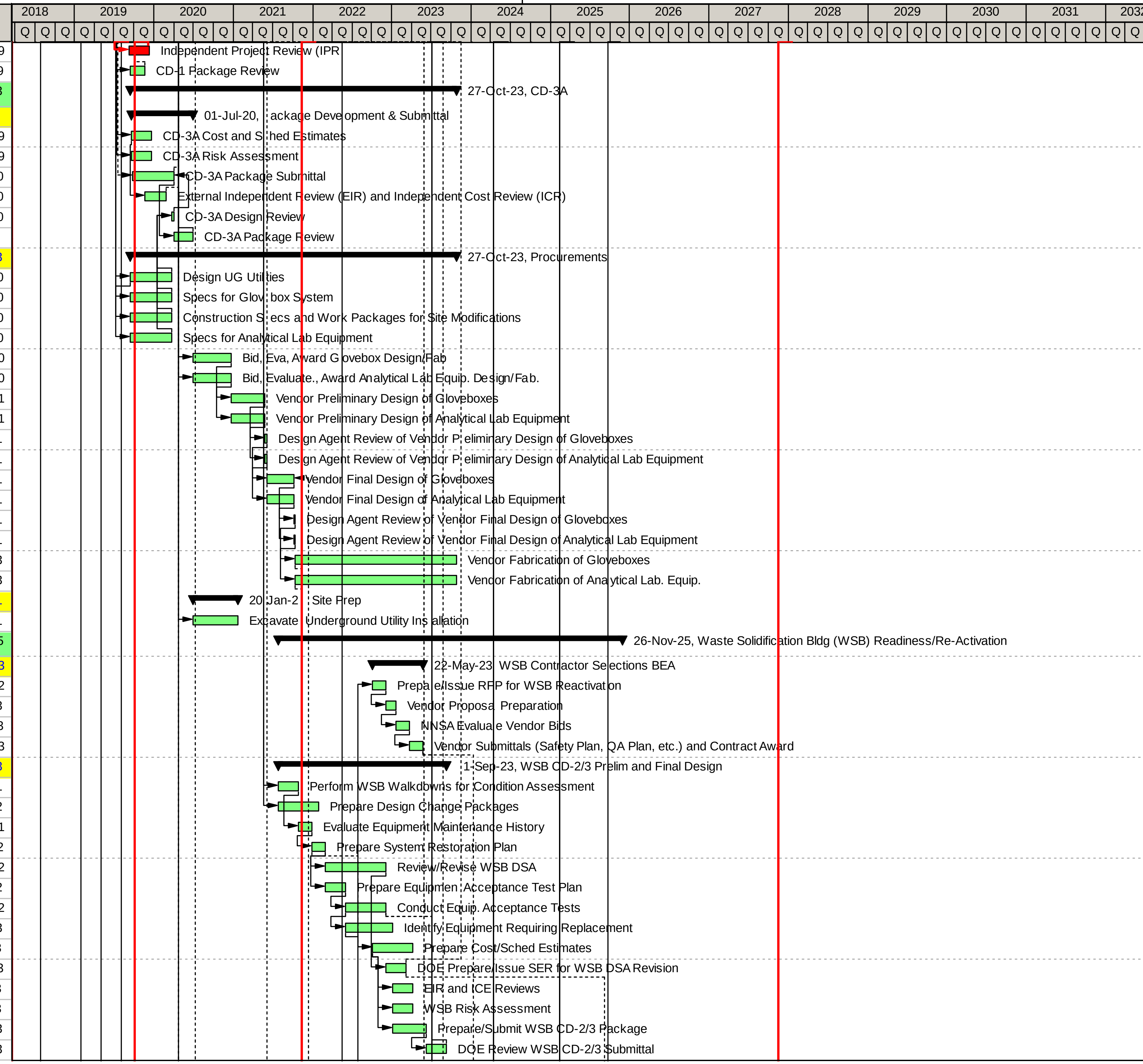
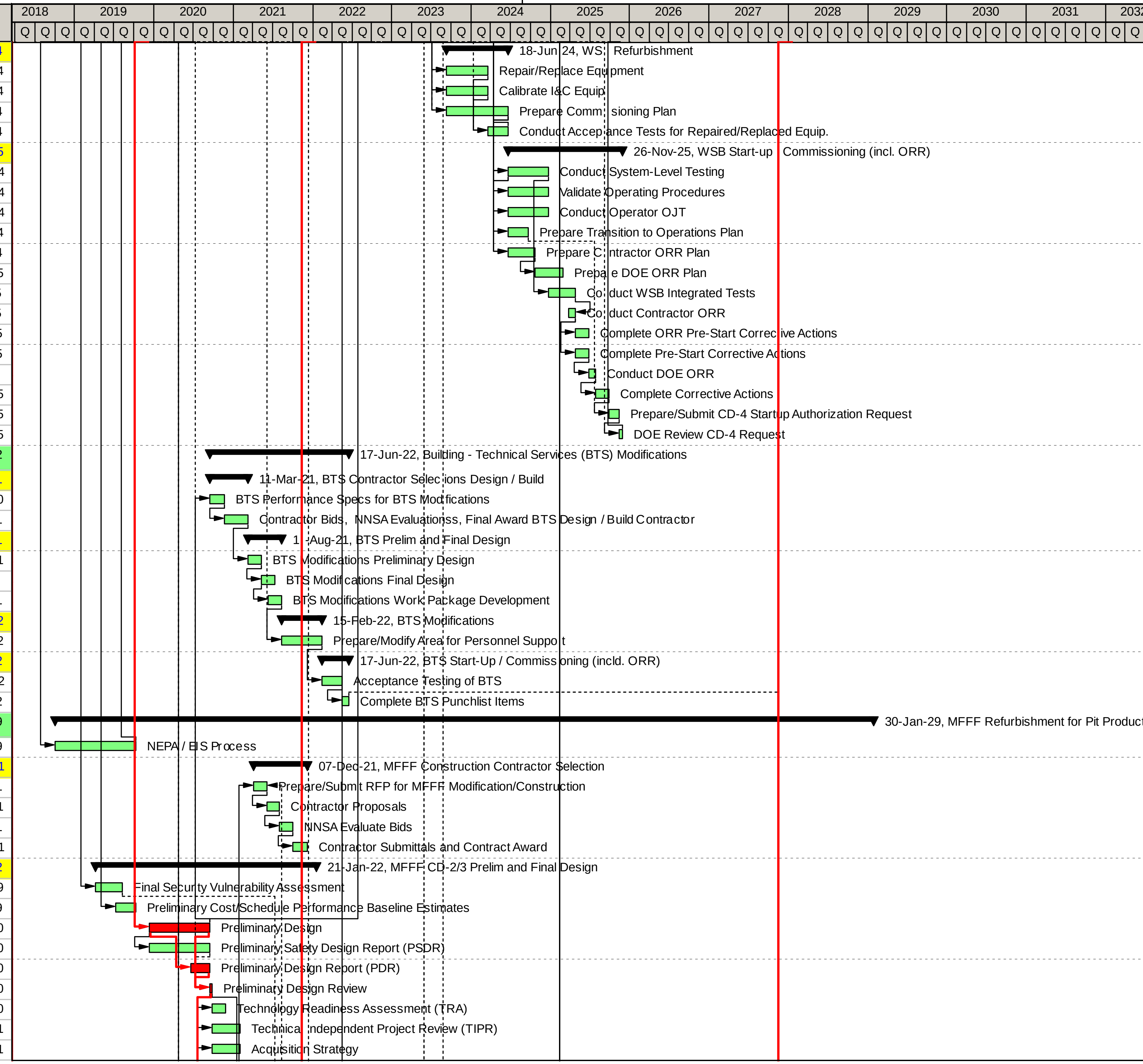
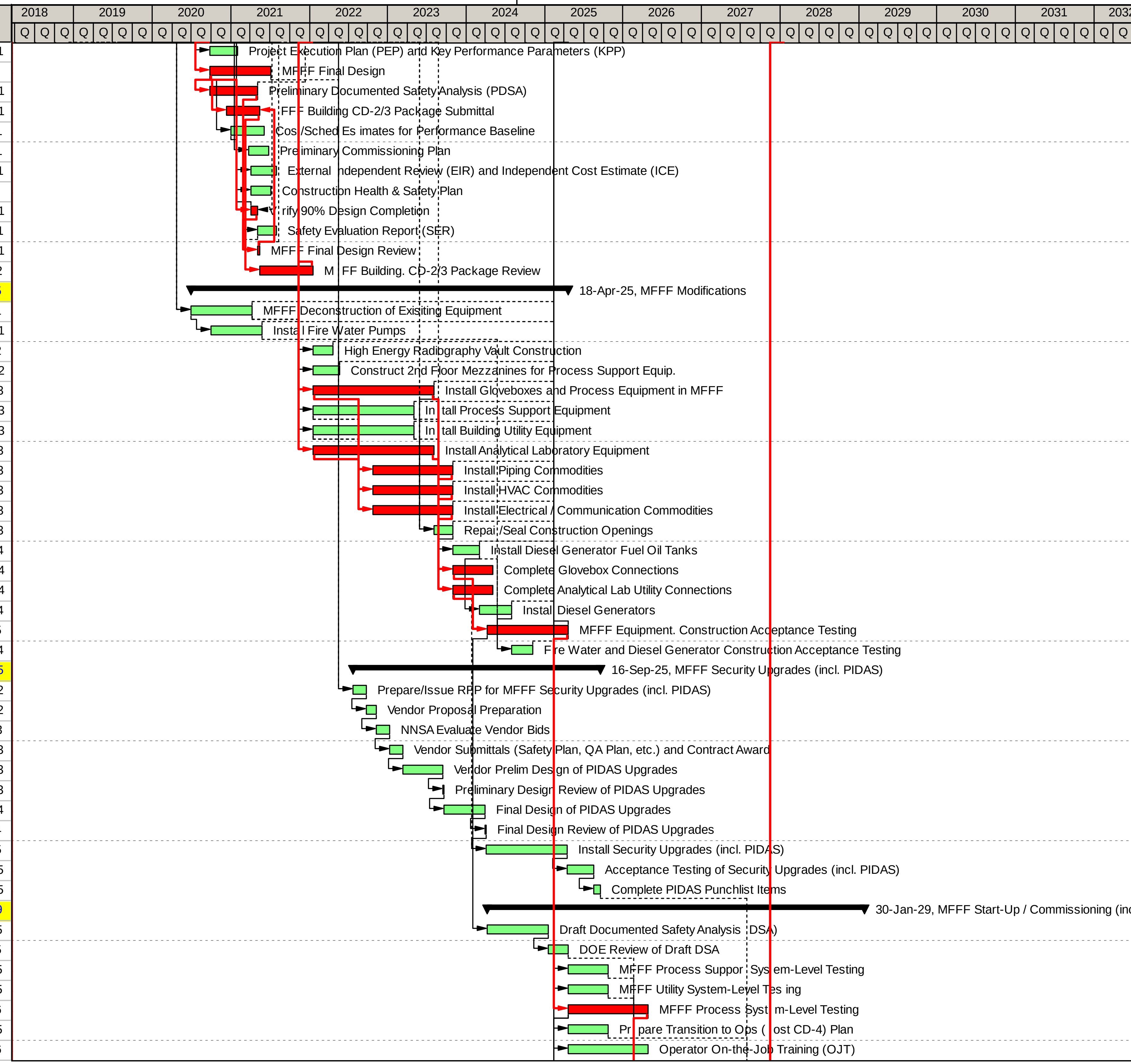
Activity ID	Activity Name	Original Duration	Start	Finish
MFFF150	Independent Project Review (IPR)	3m	10-Sep-19	12-Dec-19
MFFF165	CD-1 Package Review	2m	16-Sep-19	18-Nov-19
CD-3A		48m	16-Sep-19	27-Oct-23
Package Development & Submittal		9m	17-Sep-19	01-Jul-20
MFFF205	CD-3A Cost and Sched Estimates	3m	17-Sep-19	20-Dec-19
MFFF210	CD-3A Risk Assessment	3m	17-Sep-19	20-Dec-19
MFFF240	CD-3A Package Submittal	6m	23-Sep-19	31-Mar-20
MFFF245	External Independent Review (EIR) and Independent Cost Review (	3m	19-Nov-19	25-Feb-20
MFFF235	CD-3A Design Review	0m	24-Mar-20	31-Mar-20
MFFF250	CD-3A Package Review	3m	31-Mar-20	01-Jul-20
Procurements		48m	16-Sep-19	27-Oct-23
MFFF215	Design UG Utilities	6m	16-Sep-19	24-Mar-20
MFFF225	Specs for Glovebox System	6m	16-Sep-19	24-Mar-20
MFFF230	Construction Specs and Work Packages for Site Modifications	6m	16-Sep-19	24-Mar-20
A385	Specs for Analytical Lab Equipment	6m	16-Sep-19	24-Mar-20
MFFF255	Bid, Eva, Award Glovebox Design/Fab	6m	01-Jul-20	22-Dec-20
A390	Bid, Evaluate., Award Analytical Lab Equip. Design/Fab.	6m	01-Jul-20	22-Dec-20
MFFF226	Vendor Preliminary Design of Gloveboxes	5m	22-Dec-20	27-May-21
A391	Vendor Preliminary Design of Analytical Lab Equipment	5m	23-Dec-20	27-May-21
MFFF227	Design Agent Review of Vendor Preliminary Design of Gloveboxes	0m	27-May-21	04-Jun-21
A392	Design Agent Review of Vendor Preliminary Design of Analytical Lab	0m	27-May-21	04-Jun-21
MFFF228	Vendor Final Design of Gloveboxes	4m	04-Jun-21	05-Oct-21
A393	Vendor Final Design of Analytical Lab Equipment	4m	04-Jun-21	05-Oct-21
MFFF229	Design Agent Review of Vendor Final Design of Gloveboxes	0m	05-Oct-21	13-Oct-21
A394	Design Agent Review of Vendor Final Design of Analytical Lab Equip	0m	05-Oct-21	13-Oct-21
MFFF270	Vendor Fabrication of Gloveboxes	24m	13-Oct-21	27-Oct-23
A395	Vendor Fabrication of Analytical Lab. Equip.	24m	13-Oct-21	27-Oct-23
Site Prep		6m	01-Jul-20	20-Jan-21
MFFF260	Excavate, Underground Utility Installation	6m	01-Jul-20	20-Jan-21
Waste Solidification Bldg (WSB) Readiness/Re-Activation		51m	27-Jul-21	26-Nov-25
WSB Contractor Selections BEA		7m	04-Oct-22	22-May-23
A400	Prepare/Issue RFP for WSB Reactivation	2m	04-Oct-22	07-Dec-22
A405	Vendor Proposal Preparation	1m	07-Dec-22	19-Jan-23
A410	NNSA Evaluate Vendor Bids	2m	19-Jan-23	22-Mar-23
A415	Vendor Submittals (Safety Plan, QA Plan, etc.) and Contract Award	2m	22-Mar-23	22-May-23
WSB CD-2/3 Prelim and Final Design		25m	27-Jul-21	11-Sep-23
A420	Perform WSB Walkdowns for Condition Assessment	3m	27-Jul-21	27-Oct-21
A445	Prepare Design Change Packages	6m	27-Jul-21	31-Jan-22
A425	Evaluate Equipment Maintenance History	2m	27-Oct-21	29-Dec-21
A430	Prepare System Restoration Plan	2m	29-Dec-21	02-Mar-22
A435	Review/Revise WSB DSA	9m	02-Mar-22	07-Dec-22
A450	Prepare Equipment Acceptance Test Plan	3m	02-Mar-22	02-Jun-22
A455	Conduct Equip. Acceptance Tests	6m	02-Jun-22	07-Dec-22
A460	Identify Equipment Requiring Replacement	7m	02-Jun-22	05-Jan-23
A465	Prepare Cost/Sched Estimates	6m	04-Oct-22	10-Apr-23
A440	DOE Prepare/Issue SER for WSB DSA Revision	3m	07-Dec-22	09-Mar-23
A470	EIR and ICE Reviews	3m	05-Jan-23	10-Apr-23
A475	WSB Risk Assessment	3m	05-Jan-23	10-Apr-23
A480	Prepare/Submit WSB CD-2/3 Package	5m	05-Jan-23	09-Jun-23
A485	DOE Review WSB CD-2/3 Submittal	3m	09-Jun-23	11-Sep-23



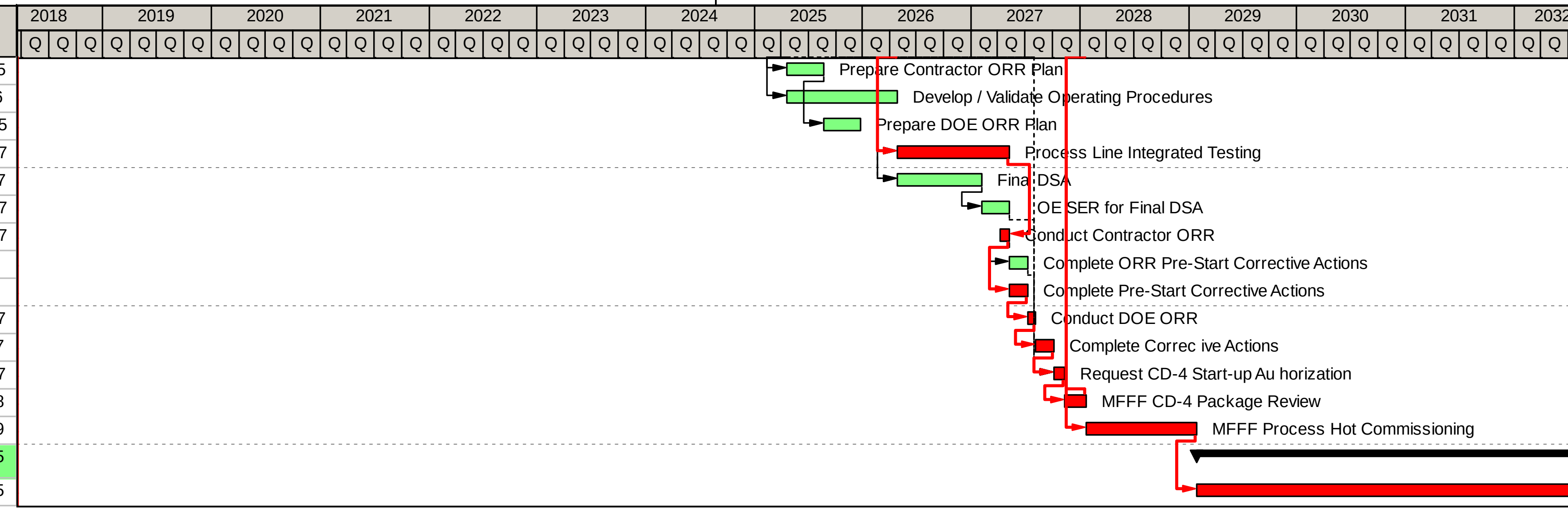
Activity ID	Activity Name	Original Duration	Start	Finish
WSB Refurbishment		9m	11-Sep-23	18-Jun-24
A495	Repair/Replace Equipment	6m	11-Sep-23	18-Mar-24
A500	Calibrate I&C Equip.	6m	11-Sep-23	18-Mar-24
A515	Prepare Commissioning Plan	9m	11-Sep-23	18-Jun-24
A505	Conduct Acceptance Tests for Repaired/Replaced Equip.	3m	18-Mar-24	18-Jun-24
WSB Start-up / Commissioning (incl. ORR)		17m	18-Jun-24	26-Nov-25
A520	Conduct System-Level Testing	6m	18-Jun-24	23-Dec-24
A525	Validate Operating Procedures	6m	18-Jun-24	23-Dec-24
A530	Conduct Operator OJT	6m	18-Jun-24	23-Dec-24
A540	Prepare Transition to Opera ions Plan	3m	18-Jun-24	18-Sep-24
A725	Prepare Contractor ORR Plan	4m	18-Jun-24	21-Oct-24
A730	Prepare DOE ORR Plan	4m	21-Oct-24	26-Feb-25
A535	Conduct WSB Integrated Tests	4m	23-Dec-24	28-Apr-25
A735	Conduct Contractor ORR	1m	27-Mar-25	28-Apr-25
A740	Complete ORR Pre-Start Correc ive Actions	2m	28-Apr-25	27-Jun-25
A745	Complete Pre-Start Corrective Actions	2m	28-Apr-25	27-Jun-25
A750	Conduct DOE ORR	1m	27-Jun-25	29-Jul-25
A755	Complete Corrective Actions	2m	29-Jul-25	29-Sep-25
A560	Prepare/Submit CD-4 Startup Authorization Request	1m	29-Sep-25	12-Nov-25
A565	DOE Review CD-4 Request	0m	12-Nov-25	26-Nov-25
Building - Technical Services (BTS) Modifications		21m	17-Sep-20	17-Jun-22
BTS Contractor Selections Design / Build		6m	17-Sep-20	11-Mar-21
A685	BTS Performance Specs for BTS Modifications	2m	17-Sep-20	19-Nov-20
A690	Contractor Bids, NNSA Evaluationss, Final Award BTS Design / Bu	4m	19-Nov-20	11-Mar-21
BTS Prelim and Final Design		5m	11-Mar-21	11-Aug-21
A695	BTS Modifica ions Preliminary Design	2m	11-Mar-21	11-May-21
A700	BTS Modifica ions Final Design	2m	11-May-21	12-Jul-21
A705	BTS Modifica ions Work Package Development	2m	11-Jun-21	11-Aug-21
BTS Modifications		6m	11-Aug-21	15-Feb-22
A145	Prepare/Modify Area for Personnel Support	6m	11-Aug-21	15-Feb-22
BTS Start-Up / Commissioning (incld. ORR)		4m	15-Feb-22	17-Jun-22
A165	Acceptance Testing of BTS	3m	15-Feb-22	17-May-22
A180	Complete BTS Punchlist Items	1m	17-May-22	17-Jun-22
MFFF Refurbishment for Pit Production		121m	01-Oct-18	30-Jan-29
MFFF200	NEPA / EIS Process	12m	01-Oct-18	09-Oct-19
MFFF Construction Contractor Selection		8m	02-Apr-21	07-Dec-21
A575	Prepare/Submit RFP for MFFF Modifica ion/Construction	2m	02-Apr-21	03-Jun-21
A580	Contractor Proposals	2m	03-Jun-21	03-Aug-21
A585	NNSA Evaluate Bids	2m	03-Aug-21	04-Oct-21
A590	Contractor Submittals and Contract Award	2m	04-Oct-21	07-Dec-21
MFFF CD-2/3 Prelim and Final Design		33m	08-Apr-19	21-Jan-22
A335	Final Security Vulnerability Assessment	4m	08-Apr-19	08-Aug-19
MFFF170	Preliminary Cost/Schedule Performance Baseline Estimates	3m	10-Jul-19	09-Oct-19
MFFF175	Preliminary Design	9m	12-Dec-19	17-Sep-20
MFFF180	Preliminary Safety Design Report (PSDR)	9m	12-Dec-19	17-Sep-20
MFFF190	Preliminary Design Report (PDR)	3m	17-Jun-20	17-Sep-20
MFFF195	Preliminary Design Review	0m	17-Sep-20	24-Sep-20
A305	Technology Readiness Assessment (TRA)	2m	24-Sep-20	27-Nov-20
A310	Technical Independent Project Review (TIPR)	4m	24-Sep-20	01-Feb-21
A315	Acquisition Strategy	4m	24-Sep-20	01-Feb-21



Activity ID	Activity Name	Original Duration	Start	Finish
A320	Project Execution Plan (PEP) and Key Performance Parameters (KI	4m	24-Sep-20	01-Feb-21
A330	MFFF Final Design	9m	24-Sep-20	05-Jul-21
A360	Preliminary Documented Safety Analysis (PDSA)	7m	24-Sep-20	04-May-21
A375	MFFF Building CD-2/3 Package Submittal	5m	11-Dec-20	18-May-21
A325	Cost/Sched Estimates for Performance Baseline	5m	30-Dec-20	03-Jun-21
A345	Preliminary Commissioning Plan	3m	26-Mar-21	28-Jun-21
A340	External Independent Review (EIR) and Independent Cost Estimate	4m	02-Apr-21	03-Aug-21
A350	Construction Health & Safety Plan	3m	02-Apr-21	05-Jul-21
A355	Verify 90% Design Completion	1m	02-Apr-21	04-May-21
A365	Safety Evaluation Report (SER)	3m	04-May-21	03-Aug-21
A370	MFFF Final Design Review	0m	04-May-21	18-May-21
A380	MFFF Building. CD-2/3 Package Review	8m	18-May-21	21-Jan-22
MFFF Modifications		**56m**	**01-Jul-20**	**18-Apr-25**
A0	MFFF Deconstruction of Exisiting Equipment	9m	01-Jul-20	09-Apr-21
A50	Install Fire Water Pumps	8m	01-Oct-20	25-May-21
A5	High Energy Radiography Vault Construction	3m	21-Jan-22	22-Apr-22
A10	Construct 2nd Floor Mezzanines for Process Support Equip.	4m	21-Jan-22	24-May-22
A35	Install Gloveboxes and Process Equipment in MFFF	18m	21-Jan-22	02-Aug-23
A40	Install Process Support Equipment	15m	21-Jan-22	01-May-23
A45	Install Building Utility Equipment	15m	21-Jan-22	01-May-23
A595	Install Analytical Laboratory Equipment	18m	21-Jan-22	02-Aug-23
A65	Install Piping Commodities	12m	26-Oct-22	02-Nov-23
A70	Install HVAC Commodities	12m	26-Oct-22	02-Nov-23
A75	Install Electrical / Communication Commodities	12m	26-Oct-22	02-Nov-23
A15	Repair/Seal Construction Openings	3m	02-Aug-23	02-Nov-23
A25	Install Diesel Generator Fuel Oil Tanks	4m	02-Nov-23	01-Mar-24
A76	Complete Glovebox Connec ions	6m	02-Nov-23	06-May-24
A77	Complete Analytical Lab Utility Connections	6m	02-Nov-23	06-May-24
A30	Install Diesel Generators	5m	01-Mar-24	01-Aug-24
A80	MFFF Equipment. Construc ion Acceptance Testing	12m	09-Apr-24	18-Apr-25
A60	Fire Water and Diesel Generator Construction Acceptance Testing	3m	01-Aug-24	04-Nov-24
MFFF Security Upgrades (incl. PIDAS)		**37m**	**26-Jul-22**	**16-Sep-25**
A760	Prepare/Issue RFP for MFFF Security Upgrades (incl. PIDAS)	2m	26-Jul-22	26-Sep-22
A765	Vendor Proposal Preparation	1m	26-Sep-22	08-Nov-22
A770	NNSA Evaluate Vendor Bids	2m	08-Nov-22	10-Jan-23
A775	Vendor Submittals (Safety Plan, QA Plan, etc.) and Contract Award	2m	10-Jan-23	14-Mar-23
A790	Vendor Prelim Design of PIDAS Upgrades	6m	14-Mar-23	14-Sep-23
A795	Preliminary Design Review of PIDAS Upgrades	0m	14-Sep-23	21-Sep-23
A800	Final Design of PIDAS Upgrades	6m	21-Sep-23	28-Mar-24
A805	Final Design Review of PIDAS Upgrades	0m	28-Mar-24	04-Apr-24
A810	Install Security Upgrades (incl. PIDAS)	12m	04-Apr-24	15-Apr-25
A815	Acceptance Testing of Security Upgrades (incl. PIDAS)	4m	15-Apr-25	15-Aug-25
A820	Complete PIDAS Punchlist Items	1m	15-Aug-25	16-Sep-25
MFFF Start-Up / Commissioning (incl. ORR)		**56m**	**09-Apr-24**	**30-Jan-29**
B236	Draft Documented Safety Analysis (DSA)	9m	09-Apr-24	15-Jan-25
B237	DOE Review of Draft DSA	3m	15-Jan-25	18-Apr-25
A605	MFFF Process Support System-Level Testing	6m	18-Apr-25	22-Oct-25
A610	MFFF Utility System-Level Testing	6m	18-Apr-25	22-Oct-25
A615	MFFF Process System-Level Testing	12m	18-Apr-25	29-Apr-26
A620	Prepare Transition to Ops (Post CD-4) Plan	6m	18-Apr-25	22-Oct-25
A625	Operator On-the-Job Training (OJT)	12m	18-Apr-25	29-Apr-26



Activity ID	Activity Name	Original Duration	Start	Finish
A630	Prepare Contractor ORR Plan	4m	18-Apr-25	20-Aug-25
A635	Develop / Validate Operating Procedures	12m	18-Apr-25	29-Apr-26
A640	Prepare DOE ORR Plan	4m	20-Aug-25	24-Dec-25
A650	Process Line Integrated Testing	12m	29-Apr-26	07-May-27
B238	Final DSA	9m	29-Apr-26	04-Feb-27
B239	DOE SER for Final DSA	3m	04-Feb-27	07-May-27
A655	Conduct Contractor ORR	1m	07-Apr-27	07-May-27
A645	Complete ORR Pre-Start Correc ive Actions	2m	07-May-27	08-Jul-27
A660	Complete Pre-Start Corrective Actions	2m	07-May-27	08-Jul-27
A670	Conduct DOE ORR	1m	08-Jul-27	06-Aug-27
A680	Complete Corrective Actions	2m	06-Aug-27	07-Oct-27
A665	Request CD-4 Start-up Authorization	1m	07-Oct-27	09-Nov-27
A675	MFFF CD-4 Package Review	2m	09-Nov-27	20-Jan-28
A715	MFFF Process Hot Commissioning	12m	20-Jan-28	30-Jan-29
Transition to War Reserve (WR) Production		72m	30-Jan-29	04-Jan-35
A720	Transition to WR Production	72m	30-Jan-29	04-Jan-35



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Appendix J Schedule for Alternative 2a

Both the Critical Path Schedule and Full Schedule for Alternative 2a are below. The Critical Path Schedule is on Page J-3. The Full Schedule begins on Page J-5.

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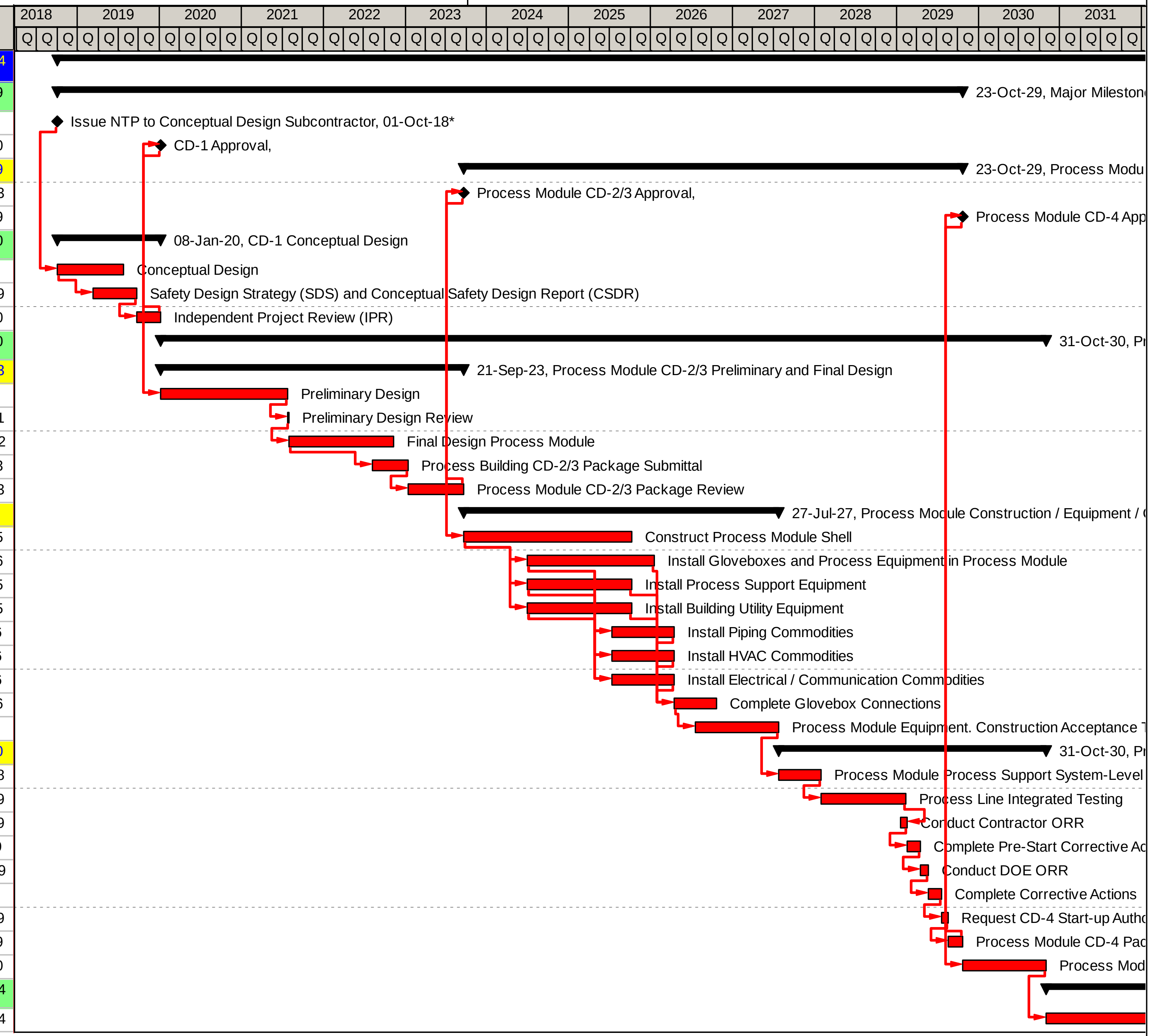
Alternative 2a - Construct a Module at LANL - Production Facility Outside of PF-4

Activity ID	Activity Name	Original Duration	Start	Finish
Alternative 2a – Construct a Module at LANL – Production F		190m	01-Oct-18	05-Dec-34
Major Milestones		130m	01-Oct-18	23-Oct-29
MS20	Issue NTP to Conceptual Design Subcontractor	0m	01-Oct-18*	
MS03	CD-1 Approval	0m		08-Jan-20
Process Module		71m	21-Sep-23	23-Oct-29
MS07	Process Module CD-2/3 Approval	0m		21-Sep-23
MS10	Process Module CD-4 Approval	0m		23-Oct-29
CD-1 Conceptual Design		15m	01-Oct-18	08-Jan-20
A055	Conceptual Design	9m	01-Oct-18	22-Jul-19
A080	Safety Design Strategy (SDS) and Conceptual Safety Design Repor	6m	08-Mar-19	20-Sep-19
A095	Independent Project Review (IPR)	3m	20-Sep-19	08-Jan-20
Process Module		127m	09-Jan-20	31-Oct-30
Process Module CD-2/3 Preliminary and Final Design		44m	09-Jan-20	21-Sep-23
B285	Preliminary Design	18m	09-Jan-20	27-Jul-21
B305	Preliminary Design Review	0m	27-Jul-21	03-Aug-21
B75	Final Design Process Module	15m	03-Aug-21	10-Nov-22
B95	Process Building CD-2/3 Package Submittal	5m	10-Aug-22	13-Jan-23
B100	Process Module CD-2/3 Package Review	8m	13-Jan-23	21-Sep-23
Process Module Construction / Equipment / Commodities Installs		45m	21-Sep-23	27-Jul-27
B140	Construct Process Module Shell	24m	21-Sep-23	09-Oct-25
B160	Install Gloveboxes and Process Equipment in Process Module	18m	27-Jun-24	14-Jan-26
B165	Install Process Support Equipment	15m	27-Jun-24	09-Oct-25
B170	Install Building Utility Equipment	15m	27-Jun-24	09-Oct-25
B175	Install Piping Commodities	9m	09-Jul-25	17-Apr-26
B180	Install HVAC Commodities	9m	09-Jul-25	17-Apr-26
B185	Install Electrical / Communication Commodities	9m	09-Jul-25	17-Apr-26
B186	Complete Glovebox Connections	6m	17-Apr-26	20-Oct-26
B190	Process Module Equipment. Construction Acceptance Testing	12m	17-Jul-26	27-Jul-27
Process Module CD-4 Commissioning / Start-up (incl. ORR)		38m	27-Jul-27	31-Oct-30
B230	Process Module Process Support System-Level Testing	6m	27-Jul-27	02-Feb-28
B320	Process Line Integrated Testing	12m	02-Feb-28	12-Feb-29
B270	Conduct Contractor ORR	1m	19-Jan-29	20-Feb-29
B275	Complete Pre-Start Corrective Actions	2m	20-Feb-29	20-Apr-29
B325	Conduct DOE ORR	1m	20-Apr-29	22-May-29
B335	Complete Corrective Actions	2m	22-May-29	24-Jul-29
B315	Request CD-4 Start-up Authorization	1m	24-Jul-29	22-Aug-29
B330	Process Module CD-4 Package Review	2m	22-Aug-29	23-Oct-29
B340	Process Module Hot Commissioning	12m	23-Oct-29	31-Oct-30
Transition to War Reserve (WR) Production		48m	31-Oct-30	05-Dec-34
B345	Transition to WR Production	48m	31-Oct-30	05-Dec-34



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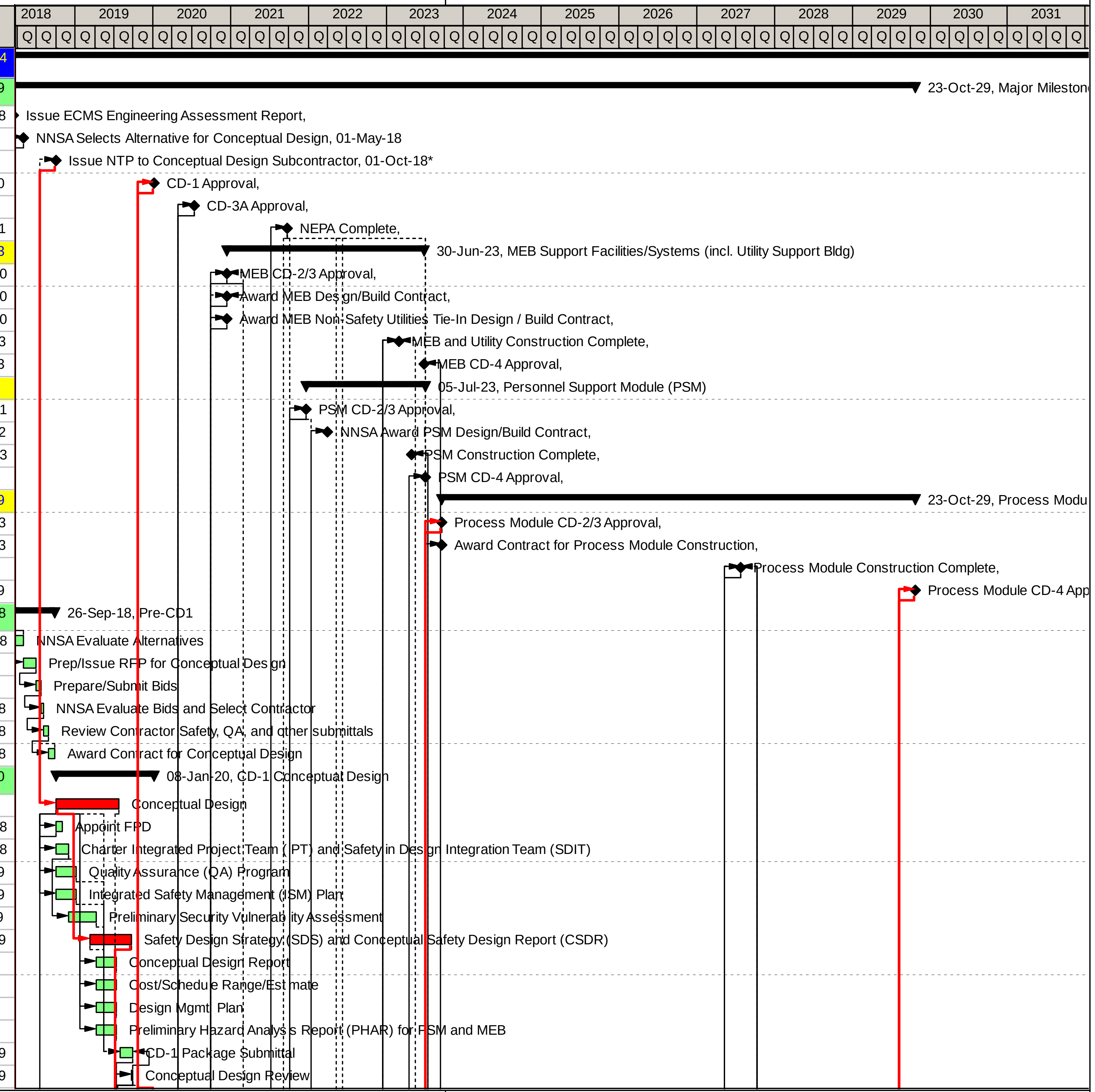
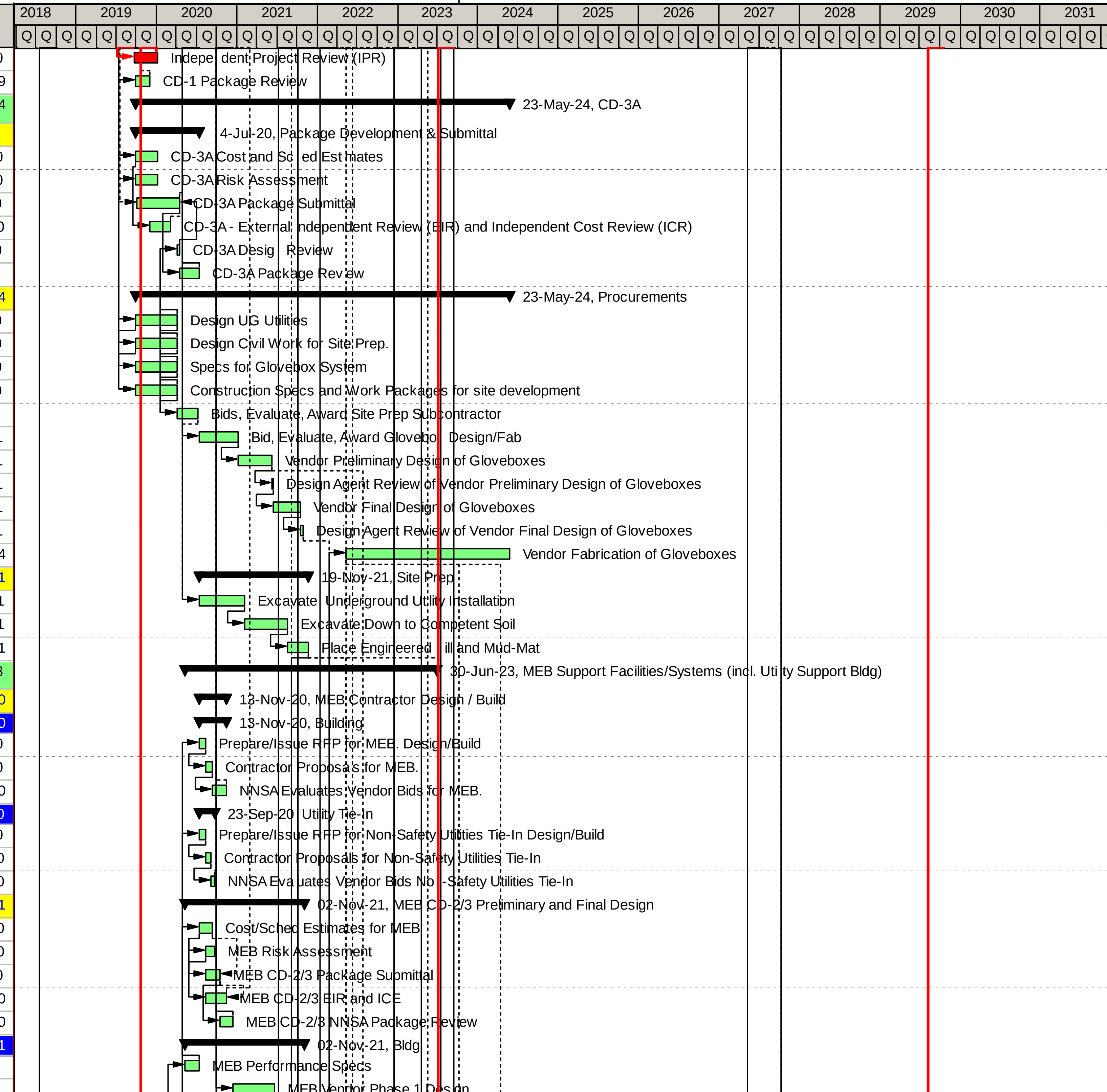
Activity ID	Activity Name	Original Duration	Start	Finish
Alternative 2a – Construct a Module at LANL – Production F		196m	16-Mar-18	05-Dec-34
Major Milestones		136m	16-Mar-18	23-Oct-29
MS01	Issue ECMS Engineering Assessment Report	0m		16-Mar-18
MS02	NNSA Selects Alternative for Conceptual Design	0m	01-May-18	
MS20	Issue NTP to Conceptual Design Subcontractor	0m	01-Oct-18*	
MS03	CD-1 Approval	0m		08-Jan-20
MS05	CD-3A Approval	0m		14-Jul-20
MS04	NEPA Complete	0m		22-Sep-21
MEB Support Facilities/Systems (incl. Utility Support Bldg)		30m	15-Dec-20	30-Jun-23
MS15	MEB CD-2/3 Approval	0m		15-Dec-20
MS16	Award MEB Design/Build Contract	0m		15-Dec-20
MS17	Award MEB Non-Safety Utilities Tie-In Design / Build Contract	0m		15-Dec-20
MS18	MEB and Utility Construction Complete	0m		01-Mar-23
MS19	MEB CD-4 Approval	0m		30-Jun-23
Personnel Support Module (PSM)		18m	23-Dec-21	05-Jul-23
MS11	PSM CD-2/3 Approval	0m		23-Dec-21
MS12	NNSA Award PSM Design/Build Contract	0m		28-Mar-22
MS13	PSM Construction Complete	0m		03-May-23
MS14	PSM CD-4 Approval	0m		05-Jul-23
Process Module		71m	21-Sep-23	23-Oct-29
MS07	Process Module CD-2/3 Approval	0m		21-Sep-23
MS08	Award Contract for Process Module Construction	0m		21-Sep-23
MS09	Process Module Construction Complete	0m		27-Jul-27
MS10	Process Module CD-4 Approval	0m		23-Oct-29
Pre-CD1		6m	16-Mar-18	26-Sep-18
A005	NNSA Evaluate Alternatives	2m	16-Mar-18	01-May-18
A010	Prep/Issue RFP for Conceptual Design	2m	01-May-18	02-Jul-18
A015	Prepare/Submit Bids	1m	02-Jul-18	24-Jul-18
A020	NNSA Evaluate Bids and Select Contractor	0m	24-Jul-18	07-Aug-18
A025	Review Contractor Safety, QA, and other submittals	1m	07-Aug-18	28-Aug-18
A030	Award Contract for Conceptual Design	1m	28-Aug-18	26-Sep-18
CD-1 Conceptual Design		15m	01-Oct-18	08-Jan-20
A055	Conceptual Design	9m	01-Oct-18	22-Jul-19
A040	Appoint FPD	1m	01-Oct-18	01-Nov-18
A070	Charter Integrated Project Team (IPT) and Safety in Design Integra	2m	01-Oct-18	03-Dec-18
A035	Quality Assurance (QA) Program	3m	01-Oct-18	04-Jan-19
A045	Integrated Safety Management (ISM) Plan	3m	01-Oct-18	04-Jan-19
A046	Preliminary Security Vulnerability Assessment	4m	03-Dec-18	08-Apr-19
A080	Safety Design Strategy (SDS) and Conceptual Safety Design Repor	6m	08-Mar-19	20-Sep-19
A060	Conceptual Design Report	3m	08-Apr-19	10-Jul-19
A065	Cost/Schedule Range/Estimate	3m	08-Apr-19	10-Jul-19
A050	Design Mgmt. Plan	3m	08-Apr-19	10-Jul-19
A075	Preliminary Hazard Analysis Report (PHAR) for PSM and MEB	3m	08-Apr-19	10-Jul-19
A090	CD-1 Package Submittal	2m	29-Jul-19	27-Sep-19
A085	Conceptual Design Review	0m	20-Sep-19	27-Sep-19



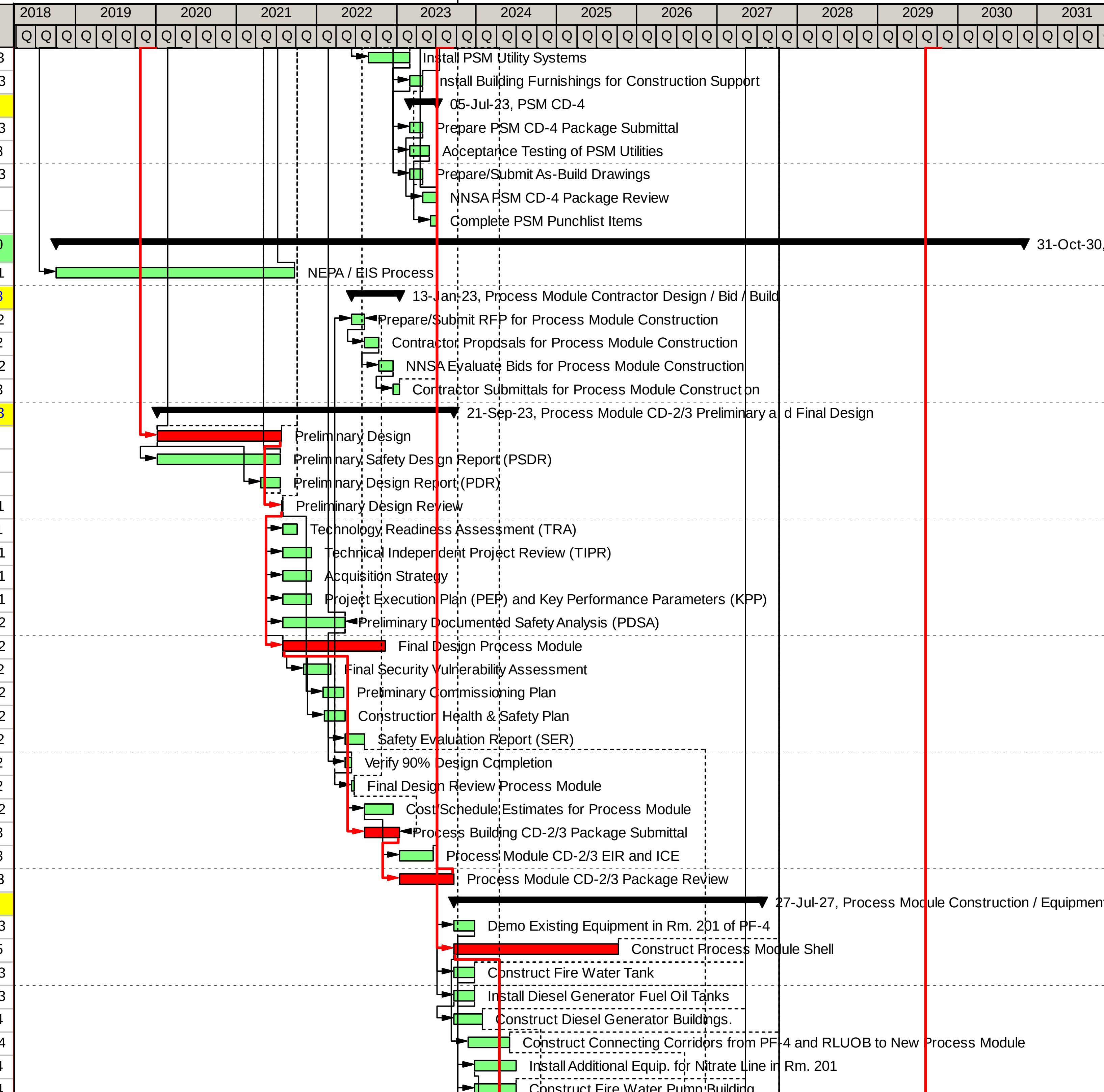
Activity ID	Activity Name	Original Duration	Start	Finish
A095	Independent Project Review (IPR)	3m	20-Sep-19	08-Jan-20
A100	CD-1 Package Review	2m	27-Sep-19	02-Dec-19
CD-3A		55m	27-Sep-19	23-May-24
Package Development & Submittal		9m	27-Sep-19	14-Jul-20
A150	CD-3A Cost and Sched Estimates	3m	27-Sep-19	03-Jan-20
A155	CD-3A Risk Assessment	3m	27-Sep-19	03-Jan-20
A165	CD-3A Package Submittal	6m	04-Oct-19	13-Apr-20
A170	CD-3A - External Independent Review (EIR) and Independent Cost	3m	02-Dec-19	06-Mar-20
A160	CD-3A Design Review	0m	06-Apr-20	13-Apr-20
A175	CD-3A Package Review	3m	13-Apr-20	14-Jul-20
Procurements		55m	27-Sep-19	23-May-24
A180	Design UG Utilities	6m	27-Sep-19	06-Apr-20
A185	Design Civil Work for Site Prep.	6m	27-Sep-19	06-Apr-20
A190	Specs for Glovebox System	6m	27-Sep-19	06-Apr-20
A195	Construction Specs and Work Packages for site development	6m	27-Sep-19	06-Apr-20
A225	Bids, Evaluate, Award Site Prep Subcontractor	3m	06-Apr-20	07-Jul-20
A200	Bid, Evaluate, Award Glovebox Design/Fab	6m	14-Jul-20	06-Jan-21
A201	Vendor Preliminary Design of Gloveboxes	5m	06-Jan-21	10-Jun-21
A202	Design Agent Review of Vendor Preliminary Design of Gloveboxes	0m	10-Jun-21	17-Jun-21
A203	Vendor Final Design of Gloveboxes	4m	17-Jun-21	19-Oct-21
A204	Design Agent Review of Vendor Final Design of Gloveboxes	0m	19-Oct-21	26-Oct-21
A205	Vendor Fabrication of Gloveboxes	24m	09-May-22	23-May-24
Site Prep		16m	14-Jul-20	19-Nov-21
A210	Excavate, Underground Utility Installation	6m	14-Jul-20	02-Feb-21
A220	Excavate Down to Competent Soil	6m	02-Feb-21	17-Aug-21
A221	Place Engineered Fill and Mud-Mat	3m	17-Aug-21	19-Nov-21
MEB Support Facilities/Systems (incl. Utility Support Bldg)		37m	12-May-20	30-Jun-23
MEB Contractor Design / Build		4m	13-Jul-20	13-Nov-20
Building		4m	13-Jul-20	13-Nov-20
E5	Prepare/Issue RFP for MEB. Design/Build	1m	13-Jul-20	11-Aug-20
E10	Contractor Proposals for MEB.	1m	12-Aug-20	11-Sep-20
E15	NNSA Evaluates Vendor Bids for MEB.	2m	11-Sep-20	13-Nov-20
Utility Tie-In		2m	13-Jul-20	23-Sep-20
E20	Prepare/Issue RFP for Non-Safety Utilities Tie-In Design/Build	1m	13-Jul-20	11-Aug-20
E25	Contractor Proposals for Non-Safety Utilities Tie-In	1m	12-Aug-20	01-Sep-20
E30	NNSA Evaluates Vendor Bids Non-Safety Utilities Tie-In	1m	02-Sep-20	23-Sep-20
MEB CD-2/3 Preliminary and Final Design		17m	12-May-20	02-Nov-21
E35	Cost/Sched Estimates for MEB	2m	13-Jul-20	10-Sep-20
E40	MEB Risk Assessment	1m	11-Aug-20	23-Sep-20
E45	MEB CD-2/3 Package Submittal	2m	11-Aug-20	13-Oct-20
E50	MEB CD-2/3 EIR and ICE	3m	11-Aug-20	13-Nov-20
E55	MEB CD-2/3 NNSA Package Review	2m	13-Oct-20	15-Dec-20
Bldg		17m	12-May-20	02-Nov-21
E60	MEB Performance Specs	2m	12-May-20	10-Jul-20
E65	MEB Vendor Phase 1 Design	6m	15-Dec-20	21-Jun-21



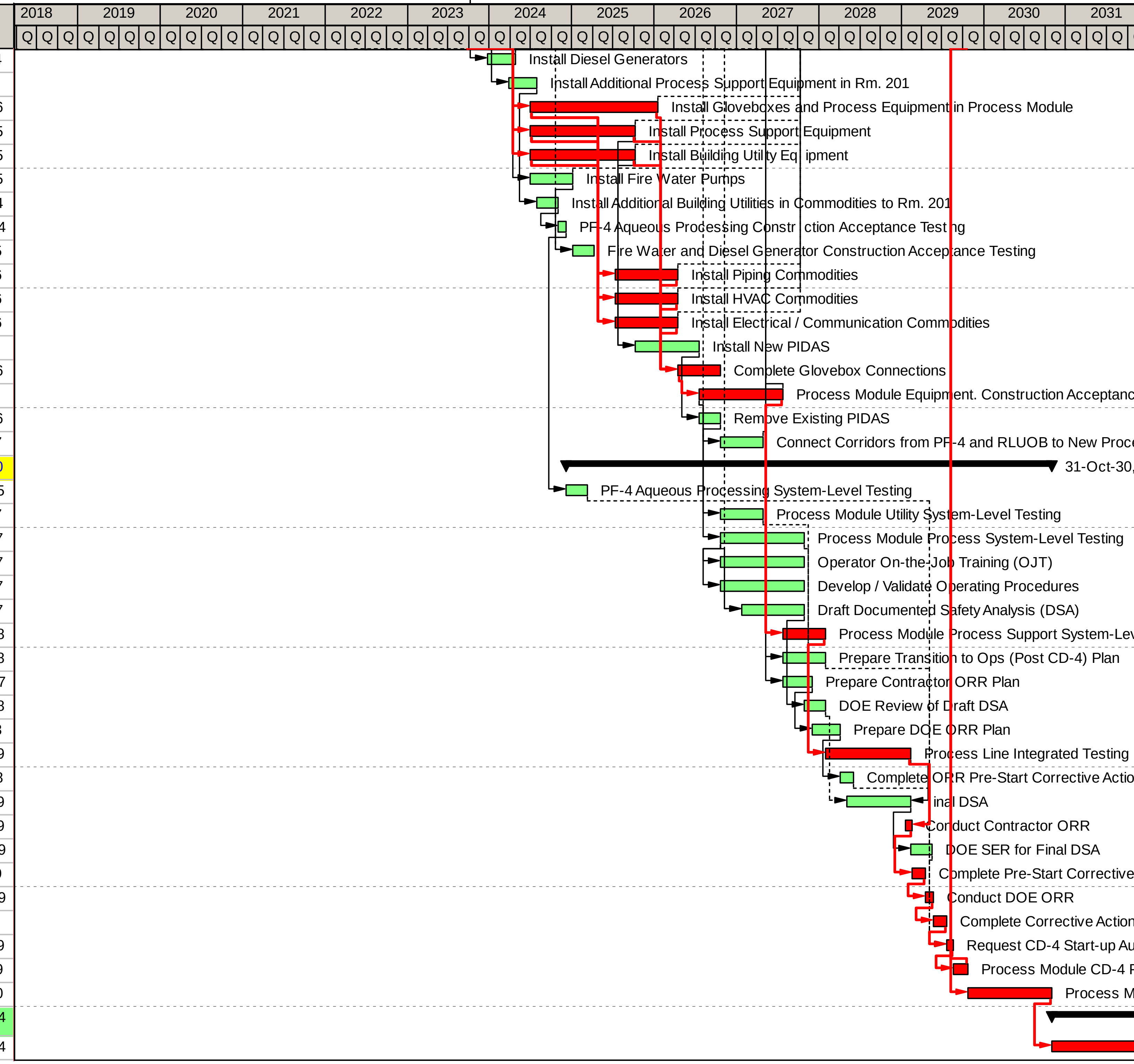
~~Unclassified Controlled Nuclear Information~~

Activity ID	Activity Name	Original Duration	Start	Finish
E70	MEB Vendor Phase 1 Design Review	0m	21-Jun-21	24-Jun-21
E75	MEB Vendor Phase 2 Design	4m	24-Jun-21	26-Oct-21
E80	MEB Vendor Phase 2 Design Review	0m	26-Oct-21	02-Nov-21
Utility Tie-In		15m	12-May-20	24-Aug-21
E85	MEB Performance Specs for Non-Safety External Utility Systems	2m	12-May-20	10-Jul-20
E90	Site Utility Tie-In Preliminary Design	4m	15-Dec-20	20-Apr-21
E95	Site Utility Tie-In Preliminary Design Review	0m	20-Apr-21	23-Apr-21
E100	Site Utility Tie-In Final Design	3m	23-Apr-21	23-Jul-21
E105	Site Utility Tie-In Final Design Review	1m	26-Jul-21	24-Aug-21
MEB Construction / Equipment / Commodities Installs		15m	19-Nov-21	01-Mar-23
E120	Construct MEB. Shell	6m	19-Nov-21	24-May-22
E110	Install Electrical Ductbanks and Cable	4m	21-Dec-21	22-Apr-22
E115	Install Communication Ductbanks and Cable	4m	21-Dec-21	22-Apr-22
E140	Installation of MEB Equipment	6m	24-Mar-22	26-Sep-22
E125	Install Piping for Process Gas	3m	22-Apr-22	26-Jul-22
E130	Install Fire Water Piping	4m	22-Apr-22	24-Aug-22
E135	Install Piping for Mechanical Utilities	4m	22-Apr-22	24-Aug-22
E145	Complete Site Tie-Ins to MEB	2m	24-Aug-22	26-Oct-22
E155	Construction Acceptance Testing of MEB Systems	4m	26-Oct-22	01-Mar-23
E150	Prepare Utility Supply As-Built Drawings	2m	26-Oct-22	28-Dec-22
MEB CD-4		9m	26-Sep-22	30-Jun-23
E160	Prepare / Submit As-Built Drawings for MEB.	2m	26-Sep-22	29-Nov-22
E170	MEB Equipment Acceptance Testing	3m	26-Sep-22	28-Dec-22
E180	Complete Punchlist Items for Non-Safety Utilities	2m	28-Dec-22	01-Mar-23
E190	Complete Punchlist Items for MEB	2m	01-Mar-23	01-May-23
E195	Prepare MEB CD-4 Package Submittal	2m	01-May-23	30-Jun-23
E200	NNSA MEB CD-4 Package Review	2m	01-May-23	30-Jun-23
Personnel Support Module (PSM)		37m	12-May-20	05-Jul-23
PSM Contractor Design / Build		3m	23-Dec-21	28-Mar-22
D05	Prepare/Issue RFP for PSM Design/Build	1m	23-Dec-21	25-Jan-22
D10	Contractor Proposals for PSM Design/Build	1m	25-Jan-22	25-Feb-22
D15	NNSA Evaluates Bids PSM Design/Build	1m	25-Feb-22	28-Mar-22
PSM CD-2/3 Preliminary and Final Design		25m	12-May-20	22-Jun-22
D20	Prepare Performance Specs for PSM Design/Build	2m	12-May-20	10-Jul-20
D25	Cost/Sched Estimates for PSM Design/Build	2m	13-Jul-20	10-Sep-20
D30	Perform Risk Analysis for PSM Design/Build	1m	11-Aug-20	23-Sep-20
D35	Perform ICE for PSM	2m	11-Aug-20	13-Oct-20
D40	Prepare PSM CD-2/3 Package Submittal	2m	21-Jul-21	20-Sep-21
D45	PSM CD-2/3 Package Review	3m	21-Sep-21	23-Dec-21
D50	Vendor Phase 1 Design PSM	3m	23-Dec-21	25-Mar-22
D55	NNSA Project Office Phase 1 Design Review PSM	0m	28-Mar-22	29-Mar-22
D60	Vendor Phase 2 Design PSM	1m	30-Mar-22	10-May-22
D65	NNSA Project Office Phase 2 design review PSM	1m	11-May-22	22-Jun-22
PSM Construction / Equipment / Commodities Installs		9m	28-Jul-22	03-May-23
D70	Construct PSM Shell	6m	28-Jul-22	31-Jan-23

Activity ID	Activity Name	Original Duration	Start	Finish
D75	Install PSM Utility Systems	6m	26-Aug-22	03-Mar-23
D80	Install Building Furnishings for Construction Support	2m	03-Mar-23	03-May-23
PSM CD-4		4m	03-Mar-23	05-Jul-23
D85	Prepare PSM CD-4 Package Submittal	2m	03-Mar-23	03-May-23
D95	Acceptance Testing of PSM Utilities	3m	03-Mar-23	02-Jun-23
D90	Prepare/Submit As-Build Drawings	2m	03-Mar-23	03-May-23
D100	NNSA PSM CD-4 Package Review	2m	03-May-23	05-Jul-23
D105	Complete PSM Punchlist Items	1m	05-Jun-23	05-Jul-23
Process Module		142m	01-Oct-18	31-Oct-30
B310	NEPA / EIS Process	36m	01-Oct-18	22-Sep-21
Process Module Contractor Design / Bid / Build		7m	09-Jun-22	13-Jan-23
B05	Prepare/Submit RFP for Process Module Construction	2m	09-Jun-22	10-Aug-22
B10	Contractor Proposals for Process Module Construction	2m	10-Aug-22	12-Oct-22
B15	NNSA Evaluate Bids for Process Module Construction	2m	12-Oct-22	14-Dec-22
B20	Contractor Submittals for Process Module Construction	1m	14-Dec-22	13-Jan-23
Process Module CD-2/3 Preliminary and Final Design		44m	09-Jan-20	21-Sep-23
B285	Preliminary Design	18m	09-Jan-20	27-Jul-21
B290	Preliminary Safety Design Report (PSDR)	18m	09-Jan-20	20-Jul-21
B300	Preliminary Design Report (PDR)	3m	20-Apr-21	21-Jul-21
B305	Preliminary Design Review	0m	27-Jul-21	03-Aug-21
B25	Technology Readiness Assessment (TRA)	2m	03-Aug-21	04-Oct-21
B30	Technical Independent Project Review (TIPR)	4m	03-Aug-21	07-Dec-21
B35	Acquisition Strategy	4m	03-Aug-21	07-Dec-21
B40	Project Execution Plan (PEP) and Key Performance Parameters (K	4m	03-Aug-21	07-Dec-21
B80	Preliminary Documented Safety Analysis (PDSA)	9m	03-Aug-21	09-May-22
B75	Final Design Process Module	15m	03-Aug-21	10-Nov-22
B50	Final Security Vulnerability Assessment	4m	03-Nov-21	09-Mar-22
B65	Preliminary Commissioning Plan	3m	31-Jan-22	03-May-22
B70	Construction Health & Safety Plan	3m	07-Feb-22	10-May-22
B85	Safety Evaluation Report (SER)	3m	09-May-22	10-Aug-22
B60	Verify 90% Design Completion	1m	09-May-22	09-Jun-22
B90	Final Design Review Process Module	0m	09-Jun-22	23-Jun-22
B45	Cost/Schedule Estimates for Process Module	4m	10-Aug-22	14-Dec-22
B95	Process Building CD-2/3 Package Submittal	5m	10-Aug-22	13-Jan-23
B55	Process Module CD-2/3 EIR and ICE	5m	12-Jan-23	16-Jun-23
B100	Process Module CD-2/3 Package Review	8m	13-Jan-23	21-Sep-23
Process Module Construction / Equipment / Commodities Installs		45m	21-Sep-23	27-Jul-27
B195	Demo Existing Equipment in Rm. 201 of PF-4	3m	21-Sep-23	22-Dec-23
B140	Construct Process Module Shell	24m	21-Sep-23	09-Oct-25
B105	Construct Fire Water Tank	3m	21-Sep-23	22-Dec-23
B110	Install Diesel Generator Fuel Oil Tanks	3m	21-Sep-23	22-Dec-23
B115	Construct Diesel Generator Buildings.	4m	21-Sep-23	26-Jan-24
B120	Construct Connecting Corridors from PF-4 and RLUOB to New Prc	6m	22-Nov-23	29-May-24
B200	Install Additional Equip. for Nitrate Line in Rm. 201	6m	22-Dec-23	27-Jun-24
B130	Construct Fire Water Pump Building	6m	22-Dec-23	27-Jun-24



Activity ID	Activity Name	Original Duration	Start	Finish
B125	Install Diesel Generators	4m	22-Dec-23	26-Apr-24
B205	Install Additional Process Support Equipment in Rm. 201	4m	28-Mar-24	30-Jul-24
B160	Install Gloveboxes and Process Equipment in Process Module	18m	27-Jun-24	14-Jan-26
B165	Install Process Support Equipment	15m	27-Jun-24	09-Oct-25
B170	Install Building Utility Equipment	15m	27-Jun-24	09-Oct-25
B150	Install Fire Water Pumps	6m	27-Jun-24	03-Jan-25
B210	Install Additional Building Utilities in Commodities to Rm. 201	3m	30-Jul-24	30-Oct-24
B215	PF-4 Aqueous Processing Construction Acceptance Testing	1m	30-Oct-24	03-Dec-24
B155	Fire Water and Diesel Generator Construction Acceptance Testing	3m	03-Jan-25	08-Apr-25
B175	Install Piping Commodities	9m	09-Jul-25	17-Apr-26
B180	Install HVAC Commodities	9m	09-Jul-25	17-Apr-26
B185	Install Electrical / Communication Commodities	9m	09-Jul-25	17-Apr-26
B350	Install New PIDAS	9m	09-Oct-25	17-Jul-26
B186	Complete Glovebox Connections	6m	17-Apr-26	20-Oct-26
B190	Process Module Equipment. Construction Acceptance Testing	12m	17-Jul-26	27-Jul-27
B355	Remove Existing PIDAS	3m	17-Jul-26	20-Oct-26
B360	Connect Corridors from PF-4 and RLUOB to New Process Module	6m	20-Oct-26	27-Apr-27
Process Module CD-4 Commissioning / Start-up (incl. ORR)		69m	03-Dec-24	31-Oct-30
B220	PF-4 Aqueous Processing System-Level Testing	3m	03-Dec-24	07-Mar-25
B235	Process Module Utility System-Level Testing	6m	20-Oct-26	27-Apr-27
B255	Process Module Process System-Level Testing	12m	20-Oct-26	28-Oct-27
B260	Operator On-the-Job Training (OJT)	12m	20-Oct-26	28-Oct-27
B265	Develop / Validate Operating Procedures	12m	20-Oct-26	28-Oct-27
B236	Draft Documented Safety Analysis (DSA)	9m	25-Jan-27	28-Oct-27
B230	Process Module Process Support System-Level Testing	6m	27-Jul-27	02-Feb-28
B240	Prepare Transition to Ops (Post CD-4) Plan	6m	27-Jul-27	02-Feb-28
B225	Prepare Contractor ORR Plan	4m	27-Jul-27	01-Dec-27
B237	DOE Review of Draft DSA	3m	28-Oct-27	02-Feb-28
B245	Prepare DOE ORR Plan	4m	01-Dec-27	04-Apr-28
B320	Process Line Integrated Testing	12m	02-Feb-28	12-Feb-29
B250	Complete ORR Pre-Start Corrective Actions	2m	04-Apr-28	05-Jun-28
B238	Final DSA	9m	04-May-28	12-Feb-29
B270	Conduct Contractor ORR	1m	19-Jan-29	20-Feb-29
B239	DOE SER for Final DSA	3m	12-Feb-29	15-May-29
B275	Complete Pre-Start Corrective Actions	2m	20-Feb-29	20-Apr-29
B325	Conduct DOE ORR	1m	20-Apr-29	22-May-29
B335	Complete Corrective Actions	2m	22-May-29	24-Jul-29
B315	Request CD-4 Start-up Authorization	1m	24-Jul-29	22-Aug-29
B330	Process Module CD-4 Package Review	2m	22-Aug-29	23-Oct-29
B340	Process Module Hot Commissioning	12m	23-Oct-29	31-Oct-30
Transition to War Reserve (WR) Production		48m	31-Oct-30	05-Dec-34
B345	Transition to WR Production	48m	31-Oct-30	05-Dec-34



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Appendix K Schedule for Alternative 2b

Both the Critical Path Schedule and Full Schedule for Alternative 2b are below. The Critical Path Schedule is on Page K-3. The Full Schedule begins on Page K-5.

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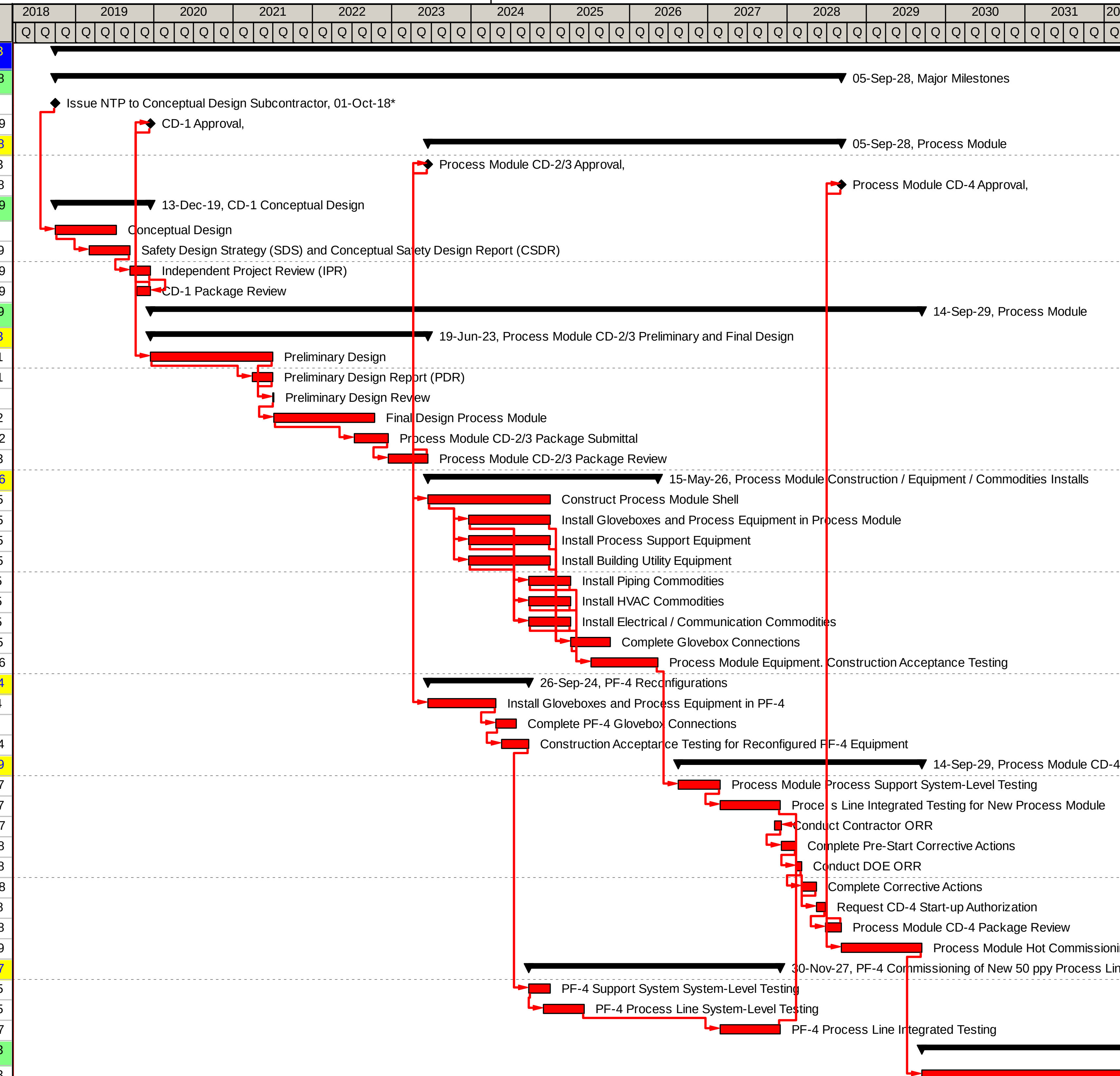
Activity ID	Activity Name	Original Duration	Start	Finish
Alternative 2b – Construct a Module at LANL – Production Capa		176m	01-Oct-18	20-Oct-33
Major Milestones		116m	01-Oct-18	05-Sep-28
MS20	Issue NTP to Conceptual Design Subcontractor	0m	01-Oct-18*	
MS03	CD-1 Approval	0m		13-Dec-19
Process Module		61m	19-Jun-23	05-Sep-28
MS07	Process Module CD-2/3 Approval	0m		19-Jun-23
MS10	Process Module CD-4 Approval	0m		05-Sep-28
CD-1 Conceptual Design		14m	01-Oct-18	13-Dec-19
A055	Conceptual Design	9m	01-Oct-18	10-Jul-19
A080	Safety Design Strategy (SDS) and Conceptual Safety Design Report (CSD	6m	08-Mar-19	10-Sep-19
A095	Independent Project Review (IPR)	3m	10-Sep-19	13-Dec-19
A100	CD-1 Package Review	2m	10-Oct-19	13-Dec-19
Process Module		114m	13-Dec-19	14-Sep-29
Process Module CD-2/3 Preliminary and Final Design		41m	13-Dec-19	19-Jun-23
B15	Preliminary Design	18m	13-Dec-19	28-Jun-21
B30	Preliminary Design Report (PDR)	3m	26-Mar-21	28-Jun-21
B35	Preliminary Design Review	0m	28-Jun-21	05-Jul-21
B125	Final Design Process Module	15m	05-Jul-21	13-Oct-22
B140	Process Module CD-2/3 Package Submittal	5m	12-Jul-22	15-Dec-22
B150	Process Module CD-2/3 Package Review	6m	15-Dec-22	19-Jun-23
Process Module Construction / Equipment / Commodities Installs		34m	19-Jun-23	15-May-26
B195	Construct Process Module Shell	18m	19-Jun-23	02-Jan-25
B220	Install Gloveboxes and Process Equipment in Process Module	12m	21-Dec-23	02-Jan-25
B225	Install Process Support Equipment	12m	21-Dec-23	02-Jan-25
B230	Install Building Utility Equipment	12m	21-Dec-23	02-Jan-25
B245	Install Piping Commodities	6m	26-Sep-24	04-Apr-25
B250	Install HVAC Commodities	6m	26-Sep-24	04-Apr-25
B255	Install Electrical / Communication Commodities	6m	26-Sep-24	04-Apr-25
B186	Complete Glovebox Connec ions	6m	04-Apr-25	07-Oct-25
B260	Process Module Equipment. Construction Acceptance Testing	10m	08-Jul-25	15-May-26
PF-4 Reconfigurations		15m	19-Jun-23	26-Sep-24
B205	Install Gloveboxes and Process Equipment in PF-4	10m	19-Jun-23	25-Apr-24
B236	Complete PF-4 Glovebox Connections	3m	25-Apr-24	26-Jul-24
B240	Construction Acceptance Testing for Reconfigured PF-4 Equipment	4m	24-May-24	26-Sep-24
Process Module CD-4 Commissioning / Start-up (incl. ORR)		36m	14-Aug-26	14-Sep-29
B305	Process Module Process Support System-Level Testing	6m	14-Aug-26	23-Feb-27
B330	Process Line Integrated Testing for New Process Module	9m	23-Feb-27	30-Nov-27
B335	Conduct Contractor ORR	1m	02-Nov-27	07-Dec-27
B340	Complete Pre-Start Corrective Actions	2m	07-Dec-27	08-Feb-28
B345	Conduct DOE ORR	1m	08-Feb-28	09-Mar-28
B350	Complete Corrective Actions	2m	09-Mar-28	16-May-28
B355	Request CD-4 Start-up Authorization	1m	16-May-28	26-Jun-28
B360	Process Module CD-4 Package Review	2m	26-Jun-28	05-Sep-28
B370	Process Module Hot Commissioning	12m	05-Sep-28	14-Sep-29
PF-4 Commissioning of New 50 ppy Process Lines		37m	26-Sep-24	30-Nov-27
B270	PF-4 Support System System-Level Testing	3m	26-Sep-24	02-Jan-25
B295	PF-4 Process Line System-Level Testing	6m	29-Nov-24	05-Jun-25
B325	PF-4 Process Line Integrated Testing	9m	23-Feb-27	30-Nov-27
Transition to War Reserve (WR) Production		48m	14-Sep-29	20-Oct-33
B375	Transition to WR Production	48m	14-Sep-29	20-Oct-33



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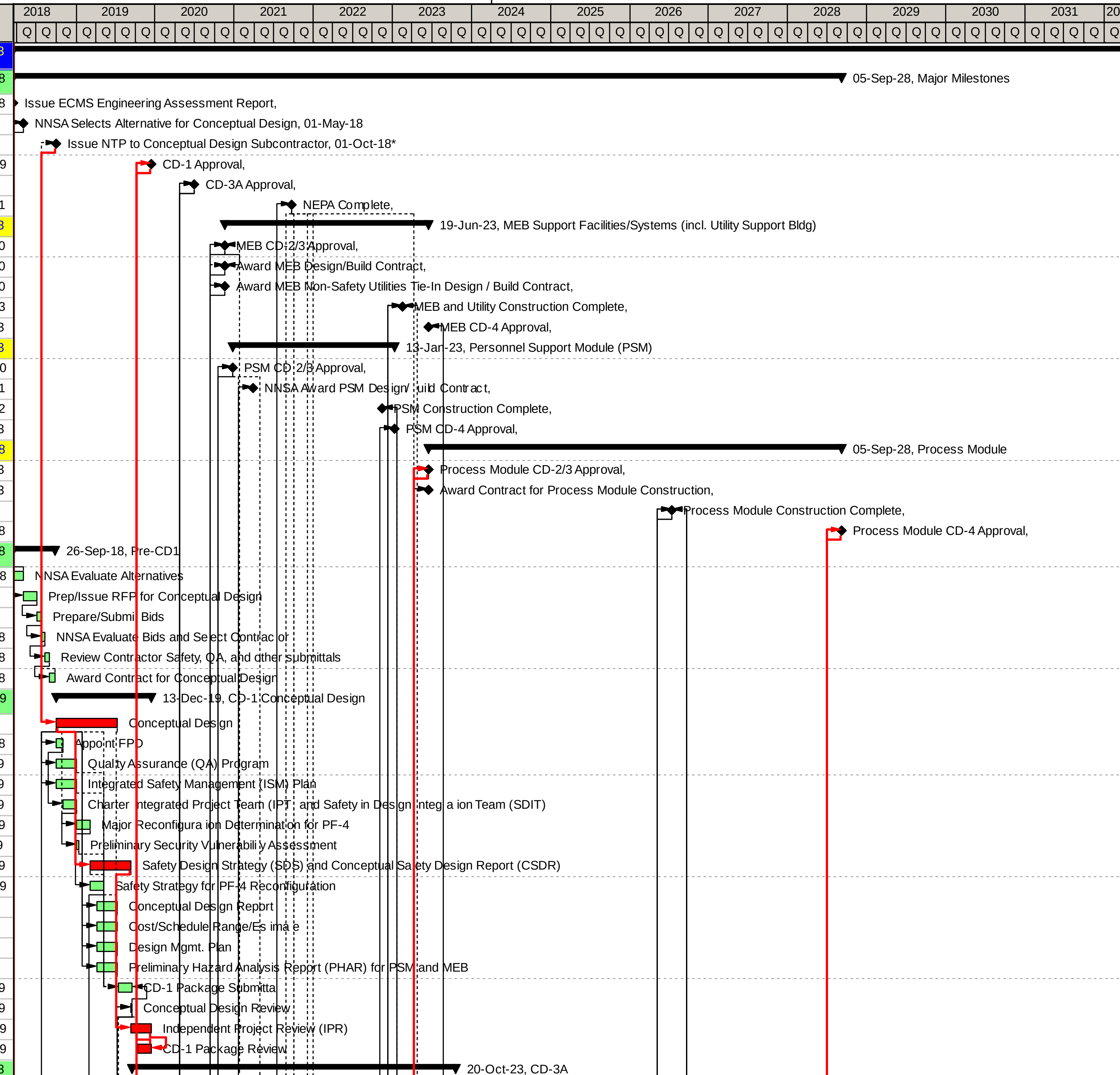
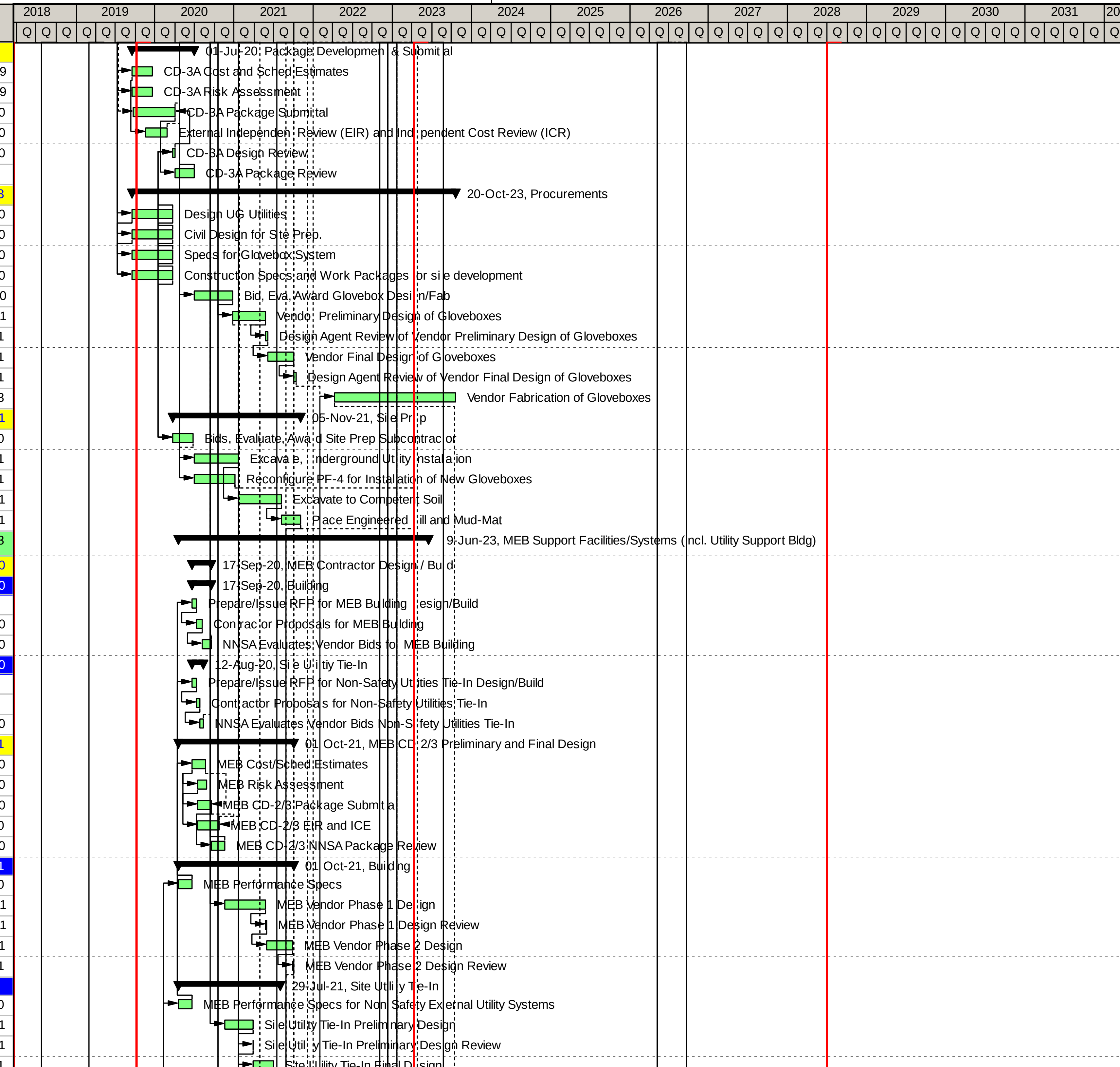
Activity ID	Activity Name	Original Duration	Start	Finish
Alternative 2b – Construct a Module at LANL – Production Capa		183m	16-Mar-18	20-Oct-33
Major Milestones		123m	16-Mar-18	05-Sep-28
MS01	Issue ECMS Engineering Assessment Report	0m		16-Mar-18
MS02	NNSA Selects Alternative for Conceptual Design	0m	01-May-18	
MS20	Issue NTP to Conceptual Design Subcontractor	0m	01-Oct-18*	
MS03	CD-1 Approval	0m		13-Dec-19
MS05	CD-3A Approval	0m		01-Jul-20
MS04	NEPA Complete	0m		22-Sep-21
MEB Support Facilities/Systems (incl. Utility Support Bldg)		30m	19-Nov-20	19-Jun-23
MS15	MEB CD-2/3 Approval	0m		19-Nov-20
MS16	Award MEB Design/Build Contract	0m		19-Nov-20
MS17	Award MEB Non-Safety Utilities Tie-In Design / Build Contract	0m		19-Nov-20
MS18	MEB and Utility Construction Complete	0m		15-Feb-23
MS19	MEB CD-4 Approval	0m		19-Jun-23
Personnel Support Module (PSM)		24m	22-Dec-20	13-Jan-23
MS11	PSM CD-2/3 Approval	0m		22-Dec-20
MS12	NNSA Award PSM Design/Build Contract	0m		26-Mar-21
MS13	PSM Construction Complete	0m		14-Nov-22
MS14	PSM CD-4 Approval	0m		13-Jan-23
Process Module		61m	19-Jun-23	05-Sep-28
MS07	Process Module CD-2/3 Approval	0m		19-Jun-23
MS08	Award Contract for Process Module Construction	0m		19-Jun-23
MS09	Process Module Construction Complete	0m		16-Jul-26
MS10	Process Module CD-4 Approval	0m		05-Sep-28
Pre-CD1		6m	16-Mar-18	26-Sep-18
A005	NNSA Evaluate Alternatives	2m	16-Mar-18	01-May-18
A010	Prep/Issue RFP for Conceptual Design	2m	01-May-18	02-Jul-18
A015	Prepare/Submit Bids	1m	02-Jul-18	24-Jul-18
A020	NNSA Evaluate Bids and Select Contractor	0m	24-Jul-18	07-Aug-18
A025	Review Contractor Safety, QA, and other submittals	1m	07-Aug-18	28-Aug-18
A030	Award Contract for Conceptual Design	1m	28-Aug-18	26-Sep-18
CD-1 Conceptual Design		14m	01-Oct-18	13-Dec-19
A055	Conceptual Design	9m	01-Oct-18	10-Jul-19
A040	Appoint FPD	1m	01-Oct-18	01-Nov-18
A035	Quality Assurance (QA) Program	3m	01-Oct-18	04-Jan-19
A045	Integrated Safety Management (ISM) Plan	3m	01-Oct-18	04-Jan-19
A070	Charter Integrated Project Team (IPT) and Safety in Design Integra ion Tea	2m	01-Nov-18	04-Jan-19
A250	Major Reconfiguration Determination for PF-4	2m	04-Jan-19	08-Mar-19
A046	Preliminary Security Vulnerability Assessment	0m	04-Jan-19	11-Jan-19
A080	Safety Design Strategy (SDS) and Conceptual Safety Design Report (CSD	6m	08-Mar-19	10-Sep-19
A255	Safety Strategy for PF-4 Reconfiguration	2m	08-Mar-19	08-May-19
A060	Conceptual Design Report	3m	08-Apr-19	10-Jul-19
A065	Cost/Schedule Range/Estimate	3m	08-Apr-19	10-Jul-19
A050	Design Mgmt. Plan	3m	08-Apr-19	10-Jul-19
A075	Preliminary Hazard Analysis Report (PHAR) for PSM and MEB	3m	08-Apr-19	10-Jul-19
A090	CD-1 Package Submittal	2m	16-Jul-19	16-Sep-19
A085	Conceptual Design Review	0m	10-Sep-19	16-Sep-19
A095	Independent Project Review (IPR)	3m	10-Sep-19	13-Dec-19
A100	CD-1 Package Review	2m	10-Oct-19	13-Dec-19
CD-3A		48m	16-Sep-19	20-Oct-23

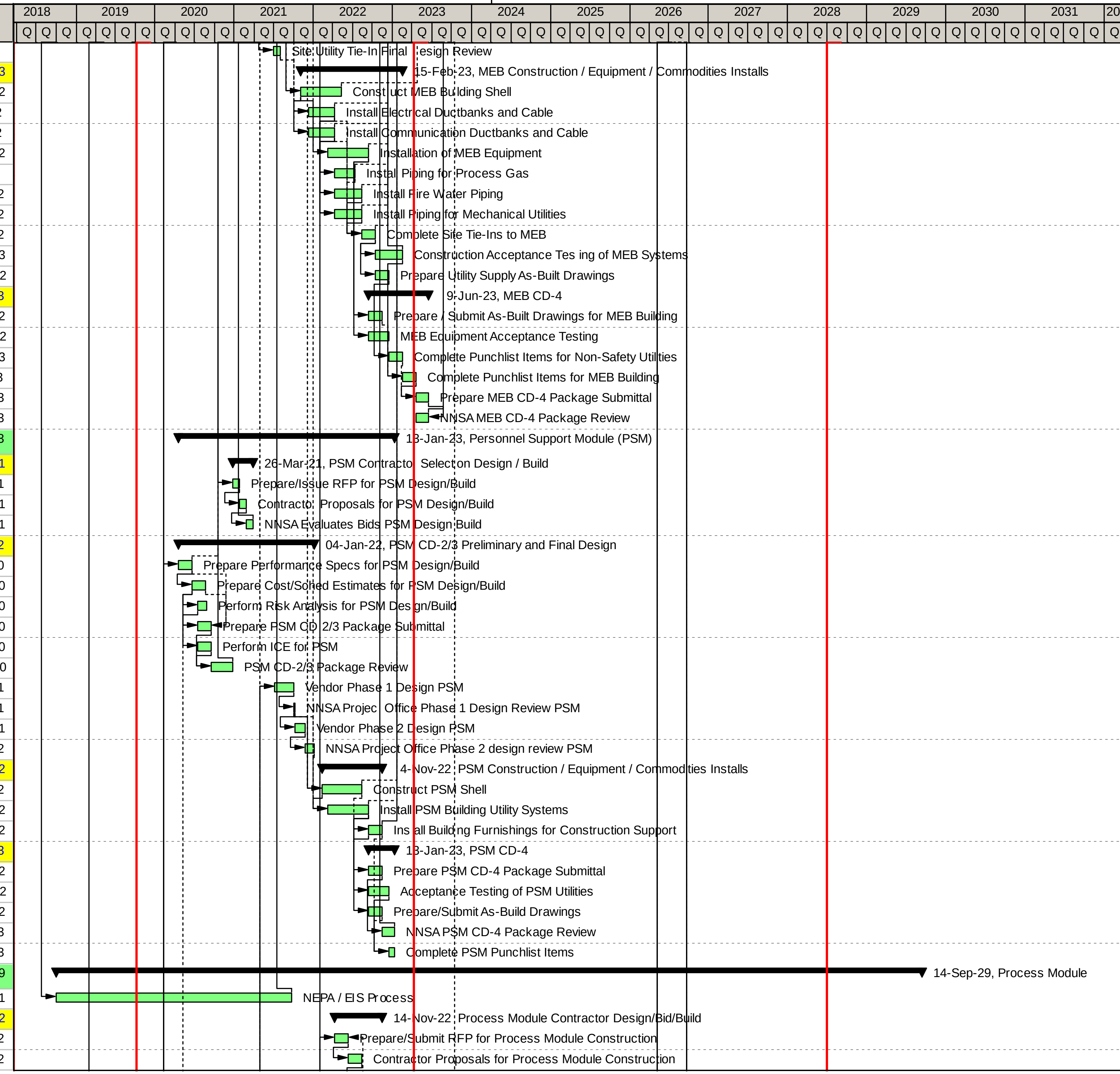


~~Unclassified Controlled Nuclear Information~~

Activity ID	Activity Name	Original Duration	Start	Finish
Package Development & Submittal		9m	16-Sep-19	01-Jul-20
A150	CD-3A Cost and Sched Estimates	3m	16-Sep-19	19-Dec-19
A155	CD-3A Risk Assessment	3m	16-Sep-19	19-Dec-19
A165	CD-3A Package Submittal	6m	23-Sep-19	31-Mar-20
A170	External Independent Review (EIR) and Independent Cost Review (ICR)	3m	18-Nov-19	24-Feb-20
A160	CD-3A Design Review	0m	24-Mar-20	31-Mar-20
A175	CD-3A Package Review	3m	31-Mar-20	01-Jul-20
Procurements		48m	16-Sep-19	20-Oct-23
A180	Design UG Utilities	6m	16-Sep-19	24-Mar-20
A185	Civil Design for Site Prep.	6m	16-Sep-19	24-Mar-20
A190	Specs for Glovebox System	6m	16-Sep-19	24-Mar-20
A195	Construction Specs and Work Packages for site development	6m	16-Sep-19	24-Mar-20
A200	Bid, Eva, Award Glovebox Design/Fab	6m	01-Jul-20	22-Dec-20
A201	Vendor Preliminary Design of Gloveboxes	5m	22-Dec-20	27-May-21
A202	Design Agent Review of Vendor Preliminary Design of Gloveboxes	0m	27-May-21	04-Jun-21
A203	Vendor Final Design of Gloveboxes	4m	04-Jun-21	05-Oct-21
A204	Design Agent Review of Vendor Final Design of Gloveboxes	0m	05-Oct-21	13-Oct-21
A205	Vendor Fabrication of Gloveboxes	18m	11-Apr-22	20-Oct-23
Site Prep		19m	24-Mar-20	05-Nov-21
A265	Bids, Evaluate, Award Site Prep Subcontractor	3m	24-Mar-20	24-Jun-20
A210	Excavate, Underground Utility Installation	6m	01-Jul-20	20-Jan-21
B155	Reconfigure PF-4 for Installation of New Gloveboxes	6m	01-Jul-20	06-Jan-21
A220	Excavate to Competent Soil	6m	20-Jan-21	04-Aug-21
A260	Place Engineered Fill and Mud-Mat	3m	04-Aug-21	05-Nov-21
MEB Support Facilities/Systems (incl. Utility Support Bldg)		37m	17-Apr-20	19-Jun-23
MEB Contractor Design / Build		3m	18-Jun-20	17-Sep-20
Building		3m	18-Jun-20	17-Sep-20
E5	Prepare/Issue RFP for MEB Building Design/Build	1m	18-Jun-20	10-Jul-20
E10	Contractor Proposals for MEB Building	1m	10-Jul-20	03-Aug-20
E15	NNSA Evaluates Vendor Bids for MEB Building	2m	03-Aug-20	17-Sep-20
Site Utilitiy Tie-In		2m	18-Jun-20	12-Aug-20
E20	Prepare/Issue RFP for Non-Safety Utilities Tie-In Design/Build	1m	18-Jun-20	10-Jul-20
E25	Contractor Proposals for Non-Safety Utilities Tie-In	1m	10-Jul-20	27-Jul-20
E30	NNSA Evaluates Vendor Bids Non-Safety Utilities Tie-In	1m	27-Jul-20	12-Aug-20
MEB CD-2/3 Preliminary and Final Design		17m	17-Apr-20	01-Oct-21
E35	MEB Cost/Sched Estimates	2m	18-Jun-20	18-Aug-20
E40	MEB Risk Assessment	1m	17-Jul-20	28-Aug-20
E45	MEB CD-2/3 Package Submittal	2m	17-Jul-20	17-Sep-20
E50	MEB CD-2/3 EIR and ICE	3m	17-Jul-20	20-Oct-20
E55	MEB CD-2/3 NNSA Package Review	2m	17-Sep-20	19-Nov-20
Building		17m	17-Apr-20	01-Oct-21
E60	MEB Performance Specs	2m	17-Apr-20	18-Jun-20
E65	MEB Vendor Phase 1 Design	6m	19-Nov-20	26-May-21
E70	MEB Vendor Phase 1 Design Review	0m	26-May-21	28-May-21
E75	MEB Vendor Phase 2 Design	4m	28-May-21	29-Sep-21
E80	MEB Vendor Phase 2 Design Review	0m	29-Sep-21	01-Oct-21
Site Utilitiy Tie-In		15m	17-Apr-20	29-Jul-21
E85	MEB Performance Specs for Non-Safety External Utility Systems	2m	17-Apr-20	18-Jun-20
E90	Site Utility Tie-In Preliminary Design	4m	19-Nov-20	26-Mar-21
E95	Site Utility Tie-In Preliminary Design Review	0m	26-Mar-21	30-Mar-21
E100	Site Utility Tie-In Final Design	3m	30-Mar-21	30-Jun-21



Activity ID	Activity Name	Original Duration	Start	Finish
E105	Site Utility Tie-In Final Design Review	1m	30-Jun-21	29-Jul-21
MEB Construction / Equipment / Commodities Installs		15m	05-Nov-21	15-Feb-23
E120	Construct MEB Building Shell	6m	05-Nov-21	11-May-22
E110	Install Electrical Ductbanks and Cable	4m	08-Dec-21	11-Apr-22
E115	Install Communication Ductbanks and Cable	4m	08-Dec-21	11-Apr-22
E140	Installation of MEB Equipment	6m	11-Mar-22	13-Sep-22
E125	Install Piping for Process Gas	3m	11-Apr-22	13-Jul-22
E130	Install Fire Water Piping	4m	11-Apr-22	11-Aug-22
E135	Install Piping for Mechanical Utilities	4m	11-Apr-22	11-Aug-22
E145	Complete Site Tie-Ins to MEB	2m	11-Aug-22	13-Oct-22
E155	Construction Acceptance Testing of MEB Systems	4m	13-Oct-22	15-Feb-23
E150	Prepare Utility Supply As-Built Drawings	2m	13-Oct-22	15-Dec-22
MEB CD-4		9m	13-Sep-22	19-Jun-23
E160	Prepare / Submit As-Built Drawings for MEB Building	2m	13-Sep-22	15-Nov-22
E170	MEB Equipment Acceptance Testing	3m	13-Sep-22	15-Dec-22
E180	Complete Punchlist Items for Non-Safety Utilities	2m	15-Dec-22	15-Feb-23
E190	Complete Punchlist Items for MEB Building	2m	15-Feb-23	18-Apr-23
E195	Prepare MEB CD-4 Package Submittal	2m	18-Apr-23	19-Jun-23
E200	NNSA MEB CD-4 Package Review	2m	18-Apr-23	19-Jun-23
Personnel Support Module (PSM)		32m	17-Apr-20	13-Jan-23
PSM Contractor Selection Design / Build		3m	22-Dec-20	26-Mar-21
D05	Prepare/Issue RFP for PSM Design/Build	1m	22-Dec-20	25-Jan-21
D10	Contractor Proposals for PSM Design/Build	1m	25-Jan-21	25-Feb-21
D15	NNSA Evaluates Bids PSM Design/Build	1m	25-Feb-21	26-Mar-21
PSM CD-2/3 Preliminary and Final Design		20m	17-Apr-20	04-Jan-22
D20	Prepare Performance Specs for PSM Design/Build	2m	17-Apr-20	18-Jun-20
D25	Prepare Cost/Sched Estimates for PSM Design/Build	2m	18-Jun-20	18-Aug-20
D30	Perform Risk Analysis for PSM Design/Build	1m	17-Jul-20	28-Aug-20
D40	Prepare PSM CD-2/3 Package Submittal	2m	17-Jul-20	17-Sep-20
D35	Perform ICE for PSM	2m	17-Jul-20	17-Sep-20
D45	PSM CD-2/3 Package Review	3m	17-Sep-20	22-Dec-20
D50	Vendor Phase 1 Design PSM	3m	05-Jul-21	05-Oct-21
D55	NNSA Project Office Phase 1 Design Review PSM	0m	05-Oct-21	07-Oct-21
D60	Vendor Phase 2 Design PSM	1m	07-Oct-21	22-Nov-21
D65	NNSA Project Office Phase 2 design review PSM	1m	22-Nov-21	04-Jan-22
PSM Construction / Equipment / Commodities Installs		9m	08-Feb-22	14-Nov-22
D70	Construct PSM Shell	6m	08-Feb-22	11-Aug-22
D75	Install PSM Building Utility Systems	6m	10-Mar-22	12-Sep-22
D80	Install Building Furnishings for Construc ion Support	2m	12-Sep-22	14-Nov-22
PSM CD-4		4m	12-Sep-22	13-Jan-23
D85	Prepare PSM CD-4 Package Submittal	2m	12-Sep-22	14-Nov-22
D95	Acceptance Testing of PSM Utilities	3m	12-Sep-22	15-Dec-22
D90	Prepare/Submit As-Build Drawings	2m	12-Sep-22	14-Nov-22
D100	NNSA PSM CD-4 Package Review	2m	14-Nov-22	13-Jan-23
D105	Complete PSM Punchlist Items	1m	15-Dec-22	13-Jan-23
Process Module		128m	01-Oct-18	14-Sep-29
B105	NEPA / EIS Process	36m	01-Oct-18	22-Sep-21
Process Module Contractor Design/Bid/Build		7m	11-Apr-22	14-Nov-22
B100	Prepare/Submit RFP for Process Module Construction	2m	11-Apr-22	10-Jun-22
B110	Contractor Proposals for Process Module Construction	2m	10-Jun-22	11-Aug-22



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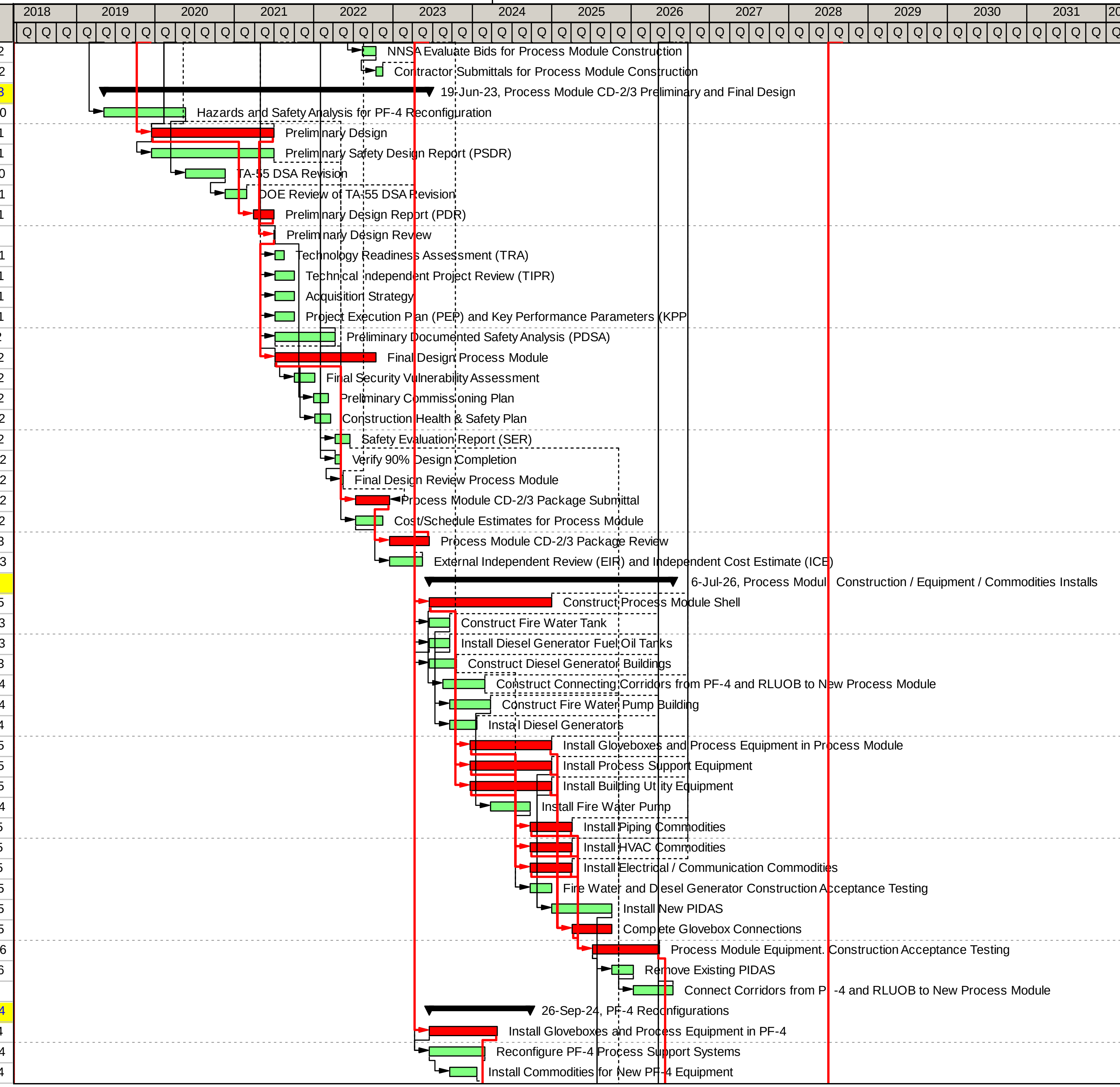
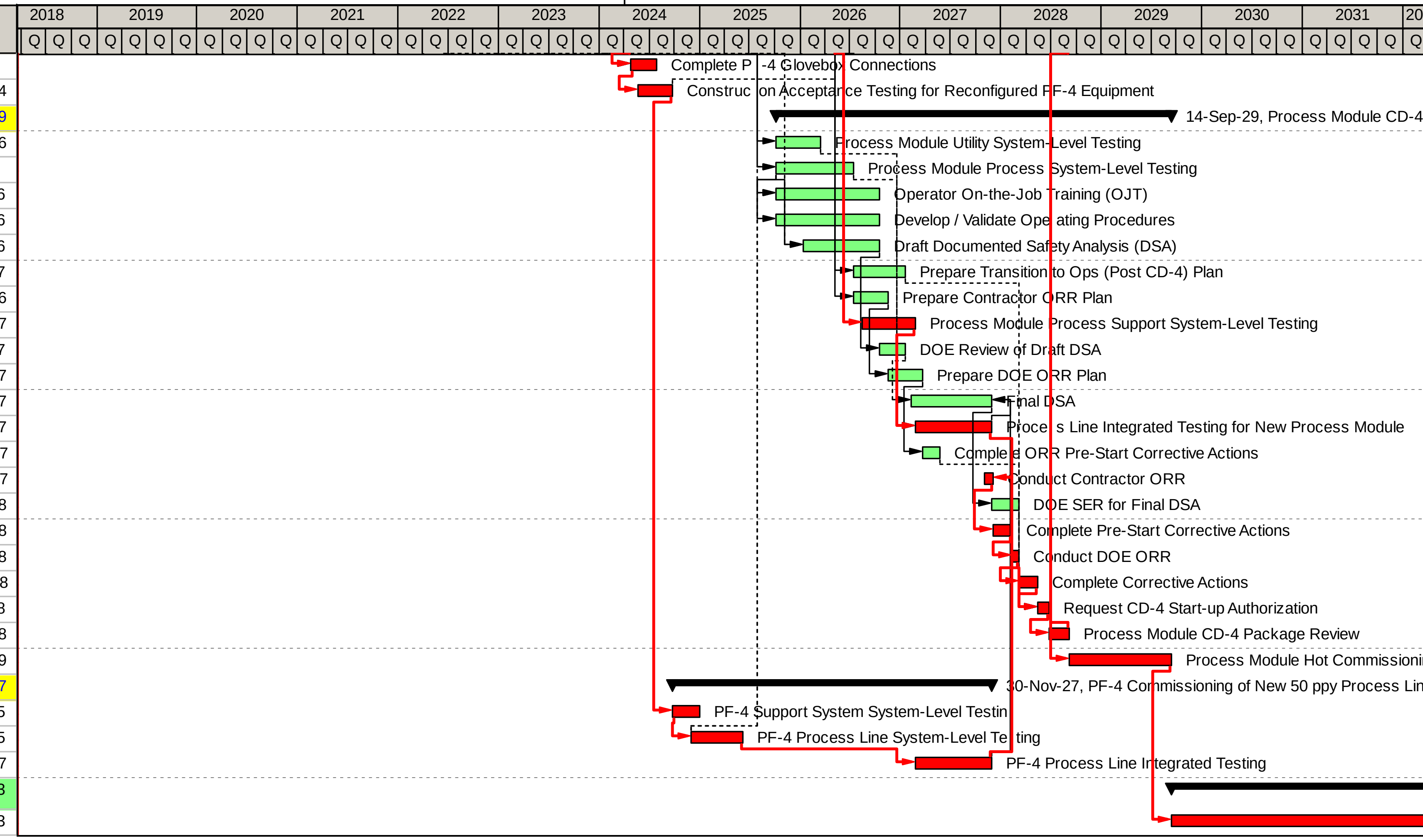
Activity ID	Activity Name	Original Duration	Start	Finish
B115	NNSA Evaluate Bids for Process Module Construction	2m	11-Aug-22	13-Oct-22
B120	Contractor Submittals for Process Module Construction	1m	13-Oct-22	14-Nov-22
Process Module CD-2/3 Preliminary and Final Design		**48m**	**08-May-19**	**19-Jun-23**
B10	Hazards and Safety Analysis for PF-4 Reconfiguration	12m	08-May-19	18-May-20
B15	Preliminary Design	18m	13-Dec-19	28-Jun-21
B20	Preliminary Safety Design Report (PSDR)	18m	13-Dec-19	28-Jun-21
B40	TA-55 DSA Revision	6m	18-May-20	19-Nov-20
B65	DOE Review of TA-55 DSA Revision	3m	19-Nov-20	25-Feb-21
B30	Preliminary Design Report (PDR)	3m	26-Mar-21	28-Jun-21
B35	Preliminary Design Review	0m	28-Jun-21	05-Jul-21
B45	Technology Readiness Assessment (TRA)	2m	05-Jul-21	19-Aug-21
B50	Technical Independent Project Review (TIPR)	3m	05-Jul-21	05-Oct-21
B55	Acquisition Strategy	3m	05-Jul-21	05-Oct-21
B60	Project Execution Plan (PEP) and Key Performance Parameters (KPP)	3m	05-Jul-21	05-Oct-21
B130	Preliminary Documented Safety Analysis (PDSA)	9m	05-Jul-21	11-Apr-22
B125	Final Design Process Module	15m	05-Jul-21	13-Oct-22
B75	Final Security Vulnerability Assessment	3m	05-Oct-21	06-Jan-22
B90	Preliminary Commissioning Plan	2m	30-Dec-21	11-Mar-22
B95	Construction Health & Safety Plan	2m	06-Jan-22	18-Mar-22
B145	Safety Evaluation Report (SER)	2m	11-Apr-22	17-Jun-22
B85	Verify 90% Design Completion	1m	11-Apr-22	03-May-22
B135	Final Design Review Process Module	0m	03-May-22	16-May-22
B140	Process Module CD-2/3 Package Submittal	5m	12-Jul-22	15-Dec-22
B5	Cost/Schedule Estimates for Process Module	4m	12-Jul-22	14-Nov-22
B150	Process Module CD-2/3 Package Review	6m	15-Dec-22	19-Jun-23
B80	External Independent Review (EIR) and Independent Cost Estimate (ICE)	5m	15-Dec-22	17-May-23
Process Module Construction / Equipment / Commodities Installs		**36m**	**19-Jun-23**	**16-Jul-26**
B195	Construct Process Module Shell	18m	19-Jun-23	02-Jan-25
B160	Construct Fire Water Tank	3m	19-Jun-23	19-Sep-23
B165	Install Diesel Generator Fuel Oil Tanks	3m	19-Jun-23	19-Sep-23
B170	Construct Diesel Generator Buildings	4m	19-Jun-23	20-Oct-23
B175	Construct Connecting Corridors from PF-4 and RLUOB to New Process M	6m	18-Aug-23	26-Feb-24
B190	Construct Fire Water Pump Building	6m	19-Sep-23	26-Mar-24
B185	Install Diesel Generators	4m	19-Sep-23	24-Jan-24
B220	Install Gloveboxes and Process Equipment in Process Module	12m	21-Dec-23	02-Jan-25
B225	Install Process Support Equipment	12m	21-Dec-23	02-Jan-25
B230	Install Building Utility Equipment	12m	21-Dec-23	02-Jan-25
B365	Install Fire Water Pump	6m	26-Mar-24	26-Sep-24
B245	Install Piping Commodities	6m	26-Sep-24	04-Apr-25
B250	Install HVAC Commodities	6m	26-Sep-24	04-Apr-25
B255	Install Electrical / Communication Commodities	6m	26-Sep-24	04-Apr-25
B180	Fire Water and Diesel Generator Construction Acceptance Testing	3m	26-Sep-24	02-Jan-25
B380	Install New PIDAS	9m	02-Jan-25	07-Oct-25
B186	Complete Glovebox Connec ions	6m	04-Apr-25	07-Oct-25
B260	Process Module Equipment. Construction Acceptance Testing	10m	08-Jul-25	15-May-26
B385	Remove Existing PIDAS	3m	07-Oct-25	13-Jan-26
B390	Connect Corridors from PF-4 and RLUOB to New Process Module	6m	13-Jan-26	16-Jul-26
PF-4 Reconfigurations		**15m**	**19-Jun-23**	**26-Sep-24**
B205	Install Gloveboxes and Process Equipment in PF-4	10m	19-Jun-23	25-Apr-24
B210	Reconfigure PF-4 Process Support Systems	8m	19-Jun-23	26-Feb-24
B235	Install Commodities for New PF-4 Equipment	4m	19-Sep-23	24-Jan-24



Activity ID	Activity Name	Original Duration	Start	Finish
B236	Complete PF-4 Glovebox Connections	3m	25-Apr-24	26-Jul-24
B240	Construction Acceptance Testing for Reconfigured PF-4 Equipment	4m	24-May-24	26-Sep-24
Process Module CD-4 Commissioning / Start-up (incl. ORR)		46m	07-Oct-25	14-Sep-29
B280	Process Module Utility System-Level Testing	5m	07-Oct-25	17-Mar-26
B310	Process Module Process System-Level Testing	9m	07-Oct-25	16-Jul-26
B315	Operator On-the-Job Training (OJT)	12m	07-Oct-25	16-Oct-26
B320	Develop / Validate Operating Procedures	12m	07-Oct-25	16-Oct-26
BB236	Draft Documented Safety Analysis (DSA)	9m	13-Jan-26	16-Oct-26
B285	Prepare Transition to Ops (Post CD-4) Plan	6m	16-Jul-26	22-Jan-27
B265	Prepare Contractor ORR Plan	4m	16-Jul-26	18-Nov-26
B305	Process Module Process Support System-Level Testing	6m	14-Aug-26	23-Feb-27
B237	DOE Review of Draft DSA	3m	16-Oct-26	22-Jan-27
B290	Prepare DOE ORR Plan	4m	18-Nov-26	25-Mar-27
B238	Final DSA	9m	10-Feb-27	30-Nov-27
B330	Process Line Integrated Testing for New Process Module	9m	23-Feb-27	30-Nov-27
B300	Complete ORR Pre-Start Correc ive Actions	2m	25-Mar-27	25-May-27
B335	Conduct Contractor ORR	1m	02-Nov-27	07-Dec-27
B239	DOE SER for Final DSA	3m	30-Nov-27	09-Mar-28
B340	Complete Pre-Start Corrective Actions	2m	07-Dec-27	08-Feb-28
B345	Conduct DOE ORR	1m	08-Feb-28	09-Mar-28
B350	Complete Corrective Actions	2m	09-Mar-28	16-May-28
B355	Request CD-4 Start-up Authorization	1m	16-May-28	26-Jun-28
B360	Process Module CD-4 Package Review	2m	26-Jun-28	05-Sep-28
B370	Process Module Hot Commissioning	12m	05-Sep-28	14-Sep-29
PF-4 Commissioning of New 50 ppy Process Lines		37m	26-Sep-24	30-Nov-27
B270	PF-4 Support System System-Level Testing	3m	26-Sep-24	02-Jan-25
B295	PF-4 Process Line System-Level Testing	6m	29-Nov-24	05-Jun-25
B325	PF-4 Process Line Integrated Testing	9m	23-Feb-27	30-Nov-27
Transition to War Reserve (WR) Production		48m	14-Sep-29	20-Oct-33
B375	Transition to WR Production	48m	14-Sep-29	20-Oct-33



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Appendix L Schedule for Alternative 2c

Both the Critical Path Schedule and Full Schedule for Alternative 2c are below. The Critical Path Schedule is on Page L-3. The Full Schedule begins on Page L-5.

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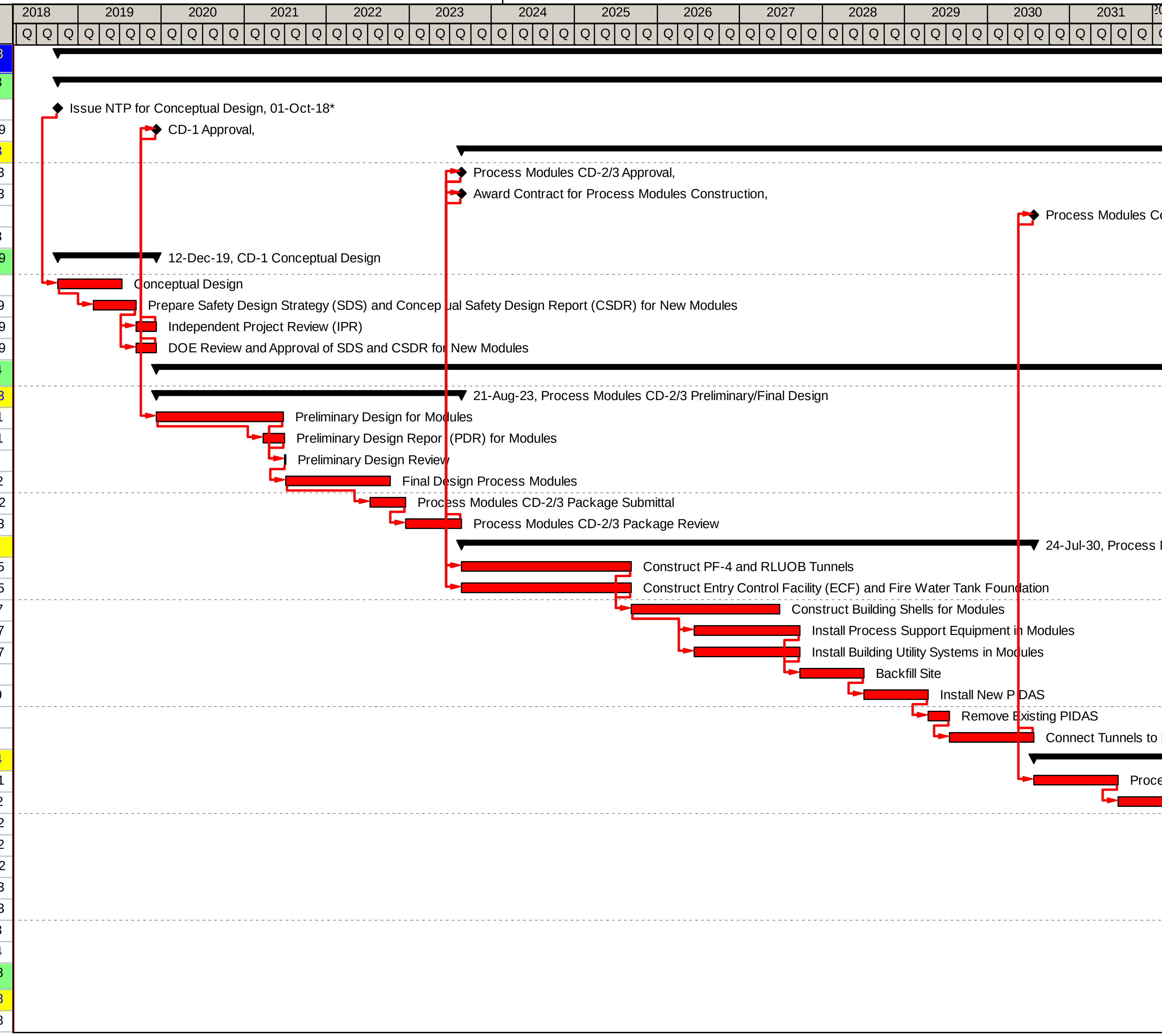
Activity ID	Activity Name	Original Duration	Start	Finish
Alternative 2c –Use PF-4 as a Bridge by FY2030 Until Constructic		230m	01-Oct-18	01-Jun-38
Major Milestones		170m	01-Oct-18	18-Apr-33
MS20	Issue NTP for Conceptual Design	0m	01-Oct-18*	
MS03	CD-1 Approval	0m		12-Dec-19
New Process Modules		113m	21-Aug-23	18-Apr-33
MS07	Process Modules CD-2/3 Approval	0m		21-Aug-23
MS08	Award Contract for Process Modules Construction	0m		21-Aug-23
MS09	Process Modules Construction Complete	0m		24-Jul-30
MS10	Process Modules CD-4 Approval	0m		18-Apr-33
CD-1 Conceptual Design		14m	01-Oct-18	12-Dec-19
A055	Conceptual Design	9m	01-Oct-18	10-Jul-19
A080	Prepare Safety Design Strategy (SDS) and Conceptual Safety Design Repor	6m	08-Mar-19	10-Sep-19
A095	Independent Project Review (IPR)	3m	10-Sep-19	12-Dec-19
A240	DOE Review and Approval of SDS and CSDR for New Modules	3m	10-Sep-19	12-Dec-19
PF-4 Reconfigurations and Process Modules		168m	12-Dec-19	25-Apr-34
Process Modules CD-2/3 Preliminary/Final Design		43m	12-Dec-19	21-Aug-23
B285	Preliminary Design for Modules	18m	12-Dec-19	25-Jun-21
B300	Preliminary Design Report (PDR) for Modules	3m	26-Mar-21	28-Jun-21
B305	Preliminary Design Review	0m	28-Jun-21	05-Jul-21
B75	Final Design Process Modules	15m	05-Jul-21	12-Oct-22
B95	Process Modules CD-2/3 Package Submittal	5m	12-Jul-22	15-Dec-22
B100	Process Modules CD-2/3 Package Review	8m	15-Dec-22	21-Aug-23
Process Modules Construction and Equipment Installation		81m	21-Aug-23	24-Jul-30
NM05	Construct PF-4 and RLUOB Tunnels	24m	21-Aug-23	09-Sep-25
NM10	Construct Entry Control Facility (ECF) and Fire Water Tank Foundation	24m	21-Aug-23	09-Sep-25
NM15	Construct Building Shells for Modules	21m	09-Sep-25	25-Jun-27
NM25	Install Process Support Equipment in Modules	15m	17-Jun-26	27-Sep-27
NM30	Install Building Utility Systems in Modules	15m	17-Jun-26	27-Sep-27
NM31	Backfill Site	9m	27-Sep-27	05-Jul-28
NM50	Install New PIDAS	9m	05-Jul-28	13-Apr-29
NM55	Remove Existing PIDAS	3m	13-Apr-29	16-Jul-29
NM60	Connect Tunnels to PF-4 and RLUOB	12m	16-Jul-29	24-Jul-30
Process Modules Commissioning		44m	24-Jul-30	25-Apr-34
NM80	Process Line System Level Testing for Modules	12m	24-Jul-30	04-Aug-31
NM95	Conduct Integrated Testing Process Line for Modules	12m	04-Aug-31	11-Aug-32
NM110	Conduct Contractor ORR for Modules	1m	11-Aug-32	13-Sep-32
NM115	Complete Contractor ORR Pre-Start Corrective Actions	2m	13-Sep-32	15-Nov-32
NM125	Conduct DOE ORR for Modules	1m	15-Nov-32	15-Dec-32
NM130	Complete DOE ORR Pre-Start Corrective Actions	2m	15-Dec-32	15-Feb-33
NM135	Prepare/Submit CD-4 Startup Authorization Request for Modules	1m	15-Feb-33	18-Mar-33
NM140	DOE Review of CD-4 Startup Authorization Request for Modules	1m	18-Mar-33	18-Apr-33
PF145	Process Line Hot Commissioning	12m	18-Apr-33	25-Apr-34
Transition to War Reserve (WR) Production		48m	25-Apr-34	01-Jun-38
Process Line		48m	25-Apr-34	01-Jun-38
PF150	Transition to WR Production - Process Modules	48m	25-Apr-34	01-Jun-38



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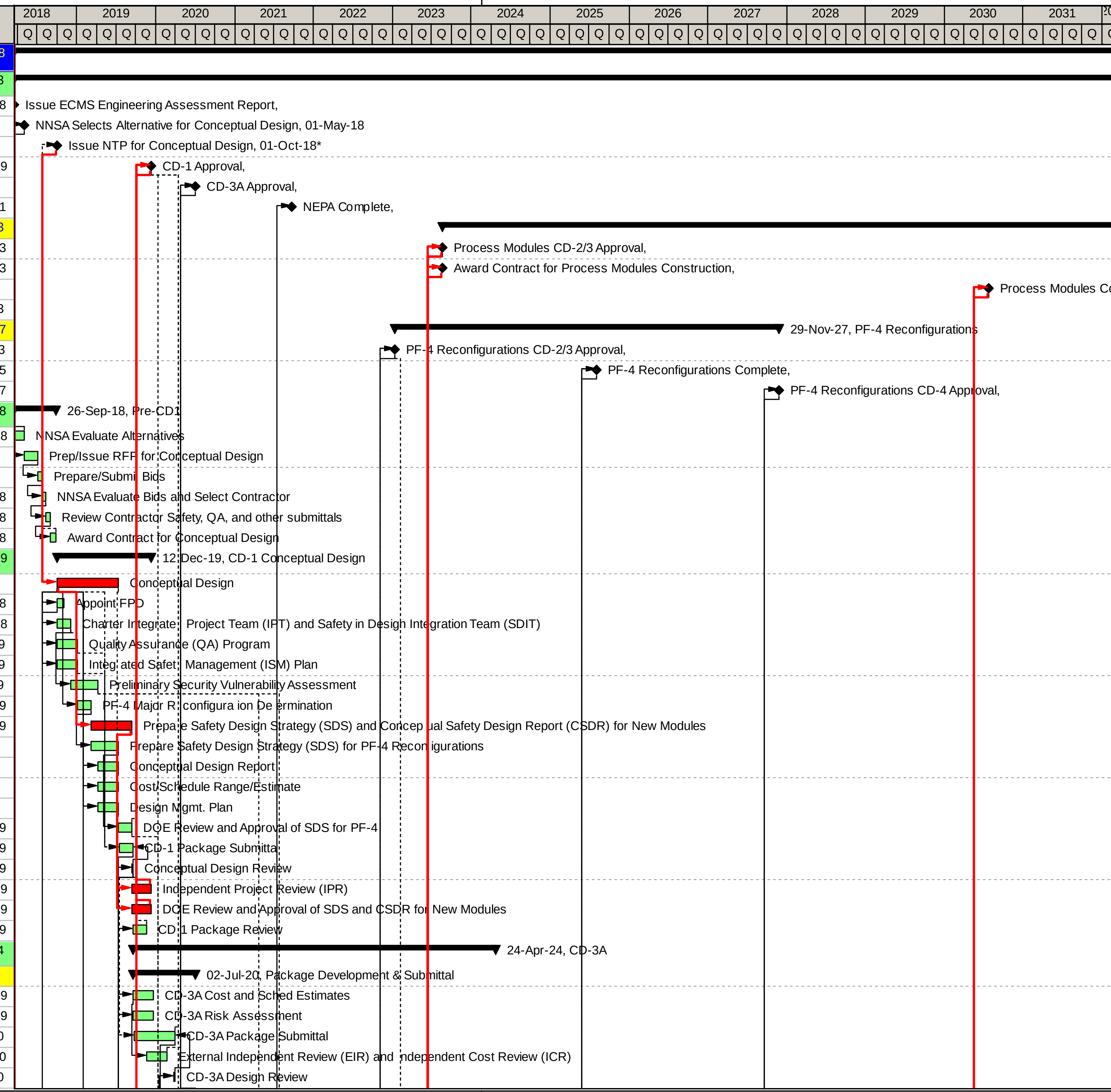
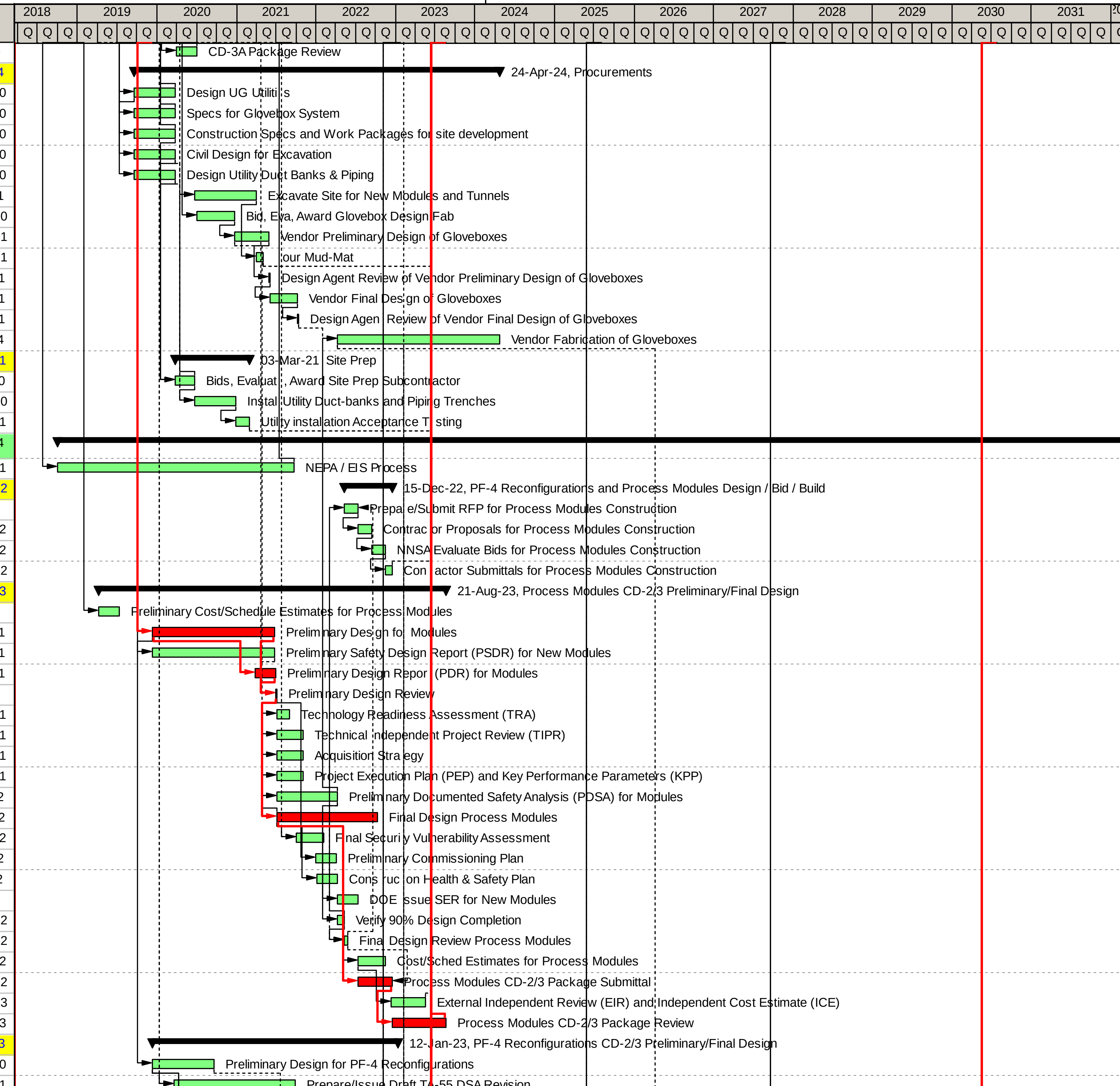
Activity ID	Activity Name	Original Duration	Start	Finish
Alternative 2c –Use PF-4 as a Bridge by FY2030 Until Constructic		237m	16-Mar-18	01-Jun-38
Major Milestones		177m	16-Mar-18	18-Apr-33
MS01	Issue ECMS Engineering Assessment Report	0m		16-Mar-18
MS02	NNSA Selects Alternative for Conceptual Design	0m	01-May-18	
MS20	Issue NTP for Conceptual Design	0m	01-Oct-18*	
MS03	CD-1 Approval	0m		12-Dec-19
MS04	CD-3A Approval	0m		02-Jul-20
MS05	NEPA Complete	0m		22-Sep-21
New Process Modules		113m	21-Aug-23	18-Apr-33
MS07	Process Modules CD-2/3 Approval	0m		21-Aug-23
MS08	Award Contract for Process Modules Construction	0m		21-Aug-23
MS09	Process Modules Construction Complete	0m		24-Jul-30
MS10	Process Modules CD-4 Approval	0m		18-Apr-33
PF-4 Reconfigurations		57m	12-Jan-23	29-Nov-27
MS13	PF-4 Reconfigurations CD-2/3 Approval	0m		12-Jan-23
MS11	PF-4 Reconfigurations Complete	0m		05-Aug-25
MS12	PF-4 Reconfigurations CD-4 Approval	0m		29-Nov-27
Pre-CD1		6m	16-Mar-18	26-Sep-18
A005	NNSA Evaluate Alternatives	2m	16-Mar-18	01-May-18
A010	Prep/Issue RFP for Conceptual Design	2m	01-May-18	02-Jul-18
A015	Prepare/Submit Bids	1m	02-Jul-18	24-Jul-18
A020	NNSA Evaluate Bids and Select Contractor	0m	24-Jul-18	07-Aug-18
A025	Review Contractor Safety, QA, and other submittals	1m	07-Aug-18	28-Aug-18
A030	Award Contract for Conceptual Design	1m	28-Aug-18	26-Sep-18
CD-1 Conceptual Design		14m	01-Oct-18	12-Dec-19
A055	Conceptual Design	9m	01-Oct-18	10-Jul-19
A040	Appoint FPD	1m	01-Oct-18	01-Nov-18
A070	Charter Integrated Project Team (IPT) and Safety in Design Integra ion Tean	2m	01-Oct-18	03-Dec-18
A035	Quality Assurance (QA) Program	3m	01-Oct-18	04-Jan-19
A045	Integrated Safety Management (ISM) Plan	3m	01-Oct-18	04-Jan-19
A046	Preliminary Security Vulnerability Assessment	4m	03-Dec-18	08-Apr-19
A225	PF-4 Major Reconfiguration Determination	2m	04-Jan-19	08-Mar-19
A080	Prepare Safety Design Strategy (SDS) and Conceptual Safety Design Repor	6m	08-Mar-19	10-Sep-19
A230	Prepare Safety Design Strategy (SDS) for PF-4 Reconfigurations	4m	08-Mar-19	10-Jul-19
A060	Conceptual Design Report	3m	08-Apr-19	10-Jul-19
A065	Cost/Schedule Range/Estimate	3m	08-Apr-19	10-Jul-19
A050	Design Mgmt. Plan	3m	08-Apr-19	10-Jul-19
A235	DOE Review and Approval of SDS for PF-4	2m	10-Jul-19	10-Sep-19
A090	CD-1 Package Submittal	2m	17-Jul-19	17-Sep-19
A085	Conceptual Design Review	0m	10-Sep-19	17-Sep-19
A095	Independent Project Review (IPR)	3m	10-Sep-19	12-Dec-19
A240	DOE Review and Approval of SDS and CSDR for New Modules	3m	10-Sep-19	12-Dec-19
A100	CD-1 Package Review	2m	17-Sep-19	19-Nov-19
CD-3A		54m	17-Sep-19	24-Apr-24
Package Development & Submittal		9m	17-Sep-19	02-Jul-20
A150	CD-3A Cost and Sched Estimates	3m	17-Sep-19	20-Dec-19
A155	CD-3A Risk Assessment	3m	17-Sep-19	20-Dec-19
A165	CD-3A Package Submittal	6m	24-Sep-19	01-Apr-20
A170	External Independent Review (EIR) and Independent Cost Review (ICR)	3m	19-Nov-19	24-Feb-20
A160	CD-3A Design Review	0m	25-Mar-20	01-Apr-20



Activity ID	Activity Name	Original Duration	Start	Finish
A175	CD-3A Package Review	3m	01-Apr-20	02-Jul-20
Procurements		54m	17-Sep-19	24-Apr-24
A180	Design UG Utilities	6m	17-Sep-19	25-Mar-20
A190	Specs for Glovebox System	6m	17-Sep-19	25-Mar-20
A195	Construction Specs and Work Packages for site development	6m	17-Sep-19	25-Mar-20
A245	Civil Design for Excavation	6m	17-Sep-19	25-Mar-20
A250	Design Utility Duct Banks & Piping	6m	17-Sep-19	25-Mar-20
A255	Excavate Site for New Modules and Tunnels	9m	24-Jun-20	02-Apr-21
A200	Bid, Eva, Award Glovebox Design/Fab	6m	02-Jul-20	23-Dec-20
A201	Vendor Preliminary Design of Gloveboxes	5m	23-Dec-20	27-May-21
A260	Pour Mud-Mat	1m	02-Apr-21	03-May-21
A202	Design Agent Review of Vendor Preliminary Design of Gloveboxes	0m	27-May-21	04-Jun-21
A203	Vendor Final Design of Gloveboxes	4m	04-Jun-21	05-Oct-21
A204	Design Agent Review of Vendor Final Design of Gloveboxes	0m	05-Oct-21	13-Oct-21
A205	Vendor Fabrication of Gloveboxes	24m	08-Apr-22	24-Apr-24
Site Prep		11m	25-Mar-20	03-Mar-21
A265	Bids, Evaluate, Award Site Prep Subcontractor	3m	25-Mar-20	24-Jun-20
A210	Install Utility Duct-banks and Piping Trenches	6m	24-Jun-20	29-Dec-20
A215	Utility installation Acceptance Testing	2m	29-Dec-20	03-Mar-21
PF-4 Reconfigurations and Process Modules		182m	01-Oct-18	25-Apr-34
B310	NEPA / EIS Process	36m	01-Oct-18	22-Sep-21
PF-4 Reconfigurations and Process Modules Design / Bid / Build		7m	10-May-22	15-Dec-22
B05	Prepare/Submit RFP for Process Modules Construction	2m	10-May-22	12-Jul-22
B10	Contractor Proposals for Process Modules Construction	2m	12-Jul-22	12-Sep-22
B15	NNSA Evaluate Bids for Process Modules Construction	2m	12-Sep-22	14-Nov-22
B20	Contractor Submittals for Process Modules Construction	1m	14-Nov-22	15-Dec-22
Process Modules CD-2/3 Preliminary/Final Design		51m	08-Apr-19	21-Aug-23
B280	Preliminary Cost/Schedule Estimates for Process Modules	3m	08-Apr-19	10-Jul-19
B285	Preliminary Design for Modules	18m	12-Dec-19	25-Jun-21
B290	Preliminary Safety Design Report (PSDR) for New Modules	18m	12-Dec-19	25-Jun-21
B300	Preliminary Design Report (PDR) for Modules	3m	26-Mar-21	28-Jun-21
B305	Preliminary Design Review	0m	28-Jun-21	05-Jul-21
B25	Technology Readiness Assessment (TRA)	2m	05-Jul-21	02-Sep-21
B30	Technical Independent Project Review (TIPR)	4m	05-Jul-21	04-Nov-21
B35	Acquisition Strategy	4m	05-Jul-21	04-Nov-21
B40	Project Execution Plan (PEP) and Key Performance Parameters (KPP)	4m	05-Jul-21	04-Nov-21
B80	Preliminary Documented Safety Analysis (PDSA) for Modules	9m	05-Jul-21	08-Apr-22
B75	Final Design Process Modules	15m	05-Jul-21	12-Oct-22
B50	Final Security Vulnerability Assessment	4m	04-Oct-21	07-Feb-22
B65	Preliminary Commissioning Plan	3m	30-Dec-21	04-Apr-22
B70	Construction Health & Safety Plan	3m	06-Jan-22	11-Apr-22
B85	DOE Issue SER for New Modules	3m	08-Apr-22	12-Jul-22
B60	Verify 90% Design Completion	1m	08-Apr-22	10-May-22
B90	Final Design Review Process Modules	0m	10-May-22	24-May-22
B45	Cost/Sched Estimates for Process Modules	4m	12-Jul-22	14-Nov-22
B95	Process Modules CD-2/3 Package Submittal	5m	12-Jul-22	15-Dec-22
B55	External Independent Review (EIR) and Independent Cost Estimate (ICE)	5m	14-Dec-22	17-May-23
B100	Process Modules CD-2/3 Package Review	8m	15-Dec-22	21-Aug-23
PF-4 Reconfigurations CD-2/3 Preliminary/Final Design		36m	12-Dec-19	12-Jan-23
PF500	Preliminary Design for PF-4 Reconfigurations	9m	12-Dec-19	17-Sep-20
PF505	Prepare/Issue Draft TA-55 DSA Revision	18m	18-Mar-20	27-Sep-21



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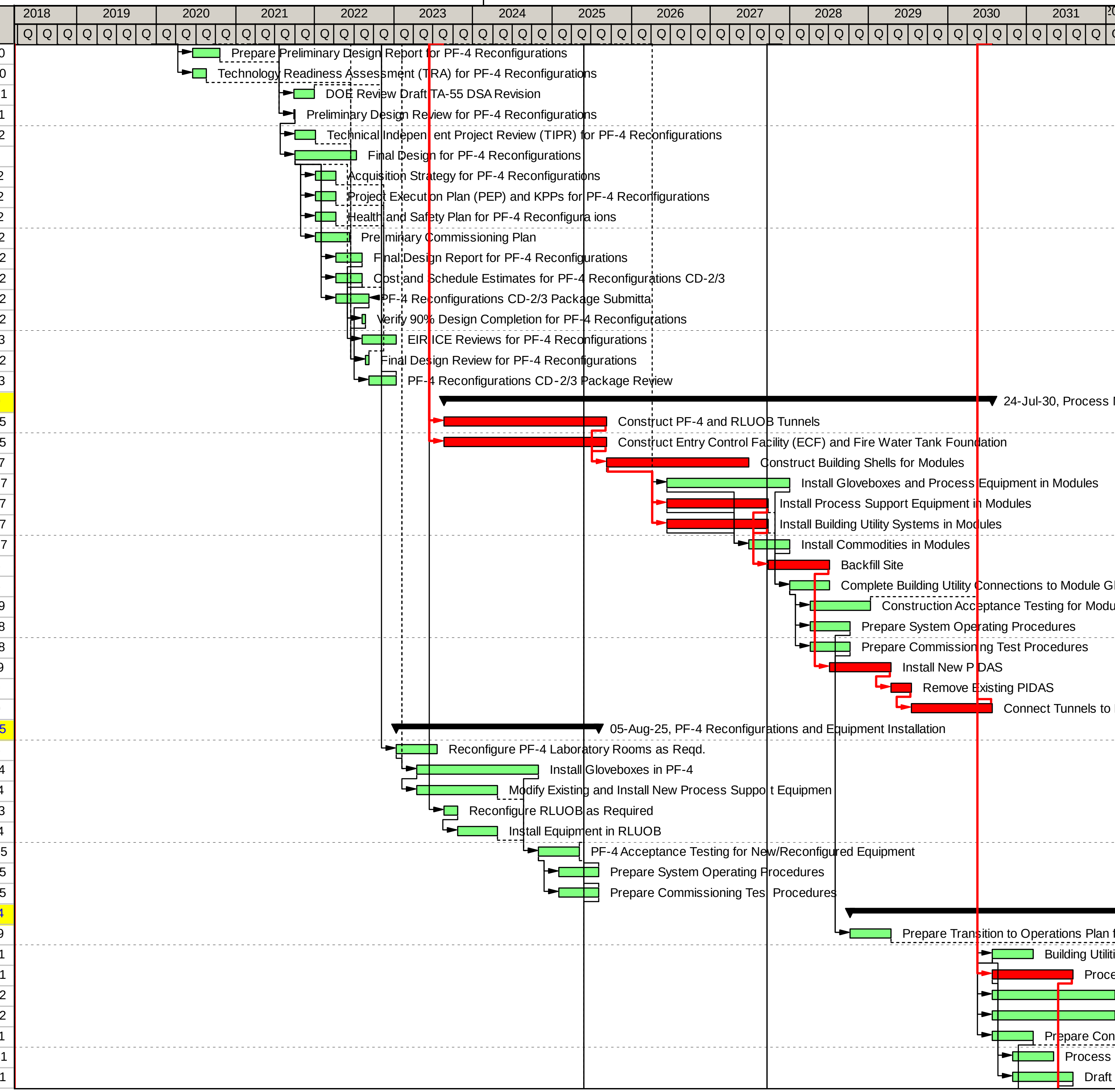
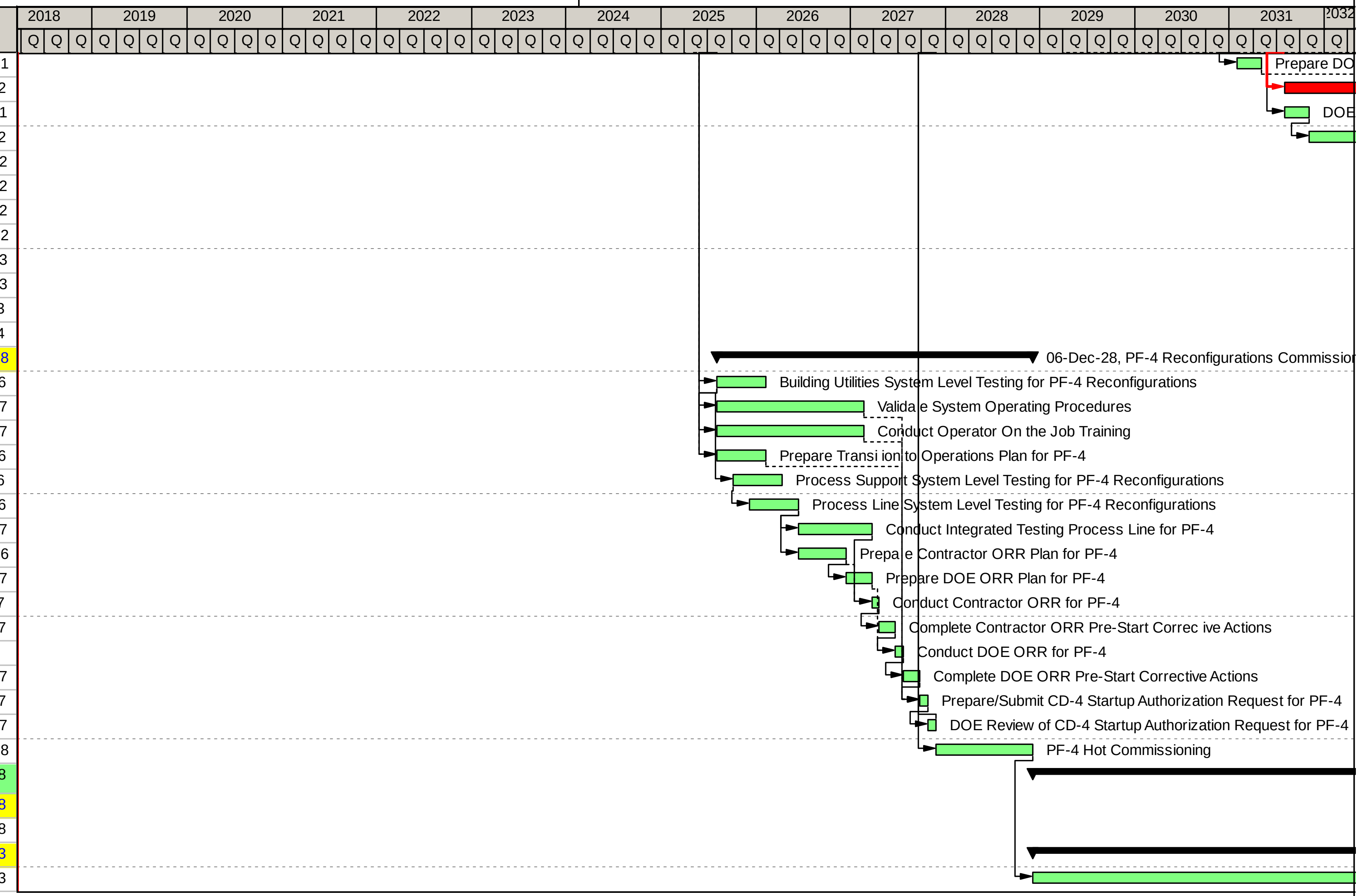
Activity ID	Activity Name	Original Duration	Start	Finish
PF515	Prepare Preliminary Design Report for PF-4 Reconfigurations	4m	17-Jun-20	19-Oct-20
PF530	Technology Readiness Assessment (TRA) for PF-4 Reconfigurations	2m	17-Jun-20	17-Aug-20
PF510	DOE Review Draft TA-55 DSA Revision	3m	27-Sep-21	29-Dec-21
PF520	Preliminary Design Review for PF-4 Reconfigurations	0m	27-Sep-21	04-Oct-21
PF525	Technical Independent Project Review (TIPR) for PF-4 Reconfigurations	3m	04-Oct-21	05-Jan-22
PF535	Final Design for PF-4 Reconfigurations	9m	04-Oct-21	11-Jul-22
PF550	Acquisition Strategy for PF-4 Reconfigurations	3m	05-Jan-22	08-Apr-22
PF555	Project Execution Plan (PEP) and KPPs for PF-4 Reconfigurations	3m	05-Jan-22	08-Apr-22
PF560	Health and Safety Plan for PF-4 Reconfigurations	3m	05-Jan-22	08-Apr-22
PF561	Preliminary Commissioning Plan	5m	05-Jan-22	09-Jun-22
PF540	Final Design Report for PF-4 Reconfigurations	4m	08-Apr-22	10-Aug-22
PF565	Cost and Schedule Estimates for PF-4 Reconfigurations CD-2/3	4m	08-Apr-22	10-Aug-22
PF575	PF-4 Reconfigurations CD-2/3 Package Submittal	5m	08-Apr-22	09-Sep-22
PF541	Verify 90% Design Completion for PF-4 Reconfigurations	0m	10-Aug-22	24-Aug-22
PF570	EIR/ICE Reviews for PF-4 Reconfigurations	5m	10-Aug-22	12-Jan-23
PF545	Final Design Review for PF-4 Reconfigurations	0m	24-Aug-22	08-Sep-22
PF580	PF-4 Reconfigurations CD-2/3 Package Review	4m	09-Sep-22	12-Jan-23
Process Modules Construction and Equipment Installation		**81m**	**21-Aug-23**	**24-Jul-30**
NM05	Construct PF-4 and RLUOB Tunnels	24m	21-Aug-23	09-Sep-25
NM10	Construct Entry Control Facility (ECF) and Fire Water Tank Foundation	24m	21-Aug-23	09-Sep-25
NM15	Construct Building Shells for Modules	21m	09-Sep-25	25-Jun-27
NM20	Install Gloveboxes and Process Equipment in Modules	18m	17-Jun-26	31-Dec-27
NM25	Install Process Support Equipment in Modules	15m	17-Jun-26	27-Sep-27
NM30	Install Building Utility Systems in Modules	15m	17-Jun-26	27-Sep-27
NM35	Install Commodities in Modules	6m	25-Jun-27	31-Dec-27
NM31	Backfill Site	9m	27-Sep-27	05-Jul-28
NM40	Complete Building Utility Connections to Module Gloveboxes	6m	31-Dec-27	05-Jul-28
NM45	Construction Acceptance Testing for Modules	9m	04-Apr-28	10-Jan-29
NM46	Prepare System Operating Procedures	6m	04-Apr-28	05-Oct-28
NM47	Prepare Commissioning Test Procedures	6m	04-Apr-28	05-Oct-28
NM50	Install New PIDAS	9m	05-Jul-28	13-Apr-29
NM55	Remove Existing PIDAS	3m	13-Apr-29	16-Jul-29
NM60	Connect Tunnels to PF-4 and RLUOB	12m	16-Jul-29	24-Jul-30
PF-4 Reconfigurations and Equipment Installation		**30m**	**12-Jan-23**	**05-Aug-25**
PF05	Reconfigure PF-4 Laboratory Rooms as Reqd.	6m	12-Jan-23	18-Jul-23
PF10	Install Gloveboxes in PF-4	18m	17-Apr-23	28-Oct-24
PF15	Modify Existing and Install New Process Support Equipment	12m	17-Apr-23	24-Apr-24
PF180	Reconfigure RLUOB as Required	2m	21-Aug-23	23-Oct-23
PF175	Install Equipment in RLUOB	6m	23-Oct-23	26-Apr-24
PF30	PF-4 Acceptance Testing for New/Reconfigured Equipment	6m	28-Oct-24	05-May-25
PF35	Prepare System Operating Procedures	6m	31-Jan-25	05-Aug-25
PF40	Prepare Commissioning Test Procedures	6m	31-Jan-25	05-Aug-25
Process Modules Commissioning		**65m**	**05-Oct-28**	**25-Apr-34**
NM100	Prepare Transition to Opera ions Plan for Modules	6m	05-Oct-28	13-Apr-29
NM70	Building Utilities System Level Testing for Modules	6m	24-Jul-30	30-Jan-31
NM80	Process Line System Level Testing for Modules	12m	24-Jul-30	04-Aug-31
NM85	Validate System Operating Procedures	18m	24-Jul-30	10-Feb-32
NM90	Conduct Operator On the Job Training	18m	24-Jul-30	10-Feb-32
NM105	Prepare Contractor ORR Plan for Modules	6m	24-Jul-30	30-Jan-31
NM75	Process Support System Level Testing for Modules	6m	25-Oct-30	02-May-31
NM81	Draft Documented Safety Analysis (DSA) for Modules	9m	25-Oct-30	04-Aug-31



Activity ID	Activity Name	Original Duration	Start	Finish
NM120	Prepare DOE ORR Plan for Modules	3m	30-Jan-31	02-May-31
NM95	Conduct Integrated Testing Process Line for Modules	12m	04-Aug-31	11-Aug-32
NM82	DOE Review of Draft DSA for Modules	3m	04-Aug-31	05-Nov-31
NM83	Final DSA for Modules	9m	05-Nov-31	11-Aug-32
NM110	Conduct Contractor ORR for Modules	1m	11-Aug-32	13-Sep-32
NM84	DOE SER for Final DSA for Modules	3m	11-Aug-32	15-Nov-32
NM115	Complete Contractor ORR Pre-Start Corrective Actions	2m	13-Sep-32	15-Nov-32
NM125	Conduct DOE ORR for Modules	1m	15-Nov-32	15-Dec-32
NM130	Complete DOE ORR Pre-Start Corrective Actions	2m	15-Dec-32	15-Feb-33
NM135	Prepare/Submit CD-4 Startup Authorization Request for Modules	1m	15-Feb-33	18-Mar-33
NM140	DOE Review of CD-4 Startup Authorization Request for Modules	1m	18-Mar-33	18-Apr-33
PF145	Process Line Hot Commissioning	12m	18-Apr-33	25-Apr-34
PF-4 Reconfigurations Commissioning		39m	05-Aug-25	06-Dec-28
PF70	Building Utilities System Level Testing for PF-4 Reconfigurations	6m	05-Aug-25	11-Feb-26
PF85	Validate System Operating Procedures	18m	05-Aug-25	22-Feb-27
PF90	Conduct Operator On the Job Training	18m	05-Aug-25	22-Feb-27
PF100	Prepare Transition to Operations Plan for PF-4	6m	05-Aug-25	11-Feb-26
PF75	Process Support System Level Testing for PF-4 Reconfigurations	6m	06-Oct-25	14-Apr-26
PF80	Process Line System Level Testing for PF-4 Reconfigurations	6m	09-Dec-25	15-Jun-26
PF95	Conduct Integrated Testing Process Line for PF-4	9m	15-Jun-26	24-Mar-27
PF105	Prepare Contractor ORR Plan for PF-4	6m	15-Jun-26	17-Dec-26
PF120	Prepare DOE ORR Plan for PF-4	3m	17-Dec-26	24-Mar-27
PF110	Conduct Contractor ORR for PF-4	1m	24-Mar-27	22-Apr-27
PF115	Complete Contractor ORR Pre-Start Corrective Actions	2m	22-Apr-27	23-Jun-27
PF125	Conduct DOE ORR for PF-4	1m	23-Jun-27	23-Jul-27
PF130	Complete DOE ORR Pre-Start Corrective Actions	2m	23-Jul-27	23-Sep-27
PF135	Prepare/Submit CD-4 Startup Authorization Request for PF-4	1m	23-Sep-27	25-Oct-27
PF140	DOE Review of CD-4 Startup Authorization Request for PF-4	1m	25-Oct-27	29-Nov-27
PF160	PF-4 Hot Commissioning	12m	29-Nov-27	06-Dec-28
Transition to War Reserve (WR) Production		111m	06-Dec-28	01-Jun-38
Process Line		48m	25-Apr-34	01-Jun-38
PF150	Transition to WR Production - Process Modules	48m	25-Apr-34	01-Jun-38
PF-4 Reconfigurations		48m	06-Dec-28	12-Jan-33
PF165	Transition to WR Production - PF-4 Reconfigurations	48m	06-Dec-28	12-Jan-33



Appendix M Risk Register and Rationale for Risk Ratings

M.1 Common Threats and Opportunities for All Alternatives

No.	Category	Risk Description	Alt.	Prior to Mitigation			Comments/Mitigation	After Mitigation		
				Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level
Threats										
1	Program	National Environmental Policy Act (NEPA) compliance is delayed which extends the schedule, increases costs, and/or delays production.	1	Low	Marginal	Low	NEPA review only required.	Low	Marginal	Low
			2a	High	Significant	Moderate	Early pursuit of NEPA approvals.	Low	Significant	Low
			2b	High	Significant	Moderate	Early pursuit of NEPA approvals.	Low	Significant	Low
			2c	Low	Critical	Moderate	Could affect all Pu programs. Early pursuit of NEPA approvals.	Very Low	Critical	Low
2	Program	Pit production capacity cannot be realized due to conveyance system issues.	1	Moderate	Significant	Moderate	New equipment systems are provided.	Low	Significant	Low
			2a	Moderate	Significant	Moderate	New equipment systems are provided.	Low	Significant	Low
			2b	Moderate	Significant	Moderate	New equipment systems are provided. Upgrade projects are planned for existing systems.	Low	Significant	Low
			2c	High	Significant	Moderate	Multishift with existing systems. Upgrade projects are planned for existing systems.	Low	Significant	Low
3	Project	Assumptions about the scope and scale with existing facilities (PF-4, MFFF) are not realized, requiring more work to meet requirements.	1	Moderate	Significant	Moderate	Lesser known information. Mitigation with early detailed investigation and characterization.	Low	Significant	Low
			2a	Very Low	Negligible	Low		Very Low	Negligible	Low
			2b	Low	Marginal	Low		Low	Marginal	Low
			2c	Low	Marginal	Low		Low	Marginal	Low

No.	Category	Risk Description	Alt.	Prior to Mitigation			Comments/Mitigation	After Mitigation		
				Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level
4	Program	Site infrastructure (outside PIDAS) capacity does not support pit production throughput.	1	Low	Significant	Low		Low	Significant	Low
			2a	Very Low	Marginal	Low		Very Low	Marginal	Low
			2b	Very Low	Marginal	Low		Very Low	Marginal	Low
			2c	Very Low	Marginal	Low		Very Low	Marginal	Low
5	Program	Process and personnel support capabilities (inside PIDAS) do not support pit production throughput.	1	Very Low	Marginal	Low		Very Low	Marginal	Low
			2a	Very Low	Marginal	Low		Very Low	Marginal	Low
			2b	Very Low	Marginal	Low		Very Low	Marginal	Low
			2c	Low	Marginal	Low		Low	Marginal	Low
6	Project	Availability and cost of craft labor for construction.	1	Very Low	Negligible	Low		Very Low	Negligible	Low
			2a	Low	Marginal	Low		Low	Marginal	Low
			2b	Low	Marginal	Low		Low	Marginal	Low
			2c	Low	Marginal	Low		Low	Marginal	Low
7	Project	Increased complexity and inefficiency for the movement of nuclear materials in and between facilities.	1	Very Low	Marginal	Low		Very Low	Marginal	Low
			2a	Low	Marginal	Low		Low	Marginal	Low
			2b	Moderate	Marginal	Low		Moderate	Marginal	Low
			2c	High	Critical	High	Multishift with existing systems. Design to ensure simplified and efficient operations.	High	Significant	Moderate
8	Program	Site operations or other facility operations disrupt pit production.	1	Very Low	Significant	Low		Very Low	Significant	Low
			2a	Low	Significant	Low		Low	Significant	Low
			2b	Low	Significant	Low		Low	Significant	Low
			2c	Low	Significant	Low		Low	Significant	Low
9	Project	Excessive vibration for critical equipment (e.g., lathe) affects pit production.	1	Low	Critical	Moderate	Vibration study not available. Mitigate by early completion of Vibration Study.	Very Low	Critical	Low
			2a	Very Low	Critical	Low		Very Low	Critical	Low
			2b	Very Low	Critical	Low		Very Low	Critical	Low
			2c	Very Low	Critical	Low		Very Low	Critical	Low

No.	Category	Risk Description	Alt.	Prior to Mitigation			Comments/Mitigation	After Mitigation		
				Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level
10	Program	Availability of skilled production personnel.	1				Labor availability and risk will be addressed in a separate Labor Study.			
			2a				Labor availability and risk will be addressed in a separate Labor Study.			
			2b				Labor availability and risk will be addressed in a separate Labor Study.			
			2c				Labor availability and risk will be addressed in a separate Labor Study.			
11	Program	Availability of capacity or certification for WIPP (or other TRU waste repository) impacts production.	1	Moderate	Negligible	Low	Significant interim storage capacity is available.	Moderate	Negligible	Low
			2a	Moderate	Negligible	Low	Significant interim storage capacity is available.	Moderate	Negligible	Low
			2b	Moderate	Negligible	Low	Significant interim storage capacity is available.	Moderate	Negligible	Low
			2c	Moderate	Negligible	Low	Significant interim storage capacity is available.	Moderate	Negligible	Low
12	Program	Training of personnel for 50 ppy mission affects 30 ppy mission at PF-4.	1				Labor training and risk will be addressed in a separate Labor Study.			
			2a				Labor training and risk will be addressed in a separate Labor Study.			
			2b				Labor training and risk will be addressed in a separate Labor Study.			
			2c				Labor training and risk will be addressed in a separate Labor Study.			
13	Project	Construction records and existing drawings are incomplete for existing facilities.	1	Very High	Critical	High	Reliability of MFFF data is questionable. Mitigate by early detailed engineering evaluation and facility walkdowns.	Low	Significant	Low
			2a	Very Low	Negligible	Low		Very Low	Negligible	Low
			2b	Low	Significant	Low		Low	Significant	Low
			2c	Low	Significant	Low		Low	Significant	Low

No.	Category	Risk Description	Alt.	Prior to Mitigation			Comments/Mitigation	After Mitigation		
				Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level
14	Project	Technical Baseline Documents, design Code of Record for existing facilities is inadequate.	1	Moderate	Critical	Moderate	NRC baseline versus DOE/NNSA. Mitigate by early and detailed engineering review and corrective actions.	Low	Significant	Low
			2a	Low	Marginal	Low		Low	Marginal	Low
			2b	Low	Significant	Low		Low	Significant	Low
			2c	Low	Significant	Low		Low	Significant	Low
15	Program	Dispersed production areas and equipment layout results in more complex logistics and higher operating costs.	1	Moderate	Marginal	Low		Moderate	Marginal	Low
			2a	Very Low	Negligible	Low		Very Low	Negligible	Low
			2b	Low	Marginal	Low		Low	Marginal	Low
			2c	Moderate	Marginal	Low		Moderate	Marginal	Low
16	Program	Facility configuration results in increased safety and security requirements and associated lifecycle costs.	1	High	Marginal	Moderate	Equipment locations in separate rooms.	High	Marginal	Moderate
			2a	Moderate	Marginal	Low		Moderate	Marginal	Low
			2b	Moderate	Marginal	Low		Moderate	Marginal	Low
			2c	Moderate	Marginal	Low		Moderate	Marginal	Low
17	Program	Implementation of the alternative does not meet the 2030 objective for 80 ppy.	1	High	Significant	Moderate	Based on EA Schedule development.	Moderate	Significant	Moderate
			2a	High	Significant	Moderate	Based on EA Schedule development.	Moderate	Significant	Moderate
			2b	High	Significant	Moderate	Based on EA Schedule development.	Moderate	Significant	Moderate
			2c	Moderate	Significant	Moderate	Based on EA Schedule development.	Moderate	Significant	Moderate
18	Program	Availability of personnel for criticality studies impact planned project costs and schedules.	1	High	Significant	Moderate	Address through staffing study. Early recruiting, training, and retention.	Low	Significant	Low
			2a	Low	Significant	Low	Address through staffing study.	Low	Significant	Low
			2b	Low	Significant	Low	Address through staffing study.	Low	Significant	Low
			2c	Low	Significant	Low	Address through staffing study.	Low	Significant	Low
19	Project	Potential requirement for Computed Tomography (CT) inspection of partial	1	Moderate	Marginal	Low	Existing space is available to support a new CT requirement.	Moderate	Marginal	Low
			2a	Moderate	Significant	Moderate	Address through a new project.	Moderate	Significant	Moderate

No.	Category	Risk Description	Alt.	Prior to Mitigation			Comments/Mitigation	After Mitigation		
				Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level
		and completed products.	2b	Moderate	Significant	Moderate	Address through a new project.	Moderate	Significant	Moderate
			2c	Moderate	Significant	Moderate	Address through a new project.	Moderate	Significant	Moderate
20	Project	Potential requirement for new process technology is identified.	1	Low	Marginal	Low	Address through a new project. Existing space is available to support a new technology requirement.	Low	Marginal	Low
			2a	Low	Significant	Low	Address through a new project.	Low	Marginal	Low
			2b	Low	Significant	Low	Address through a new project.	Low	Marginal	Low
			2c	Low	Critical	Moderate	Address through a new project. Limited space for new requirements.	Low	Marginal	Low
21	Project	Additional engineering controls based on Safety Design Strategy and Conceptual Design Safety Report.	1	Low	Marginal	Low	Lesser likelihood of active controls due to proximity to site boundary.	Very Low	Marginal	Low
			2a	Moderate	Marginal	Low	Higher likelihood of active controls due to proximity to site boundary.	Very Low	Marginal	Low
			2b	Moderate	Marginal	Low	Higher likelihood of active controls due to proximity to site boundary.	Moderate	Marginal	Low
			2c	High	Significant	Moderate	Higher likelihood of active controls due to higher source and proximity to site boundary.	High	Significant	Moderate
22	Project	Unplanned Active Safety Class controls are required by the Safety Basis Approval Authority.	1	High	Negligible	Low	New facility would include necessary controls.	Very Low	Negligible	Low
			2a	High	Negligible	Low	New facility would include necessary controls.	Very Low	Marginal	Low
			2b	High	Significant	Moderate	Some reconfiguration would be required for PF-4, or waiver by the Safety Basis Approval Authority.	Moderate	Significant	Moderate
			2c	High	Critical	High	Significant reconfiguration would be required for PF-4 and for the new Modular facility, or waiver by the Safety Basis Approval Authority.	High	Critical	High

No.	Category	Risk Description	Alt.	Prior to Mitigation			Comments/Mitigation	After Mitigation		
				Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level
23	Program	Post assembly high energy radiography is not performed at 50 ppy facility, which could result in returned parts for rework and affect pit production rate.	1	Very Low	Significant	Low	Radiography is included for new facilities.	Low	Significant	Low
			2a	Very Low	Significant	Low	Radiography is included for new facilities.	Low	Significant	Low
			2b	Very Low	Significant	Low	Radiography is included for new facilities.	Low	Significant	Low
			2c	High	Significant	Moderate	Radiography is only available at Pantex until new facilities are available.	High	Significant	Moderate
Opportunities										
1	Project	Existing infrastructure and analytical facilities can be leveraged to minimize capital costs and schedule.	1	Moderate	Efficient	Moderate	Analytical uses existing buildings only.	Moderate	Efficient	Moderate
			2a	High	Optimal	High		High	Optimal	High
			2b	High	Optimal	High		High	Optimal	High
			2c	High	Optimal	High		High	Optimal	High
2	Project	Off-site consequences can be minimized by production sites located further from site boundaries reducing Safety Class equipment.	1	High	Optimal	High		High	Optimal	High
			2a	Low	Optimal	Moderate	Proximity to site boundary.	Low	Optimal	Moderate
			2b	Low	Optimal	Moderate	Proximity to site boundary.	Low	Optimal	Moderate
			2c	Low	Optimal	Moderate	Proximity to site boundary.	Low	Optimal	Moderate
3	Project	Shared infrastructure and site resources could minimize overall costs.	1	High	Efficient	High		High	Efficient	High
			2a	High	Optimal	High		High	Optimal	High
			2b	High	Efficient	High		High	Efficient	High
			2c	High	Efficient	High		High	Efficient	High
4	Project	Potential requirement for new technology is identified that improves process operations.	1	Moderate	Optimal	High	Additional excess space is available.	Moderate	Optimal	High
			2a	Moderate	Efficient	Moderate	Limited space is available.	Moderate	Efficient	Moderate
			2b	Moderate	Efficient	Moderate	Limited space is available.	Moderate	Efficient	Moderate
			2c	Moderate	Efficient	Moderate	Limited space is available.	Moderate	Efficient	Moderate

M.2 Common Threats and Opportunities for All Alternatives Not Evaluated

No.	Category	Risk Description	Alt.	Prior to Mitigation			Comments/Mitigation	After Mitigation		
				Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level
Threats										
1	Project	Site fire or natural phenomena (storm, earthquake, flood, tornado) disrupts construction or production.					Force majeure.			
2	Program	Funding constraints.					Program threat.			
3	Program	Delay in CD Strategy or Critical Decisions.					Program threat.			
4	Program	Changes in Code of Records, Orders, Standards, or Safety requirements.					Program threat.			
5	Program	Co-location of design agency and production agency impacts the focus on production.					Program threat to LANL alternatives only.			
6	Program	Over-the-road transportation puts material at risk.					Program threat with increased likelihood for Alternative 1.			
7	Program	The Pu Pit production equipment model has not been fully validated due to limited history in current operations.					Potential impact to equipment requirements for all alternatives.			

M.3 Specific Threats and Opportunities for Alternative 1

No.	Category	Risk Description	Alt.	Prior to Mitigation			Comment/Mitigation	After Mitigation		
				Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level
Threats										
1	Program	MFFF ongoing construction leads to increased costs for modifications or facility retrofit.	1	High	Significant	Moderate	Continuing construction until Congressional halt and/or Contract direction.	High	Significant	Moderate
2	Program	Difficulties closing out the MFFF project and contract result in schedule delays.	1	Moderate	Critical	Moderate	Result would delay construction.	Moderate	Critical	Moderate
3	Program	Siting pit production in a high humidity environment impacts product quality.	1	Low	Crisis	Moderate	Result could prevent product qualification. Mitigate by early testing in a high humidity environment.	Very Low	Significant	Low
4	Program	Two production entities increase certification, qualification, and surveillance of product quality.	1	Very High	Significant	High	Duplicate functions required at both sites, could also be an opportunity for redundancy. Mitigate by early recruiting, training, and retention.	Very Low	Significant	Low
Opportunities										
1	Project	Some work required for pit production at MFFF can be completed as part of MFFF closeout.	1	High	Significant	Moderate	Opportunity for early start of some construction activities. Early identification of activities to advance the project.	Very High	Significant	High
2	Program	Analytical capability will be located in existing Hazard Category 2, Security Category 1 space.	1	High	Significant	Moderate	Reduced costs and schedule for analytical capabilities.	High	Significant	Moderate

No.	Category	Risk Description	Alt.	Prior to Mitigation			Comment/Mitigation	After Mitigation		
				Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level
3	Program	Improve operational efficiency using lessons learned and best practices with SMEs from separate sites.	1	High	Efficient	High	Shared experiences will lead to continuous improvements. Early identification of SME working group.	High	Efficient	High
4	Program	Separate sites each with production capabilities can ensure continuing mission support.	1	High	Optimal	High	Optimal redundancy for production.	High	Optimal	High
5	Program	Additional HC-2 space is available to support other NNSA programs.	1	High	Optimal	High	Existing space will be available.	High	Optimal	High
6	Project	Opportunity to make use of purchased and stored commodities from MOX Project	1	High	Efficient	High	More than $800M of equipment and commodities are available. Implement with a detailed assessment of stored equipment and commodities during design.	High	Efficient	High
7	Execution	Opportunity to remove walls for improved constructability and operational efficiency.	1	High	Efficient	High		High	Efficient	High
8	Project	The BMP would not have to be safety class due to distance from the site boundary	1	High	Efficient	High		High	Efficient	High
9	Project	Use of F/H analytical laboratory	1	Moderate	Significant	Moderate		Moderate	Significant	Moderate

M.4 Specific Threats and Opportunities for Alternative 2a

No.	Category	Risk Description	Alt.	Prior to Mitigation			Comment/Mitigation	After Mitigation		
				Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level
Threats										
1	Program	Inadequate parking for increased production workforce.	2a	High	Significant	Moderate	Known issue for the constrained site.	High	Significant	Moderate
2	Program	Inadequate local warehousing, laydown areas and/or working space to support fabrication for construction.	2a	High	Significant	Moderate	Known issue for the constrained site.	High	Significant	Moderate
3	Program	Inadequate office/training space to support operations.	2a	High	Significant	Moderate	Known issue for the constrained site.	High	Significant	Moderate
4	Program	Implementation of 50 ppy mission disrupts 30 ppy mission at PF-4.	2a	Low	Critical	Moderate	Mods within PF-4 for this option.	Low	Critical	Moderate
5	Program	Increased 400-g MAR limit at RLUOB is not approved, creating need for alternate analytical chemistry and material characterization facilities.	2a	Low	Critical	Moderate	Cost and schedule impacts.	Low	Critical	Moderate
6	Execution	Unexpected underground site conditions.	2a	Low	Significant	Low	Construction within the known Technical Area footprint.	Low	Significant	Low
7	Program	Facility upgrades are needed to extend the operational life of PF-4 to 50 years.	2a	High	Significant	Moderate	New projects will be needed for future life extension.	High	Significant	Moderate
8	Project	PF-4 could be vulnerable to seismic risks.	2a	High	Significant	Moderate	Upgrade requirements could be identified during the design phase and prior to CD-2/3.	High	Significant	Moderate

No.	Category	Risk Description	Alt.	Prior to Mitigation			Comment/Mitigation	After Mitigation		
				Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level
9	Program	Limited operational flexibility for future expansion to accommodate increases in mission requirements.	2a	Moderate	Marginal	Low	New facility provides operational flexibility.	Moderate	Marginal	Low
10	Program	Operational, safety, or equipment failures result in shutdown of PF-4 that impacts ability to meet the mission.	2a	High	Significant	Moderate	Life Cycle planning to include additional maintenance, repair, and replacement to maintain production rates. Single point failure for aqueous operations needed for the 50 ppy mission results in extended liquid waste storage.	High	Significant	Moderate
11	Project	Construction/ equipment installation disrupts ongoing site or facility operations.	2a	Very Low	Marginal	Low		Very Low	Marginal	Low
12	Project	Ongoing site or facility operations disrupts construction/ equipment installation.	2a	Low	Marginal	Low		Low	Marginal	Low
13	Project	Construction of new 50 ppy facilities at LANL and tunnel connection to PF-4 could affect high energy-radiography for plutonium operations at PF-4.	2a	High	Significant	Moderate	Evaluate construction sequence and methods to minimize impact, and verify capacity and obtain authorization to use radiography at Pantex during construction.	High	Significant	Moderate
Opportunities										
1	Program	Separate facilities (within a site) each with production capabilities can ensure continuing mission support.	2a	Very High	Efficient	High	Efficient redundancy for production.	Very High	Efficient	High

No.	Category	Risk Description	Alt.	Prior to Mitigation			Comment/Mitigation	After Mitigation		
				Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level
2	Program	The scheduled duration for NEPA can be reduced by leveraging current LANL NEPA actions and conducting NEPA determination in parallel with construction work.	2a	Low	Marginal	Low		Moderate	Marginal	Low

M.5 Specific Threats and Opportunities for Alternative 2b

No.	Category	Risk Description	Alt.	Prior to Mitigation: Likelihood	Prior to Mitigation: Consequence	Prior to Mitigation: Risk Level	Comment/Mitigation	After Mitigation: Likelihood	After Mitigation: Consequence	After Mitigation: Risk Level
Threats										
1	Program	Inadequate parking for increased production workforce.	2b	High	Significant	Moderate	Known issue for the constrained site.	High	Significant	Moderate
2	Program	Inadequate local warehousing, laydown areas and/or working space to support fabrication for construction.	2b	High	Significant	Moderate	Known issue for the constrained site.	High	Significant	Moderate
3	Program	Inadequate office/training space to support operations.	2b	High	Significant	Moderate	Known issue for the constrained site.	High	Significant	Moderate
4	Program	Implementation of 50 ppy mission disrupts 30 ppy mission at PF-4.	2b	High	Critical	High	Mods within PF-4 for this option. Early engineering assessment to minimize impacts.	Moderate	Significant	Moderate
5	Program	Increased 400-g MAR limit at RLUOB is not approved, creating need for alternate analytical chemistry and material characterization facilities.	2b	Low	Critical	Moderate	Cost and schedule impacts.	Low	Critical	Moderate
6	Execution	Unexpected underground site conditions.	2b	Low	Significant	Low	Construction within the known Technical Area footprint.	Low	Significant	Low
7	Program	Facility upgrades are needed to extend the operational life of PF-4 to 50 years.	2b	High	Significant	Moderate	New projects will be needed for future life extension.	High	Significant	Moderate
8	Project	PF-4 could be vulnerable to seismic risks.	2b	High	Significant	Moderate	Upgrade requirements could be identified during the design phase and prior to CD-2/3.	High	Significant	Moderate

No.	Category	Risk Description	Alt.	Prior to Mitigation			Comment/Mitigation	After Mitigation		
				Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level
9	Program	Limited operational flexibility for future expansion to accommodate increases in mission requirements.	2b	Moderate	Significant	Moderate	New facility provides some operational flexibility.	Moderate	Marginal	Low
10	Program	Operational, safety, or equipment failures result in shutdown of PF-4, which affects ability to meet the mission.	2b	High	Critical	High	Life cycle planning to include additional maintenance, repair, and replacement to maintain production rates. Single point failure for operations needed for the 50 ppy mission.	High	Critical	High
11	Project	Construction/equipment installation disrupts ongoing site or facility operations.	2b	Low	Significant	Low		Low	Significant	Low
12	Project	Ongoing site or facility operations disrupts construction/equipment installation.	2b	High	Significant	Moderate	Equipment installed during 30 ppy production.	High	Significant	Moderate
13	Project	Construction of new 50 ppy facilities at LANL and tunnel connection to PF-4 could affect high-energy radiography for plutonium operations at PF-4.	2b	High	Significant	Moderate	Evaluate construction sequence and methods to minimize impact, and verify capacity and obtain authorization to use radiography at Pantex during construction.	High	Significant	Moderate
Opportunities										
1	Program	Separate facilities (within a site) each with production capabilities can ensure continuing mission support.	2b	Very High	Significant	High	Significant redundancy for production.	Very High	Significant	High
2	Program	The scheduled duration for NEPA can be reduced by leveraging current LANL NEPA actions and conducting NEPA determination in parallel with construction work.	2b	Low	Marginal	Low		Moderate	Marginal	Low

M.6 Specific Threats and Opportunities for Alternative 2c

No.	Category	Risk Description	Alt.	Prior to Mitigation			Comment/Mitigation	After Mitigation		
				Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level
Threats										
1	Program	Inadequate parking for increased production workforce.	2c	High	Significant	Moderate	Known issue for the constrained site.	High	Significant	Moderate
2	Program	Inadequate local warehousing, laydown areas and/or working space to support fabrication for construction.	2c	High	Significant	Moderate	Known issue for the constrained site.	High	Significant	Moderate
3	Program	Inadequate office/training space to support operations.	2c	High	Significant	Moderate	Known issue for the constrained site.	High	Significant	Moderate
4	Program	The vault does not have the capacity to support pit production throughput.	2c	High	Critical	High	Additional capability needed with cost and schedule impacts. Include expanded vault capacity.	Moderate	Significant	Moderate
5	Program	Inadequate shipping and receiving capability to achieve pit production throughput.	2c	High	Critical	High	Additional capability needed with cost and schedule impacts. Include expanded shipping and receiving.	Moderate	Significant	Moderate
6	Program	Implementation of 50 ppy mission disrupts 30 ppy mission at PF-4.	2c	High	Critical	High	Mods within PF-4 for this option. Mitigate by early engineering assessment to reduce impacts.	Moderate	Significant	Moderate
7	Program	Increased 400-g MAR limit at RLUOB is not approved, creating need for alternate analytical chemistry and material characterization facilities.	2c	Low	Critical	Moderate	Cost and schedule impacts.	Low	Critical	Moderate
8	Execution	Unexpected underground site conditions.	2c	Low	Significant	Low	Construction within the known Technical Area footprint.	Low	Significant	Low

No.	Category	Risk Description	Alt.	Prior to Mitigation			Comment/Mitigation	After Mitigation		
				Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level
9	Program	Operational mishaps or equipment failures due to double-shift operations in PF-4 impacts production capacity and completion of the mission.	2c	High	Critical	High	Life cycle planning to include additional maintenance, repair, and replacement to maintain production rates. Single point failure during double-shift operations prior to new modules.	High	Critical	High
10	Program	Facility upgrades are needed to extend the operational life of PF-4 to 50 years.	2c	High	Significant	Moderate	New projects will be needed for future life extension.	High	Significant	Moderate
11	Project	PF-4 could be vulnerable to seismic risks.	2c	High	Significant	Moderate	Upgrade requirements could be identified during the design phase and prior to CD-2/3.	High	Significant	Moderate
12	Program	Transition to module operations during the bridge from PF-4 may disrupt 80 ppy capabilities.	2c	High	Significant	Moderate	Transition planning will strive to minimize disruption.	High	Significant	Moderate
13	Program	Limited operational flexibility for future expansion to accommodate increases in mission requirements.	2c	Moderate	Significant	Moderate	New modules provide some operational flexibility.	Moderate	Marginal	Low
14	Project	Construction/equipment installation disrupts ongoing site or facility operations.	2c	High	Significant	Moderate	Equipment installation during 30 ppy production.	High	Significant	Moderate
15	Program	Operational, safety, or equipment failures result in shutdown of PF-4, which affects ability to meet the mission.	2b	High	Critical	High	Life cycle planning to include additional maintenance, repair, and replacement to maintain production rates. Single point failure for operations needed during double-shift operations prior to new modules.	High	Critical	High

No.	Category	Risk Description	Alt.	Prior to Mitigation			Comment/Mitigation	After Mitigation		
				Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level
16	Project	Ongoing site or facility operations disrupts construction/equipment installation.	2c	High	Significant	Moderate	Equipment installation during 30 ppy production.	High	Significant	Moderate
17	Project	Construction of new 50 ppy facilities at LANL and tunnel connection to PF-4 could affect high-energy radiography for plutonium operations at PF-4.	2c	High	Critical	High	Evaluate construction sequence and methods to minimize impact, and verify capacity and obtain authorization to use radiography at Pantex during double-shift operations and during construction.	High	Significant	Moderate
18	Project	Personnel support facilities are inadequate for PF-4 double-shift operations, and unplanned for new modules.	2c	High	Significant	Moderate	Potential mitigation may be available through staggered shifts, but additional support space may be required.	High	Marginal	Moderate
Opportunities										
1	Program	Separate facilities (within a site) each with production capabilities can ensure continuing mission support.	2c	Moderate	Significant	Moderate	Significant redundancy after new modules are completed.	Moderate	Significant	Moderate
2	Program	The scheduled duration for NEPA can be reduced by leveraging current LANL NEPA actions and conducting NEPA determination in parallel with construction work.	2c	Low	Marginal	Low		Moderate	Marginal	Low

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M.7 Workshop Rationale for Risk Ratings

This section documents the results of the risk workshop conducted as a part of the EA. Subsequently, additional conferences, comments and resolutions, and discussions identified additional threats and opportunities that were not identified during the original workshop but were included as a part of the overall risk analysis.

M.7.1 Common Evaluated Threats

Threat 1: National Environmental Policy Act (NEPA) compliance is delayed, which extends the schedule, increases costs, and/or delays production.

- Alternative 1
  - Likelihood of Occurrence: Low; despite having existing plutonium operations, the SRS does not have a pit production mission however only a NEPA review is likely required.
  - Consequence of Occurrence: Marginal; lower consequence for MFFF because the schedule has more flexibility/float because of the existing structure in place.
  - Threat Level: Moderate.
- Alternative 2a
  - Likelihood of Occurrence: High; LANL has existing Pu pit production operations; however, Chemistry and Metallurgy Research Replacement Facility – Nuclear Facility (CMRR-NF) was not intended for pit production.
  - Consequence of Occurrence: Significant; based on project experience (CMRR-NF project) affected by NEPA because of multiple lawsuits.
  - Threat Level: Moderate.
- Alternative 2b
  - Likelihood of Occurrence: High; Los Alamos National Laboratory (LANL) has existing Pu pit production operations; however, CMRR-NF was not intended for pit production.
  - Consequence of Occurrence: Significant; based on project experience (CMRR-NF project) affected by NEPA because of multiple lawsuits.
  - Threat Level: Moderate.
- Alternative 2c
  - Likelihood of Occurrence: Low; based on locating in PF-4. Prior EIS efforts for 120 ppy are complete, the record of decision (ROD) is not finalized pending direction for mission.
  - Consequence of Occurrence: Critical; single point of failure by relying solely on PF-4 could affect all Pu pit production.
  - Threat Level: Low.

Threat 2: Pit production capacity cannot be realized due to conveyance system issues.

- Alternative 1
  - Likelihood of Occurrence: Moderate; uses a commercially available system but laid out in a slightly more complex manner that is dictated by facility layout.
  - Consequence of Occurrence: Significant; a single conveyance system shuts down the entire operation when an issue arises. Would have to move to a manual operation (bag in and out) while conveyance system is being corrected.
  - Threat Level: Moderate.
- Alternative 2a
  - Likelihood of Occurrence: Moderate; uses a commercially available system laid out in a rational manner.
  - Consequence of Occurrence: Significant; two conveyance systems across the whole operation minimizes the consequence.
  - Threat Level: Moderate.
- Alternative 2b
  - Likelihood of Occurrence: Moderate; primarily limited to existing system with some new equipment.
  - Consequence of Occurrence: Significant; two conveyance systems across the whole operation minimizes the consequence.
  - Threat Level: Moderate.
- Alternative 2c
  - Likelihood of Occurrence: High; used existing system.
  - Consequence of Occurrence: Significant; multishift with existing systems; a single conveyance system shuts down the entire operation when an issue arises. Would have to move to a manual operation (bag in and out) while conveyance system is being corrected.
  - Threat Level: Moderate.

Threat 3: Assumptions about the scope and scale with existing facilities (PF-4, MFFF) are not realized, requiring more work to meet requirements.

- Alternative 1
  - Likelihood of Occurrence: Moderate; dependent on the assumptions about MFFF, less known information.
  - Consequence of Occurrence: Significant; will require more work than other alternatives to meet requirements.
  - Threat Level: Moderate.

- Alternative 2a
  - Likelihood of Occurrence: Very Low; based on limited reliance on existing facilities.
  - Consequence of Occurrence: Negligible; because of less reliance, work to meet requirements is minimal.
  - Threat Level: Low.
- Alternative 2b
  - Likelihood of Occurrence: Low; slightly higher likelihood than the new at LANL alternative based on use of PF-4 and reliance on assumptions about PF-4.
  - Consequence of Occurrence: Marginal; will require slightly more work than the new at LANL alternative if assumptions are not realized.
  - Threat Level: Low.
- Alternative 2c
  - Likelihood of Occurrence: Low; slightly higher likelihood than the new at LANL alternative based on use of PF-4 and reliance on assumptions about PF-4.
  - Consequence of Occurrence: Marginal; will require slightly more work than the new at LANL alternative if assumptions are not realized.
  - Threat Level: Low.

Threat 4: Site infrastructure (outside PIDAS) capacity does not support pit production throughput.

- Alternative 1
  - Likelihood of Occurrence: Low; the capability has been studied and reviewed at SRS and most infrastructure is believed to be in place.
  - Consequence of Occurrence: Significant; requires adding an entirely new capability.
  - Threat Level: Low.
- Alternative 2a
  - Likelihood of Occurrence: Very Low; equally very low likelihood among LANL alternatives based on existing, demonstrated site infrastructure capability and capacity.
  - Consequence of Occurrence: Marginal; adding capability at LANL is incremental and adding to existing capacity.
  - Threat Level: Low.
- Alternative 2b
  - Likelihood of Occurrence: Very Low; equally very low likelihood among LANL alternatives based on existing, demonstrated site infrastructure capability and capacity.
  - Consequence of Occurrence: Marginal; adding capability at LANL is incremental and adding to existing capacity.
  - Threat Level: Low.

- Alternative 2c
  - Likelihood of Occurrence: Very Low; equally very low likelihood among LANL alternatives based on existing, demonstrated site infrastructure capability and capacity.
  - Consequence of Occurrence: Marginal; adding capability at LANL is incremental and adding to existing capacity.
  - Threat Level: Low.

Threat 5: Process and personnel support capabilities (inside PIDAS) do not support pit production throughput.

- Alternative 1
  - Likelihood of Occurrence: Very Low; design is based on meeting throughput need.
  - Consequence of Occurrence: Marginal; no real, measurable consequence based on available space.
  - Threat Level: Low.
- Alternative 2a
  - Likelihood of Occurrence: Very Low; design is based on meeting throughput need.
  - Consequence of Occurrence: Marginal; no real, measurable consequence based on available space.
  - Threat Level: Low.
- Alternative 2b
  - Likelihood of Occurrence: Very Low; design is based on meeting throughput need.
  - Consequence of Occurrence: Marginal; no real, measurable consequence based on available space.
  - Threat Level: Low.
- Alternative 2c
  - Likelihood of Occurrence: Low; design is based on meeting throughput need.
  - Consequence of Occurrence: Marginal; no real, measurable consequence based on available space.
  - Threat Level: Low.

Threat 6: Availability and cost of craft labor for construction. meet requirements.

- Alternative 1
  - Likelihood of Occurrence: Very Low: ability to pay premium wages and per diem to attract labor force, may be slightly easier to attract craft labor to the southeast region.
  - Consequence of Occurrence: Negligible; no real, measurable cost and schedule impact that has not already been planned and accounted for in cost and schedule.
  - Threat Level: Low.

- Alternative 2a
  - Likelihood of Occurrence: Low; ability to pay premium wages and per diem to attract labor force, equally applicable to all LANL alternatives.
  - Consequence of Occurrence: Marginal; slightly higher for LANL alternatives that might require housing.
  - Threat Level: Low; meets requirements.
- Alternative 2b
  - Likelihood of Occurrence: Low; ability to pay premium wages and per diem to attract labor force, equally applicable to all LANL alternatives.
  - Consequence of Occurrence: Marginal; slightly higher for LANL alternatives that might require housing.
  - Threat Level: Low.
- Alternative 2c
  - Likelihood of Occurrence: Low; ability to pay premium wages and per diem to attract labor force, equally applicable to all LANL alternatives.
  - Consequence of Occurrence: Marginal; slightly higher for LANL alternatives that might require housing.
  - Threat Level: Low.

Threat 7: Increased complexity and inefficiency for the movement of nuclear materials in, and between facilities.

- Alternative 1
  - Likelihood of Occurrence: Very Low; material not being moved between facilities.
  - Consequence of Occurrence: Marginal; the cost, schedule, and throughput impacts are relatively the same for alternatives 1, 2a and 2b.
  - Threat Level: Low.
- Alternative 2a
  - Likelihood of Occurrence: Low; 30 ppy must come from PF-4 for radiography. Waste and samples from 50 ppy mission move out of new construction but relatively little movement otherwise.
  - Consequence of Occurrence: Marginal; the cost, schedule, and throughput impacts are relatively the same for alternatives 1, 2a and 2b.
  - Threat Level: Low.
- Alternative 2b
  - Likelihood of Occurrence: Moderate; more material moving for 50 ppy between PF-4 and new construction (bag out after foundry operations and introduce to new construction).

- Consequence of Occurrence: Marginal; the cost, schedule and throughput impacts are relatively the same for alternatives 1, 2a and 2b.
- Threat Level: Low.

♦ Alternative 2c

- Likelihood of Occurrence: High; short term may differ from long term. Inherently higher likelihood in long term due to multiple modules.
- Consequence of Occurrence: Critical; the cost, schedule and throughput impacts are higher with multiple shifts with existing systems.
- Threat Level: High.

Threat 8: Site operations or other facility operations disrupt pit production.

Alternative 1

- Likelihood of Occurrence: Very Low; no operations located within or near the MFFF.
- Consequence of Occurrence: Significant; effects on pit production are relatively the same for LANL and SRS alternatives.
- Threat Level: Low.

♦ Alternative 2a

- Likelihood of Occurrence: Low; low for all LANL alternatives, only issue is if something happens in TA-55.
- Consequence of Occurrence: Significant; effects on pit production are relatively the same for LANL and SRS alternatives.
- Threat Level: Low.

♦ Alternative 2b

- Likelihood of Occurrence: Low; low for all LANL alternatives, only issue is if something happens in TA-55.
- Consequence of Occurrence: Significant; effects on pit production are relatively the same for LANL and SRS alternatives.
- Threat Level: Low.

♦ Alternative 2c

- Likelihood of Occurrence: Low; low for all LANL alternatives, only issue is if something happens in TA-55.
- Consequence of Occurrence: Significant; impacts on pit production are relatively the same for LANL and SRS alternatives.
- Threat Level: Low.

Threat 9: Excessive vibration for critical equipment (e.g., lathe) impacts pit production.

- Alternative 1
  - Likelihood of Occurrence: Low; slightly higher likelihood due to existing structure and more difficult to reconfigure space, no experience to draw upon. No operational vibration analysis has been completed for the MFFF.
  - Consequence of Occurrence: Critical; the impact is equally critical for LANL and SRS alternatives with substantial cost, schedule, and pit production consequences.
  - Threat Level: Moderate.
- Alternative 2a
  - Likelihood of Occurrence: Very Low; lowest for all LANL alternatives, new construction to be designed similar to PF-4.
  - Consequence of Occurrence: Critical; the impact is equally critical for LANL and SRS alternatives with substantial cost, schedule, and pit production consequences.
  - Threat Level: Low.
- Alternative 2b
  - Likelihood of Occurrence: Very Low; lowest for all LANL alternatives. PF-4 has experience with limited/no vibration issues. Seismic evaluation complete for PF-4.
  - Consequence of Occurrence: Critical; the impact is equally critical for LANL and SRS alternatives with substantial cost, schedule, and pit production consequences.
  - Threat Level: Low; meets requirements.
- Alternative 2c
  - Likelihood of Occurrence: Very Low; lowest for all LANL alternatives. PF-4 has experience with limited/no vibration issues. Seismic evaluation complete for PF-4.
  - Consequence of Occurrence: Critical; the impact is equally critical for LANL and SRS alternatives with substantial cost, schedule, and pit production consequences.
  - Threat Level: Low.

Threat 10: Availability of skilled production personnel. This threat was not evaluated. The threat and risk will be evaluated by a separate labor study to be completed by others.

Threat 11: Availability of capacity or certification for WIPP (or other TRU waste repository) impacts production.

- Alternative 1
  - Likelihood of Occurrence: Moderate; SRS has adequate interim storage capacity if TRU waste repository is not available.
  - Consequence of Occurrence: Negligible; no significant impact at SRS due to inherently large interim storage capacity and limited impact to production.
  - Threat Level: Low.

- Alternative 2a
  - Likelihood of Occurrence: Moderate; recent LANL projects have provided adequate interim storage capacity in the event TRU waste repository is not available.
  - Consequence of Occurrence: Negligible; no significant impacts for LANL alternatives due to more finite interim storage capacity and production impact.
  - Threat Level: Low.
- Alternative 2b
  - Likelihood of Occurrence: Moderate; recent LANL projects have provided adequate interim storage capacity if TRU waste repository is not available.
  - Consequence of Occurrence: Negligible; no significant impacts for LANL alternatives due to more finite interim storage capacity and production impact.
  - Threat Level: Low.
- Alternative 2c
  - Likelihood of Occurrence: Moderate; recent LANL projects have provided adequate interim storage capacity if TRU waste repository is not available.
  - Consequence of Occurrence: Negligible; no significant impacts for LANL alternatives due to more finite interim storage capacity and production impact.
  - Threat Level: Low.

Threat 12: Training of personnel for 50 ppy mission impacts 30 ppy mission at PF-4. This threat was not evaluated. The threat and risk will be evaluated by a separate labor study to be completed by others.

Threat 13: Construction records and existing drawings are incomplete for existing facilities.

- Alternative 1
  - Likelihood of Occurrence: Very High; based on input from MFFF PMO, very high probability for incomplete construction records/as-built drawings.
  - Consequence of Occurrence: Critical; impacts to cost and schedule are critical based on reliance on the MFFF.
  - Threat Level: High.
- Alternative 2a
  - Likelihood of Occurrence: Very Low; very low probability based on limited reliance on existing facilities.
  - Consequence of Occurrence: Negligible; impact is minimized due to limited reliance on existing facilities.
  - Threat Level: Low.

- Alternative 2b
  - Likelihood of Occurrence: Low; low probability based on existing records for PF-4.
  - Consequence of Occurrence: Significant; significant cost and schedule impacts for LANL alternatives based on reliance on PF-4.
  - Threat Level: Low.
- Alternative 2c
  - Likelihood of Occurrence: Low; low probability based on existing records for PF-4.
  - Consequence of Occurrence: Significant; significant cost and schedule impacts for LANL alternatives based on reliance on PF-4.
  - Threat Level: Low.

Threat 14: Technical baseline documents and design code of record for existing facilities are inadequate.

- Alternative 1
  - Likelihood of Occurrence: Moderate; probability is moderate because MFFF is a NRC-regulated facility and not necessarily designed or qualified to comply with all DOE standards.
  - Consequence of Occurrence: Critical; critical cost and schedule impact due to reliance on existing facilities.
  - Threat Level: Moderate.
- Alternative 2a
  - Likelihood of Occurrence: Low; low probability for all LANL alternatives; Documented Safety Analysis (DSA) may be questioned.
  - Consequence of Occurrence: Marginal; limited impact due to lack of dependency on PF-4 except for aqueous processing.
  - Threat Level: Low.
- Alternative 2b
  - Likelihood of Occurrence: Low; low probability for all LANL alternatives; DSA may be questioned.
  - Consequence of Occurrence: Significant; cost and schedule impact are significant due to reliance on PF-4.
  - Threat Level: Low.
- Alternative 2c
  - Likelihood of Occurrence: Low; low probability for all LANL alternatives; DSA may be questioned.

- Consequence of Occurrence: Significant; cost and schedule impacts are significant due to reliance on existing facilities.
- Threat Level: Moderate.

Threat 15: Dispersed production areas and equipment layout results in more complex logistics and higher operating costs.

- Alternative 1
  - Likelihood of Occurrence: Moderate; layout is slightly more constrained by the existing MFFF structure.
  - Consequence of Occurrence: Marginal; slightly more complex logistics and higher costs based on existing layout.
  - Threat Level: Low.
- Alternative 2a
  - Likelihood of Occurrence: Very Low; layout is best optimized of all alternatives.
  - Consequence of Occurrence: Negligible; logistics and costs are minimized based on new layout.
  - Threat Level: Low.
- Alternative 2b
  - Likelihood of Occurrence: Low; layout can be optimized with new construction.
  - Consequence of Occurrence: Marginal; slightly more complex logistics and higher costs based on existing layout.
  - Threat Level: Low.
- Alternative 2c
  - Likelihood of Occurrence: Moderate; layout is slightly more constrained by the existing PF-4 structure.
  - Consequence of Occurrence: Marginal; slightly more complex logistics and higher costs based on existing layout.
  - Threat Level: Low.

Threat 16: Facility configuration results in increased safety and security requirements and associated life-cycle costs.

- Alternative 1
  - Likelihood of Occurrence: High; highest likelihood due to the size of the MFFF building, much of what will not be used for pit production.
  - Consequence of Occurrence: Marginal; primarily based on the size of the building and associated cost impact.
  - Threat Level: Moderate.

- Alternative 2a
  - Likelihood of Occurrence: Moderate; moderate based on some new construction for the alternative.
  - Consequence of Occurrence: Marginal; minimal impact to requirements and associated costs.
  - Threat Level: Low.
- Alternative 2b
  - Likelihood of Occurrence: Moderate; moderate based on some new construction for the alternative.
  - Consequence of Occurrence: Marginal; minimal impact to requirements and associated costs.
  - Threat Level: Low.
- Alternative 2c
  - Likelihood of Occurrence: Moderate; moderate based on some new construction for the alternative.
  - Consequence of Occurrence: Marginal; minimal impact to requirements and associated costs.
  - Threat Level: Low.

Threat 17: Implementation of the alternative does not meet the 2030 objective for 80 ppy.

- Alternative 1
  - Likelihood of Occurrence: High; based on EA schedule, CD-4 date is availability of plutonium operations and excludes the ramp up period to achieve production rate.
  - Consequence of Occurrence: Significant; substantial programmatic impact for meeting production rate.
  - Threat Level: Moderate.
- Alternative 2a
  - Likelihood of Occurrence: High; based on EA schedule, CD-4 date is availability of plutonium operations and excludes the ramp up period to achieve production rate.
  - Consequence of Occurrence: Significant; substantial programmatic impact for meeting production rate.
  - Threat Level: Moderate.
- Alternative 2b
  - Likelihood of Occurrence: High; based on EA schedule, CD-4 date is availability of plutonium operations and excludes the ramp up period to achieve production rate.

  - Consequence of Occurrence: Significant; substantial programmatic impact for meeting production rate.
  - Threat Level: Moderate.
- Alternative 2c
  - Likelihood of Occurrence: Moderate; based on EA schedule, CD-4 date is availability of plutonium operations and excludes the ramp up period to achieve production rate.
  - Consequence of Occurrence: Significant; substantial programmatic impact for meeting production rate.
  - Threat Level: Moderate.

Threat 18: Availability of personnel for criticality studies impact planned project costs and schedules.

- Alternative 1
  - Likelihood of Occurrence: High.
  - Consequence of Occurrence: Significant.
  - Threat Level: Moderate.
- Alternative 2a
  - Likelihood of Occurrence: Low.
  - Consequence of Occurrence: Significant.
  - Threat Level: Low.
- Alternative 2b
  - Likelihood of Occurrence: Low.
  - Consequence of Occurrence: Significant.
  - Threat Level: Low.
- Alternative 2c
  - Likelihood of Occurrence: Low.
  - Consequence of Occurrence: Significant.
  - Threat Level: Low.

Threat 19: Potential requirement for Computed Tomography (CT) inspection of partial and completed products.

- Alternative 1
  - Likelihood of Occurrence: Moderate.
  - Consequence of Occurrence: Marginal.
  - Threat Level: Low.

- Alternative 2a
  - Likelihood of Occurrence: Moderate.
  - Consequence of Occurrence: Significant.
  - Threat Level: Moderate.
- Alternative 2b
  - Likelihood of Occurrence: Moderate.
  - Consequence of Occurrence: Significant.
  - Threat Level: Moderate.
- Alternative 2c
  - Likelihood of Occurrence: Moderate.
  - Consequence of Occurrence: Significant.
  - Threat Level: Moderate.

Threat 20: Potential requirement for new process technology is identified.

- Alternative 1
  - Likelihood of Occurrence: Low.
  - Consequence of Occurrence: Marginal.
  - Threat Level: Low.
- Alternative 2a
  - Likelihood of Occurrence: Low.
  - Consequence of Occurrence: Significant.
  - Threat Level: Low.
- Alternative 2b
  - Likelihood of Occurrence: Low.
  - Consequence of Occurrence: Significant.
  - Threat Level: Low.
- Alternative 2c
  - Likelihood of Occurrence: Low.
  - Consequence of Occurrence: Critical.
  - Threat Level: Moderate.

Threat 21: Additional engineering controls based on Safety Design Strategy and Conceptual Design Safety Report.

- Alternative 1
  - Likelihood of Occurrence: Low.

  - Consequence of Occurrence: Marginal.
  - Threat Level: Low.
- Alternative 2a
  - Likelihood of Occurrence: Moderate.
  - Consequence of Occurrence: Marginal.
  - Threat Level: Low.
- Alternative 2b
  - Likelihood of Occurrence: Moderate.
  - Consequence of Occurrence: Marginal.
  - Threat Level: Low.
- Alternative 2c
  - Likelihood of Occurrence: High.
  - Consequence of Occurrence: Significant.
  - Threat Level: Moderate.

Threat 22: Unplanned Active Safety Class controls are required by the Safety Basis Approval Authority.

- Alternative 1
  - Likelihood of Occurrence: High.
  - Consequence of Occurrence: Negligible.
  - Threat Level: Low.
- Alternative 2a
  - Likelihood of Occurrence: High.
  - Consequence of Occurrence: Negligible.
  - Threat Level: Low.
- Alternative 2b
  - Likelihood of Occurrence: High.
  - Consequence of Occurrence: Significant.
  - Threat Level: Moderate.
- Alternative 2c
  - Likelihood of Occurrence: High.
  - Consequence of Occurrence: Critical.
  - Threat Level: High.

Threat 23: Post-assembly high-energy radiography is not performed at 50 ppy facility, which could result in returned parts for rework impacting pit production rate.

- Alternative 1
  - Likelihood of Occurrence: Very Low.
  - Consequence of Occurrence: Significant.
  - Threat Level: Low.
- Alternative 2a
  - Likelihood of Occurrence: Very Low.
  - Consequence of Occurrence: Significant.
  - Threat Level: Low.
- Alternative 2b
  - Likelihood of Occurrence: Very Low.
  - Consequence of Occurrence: Significant.
  - Threat Level: Low
- Alternative 2c
  - Likelihood of Occurrence: High.
  - Consequence of Occurrence: Significant.
  - Threat Level: Moderate.

M.7.2 Common Evaluated Opportunities

Opportunity 1: Existing infrastructure and analytical facilities can be leveraged to minimize capital costs and schedule.

- Alternative 1
  - Likelihood of Occurrence: Moderate; MFFF must add some capability.
  - Consequence of Occurrence: Efficient.
  - Opportunity Level: Moderate.
- Alternative 2a
  - Likelihood of Occurrence: High; LANL has existing capability (RLUOB).
  - Consequence of Occurrence: Optimal.
  - Opportunity Level: High.
- Alternative 2b
  - Likelihood of Occurrence: High; LANL has existing capability (RLUOB).
  - Consequence of Occurrence: Optimal.

- Opportunity Level: High.

- Alternative 2c
  - Likelihood of Occurrence: High; LANL has existing capability (RLUOB).
  - Consequence of Occurrence: Optimal.
  - Opportunity Level: High.

Opportunity 2: Off-site consequences can be minimized by locating production sites farther from site boundaries, thus reducing Safety Class equipment.

- Alternative 1
  - Likelihood of Occurrence: High; located further from site boundary than LANL alternatives.
  - Consequence of Occurrence: Optimal; tailored approach – Safety Significant versus Safety Class equipment.
  - Opportunity Level: High.
- Alternative 2a
  - Likelihood of Occurrence: Low; proximity to site boundary.
  - Consequence of Occurrence: Optimal; tailored approach – Safety Significant versus Safety Class equipment.
  - Opportunity Level: Moderate.
- Alternative 2b
  - Likelihood of Occurrence: Low; proximity to site boundary.
  - Consequence of Occurrence: Optimal; tailored approach – Safety Significant versus Safety Class equipment.
  - Opportunity Level: Moderate.
- Alternative 2c
  - Likelihood of Occurrence: Low; proximity to site boundary.
  - Consequence of Occurrence: Optimal; tailored approach – Safety Significant versus Safety Class equipment.
  - Opportunity Level: Moderate.

Opportunity 3: Shared infrastructure and site resources could minimize overall costs.

- Alternative 1
  - Likelihood of Occurrence: High.
  - Consequence of Occurrence: Efficient.
  - Opportunity Level: High.

- Alternative 2a
  - Likelihood of Occurrence: High.
  - Consequence of Occurrence: Optimal.
  - Opportunity Level: High.
- Alternative 2b
  - Likelihood of Occurrence: High.
  - Consequence of Occurrence: Efficient.
  - Opportunity Level: High.
- Alternative 2c
  - Likelihood of Occurrence: High.
  - Consequence of Occurrence: Efficient.
  - Opportunity Level: High.

Opportunity 4: Potential requirement for new technology is identified that improves process operations.

- Alternative 1
  - Likelihood of Occurrence: Moderate.
  - Consequence of Occurrence: Optimal; additional excess space is available.
  - Opportunity Level: High.
- Alternative 2a
  - Likelihood of Occurrence: Moderate.
  - Consequence of Occurrence: Efficient; limited space is available.
  - Opportunity Level: Moderate.
- Alternative 2b
  - Likelihood of Occurrence: Moderate.
  - Consequence of Occurrence: Efficient; limited space is available.
  - Opportunity Level: Moderate.
- Alternative 2c
  - Likelihood of Occurrence: Moderate.
  - Consequence of Occurrence: Efficient; limited space is available.
  - Opportunity Level: Moderate.

M.7.3 Common Threats Not Evaluated

The Pu pit production EA Team identified several common threats that were not separately evaluated because the team consensus was that there would be no real, measurable, or discernable difference among the four Pu pit production alternatives. Nonetheless, the threats identified included the following:

- Site fire or natural phenomena (storm, earthquake, flood, tornado) disrupts production.
- Funding constraints.
- Delay in CD Strategy or Critical Decisions.
- Changes in codes of records, orders, standards, or safety requirements.
- Co-location of design agency and production agency affects the focus on production.
- Over-the-road transportation puts material at risk.
- The Pu Pit production equipment model has not been fully validated due to limited history in current operations.

M.7.4 Common Opportunities Not Evaluated

The Pu pit production EA Team did not identify any common opportunities that did not warrant evaluation.

M.7.5 Alternative 1 Specific Threats

Threat 1: MFFF ongoing construction leads to increased costs for modifications or facility retrofit.

- Likelihood of Occurrence: High; continuing construction until Congressional halt and/or contract direction.
- Consequence of Occurrence: Significant; significant cost impact.
- Threat Level: Moderate.

Threat 2: Difficulties closing out the MFFF project and contract result in schedule delays.

- Likelihood of Occurrence: Moderate.
- Consequence of Occurrence: Critical; impact would delay construction.
- Threat Level: Moderate.

Threat 3: Siting pit production in a high humidity environment impacts product quality.

- Likelihood of Occurrence: Low.
- Consequence of Occurrence: Crisis; impact could prevent product qualification.
- Threat Level: Moderate.

Threat 4: Two production entities increases certification, qualification, and surveillance of product quality.

- Likelihood of Occurrence: Very High.
- Consequence of Occurrence: Significant; duplicate functions required at both sites, thus increasing costs.
- Threat Level: High.

M.7.6 Alternative 1 Specific Opportunities

Opportunity 1: Some work required for pit production at MFFF can be completed as part of MFFF closeout.

- Likelihood of Occurrence: High.
- Consequence of Occurrence: Significant; early start for some construction activities.
- Opportunity Level: Moderate.

Opportunity 2: Analytical capability will be located in existing HC-2, Security Category 1 space.

- Likelihood of Occurrence: High.
- Consequence of Occurrence: Significant; reduced costs for analytical capabilities.
- Opportunity Level: Moderate.

Opportunity 3: Improve operational efficiency using lessons learned and best practices with SMEs from separate sites.

- Likelihood of Occurrence: High.
- Consequence of Occurrence: Efficient; results in continuous improvements.
- Opportunity Level: High.

Opportunity 4: Separate sites, each with production capabilities, can ensure continuing mission support.

- Likelihood of Occurrence: High.
- Consequence of Occurrence: Optimal; dual production capability increases capacity and mission assurance.
- Opportunity Level: High.

Opportunity 5: Additional HC-2 space is available to support other NNSA Programs.

- Likelihood of Occurrence: High.
- Consequence of Occurrence: Optimal; existing space will be available.
- Opportunity Level: High.

Opportunity 6: Opportunity to make use of purchased and stored commodities from MOX Project.

- Likelihood of Occurrence: High.
- Consequence of Occurrence: Efficient; More than $800M of equipment and commodities are currently available. Implement with a detailed assessment of stored equipment and commodities during design.
- Opportunity Level: High.

Opportunity 7: Opportunity to remove walls for improved constructability and operational efficiency.

- Likelihood of Occurrence: High.
- Consequence of Occurrence: Efficient;
- Opportunity Level: High.

Opportunity 8: Opportunity the BMP would not have to be safety class due to its distance from the site boundary.

- Likelihood of Occurrence: High.
- Consequence of Occurrence: Efficient;
- Opportunity Level: High.

Opportunity 9: Use of F/H analytical laboratory.

- Likelihood of Occurrence: Moderate.
- Consequence of Occurrence: Significant.
- Opportunity Level: Moderate.

M.7.7 Alternative 2a Specific Threats

Threat 1: Inadequate parking for increased production workforce.

- Likelihood of Occurrence: High; known issue for the constrained site.
- Consequence of Occurrence: Significant.
- Threat Level: Moderate.

Threat 2: Inadequate local warehousing, laydown areas and/or working space to support fabrication for construction.

- Likelihood of Occurrence: High; known issue for the constrained site.
- Consequence of Occurrence: Significant.
- Threat Level: Moderate.

Threat 3: Inadequate office/training space to support operations.

- Likelihood of Occurrence: High; known issue for the constrained site.
- Consequence of Occurrence: Significant.
- Threat Level: Moderate.

Threat 4: Implementation of 50 ppy mission disrupts 30 ppy mission at PF-4.

- Likelihood of Occurrence: Low.
- Consequence of Occurrence: Critical.
- Threat Level: Moderate.

Threat 5: Increased 400-g MAR limit at RLUOB is not approved, creating need for alternate analytical chemistry and material characterization facilities.

- Likelihood of Occurrence: Low.
- Consequence of Occurrence: Critical; cost and schedule impacts.
- Threat Level: Moderate.

Threat 6: Unexpected underground site conditions.

- Likelihood of Occurrence: Low.
- Consequence of Occurrence: Significant.
- Threat Level: Low.

Threat 7: Facility upgrades are needed to extend the operational life of PF-4 to 50 years.

- Likelihood of Occurrence: High; new projects will be needed for future life extension.
- Consequence of Occurrence: Significant.
- Threat Level: Moderate.

Threat 8: PF-4 has potential vulnerability to seismic risks.

- Likelihood of Occurrence: High; upgrade requirements could be identified during the design phase and prior to CD-2/3.
- Consequence of Occurrence: Significant.
- Threat Level: Moderate.

Threat 9: Limited operational flexibility for future expansion to accommodate increases in mission requirements.

- Likelihood of Occurrence: Moderate; new facility provides operational flexibility.

- Consequence of Occurrence: Marginal.
- Threat Level: Low.

Threat 10: Operational, safety, or equipment failures result in shutdown of PF-4 that impacts ability to meet the mission.

- Likelihood of Occurrence: High; life cycle planning to include additional maintenance, repair, and replacement to maintain production rates.
- Consequence of Occurrence: Significant; single point failure for aqueous operations needed for the 50 ppy mission results in extended liquid waste storage.
- Threat Level: Moderate.

Threat 11: Construction/equipment installation disrupts on-going site or facility operations.

- Likelihood of Occurrence: Very Low.
- Consequence of Occurrence: Marginal.
- Threat Level: Low.

Threat 12: On-going site or facility operations disrupts construction/equipment installation.

- Likelihood of Occurrence: Low.
- Consequence of Occurrence: Marginal.
- Threat Level: Low.

Threat 13: Construction of new 50 ppy facilities at LANL and tunnel connection to PF-4 could impact high energy radiography for plutonium operations at PF-4.

- Likelihood of Occurrence: High.
- Consequence of Occurrence: Significant.
- Threat Level: Moderate.

M.7.8 Alternative 2a Specific Opportunities

Opportunity 1: Separate facilities (within a site) each with production capabilities can ensure continuing mission support.

- Likelihood of Occurrence: Very High; dual production capacity.
- Consequence of Occurrence: Efficient; maintains production capability.
- Opportunity Level: High.

Opportunity 2: The NEPA process can be shortened.

- Likelihood of Occurrence: Low.

- Consequence of Occurrence: Marginal.
- Opportunity Level: Low.

M.7.9 Alternative 2b Specific Threats

Threat 1: Inadequate parking for increased production workforce.

- Likelihood of Occurrence: High; known issue for the constrained site.
- Consequence of Occurrence: Significant.
- Threat Level: Moderate.

Threat 2: Inadequate local warehousing, laydown areas and/or working space to support fabrication for construction.

- Likelihood of Occurrence: High; known issue for the constrained site.
- Consequence of Occurrence: Significant.
- Threat Level: Moderate.

Threat 3: Inadequate office/training space to support operations.

- Likelihood of Occurrence: High; known issue for the constrained site.
- Consequence of Occurrence: Significant.
- Threat Level: Moderate.

Threat 4: Implementation of 50 ppy mission disrupts 30 ppy mission at PF-4.

- Likelihood of Occurrence: High; requires reconfiguration of PF-4.
- Consequence of Occurrence: Critical.
- Threat Level: High.

Threat 5: Increased 400-g MAR limit at RLUOB is not approved, creating need for alternate analytical chemistry and material characterization facilities.

- Likelihood of Occurrence: Low.
- Consequence of Occurrence: Critical; cost and schedule impacts.
- Threat Level: Moderate.

Threat 6: Unexpected underground site conditions.

- Likelihood of Occurrence: Low.
- Consequence of Occurrence: Significant.
- Threat Level: Low.

Threat 7: Facility upgrades are needed to extend the operational life of PF-4 to 50 years.

- Likelihood of Occurrence: High; new projects will be needed for future life extension.
- Consequence of Occurrence: Significant.
- Threat Level: Moderate.

Threat 8: PF-4 has potential vulnerability to seismic risks.

- Likelihood of Occurrence: High; upgrade requirements could be identified during the design phase and prior to CD-2/3.
- Consequence of Occurrence: Significant.
- Threat Level: Moderate.

Threat 9: Limited operational flexibility for future expansion to accommodate increases in mission requirements.

- Likelihood of Occurrence: Moderate; new facility provides operational flexibility.
- Consequence of Occurrence: Significant.
- Threat Level: Moderate.

Threat 10: Operational, safety, or equipment failures result in shutdown of PF-4 that impacts ability to meet the mission.

- Likelihood of Occurrence: High; life cycle planning to include additional maintenance, repair, and replacement to maintain production rates.
- Consequence of Occurrence: Critical; single point failure for aqueous operations needed for the 50 ppy mission results in extended liquid waste storage.
- Threat Level: High.

Threat 11: Construction/equipment installation disrupts on-going site or facility operations.

- Likelihood of Occurrence: Low.
- Consequence of Occurrence: Significant.
- Threat Level: Low.

Threat 12: On-going site or facility operations disrupts construction/equipment installation.

- Likelihood of Occurrence: High.
- Consequence of Occurrence: Significant.
- Threat Level: Moderate.

Threat 13: Construction of new 50 ppy facilities at LANL and tunnel connection to PF-4 could impact high energy radiography for plutonium operations at PF-4.

- Likelihood of Occurrence: High.
- Consequence of Occurrence: Significant.
- Threat Level: Moderate.

M.7.10 Alternative 2b Specific Opportunities

Opportunity 1: Separate facilities (within a site) each with production capabilities can ensure continuing mission support.

- Likelihood of Occurrence: Very High; dual production capacity.
- Consequence of Occurrence: Significant; maintains production capability.
- Opportunity Level: High.

Opportunity 2: The NEPA process can be shortened.

- Likelihood of Occurrence: Low.
- Consequence of Occurrence: Marginal.
- Opportunity Level: Low.

M.7.11 Alternative 2c Specific Threats

Threat 1: Inadequate parking for increased production workforce.

- Likelihood of Occurrence: High; known issue for the constrained site.
- Consequence of Occurrence: Significant.
- Threat Level: Moderate.

Threat 2: Inadequate local warehousing, laydown areas and/or working space to support fabrication for construction.

- Likelihood of Occurrence: High; known issue for the constrained site.
- Consequence of Occurrence: Significant.
- Threat Level: Moderate.

Threat 3: Inadequate office/training space to support operations.

- Likelihood of Occurrence: High; known issue for the constrained site.
- Consequence of Occurrence: Significant.
- Threat Level: Moderate.

Threat 4: The vault does not have the capacity to support pit production throughput.

- Likelihood of Occurrence: High.
- Consequence of Occurrence: Critical; requires additional capability with cost, schedule, and throughput impacts.
- Threat Level: High.

Threat 5: Inadequate shipping and receiving capability to achieve pit production throughput.

- Likelihood of Occurrence: High.
- Consequence of Occurrence: Critical; requires additional capability with cost, schedule, and throughput impacts.
- Threat Level: High.

Threat 6: Implementation of 50 ppy mission disrupts 30 ppy mission at PF-4.

- Likelihood of Occurrence: High; requires reconfiguration of PF-4.
- Consequence of Occurrence: Critical.
- Threat Level: High.

Threat 7: Increased 400-g MAR limit at RLUOB is not approved, creating need for alternate analytical chemistry and material characterization facilities.

- Likelihood of Occurrence: Low.
- Consequence of Occurrence: Critical; cost and schedule impacts.
- Threat Level: Moderate.

Threat 8: Unexpected underground site conditions.

- Likelihood of Occurrence: Low.
- Consequence of Occurrence: Significant.
- Threat Level: Low.

Threat 9: Operational mishaps or equipment failures due to double-shift operations in PF-4 impacts production capacity and completion of the mission.

- Likelihood of Occurrence: High.
- Consequence of Occurrence: Critical; single point failure during double-shift operations prior to new modules.
- Threat Level: High.

Threat 10: Facility Upgrades are needed to extend the operational life of PF-4 to 50 years.

- Likelihood of Occurrence: High.
- Consequence of Occurrence: Significant.
- Threat Level: Moderate.

Threat 11: PF-4 has potential vulnerability to seismic risks.

- Likelihood of Occurrence: High; upgrade requirements could be identified during the design phase and prior to CD-2/3.
- Consequence of Occurrence: Significant.
- Threat Level: Moderate.

Threat 12: Transition to module operations during the bridge from PF-4 may result in disruption of 80 ppy capabilities.

- Likelihood of Occurrence: High.
- Consequence of Occurrence: Significant.
- Threat Level: Moderate.

Threat 13: Limited operational flexibility for future expansion to accommodate increases in mission requirements.

- Likelihood of Occurrence: Moderate; new facility provides operational flexibility.
- Consequence of Occurrence: Significant.
- Threat Level: Moderate.

Threat 14: Construction/equipment installation disrupts on-going site or facility operations.

- Likelihood of Occurrence: High.
- Consequence of Occurrence: Significant.
- Threat Level: Moderate.

Threat 15: Operational, safety, or equipment failures result in shutdown of PF-4 that impacts ability to meet the mission.

- Likelihood of Occurrence: High; life cycle planning to include additional maintenance, repair, and replacement to maintain production rates.
- Consequence of Occurrence: Critical; single point failure for aqueous operations needed for the 50 ppy mission results in extended liquid waste storage.
- Threat Level: High.

Threat 16: On-going site or facility operations disrupts construction/equipment installation.

- Likelihood of Occurrence: High.
- Consequence of Occurrence: Significant.
- Threat Level: Moderate.

Threat 17: Construction of new 50 ppy facilities at LANL and tunnel connection to PF-4 could impact high energy radiography for plutonium operations at PF-4.

- Likelihood of Occurrence: High.
- Consequence of Occurrence: Critical.
- Threat Level: High.

Threat 18: Personnel support facilities are inadequate for PF-4 double-shift operations, and unplanned for new modules.

- Likelihood of Occurrence: High.
- Consequence of Occurrence: Significant.
- Threat Level: Moderate.

M.7.12 Alternative 2c Specific Opportunities

Opportunity 1: Separate facilities (within a site) each with production capabilities can ensure continuing mission support.

- Likelihood of Occurrence: Moderate; dual production capacity.
- Consequence of Occurrence: Significant; maintains production capability.
- Opportunity Level: Moderate.

Opportunity 2: The NEPA process can be shortened.

- Likelihood of Occurrence: Low.
- Consequence of Occurrence: Marginal.
- Opportunity Level: Low.

Appendix N Site Visits and Outcomes

The EA Team developed and evaluated equipment configuration layouts, preconceptual facility arrangements, schedules, cost estimates, and qualitative risks by conducting a series of five site visits, meetings, and workshops at LANL in Los Alamos, New Mexico; at DOE/NNSA Headquarters in Washington, DC; and at SRS in Aiken, South Carolina

The EA Team initially met with subject matter experts (SMEs) for input on general layout configurations for a new construction option at LANL. The original focus was on the configuration of process areas. Based on the SME input, initial sketches of equipment configurations were developed. After the general focus on overall process layout, the EA Team proceeded from initial equipment pieces to different functions in specific areas. Laying out the functions in specific areas involved sequencing the equipment, including appropriate adjacencies, and minimizing conflicts to realize efficiencies. The EA Team received input from SMEs on initial layouts and sizing and the sizing was validated to confirm space requirements. The EA Team adjusted equipment sizing and clear space and subsequently revised sketches. When the equipment size and layout for process areas was complete, the new construction layout was then reconfigured for the process area in MFFF and other options. Several iterations were completed from initial gross summaries of space to further refinements and ultimate equipment configuration layouts and preconceptual facility arrangements. The following subsections summarize the five site visits, meeting, and workshops that the EA Team conducted to complete the equipment configuration layouts, preconceptual facility arrangements, schedule and cost estimate ranges, and qualitative risk analysis.

N.1 Site Visit to Los Alamos National Laboratory

The EA Team conducted a site visit to LANL on 7–8 November 2017 to discuss equipment requirements and preconceptual layouts for a 50 ppy capability for constructing a new facility at LANL, exclusive of PF-4 and refurbishing and repurposing the MFFF at SRS. Both alternatives assumed the production of 50 ppy in addition to the 30 ppy mission already planned for PF-4. The additional footprint at LANL is assumed to be in the location adjacent to PF-4 and the RLUOB, where the cancelled Chemical Metallurgy Research Replacement (CMRR) nuclear facility (NF) was sited.

The EA Team objectives for the LANL meeting were to understand: (1) the LANL pit production process; (2) the type and, where applicable, general quantities of equipment, utilities, storage, safety and security features planned for LANL; and (3) the existing space, structures, and capabilities available to support both the planned 30 ppy and proposed 50 ppy missions in Technical Area 55 (TA-55), including PF-4, RLUOB, waste facilities, and other supporting infrastructure.

The EA Team received a presentation from LANL staff that included a simplified pit production flow sheet and an overview of PF-4. The EA Team also toured laboratory spaces with LANL personnel discussing operations in their respective areas, including the foundry and machining areas; the trolley system used for material conveyance throughout PF-4; mechanical, electrical, and ventilation system spaces; the shipping and receiving area; and material storage vault.

The EA Team developed a general sense of laboratory operations, density of equipment, gloveboxes, benches, and distributed storage safes. The EA Team also observed that construction activities, such as the installation of new gloveboxes, take place in active laboratories, which was explained as a major factor in the LANL plan to achieve total production of 80 ppy (30 ppy is currently planned plus an additional 50 ppy) using existing space in PF-4 and construction of new lab modules in TA-55.

The EA Team also toured portions of RLUOB, including laboratory areas, the space was previously intended to be used as an entry control facility to connect to the now cancelled CMRR-NF, and the area that was excavated for the CMRR-NF. The Combined Utility Building (CUB) that is attached to RLUOB was also discussed. The CUB was sized to provide non-safety utilities to both RLUOB and CMRR-NF, and its current excess capacity is available for new construction defined in the EA. A significant assumption regarding the RLUOB was that the MAR limit will be increased, and the RLUOB safety basis changed to HC-3, in time to support the planned 30 ppy and potential additional 50 ppy mission in TA-55.

The EA Team was presented information on the capabilities and capacities of the Radioactive Liquid Waste Treatment Facility low-level liquid waste and transuranic liquid waste facilities. Following the waste capacity discussion, LANL personnel discussed PF-4 building systems, particularly the documented safety analysis (DSA). The driving events for the PF-4 DSA are a seismic event and post-seismic fire. Safety Class and Safety Significant systems were described, as were plans for upgrades.

Lastly, LANL personnel presented information to the EA Team regarding the production process and the facilities. It was noted that process modeling performed by LANL was based on an average ppy, whereas the AoA team modeled to “high confidence” or 90% confidence that the ppy target would be met[6]. As a result, LANL revised the equipment list and the EA Team determined that the revised equipment list could meet the 90% confidence level. The equipment lists independently generated by the EA Team align closely to the LANL equipment list.

N.2 Meeting at DOE/NNSA Headquarters, Washington, DC

After the LANL site visit, the EA Team conducted a 2-day meeting at DOE/NNSA Headquarters in Washington, DC, on 29–30 November 2017. The focus of the meeting was to understand the modeling and assumptions used by the AoA team to establish equipment requirements. An overview of the classified pit production model was provided to the EA Team. The model was used to evaluate the manufacturing equipment required for producing 80 ppy at high-confidence (greater than 90%

[6] Average confidence means that there is a 50% chance of not achieving the required production rate each year. High-confidence means that there is less than a 10^ change of not achieving the required production rate each year.

confidence). Equipment processing times, equipment failure rates, repair times, and part rejection rates were provided by LANL and reviewed by SMEs, operators from LLNL, and the former Rocky Flats Plant. Due to the limited availability of steady state production data at LANL and Rocky Flats, the AoA team acknowledged that the model is, consequently, also limited in predicting the range of all possible production scenarios and the associated equipment requirements to maintain an 80 ppy production rate in all of those scenarios. The AOA team acknowledged this uncertainty in the model and the estimated equipment requirements.

The EA Team acknowledged that the AoA team did not model material movement in a trolley system and impacts on overall throughput; rather, it assumed that a reliable conveyance system would be available. The model was used to generate an equipment list for an 80 ppy production rate. The AoA team provided the EA Team with an equipment list based on 50 ppy that was generated after the AoA and did not include an analysis of equipment redundancy requirements to avoid disruption to operations in the case of failure.

The EA Team was provided an explanation of how the equipment list, dimensions of LANL gloveboxes with similar equipment, and data from other relevant facilities were used to define space requirements. Glovebox dimensions were based on existing and comparable gloveboxes at PF-4, and LANL SMEs provided input for the clear space (initially 4 feet and subsequently refined) required around gloveboxes. Conveyance racks and other appurtenances were accounted for in a space multiplication factor.

The methodology used to determine space requirements for non-process areas was presented to the EA Team. Many requirements were based on analogous space at other facilities; others resulted from SME judgement applied to LANL inputs. Space and cost estimating methodologies were provided to the EA Team. Seismic upgrades and plans to extend the life of PF-4 were also discussed. There is no approved plan for life extension of the PF-4 facility.

N.3 Site Visit to Savannah River Site, Aiken, SC

The EA Team then traveled to SRS in Aiken on 5–6 December 2017 for an overview of the MFFF project, including a brief history and the functions and construction status of permanent and temporary facilities. The EA Team also toured the MFFF, which is separated into three areas: aqueous polishing (BAP), manufacturing process (BMP), and shipping and receiving (BSR). After the tour and discussion, the EA Team determined that the room sizes and configuration in the BMP were the most adaptable for pit production.

The MFFF was constructed to meet NRC criteria. The EA Team assumed that the MFFF design revalidation would meet DOE hazard and security requirements. The MFFF is oversized to meet the requirements for the Pu Pit Production mission. The EA Team discussed the need to document assumptions and account for the costs associated with life safety and security requirements in the unused MFFF spaces, as well as maintaining structural integrity. The EA Team noted that the MFFF is designed for specific processes and contains equipment and gloveboxes that cannot be used by other projects. Wall penetrations or other structural changes must be studied and planned to mitigate their effects on building performance. The process footprint in the MFFF represents a relatively small proportion of the overall MFFF floor-space. Thus, the number of penetrations and/or structural modifications, if needed, will affect only a small proportion of the walls and floors of the MFFF facility. Additionally, the expected size of penetrations that may be needed for glovebox conveyances and/or piping are relatively small in relation to wall areas. The EA review team discussed potential impacts of these types of modifications to the overall structural viability of the MFFF with structural SMEs (e.g. CJC & Associates) and it was concluded that potential modifications such as these would represent a minimal risk to the overall structural viability of the MFFF. The EA Team discussed that the MFFF has an advantage in that the general facility structure has largely been completed and was built to a PC-3+ seismic standard. MFFF also includes other permanent facilities that can be used during construction or operations.

The EA Team also received a presentation on the Waste Solidification Building (WSB), which has been in lay-up since 2014 and was intended to process liquid waste from MFFF. The SRS solid waste storage and shipping capability in E Area was also discussed. Analytical laboratory functions exist at both the F-H Lab and Savannah River National Laboratory (SRNL). The age and condition of F-H Laboratory and the MAR limit at SRNL are concerns, as is the inefficiency of separating the capacity from the production line.

Lastly, the EA Team toured the WSB with a focus on the potential use of its liquid waste and laboratory capabilities. WSB is an HC-2 facility, but it was not designed for Security Category 1 requirements, which would be necessary for pit production operations. WSB has inherent liquid waste processing capability that could support pit production, although the existing capacity is an order of magnitude greater than is needed for pit production. Non-process space is currently being used to train operators for the tritium area.

N.4 Workshop at Savannah River Site, Aiken, SC

After initial site visits to LANL and SRS, and a DOE/NNSA Headquarters meeting to discuss the modeling used to determine equipment requirements, the EA Team convened a workshop at SRS in Aiken, SC on 9–11 January 2018.

The SRS workshop objective was to establish EA Team concurrence on developing equipment configuration and facility layout for a LANL single process module alternative, and the approaches for the MFFF alternative, the PF-4 plus new construction and LANL modular options. The general approach was to lay out the tentatively agreed-upon equipment list for the new construction at LANL option. This would allow the EA team, with SME input, to confirm equipment sizing, ensure proper process equipment flow, and develop an unconstrained space layout. With this layout, the EA Team then worked to fit the equipment into other alternative spaces.

After the identification of equipment to be in process rooms, the EA Team arranged the equipment items in process rooms and resized the rooms as necessary. In addition, the EA Team also evaluated and revised the sizing for other rooms/areas inside the process module, and refined the location, orientation, and configuration of each room/area. The Process Module layout included the following areas:

- Disassembly and metal preparation
- Foundry
- Machining
- Subassembly and assembly
- Post-assembly

The process areas included:

- Aqueous recovery
- High energy radiography
- Actinide chemistry
- Material management
- Hot calibration and maintenance
- Material characterization

The storage areas included:

- Office space (inside process building)
- Building utilities
- Shipping and receiving
- Vault
- Solid waste storage

Other areas included:

- Operations control room
- Other processing support areas
- Exterior utilities
- Personnel support module

The EA Team initiated the process without limitations on space to address maintenance, seismic, pipe stress considerations so they could be appropriately included. The initial process module (single level) sizing was approximately 100,000 ft^2. The following general assumptions were made:

- Warehousing, cafeteria, and other associated space will be sufficient at any site
- All new construction would be meet the HC-2 requirements
- Utilities and capacities will be sized parametrically

After discussing the specifics for a new construction LANL option, the EA Team discussed the MFFF option layout. The EA Team determined the following:

- Potential exists to eliminate some conveyance for space optimization; potential to knock out walls to create additional space
- The conveyor line in B-324 must be offset and the equipment sizes corrected
- In-line radiography must be on the conveyor line (B-349 would be the most logical choice)
- Preference for keeping material characterization on the third floor due to planned glovebox ventilation zones and room sizes
- Need for more equipment underneath the foundry
- Waste storage may be moved elsewhere on the second floor

Lastly, the EA Team discussed the best way to seal up the building so that future modifications are possible. Masonry block walls were determined to be best because they could easily be removed.

N.5 Meeting at DOE/NNSA Headquarters, Washington, DC

The EA Team also conducted a final review and comment meeting at DOE/NNSA Headquarters in Washington DC on 22–24 January 2018. The purpose of the meeting was to further refine and finalize the equipment configuration layouts and preconceptual facility arrangements to support the engineering feasibility determination. The meeting also included discussion of threats and opportunities and the conduct a qualitative risk analysis, as well as review and discussion of key cost estimate and schedule parameters.

At the completion of the five site visits, workshops, and meetings, along with weekly conference calls and interim draft reviews, including incorporating the feedback from SMEs, the final process area layouts, feasibility analysis, schedules, and cost estimate ranges and qualitative risk analyses were completed.