2016 Updated Performance Baseline for the Mixed Oxide Fuel Fabrication Facility at the Savannah River Site:

Overview of DOE’s 2016 Updated Performance Baseline with a Comparison to the Contractor’s Estimates and Data

U.S. DEPARTMENT OF ENERGY
OFFICE OF PROJECT MANAGEMENT OVERSIGHT AND ASSESSMENTS

Executive Summary

The U.S. Department of Energy (DOE) Office of Project Management Oversight and Assessments (PM), partnering with the U.S. Army Corps of Engineers (USACE), developed an updated performance baseline (2016 updated PB) for the National Nuclear Security Administration's (NNSA) Mixed Oxide Fuel Fabrication Facility (MFFF) project, which is intended to contribute to the disposal of surplus weapon-grade plutonium, at the Savannah River Site in South Carolina (SRS). The MFFF contractor is CB&I AREVA MOX Services, LLC.

This performance baseline (PB) update and report focuses on the capital asset acquisition costs only. It provides an updated performance baseline estimate, including the project's performance measurement baseline, management reserve, fee, federal contingency, and other direct costs that make up the Total Project Cost (TPC) in the aggregate. It does not review all the other costs, post project completion.

To establish the updated TPC, it was necessary to assume an affordable and realistic steady-state funding profile until project completion. This 2016 updated PB assumed that the Congress would fund the project at an average of $350M per year until project completion, which is consistent with recent appropriations for the project. To illustrate the effect of varying funding levels on the project cost and duration, an alternate funding profile ($500M/year) and "unconstrained" funding profile are provided in Appendix A.

As shown in **Table ES-1**, the 2016 updated PB TPC estimate is $17.17B, which is more than $7B higher than the contractor's estimate.

Table ES-1: Comparison of the 2016 Updated Performance Baseline and Contractor's 2016 Estimate At Completion – Assuming $350M Annual Funding Constraint ($000)

	2016 Updated Performance Baseline	**Contractor's July 2016 Estimate at Completion**
Actual Cost of Work Performed (ACWP)[1]	$ 4,628,452	$ 4,855,812
Base Estimate to Complete ("to go" cost)	5,656,605	3,447,991
Escalation	5,144,027	373,595
Management Reserve (MR)/Contingency	1,444,987	1,048,211
Fees	295,187	264,516
Total Project Cost	**$ 17,169,258**	**$ 9,990,125**
Projected Completion Date	**2048**	**2029**

[1] *Contractor's ACWP includes actual costs through March 2016; updated PB's ACWP includes actual costs through January 2016. Projected February and March 2016 costs were included in the Updated PB "to go" cost estimate.*

The primary difference between the two TPC estimates is escalation. Escalation is approximately $4.8B higher in the 2016 updated PB due to three factors: a longer project duration of 19 years; different assumptions about escalation (the updated PB assumed an annual escalation rate of 4% instead of slightly under 2% assumed by the contractor); and the contractor not allocating the management reserve (MR) and contingency costs in a time phased manner across the project duration or applying escalation to these reserves.

The schedule for the updated PB is longer than the contractor's because of assumptions as to how much of the annual funding can be spent on the discrete construction scope of work and allocation of MR/contingency and escalation into the spend profile. The contractor assumes all funding is applied to work and no risks are realized during execution; MR and contingency are not allocated or escalated annually in their spend plan. The updated PB includes escalation and MR and contingency on a yearly basis, limiting what can be spent on construction, which extends the schedule.

MOX Services did not develop a resource loaded schedule to determine what is required to complete the project before applying a funding constraint to calculate the impact to completion. Rather, commodity installation rates were grossly applied to determine commodity installation schedule durations to forecast schedule completion. The outcome of that methodology at an assumed funding level of $350M/year is completion by 2029 - 13 years from now.

A more appropriate method of determining a new estimated project completion is to begin with a logically driven schedule of activities representing the remaining work scope fully loaded with the resources and costs necessary to complete all work scope. The resource loaded schedule can then be leveled against the annual funding constraint of $350M by prioritizing work based on total available float and physical work constraints. Through a series of iterations, a new project completion date can be reliably calculated that is within available funding and conforms to the physical constraints of construction sequence modeled in the schedule.

At $5.66B, the 2016 updated PB estimate of "to go" cost (excluding escalation, MR/Contingency, and fees) is 64% higher than the contractor's $3.45B estimate of "to go" cost. These differences are the result of systemic underlying issues and methods used by the contractor to calculate costs, including:

- **Unit Rates**: Unit rates reflect levels of productivity during construction. The contractor's estimate of construction costs through FY17 was based on actual unit rates achieved during FY15. However, for FY18 and beyond, the contractor's estimate of construction costs was based on more favorable unit rates that have generally not been achieved. In addition, for some commodities, like electrical, there is little performance data to date; the current estimated productivity rates appear overly optimistic. The unit rates used by PM to develop the updated PB estimate reflect the actual unit rates achieved to date by the contractor and incorporate rework that will be required while executing the balance of the project. Using actual unit rates achieved to date results in a cost increase of approximately $370M.

- **Actual Work Completed**: In 2015, the contractor performed a state-of-completeness validation. This revealed that many quantities had been overstated in the contractor's Quantity Unit Rate Reports (QURR). The QURR is a performance report that reflects the status of work completed, work remaining, and the rates at which work is progressing compared to planned. As an example, in June 2015, the QURR earned quantity for pipe was 23,631 feet, while the validated earned quantity was 12,398 feet, a difference of almost 100%. In September 2015, the contractor revised the quantities earned in performance reports to reflect the state-of-completeness validation. While the contractor updated the performance reports, their 2016 EAC did not provide the level of detail necessary to validate that the estimate was based on the revised quantities. Moreover, despite having increased quantities of work to accomplish as a result of the state-of-completeness validation information, the contractor's 2016 EAC decreased by nearly 10% from the 2015 EAC for Permanent Facility & Infrastructure. This does not appear to make sense on its surface. Without a comprehensive basis of estimate for the contractor's 2016 EAC, there is inconclusive information to determine if the contractor's 2016 EAC in fact incorporates the revised quantities. The 2016 updated PB was developed using the validated quantities to calculate quantities for remaining work.

- **Percent Complete**: Rather than basing their percent completion relative to budget, the contractor establishes percent complete based on actual costs, which overstates performance. According to the contractor's cost data as of January 2016, construction activities were 61% complete. This percentage reflects the overall status of both the stored materials and installation of these materials. This percentage is misleading for much of the mechanical piping, electrical, and heating, ventilation, and air conditioning (HVAC) systems due to the fact that much of the material was procured prior to completion of design and is stored on site awaiting installation. For example, 66% of the required piping has been procured, while just 1% has been installed, inspected and accepted. The contractor's estimate of construction percent complete does not reflect the difference between commodities that have been installed and commodities that have been inspected and accepted (refer to **Table ES-2** for examples). When comparing the actual cost of work performed to the estimate at complete, the project is 48% complete based on MOX Services' EAC and 28% complete based on the PM EAC.

Table ES-2: Examples of Differences in Percent Complete as Reported by Contractor

Commodity	February 21, 2016 QURR Cumulative Actuals % Complete	March 27, 2016 Monthly Status Report *Final Attributes % Complete
Active Gallery Pipe & Balance of Pipe	11%	1%
Pen Plates	56%	0%
Duct	28%	3%
Fire Dampers	38%	17%
Cable Tray & Wireway	10%	5%
Conduit	4%	0%
Electrical Equipment	3%	0%

***** *Final Attributes: commodities that have passed quality assurance/control and are not subject to rework.*

- **Level of Effort**: Level of effort (LOE) activities such as project management in the 2016 updated PB are $738M higher than the contractor's estimate primarily due to the longer schedule duration for the 2016 updated PB and different assumptions as to future LOE costs. Actual LOE costs averaged $29.3M per month when the project was baselined and received higher funding levels. Under reduced funding levels of $350M per year, the contractor assumed in the 2016 EAC that "to go" base costs for LOE activities would average $15M per month. The 2016 updated PB assumes higher LOE base and hotel load[1] costs over the duration of the project based on past performance and future requirements.

The updated PB "to go" cost includes $238M for Direct Metal Oxidation (DMO), which is not included in the contractor's current scope, but will be required in order to accomplish the MOX fuel approach mission. DMO converts plutonium metal to plutonium oxide in specialized DMO furnaces to be installed in the MFFF once complete.

The DOE construction activities and LOE activities in the 2016 updated PB together include approximately $500M in base costs for obsolescence that are not included in the contractor's estimates. This is based on the protracted timeline from start to project completion. Obsolescence should be expected and a factor of approximately 2% against the total project cost appears reasonable in the context of a construction timeline that extends beyond four decades.

Finally, all of these additional "to go" costs reflected in PM's PB update cost estimate, an extra $2.2B, are escalated, across a longer time horizon and at a higher escalation rate.

In summary, the biggest factor affecting the final total project cost for the MFFF is the funding profile. A stable, robust funding profile facilitates accelerated project execution to completion. Funding instability at lower levels incites uncertainty, aggravates risks, and negatively impacts project cost and schedule.

At a stable funding profile of $350 million per year, the MFFF can be completed at a TPC of $17.17 billion, with a targeted completion date in 2048.

[1] Hotel load is a term used to identify the cost associated with *level-of-effort* activities and costs that will be incurred until a given piece of work is complete. These costs can include the costs for project management and administration and other direct costs associated with generic facilities, rentals, and other indirect costs that are not part of the direct production activities.

Contents

1. Background

The DOE PM, partnering with USACE, developed an updated estimate for the DOE NNSA MFFF project. This project is intended to contribute to the disposal of surplus weapon-grade plutonium, at SRS in South Carolina.

This estimate provides the DOE with a 2016 updated PB and was executed in accordance with the requirements of Section 3119 of the National Defense Authorization Act of 2016 and DOE Order 413.3B. The PM-USACE partnership resulted in the formation of the 2016 updated PB estimating team.

USACE issued an independent cost estimate (ICE) for the construction of the MFFF in 2013. The 2016 updated PB primarily builds upon USACE's previous ICE and the funding profile analysis that was submitted to the DOE in June 2013. The 2016 updated PB accounts for Actual Cost of Work Performed (ACWP) by the contractor (CB&I AREVA MOX Services, LLC) and reflects a revised estimate-at-completion (EAC), estimate-to-complete (ETC) or "to go" costs, and completion date for the construction of the MFFF. The 2016 updated PB estimating team was provided with key documents such as the contractor's performance data, 2015 EAC, 2016 EAC, and most recent schedule (February 25, 2016 data date).

Prior to the 2016 updated PB effort, several groups and industry experts had analyzed the life cycle costs of the MFFF and alternative strategies for plutonium disposition. This 2016 updated PB reflects only the construction of the MFFF. It is not a life cycle cost analysis, nor does it include alternative disposition strategies. It is purely an update to the PB based on actuals, productivity factors, and estimator judgment. It has appropriate escalation rates and applies cost and schedule contingency with an affordable funding profile of $350M per year.

2. Methodology for Developing 2016 Updated Performance Baseline

In 2012-2013, an ICE was developed to validate the MFFF contractor's revised cost estimate and schedule. The 2016 updated PB estimating team used that 2013 ICE, as well as contractor files and documents to develop the 2016 updated PB with a revised TPC and completion date for the MFFF project. Where appropriate, the 2016 updated PB estimating team used parametric cost estimating techniques, applying statistical relationships between historical costs and other program variables such as facility or process physical or performance characteristics, contractor output measures, and manpower loading.

2.1. Ground Rules and Assumptions

This 2016 updated PB estimate factored in the following ground rules and assumptions:

<u>Ground Rules</u>

- TPC includes costs for the Engineering Procurement Construction (EPC) contractor, the NNSA, the Nuclear Regulatory Commission (NRC), and Savannah River Nuclear Solutions for the capital construction cost of the MFFF with DMO.
- Cost and Schedule Risk Analysis (CSRA) and Contingency Analysis were performed at 95% confidence level.
- Previous cost and schedule estimating efforts initiated in 2012-2013 including the *Total Project Cost Independent Cost Estimate (Rev 0, April 2013)* and the *Independent Cost Estimate Funding Profile Analysis (Rev 0, June 2013)* are the basis for updating the PB.

<u>Assumptions</u>

- Funding profiles are based on annual budget of $350M per year until completion (included in this report) and a second scenario of $500M per year until completion (provided in Appendix A).
- Hotel load represents additions to the cost of the project if overall duration is extended. These costs are assumed to be consistent with the results reported in the previous ICE (May 2013).
- Productivity rates are derived from actual contractor's performance to date, industry standards, and estimator's experience. MOX-specific productivity factors were updated based on current project information.
- Risk events associated with active requests for equitable adjustments (REAs) were incorporated.
- "To-go" values for bulk materials and engineered equipment are based on the 2015 EAC amounts. "To-install" quantities were used to estimate the labor required for installation.
- Escalation is assumed at 4% per year.
- The contractor will receive an incentives-based fee of 5.0% for the remaining work.

Factors such as working at a DOE site, applying Nuclear Quality Assurance Class 1 (NQA-1) and seismic Performance Category 3 (PC-3) requirements to the facility, as well as other constraints and limitations associated with a government capital construction project, decrease productivity of the labor force; this decrease in productivity due to the quality and complexity of nuclear work is often underestimated. Adjustment factors for obsolescence have been developed based on interviews with MFFF project personnel, certified cost professional judgment and expertise, and familiarity with working conditions at multiple DOE sites.

Key documents and data used in developing the 2016 updated PB include:

- **2013 ICE**: *Independent Cost Estimate (April 2013)* and *Independent Cost Estimate Funding Profile Analysis (June 2013)*.
- **Contractor's Performance Data**: Contractor's January 2016 performance data file from its ARES® PRISM earned value management system.
- **Contractor's 2015 EAC**: *Contractor's 2015 Annual Estimate at Completion, 31 July 2015*.
- **Contractor's 2016 EAC**: *Contractor's 2016 Annual Estimate at Completion, 14 July 2016* and additional details provided on 21 July 2016.
- **Contractor's 2015 Schedule**: Contractor's Primavera P6 .xer file dated February 25, 2016.
- **Discussions with NNSA**: Information gathered from discussions between the 2016 updated PB estimating team and NNSA during the 2016 updated PB effort, including an SRS site visit.
- **Final Attributes Report**: Contractor's Area Project Management Highlights table (March 27, 2016, labeled as page 21).
- **Discussions with CB&I AREVA MOX Services, LLC representatives**: Information gathered from discussions at SRS, including meetings on July 27-28, 2016.

2.2. Construction Activities

The 2016 updated PB estimating team reviewed the contractor's 2016 EAC, the contractor's 2015 EAC, the contractor's performance data, and trends from the contractor's 2015 EAC (i.e., work packages or planning packages) in each division, including major commodities (civil, structural, mechanical, electrical, HVAC, and gloveboxes). Using this information, the costs from the 2013 ICE were escalated and then recalculated using adjustments for items such as unit rates, quantities, and rework.

2.3. Level of Effort Activities

Level of effort (LOE) costs were based on cost per month for a duration of time. To develop LOE costs for the 2016 updated PB, adjustments were made to the LOE management accounts from the 2013 ICE. Adjustments were based on comparing the contractor's actual per-month costs and the contractor's ETC per-month costs. The contractor's performance data was used as the basis for the contractor's ACWP, EAC, and ETC. Although different from the contractor's 2015 EAC and 2016 EAC, the contractor's performance data provided the detail necessary to calculate the contractor's ETC ("to go" costs) for a like-for-like comparison to the 2016 updated PB. The ETC was calculated by subtracting the ACWP from the EAC.

The following LOE management accounts were considered for the 2016 updated PB: Plant Design, Project Management, Engineered Equipment/Title III Support, NRC Costs, Procurement Engineering, Software Design, Construction Management, Process Unit Assembly, Temporary Facilities/Services, Quality Assurance/Quality Control (QA/QC), Cold Start Up, Operations Preparation, Environment Safety and Health (ES&H), and NNSA Costs.

For LOE management accounts, per-month spend was analyzed and updated based on the following durations:

2013 ICE ETC: 78 months (May 2012 to November 2018)
Contractor's ACWP: 101 months (August 2007 to January 2016)
Contractor's ETC: 70 months (January 2016 to November 2021)

The 2016 updated PB ETC uses a start date of January 2016. The adjusted cost-per-month for LOE management accounts was multiplied for construction and startup/commissioning activities based on the following end dates:

Construction: November 2021, with an unconstrained ETC duration of 70 months
Cold Commissioning: November 2023, with an unconstrained ETC duration of 94 months

The November 2023 end date for cold commissioning aligns with the unconstrained funding profile. Using that date, the 2016 updated PB estimating team assumed cold commissioning would take two years, arriving at the November 2021 date for the end of construction. Reference Section 2.5 for additional information on methodology used for the $350M annual funding profile selected for the 2016 updated PB.

2.4. Markups and Other Costs

Management reserve, contingency, escalation, fee, and technology transfer fee are included in the 2016 updated PB and were calculated as described below.

Management Reserve and Contingency: Risk analysis was performed in accordance with CSRA guidance developed by the USACE Walla Walla District Civil Works Cost Engineering and Agency Technical Review Mandatory Center of Expertise. The quantitative risk analysis process used Monte Carlo simulation to determine confidence levels and associated range of contingencies. Risks were not independently identified; rather, inputs came from the contractor's *Risk Assessment Reports for Open and Realized Risks*. Data used included risk type and owner, residual probability of occurrence, and residual cost and schedule impacts for best case, most likely, and worst case outcomes. Programmatic risks were considered to be bounding assumptions and were not included in the CSRA.

Cost estimate uncertainty ranges from the 2013 ICE were used to quantify the 2016 updated PB cost estimating uncertainty component of management reserve. However, the overall impact to management reserve was increased by 10% because the 2016 updated PB was an update and not a full ICE, which introduced additional estimating uncertainty.

Escalation: The escalation rate was assumed to be at 4% per fiscal year (FY). This is a consistent escalation estimate used for all of NNSA's new nuclear capital asset acquisitions and has proven to be reasonable in the aggregate. Both the management reserve and contingency funds were accordingly escalated. The escalation of 4% per year is also consistent with the 2013 ICE and ensures comparability to the updated PB and funding constraint analysis.

Fee: The contractor will receive an incentives-based fee of 5.0% of the value of work completed during each fiscal year. Accordingly, this fee was included in the 2016 updated PB. This fee is an assumed amount and is less than the current contract fee rate of 6.75% given the current cost-overrun situation.

Technology Transfer Fee: A technology transfer fee of $28M was included in the 2016 updated PB. This fee compensates the French AREVA company for use of their proprietary process in the MFFF. It is included in the 2016 updated PB to calculate the TPC.

2.5. Schedule

In order to establish a basis for the 2016 updated PB, a valid schedule is required to generate the unconstrained cost profile. A schedule developed using the Oracle® Primavera P6 Professional application was provided by the contractor as part of the 2015 EAC data package. This schedule version (2016 25 Feb

DD.xer) represents remaining work as of February 25, 2016 and the project structure is shown in Table 1. The contractor did not provide an updated schedule with the July 2016 EAC.

Table 1 - MOX 2015 EAC (2016 25 FEB DD)

MOX 2015 EAC (2016 25 FEB DD)				
Project ID	**Project Name**	**Total Activities**	**Start**	**Finish**
FE-5	FE-Electrical	2,574	11-Jan-10 A	11-May-22
FC-2	FC-Civil	6,026	30-May-06 A	21-Oct-31
FT-2	FT-Procurement Eng. Group	186	13-May-11 A	31-Dec-24
FD-5	FD-Manufacturing Design Group (MDG)	74	22-Jun-11 A	7-Apr-16
FN-5	FN-Nuclear	201	01-Jun-11 A	10-May-22
GB-5	GB-Assembly Group	9,194	25-Aug-08 A	28-Jun-24
PU-5	PU-Procurement	1,422	18-Oct-99 A	5-Aug-19
SU-5	SU-Start-Up	4,654	23-Feb-11 A	21-Oct-31
LX-2	LX-ISA/Safety & Sec/MC&A Licensing	68	02-Oct-12 A	10-May-22
LL-5	LL-Milestones	144	18-Oct-99 A	21-Oct-31
FM-5	FM-Mechanical	12,317	06-Apr-06 A	31-Dec-25
CS-5	CS-Construction	46,938	18-Oct-99 A	21-Oct-31
MSFY-2	MS-Fiscal Milestones (for Float Calcs.)	70	29-Sep-14 A	4-Oct-21
LD-5	LD-Lab Design Group (LDG)	20	01-Mar-10 A	10-May-22
CT-5	CT-Coatings	7,188	29-Oct-99 A	21-Oct-31
PSSC-5	NRC_PSSC Milestones	59	25-Feb-16	18-Jun-25
FS-5	FS-Software Design Group (SDG)	1,769	02-Jan-08 A	14-Dec-27
A= Actual Date				

When compared to the planning scenarios presented in the contractor's *MFFF 2015 Annual Estimate at Completion Part 1* dated 31 July 2015, this schedule version closely aligns with the "Low Funding" scenario (Cold Commissioning Completion FY29). As the Low Funding scenario is considered a highly constrained case, it is not suitable as a planning basis for an unconstrained cost profile. Therefore, the updated PB schedule was based on the previous ICE schedule with updated activities to reflect changes in the project start up and commissioning.

Additionally, the updated 2016 PB team performed schedule quality checks against the Government Accountability Office (GAO) scheduling best practices in the *GAO Schedule Assessment Guide (GAO-16-89G, December 2015)* and the Defense Contract Management Agency's (DCMA) 14 Point Assessment. The result of those analyses raises concerns about the reliability of the provided schedule in its use for projecting project completion (see Volume II. Technical Backup, Section 3 for details).

2.6. Funding Profiles

The 2016 updated PB estimating team developed three funding profile scenarios: (1) an unconstrained scenario, (2) a constrained scenario with a $350M annual funding constraint, and (3) a constrained scenario with a $500M annual funding constraint. The unconstrained and $500M annual funding profile scenarios are included in Appendix A.

The $350M per year funding profile is the primary constrained funding profile used as the basis of this report. This funding profile was utilized since it reflects the most recent annual funding in support of the MFFF capital acquisition effort. All funding profile scenarios were based on the 2013 ICE scenarios that were derived from cost loading the ICE schedule and performing iterations of cost spreading to derive the resulting profiles.

For the 2016 updated PB scenarios, the percent distribution of ETC ("to go") cost was extracted from the 2013 ICE scenarios and loaded into a funding profile generator spreadsheet. The percent distributions served as the starting point for the scenarios. As the 2016 updated PB cost estimate was completed, the ETC costs were loaded into the funding profile generator spreadsheet to perform iterations to spread cost.

In the unconstrained profile, no changes were made to the percent distribution. In the $350M and $500M annual funding constraint profiles, adjustments were made to bring the FY cost within 10% of the funding constraint for each year. Adjustments included adding time to a section of cost or moving work from one year to the next.

2.7. Obsolescence

Obsolescence is a consideration for high-technology projects characterized by extremely long periods of construction and commissioning. In this instance, at a funding profile of $350M per year, it extends over four decades. Multiple first-of-a-kind DOE projects, including the Waste Treatment and Immobilization Plant, Uranium Processing Facility, and Dual-Axis Radiographic Hydrodynamic Test Facility, have endured significant redesign, rework, and reiterations during their project execution process as well. Obsolescence costs must be expected and planned.

Although a formal best practice process for estimating obsolescence does not exist, there is a strong likelihood that the MFFF project will incur costs due to obsolescence. Therefore, the 2016 updated PB includes estimated effects of obsolescence due to changes in technology, software, electronics, and process control systems that can be reasonably expected during the MFFF construction period.

Obsolescence affects the major activities (design/engineering, construction, start-up & commissioning, project management) of a project differently. Based on past experience with multiple DOE projects where rework and reiterations are common, the projected effects of obsolescence are included below:

Area/Activity	Obsolescence Estimate
Design/Engineering	5%
Construction	15%
Start-up/Commissioning	10%
Project Management	10%

3. Overview of 2016 Updated Performance Baseline

Consistent with direction from NNSA and appropriations levels supported by Congress the past two years, the 2016 updated PB is based on a $350M annual funding level that is considered to be both realistic and affordable.

3.1. Updated Cost Estimate

As reflected in **Table 3.A**, the 2016 updated PB Total Project Cost is $17.17B. It includes $4.63B in actual costs of work performed to date, $5.66B for base ETC costs (listed below as point estimate and additional hotel load), and $6.98B allocated to escalation, management reserve, contingency, contractor fee, and a technology transfer fee. The $4.91B point estimate amount includes $238M for DMO. DMO is not currently part of the contract or project, but will be required in order to accomplish the MOX fuel approach mission.

Table 3.A: 2016 Updated PB Estimate of TPC ($000)

	2016 Updated PB
Completion Date	*2048*
Point Estimate (BY) [1]	4,912,168
Additional Hotel Load (BY) [1]	744,437
Escalation	4,141,321
Subtotal (TY) [1]	**9,797,926**
Management Reserve (95% CL) [2] (BY) [1]	1,017,238
Escalation	705,882
Subtotal (TY) [1]	**1,723,120**
NNSA Contingency (95% CL) [2] (BY) [1]	427,749
Escalation	296,824
Subtotal (TY) [1]	**724,573**
Total "To Go" Costs (TY)[1]	12,245,619
ACWP	4,628,452
Fee	267,187
Technology Transfer Fee	28,000
2016 Updated PB TPC (TY) [1]	**17,169,258**

[1] BY designates Base Year FY2016 dollars; TY designates Then Year dollars (FY2016 dollars escalated to the Year of Execution).
[2] CL designates Point Estimate Uncertainty (95% Confidence Level).

The net change from the 2013 ICE base costs to the 2016 updated PB base costs is a result of high-level adjustments for five main categories of costs, as shown in **Table 3.B**.

Table 3.B: Summary of Changes in the ETC ($000)

Category	Cost	Explanation
2013 ICE ETC Base Costs	**$3,703,747**	
Construction % Complete Change	(295,726)	Reduction from the ETC for work completed between 2012 and 2016
Construction Adjustments	$463,469	Increase from updating unit rates and quantities (see Section 4.1)
LOE Adjustments	$279,907	Recalculated based on new duration and updated per-month spend (see Section 4.2)
Escalation	$261,693	Based on increase from 2013 ICE ETC base cost to 2016 updated PB ETC base cost
Obsolescence	$499,077	Obsolescence was not included in 2013 ICE and was added to 2016 updated PB
Subtotal of Changes	**$1,208,420**	
2016 Updated PB ETC	**$4,912,168**	

3.2. Funding Profiles

The 2016 updated PB is based on a $350M annual funding profile. This funding profile results in a 9-year extension of the schedule. The 2013 ICE estimated project completion in 2039. The new estimated completion date is 2048. This new completion date is substantially driven by the $350M annual funding constraint. While affordable and realistic, this funding level results in a cost escalation of $5.14B and an additional hotel load of $744M over the span of the project.

Appendix A provides the results of the analysis of two funding profile scenarios: (1) funding profile of $500M per year; and (2) an unconstrained annual funding profile.

4. Comparison of 2016 Updated Performance Baseline to Contractor's 2016 EAC

DOE PM performed a collaborative on-site visit to discuss the 2016 EAC and schedule. The contractor's 2016 EAC is $9.99B and the PB update is $17.17B (which is $7.1B or 72% higher than the contractor's). The contractor's EAC includes actual costs of $4.86B and the base ETC is $3.45B. With escalation, MR/contingency and fees, the ETC is $5.13B. The 2016 updated PB EAC includes actual costs of $4.63B and the base ETC is $5.66B (which is 64% higher than the contractor's base ETC of $3.45B). With escalation, MR/contingency and fees, the ETC for the updated PB is $12.54B (which is $7.41B or 144% more than the contractor's). The $227M difference in the Actual Costs of Work Performed (ACWP) costs are the ACWP reference points in time.

The primary difference between the two TPC estimates is attributable to the impact of escalation. Escalation is approximately $4.8B higher in the 2016 updated PB due to three factors: a longer project duration of 19 years (reference Section 4.1); different assumptions about escalation (the updated PB assumed an annual escalation rate of 4% instead of the less than 2% assumed by the contractor); and the contractor not incorporating escalation costs on the MR and contingency costs. It is important to note that MOX Services utilized a general escalation rate, while the project is 80% labor going forward; the Global Insight report they cited shows that inflation for professional and construction labor is expected to exceed 3% over the next several years.

These differences are also attributable to the result of systemic underlying issues and methods used by the contractor to estimate the cost of construction activities (reference Section 4.2) and LOE activities (reference Section 4.3).

4.1. Schedule

The contractor did not provide an updated schedule to support the 2016 EAC. The most recent schedule provided by the contractor was an Oracle® Primavera P6 schedule representing the remaining work as of February 25, 2016. That schedule projected a completion/start-up date of October 2031. The 2016 EAC document indicated that the project completion date was 2029.

The contractor's February 25, 2016 schedule was reviewed to determine whether it was appropriate for use in developing the 2016 updated performance baseline. The schedule was analyzed using two sets of standard schedule quality metrics. First, the schedule data was compared to the Government Accountability Office (GAO) scheduling best practices in the GAO Schedule Assessment Guide (GAO-16-89G, December 2015). Second, the schedule was analyzed with Deltek® Acumen Fuse software program to evaluate compliance with the Defense Contract Management Agency (DCMA) 14 Point Assessment.

Observations and analysis of the 2016 updated PB estimating team do not provide confidence in the contractor's February 25, 2016 schedule realism or credibility. The schedule scored poorly when evaluated against several criteria common to the GAO and DCMA guidelines. A primary concern is that the contractor's schedule is not resource loaded (only 64% of all activities) with their cost estimate nor correlated to the work breakdown structure or management accounts (MAs) which would facilitate a more accurate constrained funding impact to the schedule. A second major concern is the lack of complete schedule logic (6% of all activities without a valid predecessor or successor). The impact of missing logic is the inability to confidently forecast project completion.

The 2016 updated PB $350M annual scenario (including markups and other costs, and with a specified $350M annual funding constraint) has a construction end date in 2040 and a cold startup end date in 2048.

The methodology used by the contractor was independent of a resource loaded schedule but used the QURR performance report quantities and installation rates by commodity to establish a completion date. Use of this method does not take into consideration the time phasing of construction activities and potential delays. Constructability reviews are just now being accomplished which could be used to build a realistic schedule. Overall, the contractor has developed an overly optimistic construction schedule that is inaccurate in determining overall cost impact based on any constraints. These deficiencies in the contractor's schedule result in a significant variance in completion date – 19 years – which consequently drives the primary cost variances between the 2016 updated PB and the contractor's 2016 EAC.

4.2. Construction Activities

Approximately $1.23B, of the total variance between the 2016 updated PB ETC base costs and the contractor's ETC base costs, is in Permanent Facility & Infrastructure (construction activities). The 2016 updated PB estimating team made significant adjustments to costs for construction activities from the contractor's EAC after analyzing the methodology used to develop the contractor's unit rates, the lack of validation to support claims of state of completeness, and the differences in the basis of how percent complete is calculated and reported. Examples cited below represent systemic underlying issues and methods throughout the construction activities that result in the significant cost variance.

Unit Rate in the Major Commodities: Unit rate is the number of hours required per unit of measure. In mechanical piping, a unit rate of 2.1 is 2.1 hours to install one foot of pipe.

The contractor engaged subject matter experts to establish the unit rates for the proposed 2012 Baseline Change Proposal (BCP). The contractor then used actuals - which capture the productivity and rework associated with the MFFF project, and that were higher than the 2012 BCP rates - to produce unit rates through FY17. However, the contractor then reverted to the original lower and more favorable 2012 BCP unit rates for FY18 and beyond in the development of the contractor's EAC. Significant variance exists because the 2016 updated PB estimating team used the actual unit rates for the duration of the project in the development of the 2016 updated PB TPC.

Using piping as an example to demonstrate the impact, the unit rate based on actuals is more than 400% greater than the baseline unit rate. With over 90% of the installation of pipe and 80% of the installation of stands yet to be completed, use of the actuals for the 2016 updated PB reflects an estimate to complete increase of more than $137M over the contractor's estimate to complete using the original baseline unit rates. This piping example is representative of numerous substantial adjustments to the contractor's ETC due to unit rates in the 2016 updated PB.

Impact of Unit Rate Change for Year 2018 and Forward – Piping

Delta from FY18+ ETC unit rate to FY15-FY17 ETC unit rate: (9.72 – 2.37 = **7.35**)	X	Stated Labor Rate (**$54.78**) (Page 153 of 775)	X	Quantity of pipe to be completed FY18+ (2016 updated PB assumes 75% of 455,823 total from QURR, or **341,867**)	=	**$137.6M** increase in ETC

Actual Work Completed found in the State of Completeness Validation: In 2015, the contractor performed a state-of-completeness validation, referred to as a Kick and Count (K&C), which is a quantity survey method that validates actual progress by physically verifying permanent installation of an item in its intended location within the facility. The K&C revealed that many quantities had been overstated in the contractor's QURR performance reports.

As an example, in June 2015, QURR earned quantity for pipe was 23,631 feet, whereas the K&C earned quantity was 12,398 feet, a difference of almost 100%. This difference translates into a $26.9M increase in the estimate to complete for pipe. As with unit rate, this pipe example is representative of numerous similar adjustments based on the K&C earned quantities. In September 2015, the contractor revised the quantities earned in performance reports to reflect the K&C validation. While the contractor updated the QURR performance reports based on the K&C quantities, their 2016 EAC did not provide the level of detail necessary to validate that the estimate was based on the revised and lesser quantities of commodities actually installed. Moreover, despite having increased quantities of work to accomplish using the K&C validation, the contractor's 2016 EAC decreased by nearly 10% from the 2015 EAC for Permanent Facility & Infrastructure.

Without a comprehensive basis of estimate for the contractor's 2016 EAC, there is inconclusive information to determine if the contractor's 2016 EAC in fact incorporates the K&C quantities. Importantly, if the contractor also did not include the K&C findings in its revised unit rate calculation, this would result in approximately double the already understated unit rate. For the piping example, if actual completed piping remains approximately 50% below that being reported in the QURR, then the actual unit rate or number of hours to install a linear foot of pipe jumps to 19.44 hours instead of 9.72 hours.

Percent Complete: Rather than basing their percent completion relative to budget, the contractor establishes percent complete based on actual costs which overstates performance. The contractor's estimate of construction percent complete does not reflect the difference between commodities that have been installed and commodities that have been inspected and accepted. In addition, without being able to verify that the contractor's 2016 EAC incorporates revised K&C quantities due to the limited detail provided, there is low confidence that the percentage of work completed in the contractor's 2016 EAC is accurate, which was the case for the 2015 EAC. According to the contractor's cost data as of January 2016, construction activities were 61% complete; however, the trends within the contractor's 2015 EAC suggest this percentage was overstated. For example, with regard to Trend 15-EA08 – Mechanical Pipe, the contractor's 2015 EAC identified that 11% of the pipe had been installed, while the K&C stated that less than 5% of the pipe had been installed. The trend data also stated the estimate assumes that 2/3 of the pipe has already been fabricated and 50% of the pipe fabricated is unusable due to corrosion or design changes. The contractor faces significant rework due to the procurement of pipe prior to the completion of Title II Design. This pattern of early procurements is systemic throughout the construction activities' major commodities and the 2016 updated PB reflects corresponding adjustments.

In addition, the contractor includes final attributes in the project management highlights section of its monthly status report. The term "final attributes" refers to commodities that have passed QA/QC and are not subject to rework. In contrast, the cumulative actual quantities in the contractor's separate QURR include work-in-progress or follow "rules of credit." Therefore, the percent complete based on the final attributes data is very different than the percent complete based on the QURR data. Examples are included in **Table 4.A** on the next page.

Table 4.A: Comparison Between Cumulative Actuals and Final Attributes

		February 21, 2016 QURR		March 27, 2016 Monthly Status Report	
Commodity	**Total at Completion (lf)**	**Cumulative Actuals (lf)**	**Cumulative Actuals % Complete**	**Final Attributes (lf)**	**Final Attributes % Complete**
Active Gallery Pipe & Balance of Pipe	455,813	51,714	11%	2,348	1%
Pen Plates	342	190	56%	0	0%
Duct	1,320,508	373,464	28%	40,010	3%
Fire Dampers	1,185	452	38%	206	17%
Glove Box - Phase 1	429	81	19%	81	19%
Cable Tray & Wireway	86,346	8,330	10%	4,040	5%
Conduit	745,787	26,421	4%	0	0%
Electrical Equipment	3,967	121	3%	0	0%
Fire Protection Pipe	25,378	N/A	N/A	0	0%

4.3. LOE Activities

The ETC for LOE activities in the 2016 updated PB are $738M higher than the contractor's ETC for LOE activities, primarily due to a longer duration and higher spend per month used in the 2016 updated PB.

The contractor's LOE actual costs that have averaged $29.3M per month since baselining were reduced to approximately $15.0M per month for the contractor's ETC taking into consideration anticipated inefficiency reductions. Granted, this average for LOE reflects years when funding was much higher after baselining; however, the drastic reduction in LOE may indicate that some costs are underestimated as they do not consider actuals. Examples are shown in **Table 4.B**. LOE costs in the contractor's 2015 EAC were $23.2M per month using a "low" funding scenario that was not specified. For comparison purposes, the 2016 updated PB ETC averages $26.2M per month for LOE base costs for the unconstrained funding profile scenario (this LOE average is reduced in the constrained funding profile scenarios).

Table 4.B: Examples of Contractor's Monthly Actuals and Contractor's ETC Monthly Average ($)

Management Account	Contractor's 2007-2016 Actual Monthly Average	Contractor's ETC Monthly Average
Project Management	5.23M	3.62M
Regulatory Affairs	1.05M	771K
Title III Engineering	5.57M	2.14M
Temporary Facilities/Services	1.7M	1.16M
Quality Assurance/Quality Control	1.17M	803K

The contractor's performance data shows, for some cost items totally approximately $76M, the actual cost of work performed is greater than the cost at completion, which indicates there is no remaining budget for those cost items. The contractor did not adjust the schedule or EAC to reflect the overrun, and without any management reserve to apply to the overrun, the work will be delayed and increase project duration.

4.4. Markups and Other Costs

Table 4.C below shows the comparison of the Contractor TPC and the 2016 updated PB. Escalation of the Base ETC, due to the schedule duration, is a driving factor between the $17.17B TPC of the 2016 updated PB

and the $9.99B Contractor TPC. Also, the 2016 updated PB includes escalation of MR and contingency, whereas the contractor does not.

The remaining ETC variance includes $238M for DMO, which is not included in the contractor's current scope, but will be required in order to accomplish the MFFF mission.

Table 4.C: Comparison of 2016 Updated PB TPC to Contractor TPC ($000)

	Contractor Data	2016 Updated PB
ACWP January 2016	4,855,812	4,628,452
Base ETC	**3,447,991**	**5,656,605**
Escalation	373,595	4,141,321
Management Reserve	772,904	1,017,238
Management Reserve Escalation	Not included	705,882
NNSA Contingency	275,307	427,749
NNSA Contingency Escalation	Not included	296,824
To Go Fee	244,446	267,187
Technology Transfer Fee	20,070	28,000
Total Project Cost	**9,990,125**	**17,169,258**

4.5. Funding Profiles

The difference between the funding profiles is caused by the fact that the 2016 updated PB funding profiles include markups and other costs distributed yearly, while the contractor's 2016 EAC funding profiles include MR and contingency predominately in out years and do not include escalation for MR and contingency (reference Section 4.4). The exclusion of markups and other yearly costs causes the contractor's end dates for both construction and cold startup to be substantially understated in the funding profiles. Since the 2016 updated PB funding profiles include markups and other costs on a yearly basis, the schedule duration gets lengthened.

4.6. Obsolescence

As shown in **Table 4.D**, the 2016 updated PB base costs (before escalation) reflect obsolescence costs of $499M. The contractor's EAC does not contain costs for obsolescence.

Table 4.D: 2016 Updated PB Obsolescence Costs ($000)

Area/Activity	Obsolescence Percentage	Obsolescence Costs
Design/Engineering	5%	$23,532
Construction	15%	$351,946
Startup/Commissioning	10%	$36,015
Project Management	10%	$87,585
	TOTAL	**$499,078**

5. Comparison to Other Reports

In preparation for the 2016 updated PB effort, the estimating team reviewed reports initiated by the DOE, including the April 2015 study by the Aerospace Corporation (Aerospace) and the August 2015 report developed by the Plutonium Disposition Red Team (Red Team) at the Oak Ridge National Laboratory. These reports assisted the 2016 updated PB estimating team in understanding how costs were independently updated/estimated since the 2013 ICE, for only the construction effort for the MFFF, to include better understanding project duration and other general concerns.

The 2016 updated PB estimating team reviewed these reports with only the construction and cold commissioning effort in mind, excluding operations and the alternative disposal methods reflected in the other reports. Throughout the 2016 updated PB effort, the estimating team identified several consistent results and findings provided by the previous efforts from the Plutonium Working Group, Aerospace, and the Red Team.

Based on the $350M annual funding constraint, the 2016 updated PB end date of 2048 is in line with the Red Team report. The 2016 updated PB estimating team's schedule update is also in line with the Red Team's analysis, which indicates the Aerospace Corporation report overestimated the end date. Likewise, both teams took exception with Aerospace Corporation's cost estimating practices and its method, or lack thereof, to project a realistic cost contingency.

The 2016 updated PB estimating team again agrees with the Red Team that "a true ETC cannot be developed and authenticated until it can be based on a sound schedule that in turn is based on firm funding level commitments at a realistic, affordable, and sustained level through project completion." The end date must factor in reliable performance based on actuals to date and mature risk analysis. MOX Services has not kept their schedule current in accordance with their approved Earned Value Management System or their Project Management Control System Description.

Similar to Aerospace's approach, the 2016 updated PB estimating team developed its updated costs by utilizing previously developed independent, analogous, and actual costs. Due to the maturity of the project and the actuals which accounted to constructing the MFFF to date, project costs have been updated to reflect a more accurate EAC.

In an effort to develop an improved cost estimate, the Red Team evaluated previous costs estimates provided by USACE, the Plutonium Working Group, Aerospace, and the contractor. In each of these previous efforts, actual costs were not considered or credited.

For the 2016 updated PB, many of the costs are based on contractor actuals. In line with the Aerospace report, the 2016 updated PB estimating team also performed a risk analysis to determine contingency. The 2016 updated PB estimating team also factored the contractor's risk to determine costs for management reserve and an NNSA contingency.

Since 2012, numerous reports have been developed that independently reviewed costs associated with the MFFF project. These costs include efforts associated with construction and operations to include alternatives strategic to the MOX fuel approach. For the 2016 updated PB, the 2016 updated PB estimating team has focused solely on the construction and commissioning effort only.

6. Conclusion

Based on this 2016 updated PB analysis, the TPC for the MFFF project is estimated at $17.17B with a projected completion date of 2048. This is based on an annual funding profile of $350M, which reflects recent appropriations levels for the project. This level of funding results in an inefficient utilization of resources in accomplishing the current MFFF project scope. At this level of funding, the extended construction period generates significant hotel load, escalation, management reserve, contingency, and obsolescence costs. The MOX Services EAC is not credible because it was developed using unrealistic production and productivity rates, artificially low escalation, inappropriate allocation of management reserves and contingency that is not time phased across the project duration, and lack of escalation applied to these reserves. This results in a 2016 updated PB ETC that is 144% higher than the contractor's ETC.

2016 Updated PB Estimating Team Biographies

Jeremy S. Stevenson

Mr. Stevenson is currently the Chief, of Cost & Technical Support Branch for the U.S. Army Corps of Engineers (USACE), Huntington District which consists of thirty personnel in Cost Engineering, Geospatial, & Quality Management Sections. He served as the Cost Engineering Section Chief and Cost Engineer Subject Matter Expert in his prior positions. He has over 20 years of experience in developing cost estimates, schedules, and risk analyses for a wide variety of civil works, environmental cleanup, and unique construction projects. His project experience includes large navigational locks & dams; flood protection systems (dams, levees, floodwalls, pump stations); and unique energy, defense, or waste cleanup projects. He has provided interagency cost engineering support to a variety of USACE internal and interagency external customer including DAF, DOE-NNSA, DOE-EM, DOE-NE, FEMA, DHS, NFS, & NPS. He served as the Project Manager of the Interagency Performance Evaluation Task (IPET) Force, a 300+ multi-disciplined engineer & scientist forensics team which analyzed the New Orleans Hurricane Protection System performance during Hurricane Katrina, making recommendations for increased resiliency and improved performance of Hurricane Protection Systems. Mr. Stevenson served in the U.S. Naval Reserve both as a Radioman Third Class Petty Officer assigned to the USS Recovery and a Lieutenant (CEC) with the Seabees as an NMCB-24 Detachment OIC. Mr. Stevenson is a registered professional engineer in the state of Ohio. He also is a Tri-Services Automated Cost Engineering System (TRACES) Certified Cost Engineer (CCE) and serves on the TRACES Cost Engineering Steering Committee. Mr. Stevenson holds a Bachelor of Science degree in civil engineering from the West Virginia Institute of Technology and a Master of Engineering (Environmental Emphasis) from the Marshall University College of Graduate Studies.

Simon Fet

Mr. Fet is the Chief of the Cost Engineering Section, Huntington District Corps U.S. Army Corps of Engineers. Mr. Fet acts as the District's primary POC for cost estimates along with the Chief, Cost & Technical Support Branch. Mr. Fet Leads District Cost Engineering teams to develop cost estimates for the civil works mission including: navigational locks and dams; flood-control dams; local protection projects; recreational facilities; channel improvement projects; nonstructural flood-proofing; utility and infrastructure relocations; potable and sanitary water treatment facilities; environmental remediation, and other water resource civil works projects. Mr. Fet also supports the USACE International and Interagency (IIS) mission by managing cost engineering support to various offices of the Department of Energy as well as other government agencies. IIS Cost Engineering Support includes development of Independent Cost Estimates (ICE), External Independent Reviews (EIR), Project Peer Reviews (PPR), project controls activities and various project management support throughout DOE. Mr. Fet is a registered professional engineer in the state of West Virginia, a certified Project Management Professional, and Tri-Services Certified Cost Engineer (CCE). Mr. Fet holds a Master of Engineering degree from Marshall University and a Bachelor of Science in Civil Engineering from West Virginia University Institute of Technology.

Robin Y. Noyes

Ms. Noyes has over 25 years of project management and contracting experience in the federal government and private sector. She is currently serving as a project engineer within the DOE PM providing analysis and assessments of capital asset projects greater than $100M. She served in the U.S. Navy for 20 years as a member of the Navy's Civil Engineer Corps and Seabee Community. In that capacity, she held different assignments in multiple locations, predominately involved in real property and project management, executing construction programs and projects worldwide. In her last tour of duty for the Navy, Ms. Noyes served at the White House Military Office as the Project Director directly responsible for planning, acquisition, design, and construction of specialized facilities in support of the Presidency. She executed a diverse portfolio of sophisticated infrastructure projects which improved uninterrupted functioning of the Presidency post 9/11. As a diving officer in the Navy, Ms. Noyes also oversaw hyperbaric acquisitions and executed waterfront and specialized ocean construction and maintenance projects throughout the world including underwater hydrophone array systems, offshore towers, and waterfront barriers to protect naval assets. While in the Navy, she was selected as a member of the acquisition professional community and earned Level III certification. After retiring from the military, Ms. Noyes went to work for a real estate investment trust as a Director of Capital Expenditures and Technical Services for Host Hotels and Resorts.

Ms. Noyes is a registered professional engineer in the Commonwealth of Virginia, a Certified Cost Professional, and a Leadership in Energy and Environmental Design Accredited Professional. Ms. Noyes holds a Master of Engineering degree from the University of California Berkeley and a Bachelor of Science degree in Ocean Engineering from the United States Naval Academy.

Victoria S. Premaza

Ms. Premaza has 15 years of domestic and international engineering and project and program management experience. She is currently an engineer for the DOE PM. Ms. Premaza began her career in a Fortune 500 semiconductor company within the central Industrial Engineering group for high-volume cleanroom manufacturing and engineering, working on facility lay-outs and production process flows, facility projects (domestic and international) and respective simulations, and manufacturing ergonomics. She then worked with the United Nations International Atomic Energy Agency in Vienna, Austria within the area of nondestructive analysis and novel technology maturation and most recently in federal service of the DOE. While in the DOE, Ms. Premaza has held various roles including the program manager within the Enhanced Surveillance Program ($100M+) of the Engineering Campaign in the NNSA, Defense Programs, and served as liaison between DOD OSD-CAPE and NNSA during an Interagency Study. She currently works in the area of project assessments for DOE capital asset projects over $100M.

Ms. Premaza has a Bachelor of Science degree in Industrial Engineering, a Master of Science degree in Nuclear Engineering, and is a licensed professional engineer in Maryland.

She holds the following AACE International credentials: Certified Cost Professional, Earned Value Professional, and Project Schedule Professional. She is also credentialed as a Project Management Professional from the Project Management Institute.

Chris Watson

Mr. Watson has more than 30 years of experience in project management, principal oversight, multi-disciplinary cost engineering/cost estimating, value engineering, environmental consulting, and geotechnical fieldwork. He has a broad range of project and program experience for large federal environmental restoration and decontamination and decommissioning (D&D) projects involving radioactive hazardous and chemical waste and multi-billion dollar weapons system acquisition programs. His responsibilities include providing cost estimating, cost engineering, scheduling, project review, validation support, and value engineering services.

Mr. Watson has supervised external independent reviews for DOE Capital Asset Projects. Efforts included cost estimating, cost estimate reviews, cost engineering, performance baseline reviews, and construction and execution readiness reviews. The external independent reviews were used to support validation of the program plan and performance baseline to provide reasonable assurance that the projects can be successfully executed. Mr. Watson was responsible for cost estimating, cost engineering, and validation and quality control. Additionally, Mr. Watson has conducted well drilling, geotechnical investigations, sample collection, analysis, and validation as project manager for major projects such as the Oak Ridge Associated University, the Center of Energy and Environmental Research, the Puerto Rico superfund site, the Atomic City Auto Parts superfund site, the David Witherspoon, Inc. Superfund site, and the Lower Watts Bar Clinch River and East Fork Polar Creek sites.

Mr. Watson is a Certified Cost Professional and holds a B.S.E. in Nuclear Engineering from Arizona State University.

Dennis Horne

Mr. Horne has over 25 years of project management, cost engineering, and design experience, primarily in the mechanical field. He has particular expertise with building automation systems and laboratory installation. His responsibilities have included manpower and subcontractor coordination, material procurement, cost estimating and control, schedule and budget control, and profit and revenue projections.

Some of Mr. Horne's specific project experience includes providing consultation to the NDA on over 25 major projects in the long-term performance plan. He researched cost data for modeling of nuclear facilities. As a cost consultant to Sellafield Limited, Mr. Horne provided analysis through an independent project review of an estimate produced by a subcontractor for nuclear waste retrieval machines. The review examined how the estimate was developed and provided feedback on issues and areas of concerns where cost reductions could be achieved. Mr. Horne provided on-site mechanical cost estimating for the replacement of a petrochemical reactor unit used to manufacture gasoline at the Co-Operatives Refinery Complex in Saskatchewan, Canada, which had been damaged in a fire. His responsibilities included equipment (fractionator, coker, heaters), instrumentation and controls, pumps, heat exchangers, pressure vessels, and storage tanks. He also conducted a market survey for local labor and rates.

He is a Certified Cost Professional. He has a Bachelor of Science in Engineering Management from the University of Tennessee at Chattanooga and a Master of Science, in Accounting from the University of Phoenix.

Brandon C. Bier

Mr. Bier has 15 years of experience in the construction industry, including construction estimating, design, and project management. His experience includes managing subcontractors, scheduling work, budgeting, preparing fixed price contracts, and performing preconstruction coordination. Mr. Bier has been involved in several projects in the nuclear sector for the US DOE, including quality reviews of the independent cost review for the total project cost range for the construction of three facilities, the Mechanical and Electrical Building, the Salvage and Accountability Building, and the Main Processing Building, at UPF. He participated in a 4-tiered review approach, reviewed quantities and contingencies, and summarized review findings. Mr. Bier was also responsible for the WBS and WBS dictionary for the UPF site preparation performance baseline project, which involved assisting USACE in issuing an RFP for work to be performed at UPF. He created a WBS of the scope, defined each element of the work to be performed, and created pay items to standardize the way in which contractors report costs in the bidding process. He also identified conflicts in scope and sequencing between USACE and the site contractor, identified cost savings and LEED points through material reuse, and provided insight to USACE for building a better request for proposal and minimizing risk/cost overruns and change orders.

He has provided cost consulting through project benchmarking, independent reviews, and estimates, for projects ranging from nuclear waste storage facilities to waste retrieval machines to vitrification plants.

Additionally, Mr. Bier was instrumental in the execution of an ICE for the National Bio Agro-Defense Facility as an assistant project manager and estimator.

Mr. Bier is a certified Project Management Professional and a Certified Cost Professional, and holds a Bachelor of Science in Industrial Design and MBA from the Georgia Institute of Technology.

Nicholas C. Adair

Mr. Adair has 14 years of experience in architectural and structural cost engineering. His work has included several DOE projects, including serving as a cost consultant on the team that led the ICE sufficiency review, developed the ICE methodology report, and subsequently developed the ICE for the UCR (formerly UPF) project at the Y-12 National Security Complex in preparation for CD-3A, site preparation and long lead procurement. Mr. Adair also helped develop an ICE for the Salt Waste Processing Facility. His responsibilities included creating and maintaining the estimate and WBS, creating estimating reports and estimate documentation, and assisting the estimating lead development of the final report.

Mr. Adair provided expertise in new construction estimating and database development for an NDA Magnox benchmarking project. In addition to collecting site data from 10 separate nuclear power plants located throughout the United Kingdom, performing the estimates, and developing a first-of-a-kind cost model, the team also reviewed the contractor's baseline, compared the team's estimated cost against the current contractor's cost, and provided a summary on the cost variances.

Mr. Adair is highly skilled in the use of cost estimating software, including MII, On-Screen Takeoff, and Success Estimator, as well as database software, including MS Access and Excel. As an expert in MII, Mr. Adair often assists with leading MII training courses.

Mr. Adair is a Certified Cost Professional and has a Bachelor of Science in Construction from Southern Polytechnic State University.

Gordon Ballentine

Mr. Ballentine is a senior risk management specialist with more than 25 years of experience working with government organizations and private enterprises to identify, analyze, and proactively manage risk. He provides customers with the collaborative tools they need to make more effective, data-driven decisions across the enterprise and at the project level for a wide variety of nuclear facilities, civil works infrastructure, water resources, transportation, and environmental projects. His risk management work has covered a broad spectrum of project types and sizes, with estimated costs ranging from under $100 million to over $10 billion. He is a highly experienced expert user of Oracle® Crystal Ball and Primavera Risk Analysis software.

He has successfully completed CSRAs for multiple agencies, including USACE, DOE, the Environmental Protection Agency (EPA), the U.S. Agency for International Development, Tennessee Valley Authority and state/local governments for civil works, energy, water resources, transportation, communication, medical, nuclear, and environmental projects. His DOE experience has included preparation of the ICE for procurement and construction of the Direct Feed Low Activity Waste program for the Waste Treatment and Immobilization Plant project at DOE's Hanford Site, and for completion of DOE's Salt Waste Processing Facility at SRS. In addition, he supported the Integrated Baseline Review for the Salt Waste Processing Facility. As a subcontractor under a Tennessee Valley Authority contract, Mr. Ballentine supported project and enterprise risk management during construction of the Watts Bar Nuclear Plant Unit 2 in Rhea County, Tennessee. Outside of the U.S., he supported preparation of the CSRA and project delivery model analysis for the New Waste-to-Energy Capacity project in Vancouver, British Columbia, Canada.

Mr. Ballentine recently presented *Quantitative Approaches for Establishing Cost and Schedule Contingencies using Project Risk Analysis* at an AACE International meeting. He is a Chartered Financial Analyst and has a Bachelor of Science in Geophysics from the University of the Pacific.

James A. Prock

With more than 45 years of project management, scheduling, project controls, and cost engineering experience, Mr. Prock is an expert at developing detailed construction and integrated master schedules for a multitude of capital construction and environmental projects for both government and private sector clients. He has extensive experience coordinating project controls functions, subcontractor activities, and schedules on projects where completion dates are of vital contractual concern. As the first licensed Primavera P3 user, Mr. Prock has provided input and beta testing for the manufacturer throughout Primavera' s continued development.

Mr. Prock provided scheduling support for the review, analysis, and evaluation of all SRS site contractors' monthly schedule status. He monitored and provided assessments of the contractors' weekly plan for progress on the Capital Asset Projects, including Tank 48, Saltstone Disposal Vault 2, Saltstone Disposal Vaults 3 and 5, Glass Waste Storage Building #3, maintenance and operations projects, and operating activities. In addition, Mr. Prock served as the lead scheduler for the startup and commissioning of the MFFF project at SRS. The team developed an ICE and a Primavera P6 resource-loaded schedule for the completion of this project. Mr. Prock also provided Primavera scheduling for an upgrade of the Universal Cells Facility at Atomic Energy of Canada Limited's Chalk River Laboratories site as a part of the Shielded Facilities Refurbishment Project. The project included the design for an upgraded B234 ventilation system and building modifications.

Mr. Prock is a certified Project Management Professional and a Certified Cost Professional, and has a Bachelor of Science in Building Sciences from Auburn University and an Masters of Science in Building Construction from the University of Florida.

James J. McElligott

Mr. McElligott is an engineer with experience in project management, cost estimating, and engineering. His areas of expertise include construction and industrial cost estimating, the Environmental Protection Agency regulations, metal fabrication, concrete construction, manufacturing, and product management. Mr. McElligott developed civil estimates for the ICE for the site preparation and long-lead procurement (CD-3A) for the Main Processing Building at UPF. His team provided cost, schedule, and risk assessments for this ICE. He provided estimates for the concrete and material excavation portions. Mr. McElligott also served as a cost estimator for the independent cost review for the total project cost range for the construction of three facilities, the Mechanical and Electrical Building, the Salvage and Accountability Building, and the Main Processing Building, at UPF. He reviewed costs for long lead time items such as gloveboxes and heavy equipment.

As a case development officer and EPA inspector, Mr. McElligott was responsible for inspections and enforcement of the provisions of the Emergency Planning and Community Right-to-Know Act and Clean Air Act Section 112(r). He inspected chemical, refrigeration, and other facilities that handle hazardous chemicals per the Superfund Amendments and Reauthorization Act Title III and prepared administrative penalty enforcement actions documentation.

He has a Bachelor of Science in Mechanical Engineering from Christian Brothers College and a Masters of Science in Industrial Management from Purdue University.

Luther L. Hill

Mr. Hill has more than 25 years of project management, program management, consulting, cost estimating, scheduling, project controls, and unit price book development experience. He has expertise in life cycle baseline development, primarily for NNSA projects, including Los Alamos National Laboratory and the Nevada Test Site, as well as EM baseline independent cost review and ICE development for DOE and USACE.

Mr. Hill updated the integrated life cycle estimate for the DOE Office of Integration and Planning at SRS. He managed the cost processor that applied the Site Indirect and Overhead Structure to the time-phased cost to portray the remaining life cycle cost. In addition to this system, he facilitated estimate development for PBS 100 - Community and Regulatory Support; PBS 20 - Safeguards and Security; Site Indirect and Overheads; and numerous documentation and oversight, which also included the development of an automated cost processor replacement.

In addition, Mr. Hill implemented a life cycle cost estimate of approximately $47 billion for DOE EM that was formally approved by DOE Headquarters in Washington, DC. He also provided schedule integration and website updates for all of the SRS PBS components comprising the DOE integrated federal baseline, which was formally accepted by the DOE and renamed the integrated life cycle estimate. This baseline included cost estimates, a WBS dictionary, parametric cost models, and Primavera resource-loaded project schedules and documentation.

He is a Certified Cost Professional and has a Bachelor of Science in Building Construction from Auburn University.

Loc Tran

Mr. Tran has over 15 years of project management and cost engineering experience in the federal government and private sector. He has provided cost estimating support to DOE projects including quality reviews of a $350M estimate covering both procurement and construction of a new Effluent Management Facility at the DOE Waste Treatment and Immobilization Plant. This project included five construction packages for modifications to existing facilities and construction of a new facility.

Mr. Tran also served as a cost engineer for the independent cost review of the TPC range for the construction of three facilities, the Mechanical and Electrical Building, the Salvage and Accountability Building, and the Main Processing Building, at UPF. He reviewed the site work, structural, and construction costs for this project. Mr. Tran also provided structural and civil cost estimates for the NDA's assurance and oversight of financial sanction for the Sellafield D&D capital construction project. He built assemblies for pipe bridges, structural designs, and concrete foundations.

Mr. Tran holds a Bachelor of Science in Civil Engineering from Clemson University.

Abbreviations

ACWP	actual cost of work performed
B	billion
BY	base year
CL	confidence level
CD	critical decision
CSRA	cost and schedule risk analysis
D&D	decontamination and decommissioning
DCMA	Defense Contract Management Agency
DMO	direct metal oxidation
DOE	U.S. Department of Energy
EAC	estimate at completion
EM	Office of Environmental Management
EPA	Environmental Protection Agency
ES&H	environment safety and health
ETC	estimate to complete
FY	fiscal year
GAO	Government Accountability Office
ICE	independent cost estimate
LOE	level of effort
K&C	kick and count
M	million
MA	management account
MFFF	Mixed Oxide Fuel Fabrication Facility
NDA	Nuclear Decommissioning Authority
NNSA	National Nuclear Security Administration
PBS	program baseline summary
PB	performance baseline
PM	Office of Project Management Oversight and Assessments
QA/QC	quality assurance/quality control
QURR	quantity unit rate report
SRS	Savannah River Site
TY	then year
UPF	Uranium Processing Facility
U.S.	United States
USACE	U.S. Army Corps of Engineers
WBS	work breakdown structure

Appendix A: Funding Profiles

	Unconstrained	$500M/year funding	$350M/year funding
Cost Element	**Total ($Thousands)**	**Total ($Thousands)**	**Total ($Thousands)**
MII Point Estimate (BY[1])	**$4,912,168**	**$4,912,168**	**$4,912,168**
Additional Hotel Load	-	**$555,595**	**$744,437**
Escalation	$431,579	$1,898,224	$4,141,321
Subtotal (TY[1])	**$5,343,747**	**$7,365,987**	**$9,797,926**
Management Reserve (95% CL[2]) (BY[1])	**$1,017,238**	**$1,017,238**	**$1,017,238**
Escalation	$94,168	$369,479	$705,882
Subtotal (TY[1])	**$1,111,406**	**$1,386,717**	**$1,723,120**
NNSA Contingency (95% CL[2]) (BY1[3])	**$427,749**	**$427,749**	**$427,749**
Escalation	$39,598	$155,366	$296,824
Subtotal (TY[1])	**$467,347**	**$583,115**	**$724,573**
Total "To Go" Costs (TY[1])	**$6,922,499**	**$9,335,819**	**$12,245,619**
Actual Cost to Date (ACWP)	$4,628,452	$4,628,452	$4,628,452
Fee	$267,187	$267,187	$267,187
Technology Transfer Fee	$28,000	$28,000	$28,000
Total Project Cost Estimate (TY[3])	**$11,846,139**	**$14,259,458**	**$17,169,258**

1. BY designates Base Year FY2016 dollars; TY designates Then Year dollars (FY2016

2. Point Estimate Uncertainty (95% Confidence Level).

The 19 year extension of the schedule is a function of the $350M constraint being applied to the unconstrained funding profile. If there were no funding constraints, the project would require in excess of $1B a year for four years with a peak of $1.48B to complete the work in 2023 (i.e. 7 years from today).

Unconstrained USACE ICE Funding Profile - MFFF Project and DMO Capability Option
$ in Thousands

Fiscal Year	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23		TOTAL COST
Annual Profile (BY)	**$1,161,507**	**$1,395,948**	**$1,480,679**	**$1,359,122**	**$795,244**	**$626,276**	**$92,502**	**$11,220**		
01.01.01 Design/Engineering (BY)	$129,844	$128,527	$114,802	$44,305	$35,630	$35,307	$5,749	$0		494,165
01.01.02 Construction (BY)	$487,986	$649,011	$685,509	$650,756	$197,921	$26,575	$493	$0		2,698,251
01.01.03 Startup / Operations Preparation (BY)	$105,885	$105,885	$113,448	$115,717	$130,087	$155,045	$22,690	$7,563		756,318
01.01.04 Project Management (BY)	$163,784	$163,784	$163,784	$161,857	$146,442	$141,625	$21,196	$963		963,433
USACE ICE Estimate (BY)	**$887,499**	**$1,047,206**	**$1,077,542**	**$972,635**	**$510,080**	**$358,552**	**$50,127**	**$8,527**		
Escalation on USACE ICE Estimate	$0	$41,888	$87,927	$121,447	$86,641	$77,681	$13,300	$2,694		431,579
USACE ICE Estimate Subtotal (TY)	**$887,499**	**$1,089,095**	**$1,165,470**	**$1,094,082**	**$596,721**	**$436,233**	**$63,426**	**$11,220**		
Management Reserve (BY)	$192,895	$207,709	$205,159	$165,871	$119,464	$109,962	$16,176	$0		1,017,238
Management Reserve Escalation	$0	$8,308	$16,741	$20,711	$20,292	$23,824	$4,292	$0		94,168
Management Reserve Subtotal (TY)	**$192,895**	**$216,018**	**$221,900**	**$186,582**	**$139,756**	**$133,786**	**$20,468**	**$0**		
NNSA Federal Contingency (BY)	$81,113	$87,342	$86,270	$69,749	$50,235	$46,239	$6,802	$0		427,749
NNSA Federal Contingency Escalation	$0	$3,494	$7,040	$8,709	$8,533	$10,018	$1,805	$0		$39,598
NNSA Federal Contingency Subtotal (TY)	**$81,113**	**$90,836**	**$93,309**	**$78,458**	**$58,767**	**$56,257**	**$8,607**	**$0**		

MFFF Project and DMO Capability – Unconstrained Summary

Cost Element	Total ($Thousands)
MII Point Estimate (BY[1])	**$4,912,168**
Escalation	$431,579
Subtotal (TY[1])	**$5,343,747**
Management Reserve (95% CL[2]) (BY[1])	**$1,017,238**
Escalation	$94,168
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Total "To Go" Costs (TY[1])	**$6,922,499**
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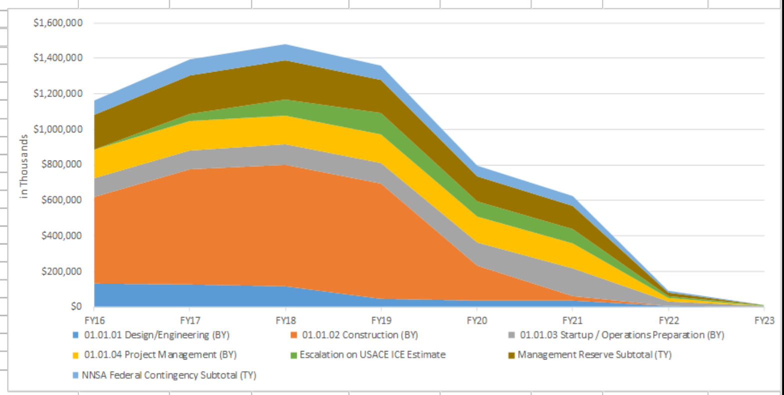
Fee	$267,187
Technology Transfer Fee	$28,000
Total Project Cost Estimate (TY[3])	**$11,846,139**

[1] BY designates Base Year FY2016 dollars; TY designates Then Year dollars

[2] Point Estimate Uncertainty (95% Confidence Level).



When the $350M constraint is applied for all of the "work" or funding in excess of $350M, each year is shifted to the next year creating a rolling bow wave that ultimately pushes the completion date to 2048. So the before and after scenario can be seen. See the minimized figure below of the attached technical backup.