

**DEVELOPMENT AND USE OF LIFE-CYCLE ANALYSIS CAPABILITES TO
EVALUATE, SELECT, AND IMPLEMENT PLANS TO
ACCELERATE HANFORD SITE CLEANUP**

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ABSTRACT

Over the past year the U.S. Department of Energy (DOE) has made significant progress in developing and executing plans to transform and accelerate cleanup of the Hanford Site. Notable progress has been in the cleanup of the River Corridor, including the relocation of spent nuclear fuel to the Central Plateau, and the stabilization of plutonium materials. However, difficult work still remains. DOE believes it can accelerate the completion of the Environmental Management (EM) cleanup mission from 2070 to 2035, and possibly sooner, by reducing excess conservatism, substantively changing technical strategy and management approach, and making new front-end investments.

Hanford is now actively engaged in the detailed planning, analyses and decision making required to implement and support the execution of the accelerated cleanup program at Hanford. Various cleanup, contract, and regulatory approaches are being explored. This paper provides a means to share the planning approach and the life-cycle modeling and analysis tools used with other sites and interested parties. This paper will be of particular interest to analysts performing similar planning and evaluations at other sites as well as provide insight into the current status of Hanford's cleanup program and DOE's plans for the future.

INTRODUCTION

Cleanup of the Hanford Site is a technically challenging, politically dynamic, and many faceted endeavor. The inherent hazards associated with the significant inventory of nuclear materials and wastes, the large number of aging contaminated facilities, the number, diverse nature, and extent of environmental release sits, and the proximity to the Columbia River make the Hanford Site perhaps the world's largest and most complex environmental cleanup project. Accelerating cleanup of Hanford can only be accomplished through the careful alignment of baseline plans, contracts, and the regulating framework contained within the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement).

Both RL and ORP have established life cycle baselines for their respective work scopes and are currently managing site contractors to make progress against those baselines. Over the past 6 months, DOE has incorporate baseline changes consistent with the acceleration initiatives. Currently, RL and OPR are in the process of working together to develop one Integrated Hanford Site Baseline with a 2035 completion date.

INTEGRATED PLANNING APPROACH

Hanford's approach to integrated planning is illustrated on Fig. 1. RL and ORP establish the top level goals and objectives for the cleanup programs and communicate these to the cleanup contractors through contract guidance and performance targets. This guidance is then used to develop mutually agreed to performance metrics and the detailed contractor execution plans. Due to the dynamic nature of the cleanup programs, the length of the contract periods, and the uncertainties associated with final end state, these execution plans are clearly focused on the near-term risk reduction and cleanup actions.

The cleanup contractors maintain these near-term plans within project baselines, which include detailed execution level schedules and basis of estimate. The detailed project baselines are used to perform earned value reporting and are under stringent baseline change control.

Hanford's Integrated Planning Process

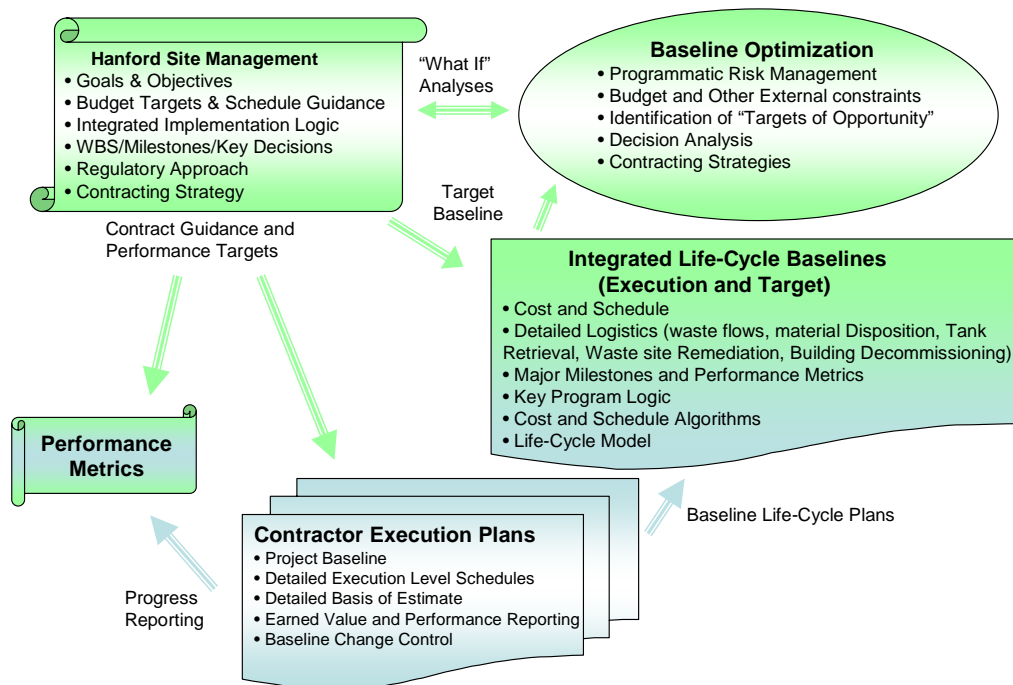


Fig. 1 Development and management of the integrated Hanford baseline

To better understand how decisions might affect the long-term (life-cycle) requirements it is necessary to have a fully comprehensive and integrated life-cycle baseline covering Hanford's entire cleanup program. Such a baseline will by necessity be at a higher level in the out years than the nearer term, contractor project baselines, yet the life-cycle baseline must be of sufficient detail to provide a means to understand the long-term liabilities associated with Hanford's cleanup program. The scope must be fully represented, with key schedule and logic ties, so that total committed costs and annual funding profiles can be developed for the entire duration of the cleanup.

An integrated life-cycle baseline can also be used to illustrate the transition from current planning (or execution) baselines to target baselines where optimization approaches, alternative end point assessment, and new contracting strategies are explored. At Hanford the integrated life-cycle baseline is captured in a life-cycle cost model capable of consistently representing multiple cases or strategies. This tool is described in greater detail in the following section.

The goal of this integrated planning approach and the integrated Hanford Site Baseline is to provide:

- a comprehensive description of the scope of work, implementation logic, and associated key milestones,
- a record of the key planning assumptions and pending key decisions,
- a schedule which closely couples the design, construction, and operation of the waste treatment plant with the facility decontamination and decommissioning (D&D), waste disposal, and environmental restoration tasks,
- a defensible estimate and basis for the total project cost along with annual funding profiles,
- a means for developing contracting strategies,
- a structure for identifying and maintaining priorities and critical work items,
- a listing of areas of uncertainties, issues, or information gaps and the plan to resolve these items, and
- an identification of areas where there are opportunities for cost reduction, improved performance, and schedule acceleration.

This integrated baseline would be represented in detail in the Life-Cycle Baseline Model. The Life-Cycle Baseline Model would house the detailed project level execution cost and schedule elements and the material and waste flow logistics, and would be used to assess strategic alternatives. The integrated baseline will be periodically updated as new approaches are adopted, key decisions are reached, and assumptions change.

LIFE-CYCLE PLANNING TOOLS

Life-cycle models, web-based displays of baseline information, and interface management tools are all being developed and deployed in support of the accelerated cleanup efforts at Hanford. Supporting the development and management of the life-cycle baseline is a collection of life-cycle analysis tools, models, and databases. These tools include the *Life-Cycle Model (LCM)* and computer based risk assessment tools as well as communication tools and management documents such as the Management Summary Schedule and the Interface Control Documents. This paper will focus primarily on the Computer based tools used to support life-cycle planning and strategic management of the clean-up mission at Hanford.

The LCM is a database-driven, object-oriented computer model which loads, links, and displays the detailed project baselines. The model is used to estimate the cost and performance impacts of changes to the baseline due to either changing external constraints (budget targets, planned off-site transfers, or management goals) or evolving implementation strategies (contract strategies, performance incentive structures, work sequencing, technology).

The LCM provides integration of and visibility into the performance of Hanford's relatively detailed contractor baselines. Based on the contractor's baseline information, the model links the planned cost and schedule data with other performance metrics such as the annual number of tanks retrieval/closures, amount of waste treated or disposed, the number of buildings and waste sites dispositioned. Each of Hanford's 177 High Level Waste Tanks, 4360 existing Facilities, and 2990 existing Waste Sites is linked to the contractor baseline activity containing the scope associated with retrieval, deactivation, decommissioning or remediation of that tank, building or waste site. As the baseline evolves and changes the overall site performance metrics change to reflect the modified scope.

The Hanford baseline reflects the clean-up of thousands of individual sites and the safe disposal of millions of cubic feet of radioactive waste. Although summary statistics are important for measuring overall progress, they do not in themselves provide a sufficient basis for making programmatic decisions. The LCM allows the user to display and drill down through the cost, schedule and multi-dimensional performance data to help in understanding the scope relationships within the baseline.

On the bottom of Fig. 2, the December 2003 Richland Operations Office baseline cost data (in Constant FY04 dollars) is shown. The user can drill down through the *Life-Cycle Work Breakdown Structure* (LCWBS) in the lower left of the figure to any level in the site baseline. The plots on the lower right of the screen display the current scenario (chosen by the tab on the far left of the screen) and compare it visually to the original contractor baseline data (directly above). The top of the screen displays a table of the data displayed graphically on the screen. The top section of the screen can also be toggled to display a Gantt chart of the activities directly below the LCWBS element chosen in the lower left section of the screen. This screen is invoked through the Cost/Schedule Detail tab.

Figure 2 also shows the completion date, by phase, for the life-cycle of each facility on site (on the top right side). A specific subset of facilities can be shown by selecting specific elements of scope, geographical areas, facility life-cycle phase, completion status, and/or contractors. Similar information is also available for each Waste Site. This screen is invoked through the Facility/Waste Site tab.

The Operations and Deactivation of facilities at Hanford generates TRU, Mixed, and Low Level Wastes that require Storage, Treatment, and Disposal. The LCM tracks the volume of wastes generated by these activities as well as off-site wastes that are planned for processing or disposal at Hanford. Figure 2 shows the relevant time dependent volumes (displayed on the upper left side of the figure). The LCM allows the user to drill down through the various sub-groups of each of these waste streams to identify the specific generators identified with each stream in each year. This screen is invoked through the System Performance tab.

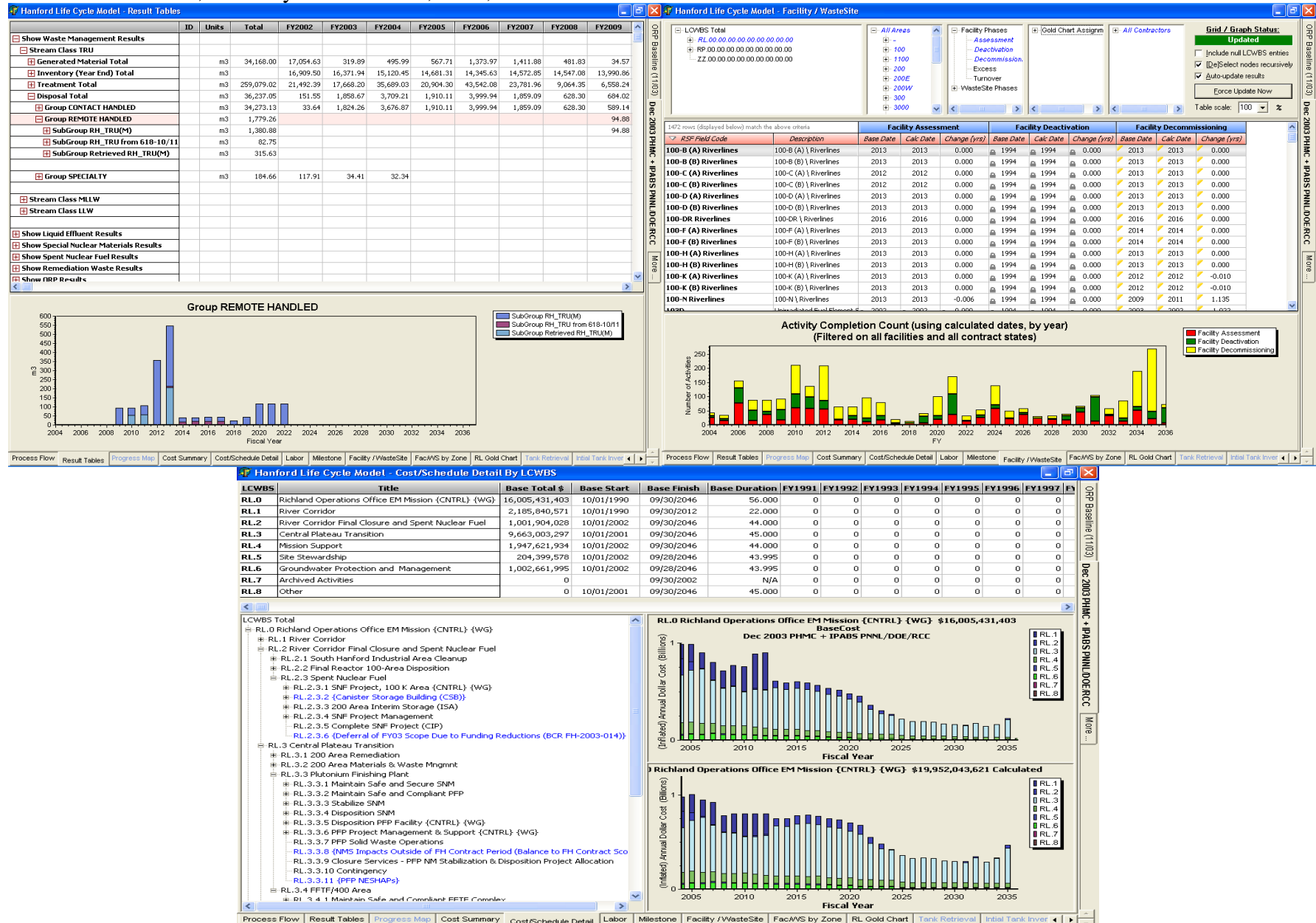


Fig. 2 Typical Cost and Performance Metric Screens Available on the LCM

High-Level Waste Tanks - Currently, Hanford has millions of gallons of high-level waste stored in 149 *Single Shell Tanks* (SSTs) and 28 *Double Shell Tanks* (DSTs). The display in the lower left of Fig. 3 shows the LCM screen for accessing the current status of each of the High-Level waste Tanks at Hanford. The current Inventory estimates for each tank are also available through this interface.

The LCM integrates the cost and schedule data with the movement of materials through the system to final disposition. Figure 3 also shows the flow diagram used by the LCM for estimating volume of waste as they move from their current storage locations through treatment to their final disposition.

The two additional graphs displayed on Fig. 3 show the performance of the current scenario with respect to tank retrievals and the disposition of the resulting waste materials. Similar information for the treatment and disposition of TRU (Fig. 2), Mixed and Low Level Waste as well as spent nuclear fuel, special Nuclear Materials and CERCLA wastes are also available.

BASELINE OPTIMIZATION

A series of tradeoff analyses will be conducted in the near future to evaluate the relative merits of various possible endpoints for categories of waste sites and facilities on the Central Plateau. This is one such example of how the integrated baseline tools will be used to evaluate the benefits of these new approaches. These tradeoff analyses should clarify the impacts of alternative endpoints for cost, risk and land use considerations.

There are several categories of “endpoint” decisions that will be evaluated from a Plateau-wide perspective rather than on a case-by-case basis. The following issues have been raised and would be the subject of such tradeoff analyses:

- Alternative capping strategies.
- Appropriate endpoint for surplus facilities.
- Tradeoff for “remove-treat-dispose” decisions versus “characterize-then-decide”.
- Approach for remediating/closing pipelines.
- Strategy for disposition of TRU residuals.

Each of these analyses will clarify the tradeoffs among cost, risk and land use (or required institutional controls). The purpose of these analyses is to understand the Plateau-wide impacts of alternative endpoints for each of these topics. In addition, concepts surrounding various geographic closure options for the Central Plateau will be explored in an effort to develop optimal sequencing of the remediation work scope. The life-cycle analysis tools, models, and databases that have been developed over the past two years will provide a consistent, repeatable basis for assessing the various alternatives. Figure 4 provides an illustration of the programmatic, regulatory, and technical steps needed in developing such an approach.

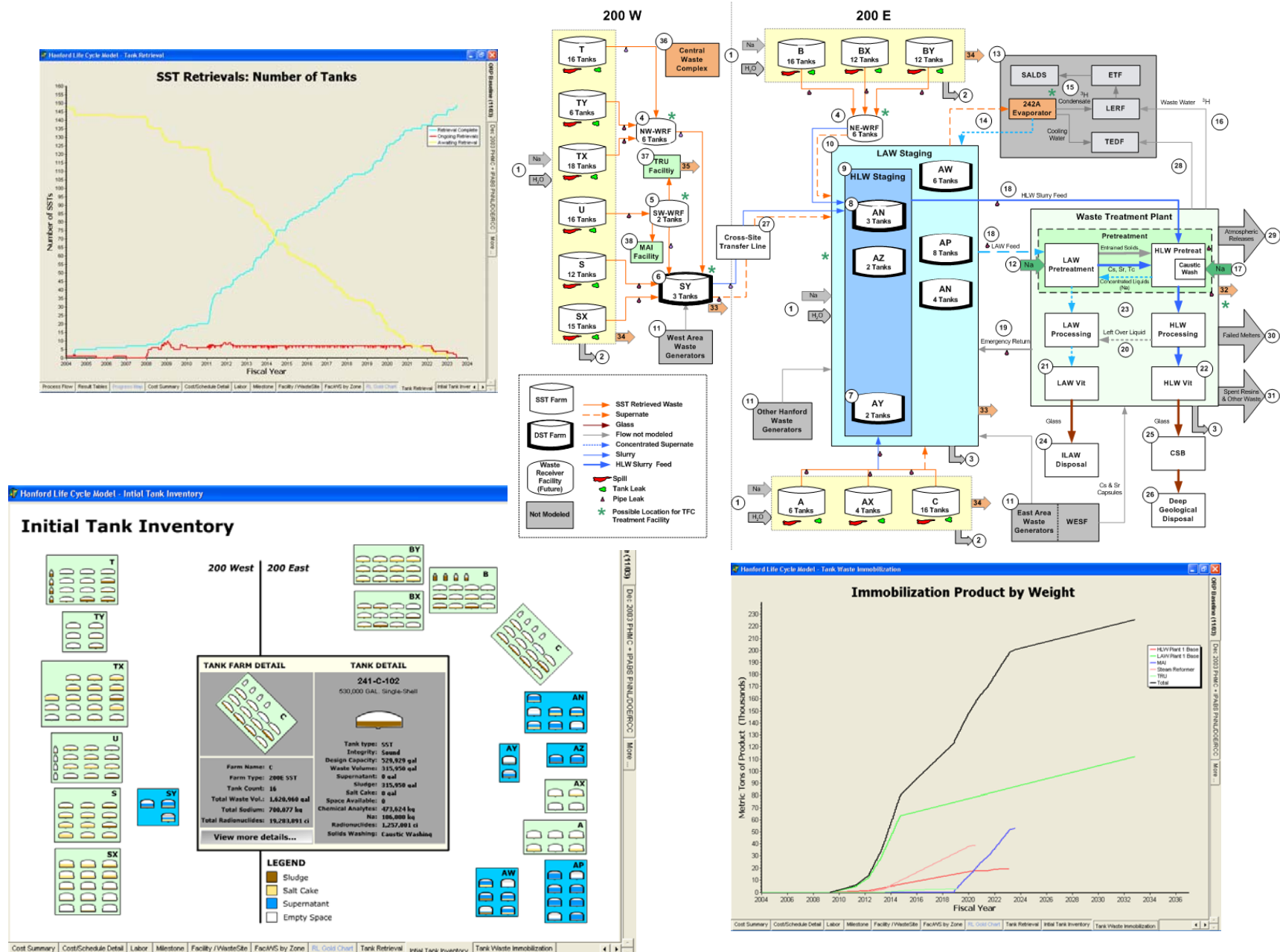


Fig. 3 Typical LCM Screens Illustrating the High-Level Waste Tank Program

Central Plateau Closure Decision Logic/Roadmap

U Area Prototype Actions/Impacts

U Area Waste Sites Remediation (FFS/PP/ROD)

- Define and evaluate options for waste site remediation.
- Decision precedents for removal versus capping.
- Application of risk exposure scenarios.
- RCRA/CERCLA integration prototype for other Plateau waste sites.

U Area Pipeline Disposition (EE/CA/AM)

- Define and evaluate options for pipeline disposition.
- Include tank system components.
- Define and apply DQO and SAP for pipeline components.
- Develop boundary rules for assessment and remediation of pipelines.

U Plant CDI (FS/PP/ROD)

- Evaluate barrier options and closure of adjacent waste sites.
- Application of risk exposure scenarios.
- Evaluate potential for co-disposal waste streams.
- Resolve LDR status for residual materials

U Area Ancillary Facility Disposition (EE/CA/AM)

- Decision precedents for ancillary facilities. Endpoint definition and hand-off condition to ER.
- Prototype regulatory pathway for ancillary facility decisions on the Plateau. Plug-in approach?

200-UP-1 RI/FS/PP and ROD by 9/30/06.

Remediation, Closure, D&D Element

Waste Site Remediation

High Risk Sites (NRDWL, TW-1/2)
 Ex-Core Zone (CW-1)
 In-Core Zone (TW-1/2, CW-5, etc.)
 Tank Waste (TW-1/2)
 Pu/TRU Residuals (TW-1, CW-5, PW-6 [Z-9])
 Burial Grounds (SW-1/2)
 Pipelines, Tank Components (IS-1)

Tank Waste Retrieval & WMA Closure

Pipelines, Tank Components (IS-1)
 Vadoze Zone, Past Leaks, GW (RFI/CMS)
 WMA A-AX WMA T
 WMA B-BX-BY WMA TX-TY
 WMA C WMA U
 WMA S-SX

Canyons & Key Facilities

U Plant T Plant
 PUREX B Plant
 REDOX PFP

Other Surplus Facilities

Waste Disposal System (Composite Analysis & SAC)

Key Actions to Create Central Plateau Strategy

- Establish Core Zone risk scenario and remediation goals.
- Develop approach for decision making on TRU residuals.
- Integration with tank closure and remediation of components that are external to WMA boundaries.
- Develop decision rules for "presumptive remedies."
- Establish optimized sequence for implementing remedies (e.g., by zone, type, etc.)

- Reconcile IS-1 pathway for ORP components. Develop interface with tank system components that are external to WMA boundaries.
- Integrate ancillaries and pipelines with RFI/CMS process.
- Develop WMA Closure process.
- Apply waste classification authority for HLW and TRU residuals.
- Exercise Appendix H – "stopping rules" for retrieval.
- Complete risk assessments for past leaks, retrieval losses, and residuals.
- Develop sequence for WMA closures.

- Develop sequence for Canyon closures.
- TRU residual endpoints, especially for PFP facilities.

- Develop regulatory/decision pathway for surplus facilities.
- Develop hand-off or endpoint criteria.

- Identify coupled and decoupled source terms, relative to potential GW impact.
- Develop risk allocation approach based on Composite Analysis.

Prerequisites for Final GW Decisions (from IAMIT GW team 12/3/03, except *italics*)

- Complete remediation of high risk to groundwater waste sites.
- *Complete all waste site RI/FSs (12/31/08).*
- *Assess impact of interim remediation actions for UP-1 and ZP-1 and complete FS/PP for final actions.*

- Complete vadose zone investigation of the tank farms to provide further characterization of the tank farms.
- Complete drilling of the well monitoring system around the tank farms.
- Complete interim closure of ___% of tanks within a tank farm to provide data for risk analysis to groundwater.

- Determine the disposal capacity needed for waste to meet ORP and RL needs and determine the potential impact to groundwater based on sitewide analysis.
- Determine the impact of "secondary waste" sources on groundwater.
- *Update Composite Analysis.*

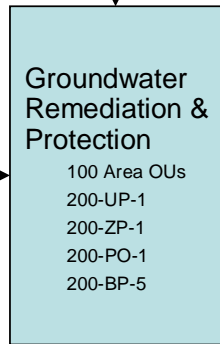


Fig. 4 Central Plateau Closure Decision Framework

PROGRAMMATIC RISK MANAGEMENT

To fully realize the benefits of the acceleration and integration initiatives, DOE's work must be managed in a manner that will help guard against cost growth, schedule delays, and other programmatic risks that could impact progress. Programmatic risks can be generally categorized as 1) estimating uncertainty; risks associated with uncertainties in cost, schedule, and scope; 2) Identified risks; Risks associated with explicit assumptions in the baseline which have been assumed to be certainties in preparing the cost and schedule estimates; and 3) unidentified risks; Risks that cannot practically be identified in the planning phase but are realized during the course of the project.

Estimating uncertainty is generally provided by the cost estimators and is based on the level of detail in the planning activity, the amount of prior cost and schedule history available at the time the estimate is prepared, and the degree that costs have already been committed through existing contracts or procurement agreements.

Identified risks are generally identified by the project organization and reflect areas of the project where future activities will confirm or deny the approach that has been planned. Examples of these risks include regulatory and institutional uncertainties, the ability of the proposed technology to achieve project cleanup goals for the resources allotted, and the unavailability of external resources key to the execution of the proposed work scope. These risks are generally shared to a larger or lesser extent between contractors and DOE depending on the contract in force at the time.

Unidentified Risks, by their very nature, are difficult to accurately assess even with historical data. These are generally realized through events that affect the timing or cost of the project that cannot be realistically anticipated. Smaller events generally fall within the "estimating uncertainty". The degree to which larger events such as major off-normal operational events, unanticipated funding shortfalls, and unanticipated labor or contract interruptions are absorbed within a contracting vehicle again depend upon the details of the particular vehicle.

DOE contractors utilize custom stochastic spreadsheet-based tools to assess the impact of these risks on cost and schedule. After enumerating the identified risks, Monte Carlo techniques are deployed to generate frequency distributions of project costs to completion. Figure 5 shows typical example of a project cost frequency distribution. These distributions are then used to allocate funds to maximize the attainment of project objectives.

DOE's programmatic risk management approach is focused on identifying, analyzing, prioritizing, and mitigating these three overall categories of programmatic risks. DOE, through her contractors, will develop risk mitigation plans for all high-priority risks to document how it will avoid or mitigate the effect on schedule, technical performance, or cost.

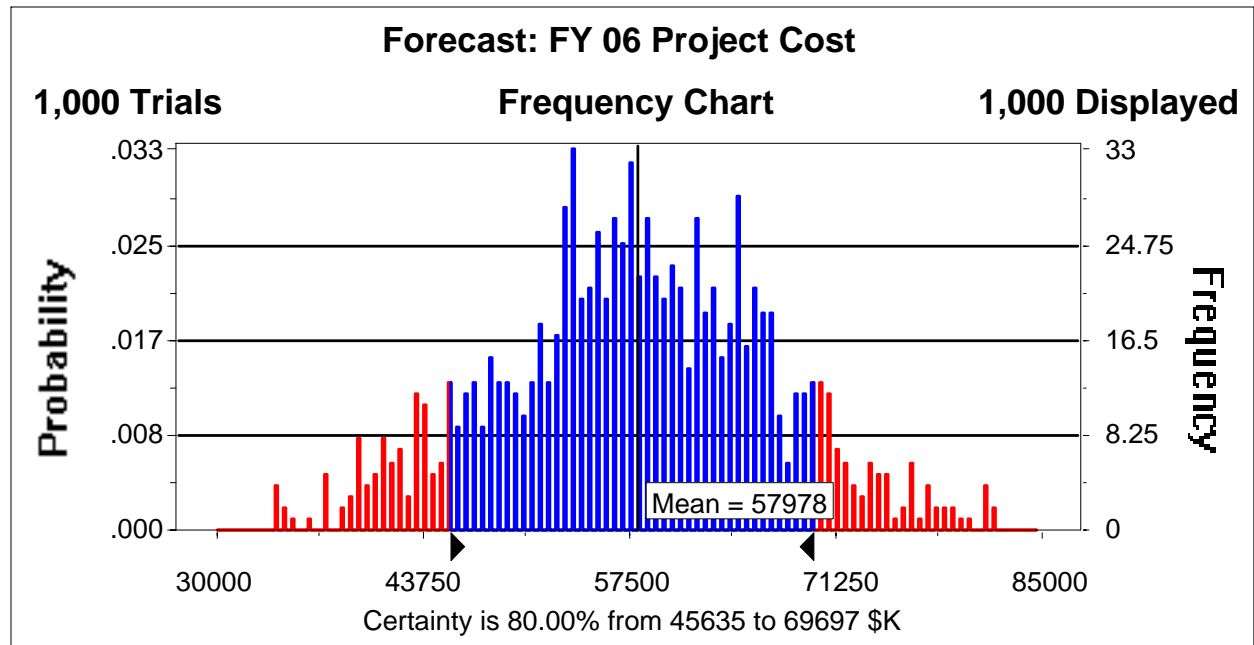


Fig. 5 Development of Risk Based Contingencies

CONCLUSIONS

Hanford is now actively engaged in the detailed planning, analyses and decision making required to implement and support the execution of the accelerated cleanup program at Hanford. These planning activities will be used, in a large way, to define the ultimate completion end state for the ongoing cleanup program. Various cleanup, contract, and regulatory approaches are being explored. This paper and the associated poster session provides a means to share the planning approach and the life-cycle modeling and analysis tools used with other sites and interested parties.