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Revision 0

An Approach To Characterizing And Evaluating Alternatives For The Decommissioning Of Sub-Grade Structures At The Plutonium Finishing Plant

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

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P.O. Box 1000
Richland, Washington

Approved for Public Release;
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ABSTRACT

In 2002, the Richland Operations Office (RL) of the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology) developed milestones for transitioning the Plutonium Finishing Plant (PFP) facility to a clean slab-on-grade configuration. These milestones required developing an engineering evaluation/cost analysis (EE/CA) for the facility's sub-grade structures and installations as part of a series of evaluations intended to provide for the transition of the facility to a clean slab-on-grade configuration. In addition to supporting decisions for interim actions, the analyses of sub-grade structures and installations performed through this EE/CA will contribute to the remedial investigation feasibility study(ies) and subsequently to the final records of decision for the relevant operable units responsible for site closure in the 200 West Area of the Hanford Site.

To preclude the cost of extensive sampling and analysis, the approach to characterizing the PFP sub-grade was to use all available historical data to provide the information necessary to describe the sub-grade items accurately and to characterize the process wastes carried through the individual pipeline, diversion boxes and installations. Historical records from original sources including operator's handwritten logs were researched to determine the chemicals used and the number, location and volume of unplanned releases of waste constituents to the soil. Additionally, historical photographs were used to help ensure all process waste lines were identified as to their original and final configuration. Plutonium processing flow diagrams were used to identify the *Comprehensive Environmental Response Compensation and Liability Act of 1980* (CERCLA) [1] hazardous constituents of concern.

The scope of activities for this EE/CA is to identify the sub-grade items to be evaluated, determine the CERCLA hazardous substances through process history and available data, evaluate these hazards and, as necessary, identify the available alternatives to reduce the risk associated with the contaminants against the criteria of effectiveness, implementability, and cost.

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Alternatives were compared using a value-analysis method that measured qualitative attributes of effectiveness and the ability to implement with the quantitative cost estimates, resulting in the Surveillance & Maintenance (S&M) alternative as preferred. Inspection of results indicated that the costs of alternatives other than S&M were a major influence. Sensitivity analyses on significant cost assumptions that favored S&M indicated that it remained the preferred alternative in all cases when these assumptions were varied significantly to give preference to other alternatives.

INTRODUCTION

The PFP EE/CA supports the CERCLA removal action activities for the contaminated PFP sub-grade structures (i.e., building slabs, vaults, pipe tunnels, ductwork, and diversion boxes) and installations (i.e., buried pipelines, French drains, injection wells, and known unplanned releases). The requirement for this process is described in the M-083-00A milestone series of the PFP transition milestones as recorded in the *Hanford Federal Facility Agreement and Consent Order* (HFFACO) [2].

In 2002, the DOE-RL, EPA, and Ecology developed milestones for the transition of the PFP facility. The result of the milestone development is documented in HFFACO Change Request M-83-00-01-03. The driver for the development of the PFP sub-grade EE/CA is the HFFACO Interim Milestone M-083-22, which requires that the PFP facility develop engineering evaluations and cost analyses for the purpose of transitioning the facility from the operations phase to the disposition phase as described in the HFFACO Action Plan Section 8. In addition to supporting decisions for interim actions at these sites, the analyses of sub-grade structures and installations performed through this EE/CA will contribute to the remedial investigation feasibility study(ies), and subsequently to the final records of decision for the relevant operable units responsible for site closure.

The scope of activities for the sub-grade EE/CA was to identify the contaminated sub-grade items, to determine the CERCLA hazardous substances through process history and available data, to evaluate these hazards and, as necessary, to identify and evaluate the available alternatives to reduce the risk associated with the contaminants against the criteria of effectiveness, implementability, and cost. The sub-grade EE/CA considered four alternatives for an interim removal action: (1) No Action, (2) Surveillance and Maintenance, (3) Stabilize and Leave in Place, and (4) Remove, Treat and Dispose. Within Alternative Four, the evaluation considered three options for the removal of building slabs: Option A would remove all building slabs, Option B would remove only those building slabs with known plutonium inventory, and Option C would not remove any building slabs. Each alternative was evaluated against the CERCLA criteria for effectiveness, implementability, and cost. Each criterion was given equal weight in the evaluation process.

The S&M alternative (Alternative Two) was determined to be the most efficient approach to address contamination concerns for the sub-grade structures and installations and is the preferred alternative.

BACKGROUND AND SITE CONDITIONS

The PFP facility, located on the Hanford Site in Richland, Washington (Figure 1), was used to conduct plutonium processing, storage, and support operations for national defense, including the following activities:

- Converting and processing plutonium
- Fabricating of weapons components
- Producing and blending plutonium and uranium feed materials for advanced reactor fuel
- Recovering plutonium and americium

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- Handling and storing special nuclear material
- Providing laboratory support
- Handling process waste.

Plutonium production operations ceased at PFP in 1990 under direction from DOE-Headquarters. Plant resources were then re-directed toward cleanout of the facilities and the stabilization/repackaging of the several tons of special nuclear material then in inventory. In October 1996, the DOE issued a letter, *Approval to Initiate Deactivation and Transition to the Plutonium Finishing Plant* [3] which directed the DOE-RL to “initiate deactivation and the transition of the PFP in preparation for decommissioning.” Planning was initiated for integrating deactivation activities with the ongoing plutonium-bearing material stabilization activities in order to transition the PFP facility to a low-risk/low-cost S&M condition.

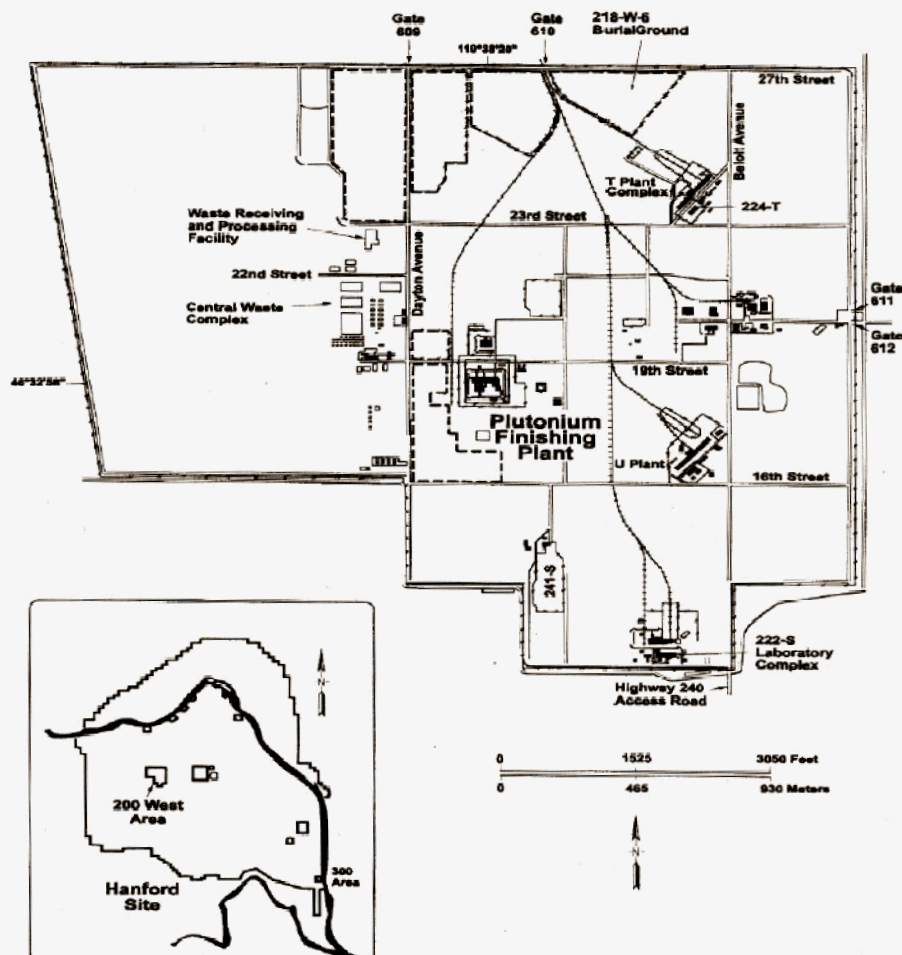


Figure 1. 200 West Area.

13.2

APPROACH TO CHARACTERIZING THE PFP SUB-GRADE

To perform an EE/CA of the PFP sub-grade, information regarding the configuration, condition, and integrity of the sub-grade structures and installations had to be determined and then mapped. Additionally, the nature and extent of possible contamination within the sub-grade of PFP had to be determined. Unlike surface structures where the configuration and condition of the structure is readily apparent, to characterize the sub-grade, extensive research of historical documents, as-built drawings, engineering design change documents, and construction photographs were needed. These data were captured on H-2 (type) drawings and issued as the current configuration of potentially contaminated pipelines within the PFP sub-grade area. Historical photographs of sub-grade structures and installations during construction of PFP are shown in Figures 2 and 3.

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Figure 2. Historical photograph of sub-grade structures and installations during PFP Construction (Photo 1).

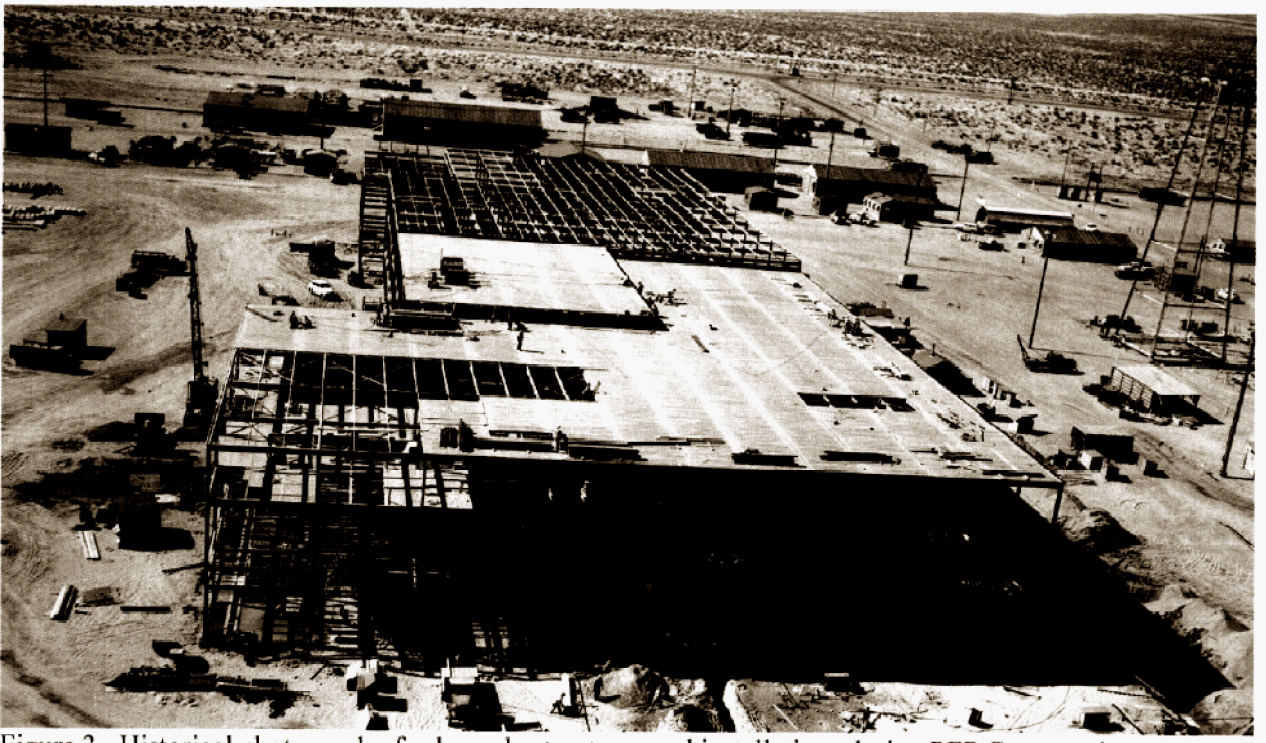


Figure 3. Historical photograph of sub-grade structures and installations during PFP Construction (Photo 2).

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To determine the contaminants that could reside in the sub-grade, extensive research of the plutonium production and recovery processes was conducted. In addition, actual analytical data from boreholes within the protected area fence line surrounding PFP were researched for chemical and radiological hazardous constituents in the sub-grade. This research resulted in a paper, *Study of Liquid Effluents and CERCLA Hazardous Constituents Generated and Discharged by the Plutonium Finishing Plant* [4], documenting, in a bounding fashion, chemicals historically used in the PFP processes and hazardous constituents in the PFP sub-grade.

SCOPING THE PFP SUB-GRADE FOR REMOVAL ACTION

The scope of the removal action PFP sub-grade structures and installations was to evaluate and recommend interim mitigation, as appropriate, of the risks associated with CERCLA hazardous constituents in, on, or within building slabs, buried pipelines, contaminated soil resulting from spills, and other buried structures and installations associated with PFP chemical processes, waste transfers, and disposal activities, prior to final remedial action. The items addressed by the EE/CA included evaluating interim removal actions prior to their final remedial action. For example, interim removal action activities may in part address removing a building slab, but may defer removing all underlying contaminated soil, if any, to final remediation. Final remediation will be determined as a result of remedial investigation/feasibility study evaluations and ultimately a record of decision for the appropriate operable unit (OU).

The PFP complex covers approximately 25 acres, more than 60 structures, numerous sub-grade structures and installations, and a wide variety of waste sites and unplanned release sites. The first element of the approach to the EE/CA was to determine which items in the sub-grade of the PFP were candidates for a CERCLA removal action. Therefore, screening criteria were developed. Sub-grade structures and installations within the PFP complex were evaluated for inclusion in the removal action scope through the following screen:

1. Is the structure/installation part of the PFP Complex? If yes, it potentially is within the scope of the EE/CA. For example, the sub-grade (crib) portion of the 216-Z-9 Facility received waste from processes at PFP, but has been assigned to the Central Plateau Project for remedial action. Therefore, the 216-Z-9 Crib is not included in the scope of the EE/CA.
2. Is the structure/installation contaminated or potentially contaminated with CERCLA hazardous substances? If yes, it is included in the scope of the EE/CA. If not, there is no basis for response action under CERCLA (e.g., building slabs that are not contaminated, electric lines, service and clean water pipelines, telecommunications, cathodic protection, etc.) and the structure/installation is excluded from the scope.
3. Is the structure/installation situated in the sub-grade (e.g., contaminated buried pipelines)? If yes, it is within the scope of the EE/CA.
4. Has the structure/installation previously been or is it currently being evaluated under CERCLA? If yes, it does not belong within the scope of the EE/CA (e.g., Tank 241-Z-361).
5. Is the structure/installation scoped in by HFFACO Interim Milestone M-083-22? For example, contaminated building slabs, though not buried, are in the scope of the EE/CA to satisfy the conditions of Interim Milestone M-083-22.

These five criteria were applied to identified structures and installations associated with the PFP complex.

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DETERMINING SOURCE, NATURE AND EXTENT OF CONTAMINATION

The second element of the approach to evaluating the PFP sub-grade was to determine the nature and extent of contamination from PFP operations in the sub-grade piping and installations. Sampling and analysis were not performed; instead process records were used to determine hazardous constituents of concern and spill/leak histories.

The process flow sheets of PFP operations were used to describe the chemical and radiological constituents discharged in liquid effluent streams through the various PFP sub-grade installations. This information is provided in the investigative paper [4], which describes PFP liquid effluents, from processes that resulted in the discharge of liquid effluent containing hazardous constituents through the PFP buried pipelines. It describes the CERCLA hazardous constituents resulting from the individual processes and found in these waste streams. Additionally, the paper provides analytical data from boreholes sampled within the PFP fence line.

The processes contributing hazardous constituents to the sub-grade included effluent streams from the following:

- PFP Process Operations: 234-5Z Rubber Glove, Remote Mechanical "A" line, Remote Mechanical "C" line, and Recovery of Uranium and Plutonium by Extraction wastes generated included hydrofluoric, oxalate, and nitric acids, plutonium and other transuranic metals and heavy metals. Organic wastes included carbon tetrachloride, tributyl phosphate (TBP), and dibutylbutyl phosphonate (DBBP). Very small quantities of sulfuric acid were occasionally used.
- 242-Z Waste Treatment and Americium Recovery Facility generated hydrochloric, hydrofluoric, phosphoric, and nitric acids; plutonium, americium, metals; and organics such as TBP, DBBP and carbon tetrachloride.
- PRF or 236-Z Building: Processes used nitric and hydrofluoric acids, aluminum nitrate, hydroxyl amines, and organics, primarily carbon tetrachloride and TBP, and generated wastes which included organics, metals, and transuranics.
- Laboratory operations generated laboratory wastes containing organic (including acetone), radioactive and metal constituents.

Hazardous constituents of concern for the PFP sub-grade installations EE/CA were determined to include radionuclides, organic chemicals, and heavy metals. Key radionuclide contaminants are transuranic including various plutonium isotopes (Pu-238 through Pu-240) and their decay products (Am-241, uranium isotopes U-234 through U-238, and Np-237), and lesser amounts of radioactive corrosion and fission products (e.g., Co-60, Sr-90, Tc-99 and Cs-137). The major organic chemicals contributing to PFP waste streams and resulting contamination include solutions of carbon tetrachloride, TBP, and DBBP. The major inorganic contaminants include primarily heavy metals such as lead, chromium, cadmium, mercury, and silver.

In addition to process waste, an unspecified volume of generally dilute non-process and non-contact process water was discharged to disposal fields and trenches [4].

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CERCLA/RCRA INTEGRATION

The engineering evaluation of the PFP sub-grade structures and installations is performed under the requirements of the CERCLA. When an individual waste management unit scoped within the engineering evaluation is regulated under the RCRA, the analysis under the engineering evaluation integrates the requirements of the RCRA with the proposed CERCLA removal action. This is applicable to the 241-Z tank system, a process liquid treatment system, at PFP. Figure 4 shows an historical photograph of the 241-Z Facility during construction.



Figure 4. Historical photograph during construction of the 241-Z Facility tank system.

The *Hanford Facility Dangerous Waste Closure Plan, 241-Z Treatment and Storage Tanks*, [5] provides the process for closing the *Resource Conservation and Recovery Act of 1976 (RCRA)* [6] Storage Facility Permit for the 241-Z Tank system at PFP, and describes the process for integrating the closure activities with CERCLA as appropriate. Under this closure plan, the 241-Z Facility closes four RCRA regulated tanks and defers cleanup of ancillary piping to CERCLA. Ancillary piping is evaluated under the PFP sub-grade EE/CA.

The 241-Z treatment, storage, and disposal (TSD) unit consists of below-grade tanks D-4, D-5, D-7, and D-8, an overflow tank located in a concrete containment vault, and associated ancillary piping and equipment. Waste managed at the TSD unit was received through underground piping from various PFP sources. Tank D-6 is a past-practice tank designated for action under CERCLA. Tank D-6, its containment vault cell, and soils beneath the vault that were contaminated during past-practice activities (*An Estimate of the Leakage from the 241-Z Liquid Waste Treatment Facility* [7]) were evaluated as part of the sub-grade EE/CA. Ancillary piping related to the TSD unit was also evaluated under the EE/CA. Estimating the leakage from documented spills is the third element of the approach to evaluating the sub-grade structures and installations.

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The above grade portions of the 241-Z Facility building will be removed under the PFP CERCLA above-grade removal action, *Engineering Evaluation/Cost Analysis for the Plutonium Finishing Plant Above-Grade Structures* [8].

DEFINING ALTERNATIVES FOR THE SUB-GRADE

Since all plutonium production processes at PFP were shutdown many years ago, there is no current source of on-going contamination. Determining if and how existing contamination could spread or migrate, and preventing this migration, were used as the basis for developing the alternatives. Ultimately, four removal action alternatives were defined for analysis for the PFP sub-grade structures and installations.

Alternative One: No Action

Evaluation of a No Action alternative under CERCLA is required to provide a baseline for other active alternatives. Under a No Action alternative, no building slabs, wastes, or pipelines would be removed and there are no S&M activities specific to the sub-grade structures and installations. Existing institutional controls (e.g., signage, fencing) would not be maintained. This alternative delays any action regarding the sub-grade structures and installations until the final remedial action(s) for PFP, or the multiple OUs that address components of PFP, is/are implemented.

Alternative Two: Surveillance and Maintenance

The Surveillance and Maintenance alternative involves regular inspection and maintenance of building slabs and contamination control covers to ensure their continued integrity, along with visual inspection and radiation surveys of the surface areas surrounding sub-grade structures and installations to detect any physical changes (e.g., structural collapse) or releases.

For purposes of costing the alternatives analysis, an assumption was made that the S&M program will cover the entire area inside the outer security fence at PFP, which encompasses approximately 25 acres and the majority of the sub-grade items.

Alternative Three: Stabilize and Leave in Place

Under this alternative, select contaminated sub-grade items are evaluated as to the appropriateness of their condition as provided by the PFP Above-Grade Structures EE/CA [8] or the 232-Z EE/CA, *Engineering Evaluation/Cost Analysis for the Removal of the Contaminated Waste Recovery Process Facility, Building 232-Z* [9]. Other contaminated sub-grade items are selected for specific stabilization activities. S&M activities are effectively the same as for Alternative Two.

The designated end point for building slabs under the PFP Above-grade Structures EE/CA and 232-Z EE/CA requires that building slabs are covered with a fixative to stabilize any contamination. Piping and equipment in below-grade portions of structures are removed to the extent possible or decontaminated to low-level waste criteria. Contamination control covers are placed where necessary. The 232-Z buried ductwork is filled with concrete. The 241-Z-RB Retention Basin, its valve pit, the two diversion boxes and the 243-ZA tank pit are filled with a controlled-density fill material.

There are only two additional sub-grade structure activities undertaken by this alternative as appropriate for stabilization. The first is to fill the ductwork between 236-Z and 291-Z with a stabilizing fill material. The second is to fill the 241-Z concrete trench that travels between the 234-5Z Building and the 241-Z

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Building including the branch from 242-Z to 234-5Z. Prior to filling this trench, piping within is removed.

Alternative Four: Remove, Treat, and Dispose (RTD)

Under this alternative, sub-grade structures and installations will be excavated, packaged, and disposed of at an appropriate waste facility. Removal of sub-grade items generally includes an additional 1 m (3 ft) of soil beneath the sub-grade item and 1 m (3 ft) beyond the sub-grade items footprint (if a building slab) or centerline (if a pipeline) in order to capture nearby contaminated soil. S&M will still be needed, as not all sub-grade items will necessarily be removed and some amount of contaminated soil will remain.

The end point under this alternative is driven by the target depth, which is based on reducing an exposure hazard, not a defined cleanup standard. Sampling will be performed only to establish residual contamination levels at the completion of the action, not to verify “final” cleanup levels.

To give some consideration to the extent of contamination on building slabs, this alternative provides three removal options for the building slabs:

- Option (A) – All building slabs (including below-grade sections) are removed.
- Option (B) – Building slabs (including below-grade trenches, ductwork, 241-Z tanks and vaults, 291-Z fan houses and exhaust plenums) are removed for priority buildings, 236-Z, 241-Z, 242-Z, and 291-Z only. These structural slabs were selected for individual treatment based on the residual plutonium expected to remain on these slabs.
- Option (C) - No building slabs are removed.

Removal of a building slab includes an additional 1 m (3 ft) of soil beneath the lowest portion of the building slab (e.g., the 241-Z below-grade vault floor) and laterally beyond the footprint of the building slab.

ANALYSIS OF ALTERNATIVES

CERCLA requires that removal action alternatives be evaluated against three primary criteria: effectiveness, implementability, and cost. To provide a more comprehensive evaluation, the EE/CA divides the criterion of effectiveness into several subcategories. The removal action alternatives were evaluated against the following factors:

- Effectiveness
 - Protectiveness
 - Overall protection of human health and the environment
 - Protection of workers during implementation
 - Protection of the environment
 - Compliance with applicable federal and state laws and regulations (e.g., applicable or relevant and appropriate requirements)
 - Long-term effectiveness and permanence
 - Ability to achieve removal action objectives
 - Reduction of toxicity, mobility, or volume through treatment
 - Short-term effectiveness

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- **Implementability**
 - **Technical feasibility**
 - Construction and operational considerations
 - Demonstrated performance/useful life
 - Adaptable to environmental conditions
 - Contributes to remedial performance
 - Can be implemented quickly
 - **Availability of equipment, personnel, services, and disposal**
 - Equipment
 - Personnel and services
 - Treatment and disposal services

- **Cost.**

An analysis of each alternative relative to each criterion was performed and the alternatives were compared against one another relative to each criterion.

Cost Estimates

Cost estimates were prepared by professional estimators experienced in construction, decontamination, removal, treatment, and disposal activities. The estimates include costs for activities such as mobilization and demobilization, monitoring and sampling, site work, soil excavation, cap placement, and others. Labor cost categories include construction labor, project management, and remedial design. Details of the estimate are presented in the cost backup report (*Cost Estimate Documentation for the Engineering Evaluation/Cost Analysis for the Plutonium Finishing Plant Sub-Grade Structures and Installations* [10]).

APPROACH TO EVALUATION OF ALTERNATIVES

The four alternatives included three options and were compared using a value analysis spreadsheet method that combined qualitative attributes of effectiveness and implementability with the quantitative cost estimates. Structured value analyses similar to this one are applied in a wide variety of decision-making venues. The method compares alternatives using normalization and weighting of individual scoring of the various attributes and criteria for each alternative.

Description of Scoring for Effectiveness and Implementability

For qualitative criteria of Effectiveness and Implementability, the scoring method is a semi-qualitative one that uses expert judgment of the characteristics of the alternatives as they relate to each criteria/sub-criteria. A simplified numerical value or a “na” indicator is assigned to each of eight categories of PFP sub-grade features, with the following guidance:

- 1 The alternative is very effective or readily implemented*
- 0 The alternative is somewhat effective or nominally implemented*
- 1 The alternative is ineffective or difficult to implement*
- “na” The condition does not exist or the criterion is not relevant for the alternative*

Using expert judgment, one of these numeric values was assigned to each attribute for each alternative for each criterion. Averaging was used to combine attribute scores, noting that “na” was ignored in the averaging process (i.e., it was not assigned a zero value). Table I shows one of the 14 scoring matrices

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for the qualitative criterion of Implementability for Alternative Four, Option B. This example was chosen because it has all of the four scoring values.

Table I. Example of Evaluating a Qualitative Criterion for One Alternative.

Alternative 4 (RTD) Option B (Priority Slabs) Score = 0.26 of maximum of 1.00	Slabs		Pipelines		UPRs		Other	
	Other Slabs	Priority Slabs	Other Pipelines	Pipelines to 241-Z	Beneath Slabs	Beneath Pipe Trench	Ductwork	Injection Wells
II. Implementability								
A. Technical Feasibility								
a. Construction and operational considerations	1	-1	0	-1	1	0	-1	0
b. Demonstrated performance/useful life	1	na	na	na	0	na	na	Na
c. Adaptable to environmental conditions	na	na	na	na	na	na	na	Na
d. Contributes to remedial performance	0	1	1	1	0	1	1	1
e. Can be implemented quickly	1	-1	-1	-1	1	-1	-1	0
B. Availability								
a. Equipment	na	0	0	0	na	0	0	0
b. Personnel and services	1	0	0	0	1	0	0	0
c. Treatment and disposal services	0	1	1	1	0	1	1	1

Cost Scoring

The cost inputs to the scoring method are the estimates of capital costs and surveillance & maintenance costs, which are summed for each alternative. The evaluation uses present worth costs (i.e., not constant dollar) to conform to the guidance in EPA 540-R-00-002, *A Guide to Developing and Documenting Cost Estimates during the Feasibility Study* [11]. The rolled up costs are shown in Table II.

Table II. Cost of Alternatives.

Cost Element	Alternative 1 (No Action)	Alternative 2 (S&M)	Alternative 3 (Stabilization)	Alternative 4 (RTD) Option A (All Slabs)	Alternative 4 (RTD) Option B (Priority Slabs)	Alternative 4 (RTD) Option C (No Slabs)
Surveillance and Maintenance	\$0	\$5,699	\$5,699	\$5,539	\$5,539	\$5,699
Capital	\$0	\$0	\$5,519	\$54,874	\$39,144	\$30,527
Sum of Present Worth Costs	\$0	\$5,699	\$11,218	\$60,413	\$44,683	\$36,226

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Combining the Individual Criteria Scores

To arrive at an overall ranking, the three criteria are combined in Table III to arrive at an overall relative figure-of-merit for each alternative. The highest score is the preferred alternative. The individual scores are combined in Table III with the following steps:

- Step 1: The uppermost section contains individual scores for the qualitative criteria and the sum of the present-worth estimated S&M and capital costs for the Cost criterion.
- Step 2: The middle section normalizes the values in Step 1 to a value of 100 across the six alternatives for a ranking within each criterion row. The inverse of cost is used for normalization because a high cost should result in a low score.
- Step 3: In the lower section, equal importance (i.e., weight) of 33.3% is applied to the normalized scores from Step 2 for each criterion. This step creates an overall total score of 100 (i.e., the sum of the bottom row containing the overall scores) among the alternatives.

The result is the relative value among the alternatives in which the one with the highest score is the most favorable, in the highlighted bottom row of Table III.

Table III. Combining the Individual Scores.

Overall Criteria	Alternative 1 (No Action)	Alternative 2 (S&M)	Alternative 3 (Stabilization)	Alternative 4 (RTD) Option A (All Slabs)	Alternative 4 (RTD) Option B (Priority Slabs)	Alternative 4 (RTD) Option C (No Slabs)	
Step 1. Scoring and Estimating Results Prior to Normalization (from individual factor scoring and cost estimates)							
I. Effectiveness	0.0	0.19	0.28	0.89	0.68	0.64	
II. Implementability	0.0	0.55	0.33	0.10	0.26	0.39	
III. Cost (PW, \$1,000s)	\$0	\$5,699	\$11,218	\$60,413	\$44,683	\$36,226	
Step 2. Normalized Results (Results in Step 1 are normalized to 100 for each criterion row)							
I. Effectiveness	0.0	7.03	10.35	33.20	25.39	24.02	
II. Implementability	0.0	33.44	20.38	6.37	15.92	23.89	
III. Cost	0.0	52.99	26.92	5.00	6.76	8.34	
Note: Lower cost gets higher score by applying inverse of cost prior to normalization.							
Step 3 Alternative Analysis Results (Sum of the weights = 100% so that the bottom row score totals 100)							
	Weight						
I. Effectiveness	33%	0.0	2.34	3.45	11.07	8.46	8.01
II. Implementability	33%	0.0	11.15	6.79	2.12	5.31	7.96
III. Cost	33%	0.0	17.66	8.97	1.67	2.25	2.78
	Score	0.0	31.2	19.2	14.9	16.0	18.7

Sensitivity Analyses

The relative costs of the alternatives were a significant factor in arriving at a conclusion that the S&M alternative is preferred. Therefore, sensitivity analyses were conducted to test if results were grossly skewed towards the recommended alternative because of cost conservatism. Three factors were tested as follows:

- The cost of mobilization and demobilization was reduced by 75% for alternatives other than S&M.

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- S&M costs were reduced to zero for stabilization and RTD alternatives.
- The importance of the cost criteria was reduced by changing its weight from 33% to 10%.

The sensitivity analyses results are summarized in Table IV. In all cases, the S&M alternative has the highest ranking, as shown in the Alternative Two column. The basic reason for the unchanged conclusion is that the cost for stabilization and RTD are considerably higher than for S&M, and that the Effectiveness and Implementability criteria scorings remain unchanged for the sensitivity analyses, since they are independent of cost.

Table IV. Sensitivity Analyses Ranking Summary.

Sensitivity Analyses Cases	Alt. 2 (S&M)	Alt. 3 (Stabilization)	Alt. 4 (RTD)		
			Option A (All Slabs)	Option B (Priority Slabs)	Option C (No Slabs)
Base Case (EE/CA Analysis) for Comparison	31.2	19.2	14.9	16.0	18.7
#1 Reduced Mobilization/Demobilization by 75% for 3, 4A, 4B, 4C	30.4	19.4	15.0	16.2	19.0
#2 Eliminated S&M for 4A, 4B, 4C	30.4	18.8	14.9	16.2	19.1
#3 Cost Importance Reduced to 10%	23.3	16.4	18.3	19.2	22.4

CONCLUSION

To effectively evaluate the PFP sub-grade for a CERCLA interim action while meeting schedule constraints of other CERCLA investigations around the PFP, save sampling and analysis costs, and reduce bias in alternatives analysis, PFP designed a specific approach to accomplish the sub-grade EE/CA. This approach used historical documents including historical photographs and handwritten operators logs to establish the nature and extent of contamination required by CERCLA. Additionally, because expert judgment is used in alternatives analysis, a semi-quantitative value analysis technique was used to reduce bias in determining the preferred alternative.

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