

Treatment and Disposal Alternative Assessment/ Implementation Plan for the 300-FF-1 Operable Unit Depleted Uranium Metal in Oil Drummed Waste

*Prepared for the U.S. Department of Energy, Richland Operations Office
Office of Environmental Restoration*

Submitted by: Bechtel Hanford, Inc.

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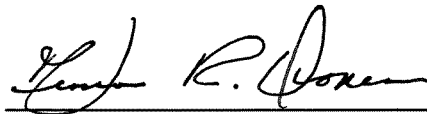
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Treatment and Disposal Alternative Assessment/Implementation Plan for the 300-FF-1 Operable Unit Depleted Uranium Metal in Oil Drummed Waste

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EXECUTIVE SUMMARY

This report documents the selection of phase separation and solids stabilization and liquid incineration as the preferred treatment alternative for drums containing depleted uranium chips and oil that were excavated from the 618-4 Burial Ground in 1998 and 2002. Characterization data indicate that the uranium chips are in a depleted enrichment state (<0.73% uranium-235 by weight) and that the oil contains concentrations of metals, polychlorinated biphenyls, and organic compounds that exceed regulatory thresholds under the *Resource Conservation and Recovery Act of 1976* and the *Toxic Substances Control Act of 1976*. Depending on the amount of residual liquid remaining, the uranium chips may also be regulated under these statutes. The drums are currently stored at the Environmental Restoration Disposal Facility staging area. Approval to store the drums in their current condition expires in October 2004, by which time the regulatory agencies expect the drums to be dispositioned.

A large number of technologies were screened to identify potential treatment alternatives for detailed assessment. Screening was performed based on the effectiveness, implementability, and cost of the technology. Results of the screening identified no action, vitrification, whole-drum stabilization, phase separation/liquid incineration/solids stabilization, and phase separation/liquid incineration/solids oxidation as treatment alternatives for further assessment. The alternatives were evaluated using the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) criteria of overall protectiveness; compliance with applicable or relevant and appropriate requirements; long-term effectiveness; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost.

Based on the CERCLA evaluation, the preferred treatment alternative was identified as the phase separation/liquid incineration/solids stabilization alternative. Key reasons include the following:

- The phase separation and solids stabilization processes have undergone bench-scale and full-scale treatability testing. Bench-scale testing indicated that the technology is effective. Preliminary results of full-scale testing are promising.
- At least one vendor is available who could perform treatment in the near future.
- An incinerator authorized to accept waste similar to the oil is already operational, available, and effective.
- Because full-scale treatability testing is nearly complete (final results are pending), this alternative would have a timely implementation and completion schedule.
- The phase separation and solids stabilization components of this alternative would avoid the risks associated with other high-temperature treatment technologies.

This report also includes an implementation plan and implementation barrier assessment for the preferred treatment alternative. The implementation plan presents a schedule of activities necessary to meet the 30-month window that the waste is authorized to be staged at the Environmental Restoration Disposal Facility staging area. The 30-month staging window ends in mid-October 2004.

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ACRONYMS

ARAR	applicable or relevant and appropriate requirement
BOA	basic ordering agreement
CAMU	corrective action management unit
CERCLA	<i>Comprehensive Environmental Response, Compensation, and Liability Act of 1980</i>
CFR	<i>Code of Federal Regulations</i>
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
ERC	Environmental Restoration Contractor
ERDF	Environmental Restoration Disposal Facility
HEPA	high-efficiency particulate air
LDR	land disposal restriction
OU	operable unit
PCB	polychlorinated biphenyl
ppm	parts per million
RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
ROD	Record of Decision
TBC	to-be-considered
TCLP	toxicity characteristic leaching procedure
Tri-Party Agreement	<i>Hanford Federal Facility Agreement and Consent Order</i>
TSCA	<i>Toxic Substances Control Act of 1976</i>
VOC	volatile organic compound

1.0 INTRODUCTION

In 1998 and 2002, a total of 520 drums containing depleted uranium chips and oil were excavated from the 618-4 Burial Ground during remediation of the site. The drums are currently staged at the Environmental Restoration Disposal Facility (ERDF). The purpose of this report is to identify a preferred treatment and disposal alternative for the depleted uranium chips and oil and to present a detailed plan for implementing the alternative.

1.1 BACKGROUND

The 618-4 Burial Ground is located in the 300 Area of the Hanford Site. In 1989, the 300 Area was added to the U.S. Environmental Protection Agency's (EPA's) National Priorities List for remediation under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). For purposes of evaluation, the 300 Area was divided into three operable units (OUs) consisting of two source OUs (300-FF-1 and 300-FF-2) and one groundwater OU (300-FF-5). In 1996, a CERCLA Record of Decision (ROD) was issued for remediation of waste sites in the 300-FF-1 OU, including the 618-4 Burial Ground (EPA 1996). The ROD specified that the burial ground would be remediated by removing, treating as needed, and disposing of contaminated soil and debris that exceeded cleanup levels. Remediation of the 618-4 Burial Ground was initiated in fiscal year 1998.

In March 1998, drummed waste was discovered in a central location of the 618-4 Burial Ground and work was stopped pending identification of the drum contents. Most of the drums were intact and approximately 113.5 L (30 gal) in size. Observations indicated that the drums contained fine sediments and/or metal cuttings in oil. Initial sample results from four drums indicated the presence of heavy metals, polychlorinated biphenyls (PCBs), and volatile organic compounds (VOCs) in the oil. The sample results also indicated that the metal cuttings were depleted uranium. Depleted uranium is a byproduct of the uranium enrichment process for production of nuclear reactor fuel. Depleted uranium has had a portion of its uranium-235 isotope removed for use in reactor fuel. As such, depleted uranium is less radioactive than naturally occurring uranium. It is a dense reactive metal that reacts with oxygen. The reaction has the potential to build up enough heat to become pyrophoric (ignite).

In August 1998, additional samples were collected from 32 of the uranium chip and oil drums to characterize the contents. Field observations and sample results from the characterization effort confirmed the presence of depleted uranium metal chips and oil in all of the intact 113.5-L (30-gal) drums. Results from the characterization effort are discussed in Section 2.0.

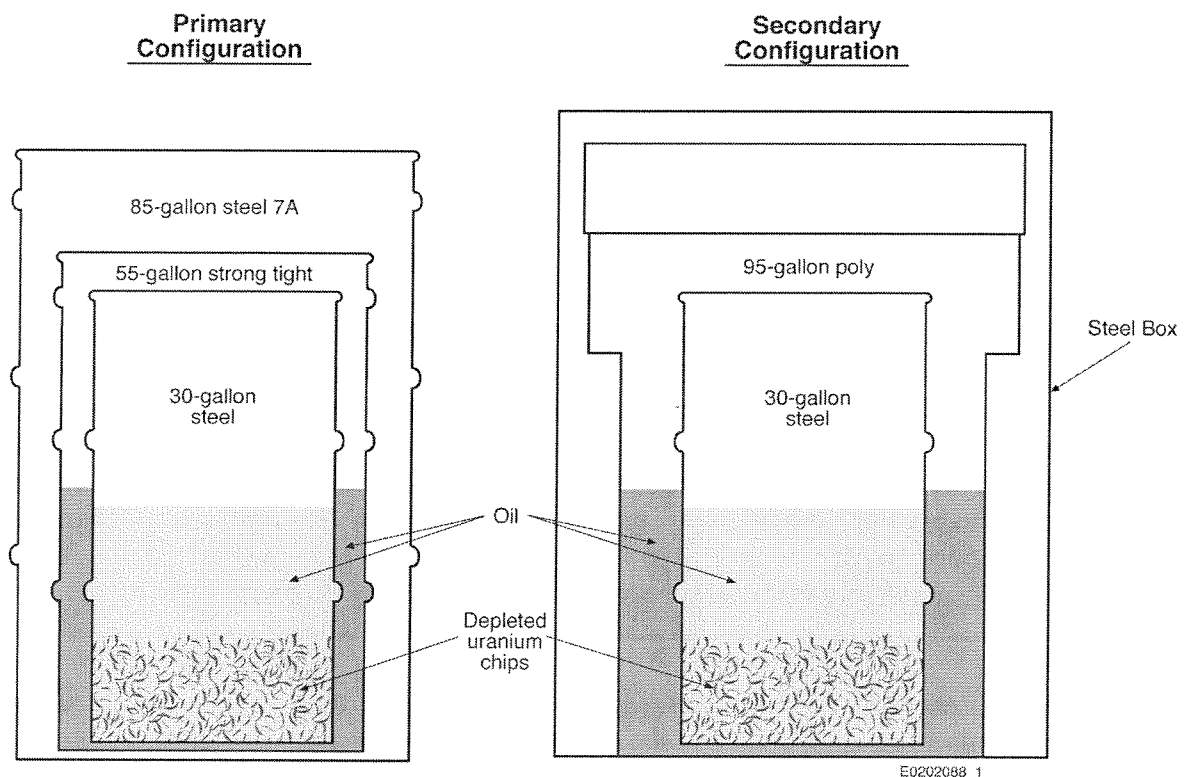
In 2002, excavation of drums containing uranium chips and oil from the 618-4 Burial Ground was resumed. All of the excavated uranium chip and oil drums excavated in 1998 and 2002 were placed in overpacks. Oil was added to the annular space between the drum and the overpack with the exception of about 20 drum/overpack combinations generated in 1998. Enough oil was added to the annular space to ensure that the depleted uranium would be covered with oil at all times during transportation and staging. For transportation to the ERDF, the overpacked drums

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were placed in either another steel drum or a steel box. The drum package configurations are shown in Figure 1-1. Between April and August 2002, all of the uranium chip and oil drums (520 drums total) and the stabilized soil and oil drums (about 35 drums) were shipped to the ERDF for staging.

Staging is operated under corrective action management unit (CAMU) provisions and is authorized in accordance with the ERDF ROD amendment (EPA 2002). The current drum packaging configuration for the uranium chip and oil drums is shown in Figure 1-1. A few drums were configured in other various ways, including the following: a 113.5-L (30-gal) original drum inside a 322-L (85-gal) drum inside a 416-L (110-gal) drum; a 208-L (55-gal) original drum inside a 322-L (85-gal) drum inside a 416-L (110-gal) drum; and 208-L (55-gal) original drums configured as shown in Figure 1-1 (see the secondary configuration).

Figure 1-1. Drum Configuration.



Not to Scale

Although the majority of the excavated drums were intact, a few showed indications of oil leaks. Soil impacted by the leaking oil was excavated, drummed, and stabilized with an oil-dry material. In addition, a few of the excavated drums contained only oil (they did not contain the depleted uranium chips found in most other drums). These drums were also stabilized using an

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oil-dry material. A total of about thirty-five 208-L (55-gal) drums of stabilized soil and oil were generated, placed in 321-L (85-gal) overpacks, and shipped to the ERDF staging area.

The stabilized drums of soil and oil are not part of this treatment plan. Depending on the preferred treatment alternative, it may be possible to treat the solidified drums along with the drums of uranium chips and oil using the same treatment alternative. However, because the solidified waste is a different waste form, the preferred alternative for the chips and oil waste may not be suitable for the solidified waste. Therefore, any discussion of drums or treatment from this point forward applies only to depleted uranium chips and oil.

1.2 PREVIOUS WASTE TREATMENT STUDIES

Three reports have been generated addressing potential treatment alternatives for the uranium chip and oil waste. The reports are as follows:

- *Treatment/Disposal Plan for Drummed Waste from the 300-FF-1 Operable Unit, 618-4 Burial Ground* (BHI 1999b)
- *Technology Alternatives Baseline – 618-4 Burial Ground Drum Treatment and Disposal Project* (BHI 1999a)
- *Technology Alternatives Baseline – Nondestructive Characterization and Treatment of Drummed Depleted Uranium Chips/Shavings in Oil* (BHI 2002b).

The two baseline documents contain general technologies and descriptions and were used as the basis for the treatment alternatives evaluated in this document. The treatment/disposal plan (BHI 1999b) identified hydrocarbon solidification compound and vitrification technologies as potential alternatives for treatment of the uranium chip and oil waste. Both of these technologies are reassessed in this document for potential application to the uranium chip and oil waste.

1.3 SCHEDULE

Currently, the only *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1998) milestone associated with the treatment and disposal of the uranium chip and oil drums is milestone M-016-03I. The milestone requires that treatment of the drummed waste be completed by a date that is to be determined. There is, however, a 30-month temporary storage limitation at the ERDF staging area, which is stipulated in the ERDF ROD (EPA 1995). The 30-month limitation requires either removal of the drums from storage at the ERDF or an extension of the temporary storage period and possibly an upgrade of the staging area for more permanent storage. A storage extension would require regulator approval. An upgrade would likely require additional groundwater monitoring wells and other monitoring and waste release controls. For the drummed uranium chip and oil waste, the 30-month temporary storage period expires in mid-October 2004. The disposition of these drums should be complete prior to mid-October 2004. It should, however, be recognized that this date as a driving force is

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somewhat flexible in that the substantive CAMU provisions under which the drummed waste is currently managed allow for extended time frames to achieve a “timely remedy.”

1.4 REPORT ORGANIZATION

Sections 1.0 through 7.0 present the introduction, background, objectives, assessment, and selection of a preferred treatment alternative for the uranium chip and oil waste. Section 8.0 provides a detailed plan and schedule for implementation of the preferred treatment alternative. The report organization is summarized below.

- Section 1.0, Introduction, presents the purpose, background, previous waste treatment studies, schedule, and report organization.
- Section 2.0, Waste Characterization and Designation, presents waste characterization information and discusses applicable waste regulations.
- Section 3.0, Treatment Objectives, presents specific objectives of this action.
- Section 4.0, Development and Description of Drum Treatment/Disposal Alternatives, presents the results of technology screening and the identified treatment alternatives for additional assessment.
- Section 5.0, Detailed Analysis of Alternatives, presents the alternative evaluation criteria and evaluates each alternative against the criteria.
- Section 6.0, Comparative Analysis of Remedial Alternatives, comparatively assesses the alternatives against each other.
- Section 7.0, Preferred Alternative and Implementation Barrier Assessment, identifies the preferred treatment alternative and assesses potential barriers to the implementation of this alternative.
- Section 8.0, Implementation Plan, discusses and summarizes the plan and schedule for the implementation of the preferred treatment alternative.
- Section 9.0, References, lists the references cited in this document.
- Appendix A, Applicable or Relevant and Appropriate Requirements, discusses the applicable or relevant and appropriate requirements (ARARs).
- Appendix B, Implementation Resources and Schedule, presents the detailed resource-loaded plan and schedule for the implementation of the preferred treatment alternative.

2.0 WASTE CHARACTERIZATION AND DESIGNATION

The uranium chip and oil waste from 32 drums was sampled, analyzed, and used for waste designation in 1998. Analysis results and the waste designation are summarized in *Treatment/Disposal Plan for Drummed Waste from the 300-FF-1 Operable Unit, 618-4 Burial Ground* (BHI 1999b) as well as in this section. On a percentage basis, 6% of the total 520 uranium chip and oil drums were sampled. Findings from the characterization effort include the following:

- Uranium enrichment is in a depleted state in all of the solid samples.
- Drum solids consist of uranium chips, uranium fines, and sludges.
- Free liquids (i.e., oil) are present in each drum.
- Heavy metals, PCBs, and VOCs are present in the oil material at concentrations that exceed regulatory thresholds.

All drums unearthed in 2002 were physically inspected to confirm that the contents were consistent with the uranium metal and oil waste stream. Ten percent of the drums were screened to verify that the uranium was in a depleted state.

Findings from waste designation include the following:

- The solids and oil are not a listed waste.
- The oil is a toxicity characteristic dangerous waste for metals and organics.
- The solids may be a toxicity characteristic dangerous waste depending on the amount of residual oil remaining with the solids.
- The solids and oil are a low-level radioactive waste.
- The oil is a *Toxic Substances Control Act of 1976* (TSCA) PCB waste.
- For purposes of disposal, the solids may be a TSCA-regulated PCB waste depending on the amount of residual oil remaining with the solids.

Waste Characterization and Designation

2.1 WASTE CHARACTERIZATION DATA

2.1.1 Oil Sample Results

The oil phase of the waste was analyzed for radionuclides, metals, VOCs, semi-VOCs, and PCBs.

Uranium-238 and uranium-235 were the primary radionuclides detected in the oil. Uranium-238 was detected at concentrations ranging from 7.1 pCi/mL to 1,000 pCi/mL. Uranium-235 was detected at concentrations ranging from 0.45 pCi/mL to 9.4 pCi/mL.

A variety of metal and organic constituents were detected in the oil. Based on concentrations of both metal and organic constituents, the oil is designated as a dangerous waste and regulated for disposal under the *Resource Conservation and Recovery Act of 1976* (RCRA). Table 2-1 lists those constituents with concentrations that exceeded the toxicity characteristic dangerous waste designation criteria (*Washington Administrative Code* 173-303-090). The table includes the maximum detected concentrations, the frequency of drums exceeding the toxicity designation criteria, and the current land disposal restriction (LDR) treatment standards under RCRA (40 *Code of Federal Regulations* [CFR] 268). The toxicity characteristic waste designation criteria and current LDR treatment standard criteria are provided here as a reference for comparison with the waste characterization data. Appendix A contains a more detailed discussion of the applicable and appropriate regulations and requirements (i.e., ARARs) associated with the LDR treatment standards, as well as a discussion of other ARARs including those specific to PCBs.

Table 2-2 lists additional organic constituents that were detected in the oil. Toxicity characteristic waste designation criteria have not been established for these constituents, but several of them are defined as underlying hazardous constituents that must be considered during waste disposition. Table 2-2 includes the range and frequency of detection and the LDR treatment standard, if applicable.

All of the compounds listed in Table 2-2, with the exception of the PCB Aroclor-1254, are typical component constituents of petroleum hydrocarbon products such as kerosene, oil, and gasoline, or are petroleum hydrocarbon-based solvents.

The oil is also regulated under TSCA. Based on the assumption that the uranium chip and oil drums were disposed prior to 1978, the concentration threshold for regulation is 50 parts per million (ppm). PCB concentrations exceeded 50 ppm in many of the oil samples, and exceeded 500 ppm in two of the drums.

Table 2-1. Comparison of Waste Oil Concentrations to Toxicity Designation Criteria and Treatment Standards.

Constituent	Toxicity Characteristic Waste Designation Criteria (mg/L)	Maximum Concentration (mg/L)	Frequency of Detection Above Toxicity Waste Designation Criteria	Current Treatment Standard ^{a,b} (mg/kg total unless noted)
Barium	100	1,170	3 / 32	21 mg/L TCLP
Lead	5.0	277	13 / 32	0.75 mg/L TCLP
Mercury	0.2	1.41	9 / 32	0.025 mg/L TCLP
Benzene	0.5	75	18 / 32 ^c	10
Chloroform	6.0	63	4 / 32 ^c	6.0
2-butanone (MEK)	200	1,900	3 / 32	36
Tetrachloroethene (PCE)	0.7	99	10 / 32 ^c	6.0
Trichloroethene (TCE)	0.5	2,000	19 / 32 ^c	6.0

^a Current treatment standard based on 2002 values for nonwastewater from 40 CFR 268.

^b These treatment standards are specific to the constituents for which the waste was originally designated. Treatment must also address underlying hazardous constituents that might reasonably be expected to be present in the waste.

^c Many of the samples without detections had practical quantitation limits greater than the waste designation criteria.

MEK = methyl ethyl ketone

TCLP = toxicity characteristic leaching procedure

Table 2-2. Other Organic Constituents in Waste Oil. (2 Pages)

Constituent	Range of Detected Concentrations (units in mg/L unless noted)	Frequency of Detection	Treatment Standard ^a (mg/kg total unless noted)
Acetone	2.1 – 130	29 / 32	160
Bis (2-ethylhexyl) phthalate	180 – 1,300	5 / 32	28
Decane	480 – 1,600	10 / 10	--
Di-n-octyl phthalate	54	1 / 32	28
Eicosane	270 – 290	2 / 2	--
Ethylbenzene	0.16 – 190	20 / 32	10
Dodecane	250 – 620	5 / 5	--
4-Methyl-2-pentanone (MIK)	9.9 – 18.0	4 / 32	33
Methylene chloride	0.16 – 200	24 / 32	30
2-Methylnaphthalene	110 – 360	9 / 32	--
Naphthalene	1.1 – 400	12 / 32	5.6

Table 2-2. Other Organic Constituents in Waste Oil. (2 Pages)

Constituent	Range of Detected Concentrations (units in mg/L unless noted)	Frequency of Detection	Treatment Standard ^a (mg/kg total unless noted)
PCB Aroclor-1254	18 – 540 mg/kg	21 / 32	10
Toluene	0.18 – 410	30 / 32	10
Undecane	190 – 450	11 / 11	--
Xylenes	0.5 – 1,200	29 / 32	30

NOTE: The frequency of detection in this table is a simple listing of the number of detections of the constituent for the number of samples analyzed.

^a Treatment standard based on 2002 values for nonwastewater from 40 CFR 268.

-- = treatment standard not identified from 40 CFR 268

MIK = methyl isobutyl ketone

2.1.2 Uranium Chip and Sludge Sample Results

The uranium chip solids and sludges were analyzed for radionuclides and metal constituents. The chips and sludge solids were not analyzed for organic constituents.

Uranium-235 and uranium-238 were the primary radionuclides detected in the solids. Uranium-235 was detected in the solids at concentrations ranging from 290 pCi/g to 4,500 pCi/g. Uranium-238 was detected in the solids at concentrations ranging from 28,000 pCi/g to 450,000 pCi/g.

Based on concentrations of the metal constituents, the uranium solids alone do not exceed the dangerous waste designation criteria. From BHI (1999b), this determination is based on a statistical calculation of the 90% upper confidence limit. Metal concentrations generally were below the toxicity characteristic waste designation criteria. However, concentrations of lead and selenium exceeded designation criteria in a small number of samples. Considering the two solid waste types of chips and sludges, there does not appear to be a correlation between the different solid waste phases and contaminant concentrations.

The determination that the uranium solids do not exceed the dangerous waste designation criteria is based on the assumption that essentially 100% of the oil is removed from the solids. If sufficient residual oil remains with the solids, this could change the waste designation. The EPA views phase separation of characteristic hazardous waste (Washington State dangerous waste) as acceptable pretreatment provided the remaining material that exhibits the characteristic (the oil in this instance) is treated to meet LDR standards (55 *Federal Register* 22544). The EPA allows the separated waste streams to be considered individually to determine hazardous waste designation. A phase that no longer exhibits a hazardous waste characteristic (and which is not a listed waste) would not be subject to hazardous waste standards.

Waste Characterization and Designation

The TSCA requires a multi-phase waste to be separated by phase, with the regulatory status of each phase determined separately. The uranium solids were not analyzed for PCBs, and additional analysis would be required to make a definitive determination of PCB concentrations and the TSCA status. However, it is anticipated that the PCBs would occur predominantly in the oil phase, and thus it is unlikely that the dry uranium solids would exceed a PCB concentration of 50 ppm (the concentration that specifically defines a PCB remediation waste) or 10 $\mu\text{g}/100\text{ cm}^2$ (a surface concentration for contaminated surfaces that is generally considered to be equivalent). Assuming that this is the case and that the uranium solids are sufficiently separated from the oil to pass a paint filter test, the solids would not be regulated for purposes of disposal under TSCA. More detailed information is provided in Appendix A.

2.2 PHASE SEPARATION CALCULATION

The BHI (1999b) and BHI (2002b) documents evaluate the degree of phase separation required such that the uranium chip solids will not designate as a dangerous waste and will meet the LDR treatment standards. The results are presented in terms of an allowable weight percent residual oil. However, because of the large difference in density between depleted uranium and oil, the weight percent calculation can be misleading. Presented below is an example of the weight percent calculation followed by an example based on volume percent for both the dangerous waste as well as the LDR criteria.

From the dangerous waste perspective, it was previously determined in the BHI (2002b) document that the uranium solids could contain 0.44 weight percent residual oil or less and not designate as a dangerous waste. This weight percent was calculated using the maximum detected trichloroethene concentration in oil of 2,000 mg/L (BHI 1999b, 2002b), a dangerous waste toxicity characteristic concentration of 0.5 mg/L for trichloroethene, and an oil density of 0.88 kg/L (BHI 1999b). The toxicity characteristic leaching procedure (TCLP) analysis is used for comparison to toxicity characteristic designation criteria. In the TCLP analysis, 100 g of sample is used with 2 L of leaching solution. For the phase-separated solids to meet the designation criteria, a mass of no more than 1 mg of trichloroethene can leach during the TCLP (2 L of leaching solution multiplied by 0.5 mg/L). A mass of 1 mg trichloroethene will occur in an oil mass of 0.44 g (1 mg mass allowed divided by the oil trichloroethene concentration of 2,000 mg/L multiplied by an oil density of 880 g/L). The weight percent of residual oil on the solids to not designate as a dangerous waste is 0.44% (0.44 g mass allowable oil on sample divided by 100 g sample weight).

Calculating the percent residual oil on a volume basis provides a different perspective. From various sources including the periodic table of elements, the density of uranium is 19 kg/L. From above no more than 1 mg of trichloroethene can leach during the TCLP (2 L of leaching solution multiplied by 0.5 mg/L). A mass of 1 mg trichloroethene will occur in an oil volume of 0.0005 L (1 mg mass allowed divided by the oil trichloroethene concentration of 2,000 mg/L). The volume of the 100-g sample used in the TCLP analysis is the residual oil volume (residual oil mass divided by the oil density) plus the depleted uranium volume (difference of the 100-g sample and the oil mass divided by the depleted uranium density). The volume percent of

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residual oil on the solids to not designate as a dangerous waste is 8.7% (0.0005 L volume allowable oil on sample divided by volume of residual oil plus volume of depleted uranium). Using the LDR treatment standards, it was previously determined that the uranium solids could contain 0.26 weight percent residual oil or less and still meet LDR treatment standards. This weight percent was calculated using the maximum detected trichloroethene concentration in oil of 2,000 mg/L (BHI 1999a, 2002b). The calculation assumed a uranium solids mass of 28 kg depleted uranium and an oil mass of 56 kg (64 L at a density of 0.88 kg/L) (BHI 1999a). The LDR treatment standard for trichloroethene is 6.0 mg/kg. The mass of trichloroethene mixed with the uranium solids that would meet the 6 mg/kg standard is 168 mg (6 mg/kg multiplied by 28 kg of depleted uranium). The associated mass of oil mixed with the solids would be 0.074 kg of oil (168 mg divided by 2,000 mg/L multiplied by 0.88 kg/L density). The total solids and oil mass that would meet the treatment standard of 6 mg/kg for trichloroethene would be 28.074 kg (28 kg solids plus 0.074 kg residual oil). The weight percent of residual oil on the solids would be 0.26% (0.074 kg divided by 28.074 kg).

For the residual oil volume percent using the LDR standards, the volume of solids associated with this mass is only 1.47 L (28 kg of solids divided by a density of 19 kg/L). The oil volume allowable is 0.084 L (0.074 kg of residual oil allowed divided by a density of 0.88 kg/L). The volume percent of residual oil on the solids is 5.4% (0.084 L of residual oil divided by 1.554 L of solids and residual oil).

These calculations assume that the trichloroethene occurs exclusively in the liquid oil phase of the waste. This is likely a good assumption for the uranium chips, but may not necessarily be a good assumption for the fine sludges. As discussed in Section 2.1.2, the chips and sludges were not analyzed for organics. However, most phase-separation activities are likely to remove the fine sludges with the oil.

Table 2-3 shows the results of a residual oil analysis using both the weight percent and volume percent methods. The residual percentage in the designation calculation column reflects the quantity of oil that could remain with the uranium solids following phase separation and allow the solids to not be designated as a dangerous waste. It is important to note that if the solids were to be redesignated they would have to pass the paint filter test (no free liquids). The correlation between the percent of residual oil and passing the paint filter test for this waste is not known. Also included in Table 2-3 are percent residual calculations for meeting the LDR treatment standards for the mixture. The analysis considered four primary contaminants of concern and was performed for those drums that were sampled and determined to contain oil that exceeds the designation or the treatment standards. The oil in 7 of the 32 drums sampled is below the dangerous waste designation criteria and below the LDR treatment standards; therefore, these drums are not included in Table 2-3.

Table 2-3. Solid/Oil Separation Calculations. (3 Pages)

Drum No. (300A-98- prefix)	Oil Concentration (mg/L)					
	PCB Aroclor-1254	Trichloroethene (TCE)		Naphthalene	Tetrachloroethene (PCE)	
	LDR Calculation	Designation Calculation ^a	LDR Calculation	LDR Calculation	Designation Calculation ^a	LDR Calculation
0207	180	0.29 J	0.29 J	ND	ND	ND
% wt residual	4.66%	--	--	--	--	--
% vol residual	51.35%	--	--	--	--	--
0226	97.0	0.48 J	0.48 J	ND	ND	ND
% wt residual	8.32%	--	--	--	--	--
% vol residual	66.20%	--	--	--	--	--
0219	10.0	0.67 J	0.67 J	ND	6.5	6.5
% wt residual	46.81%	>30%	--	--	>30%	>30%
% vol residual	95.00%	>30%	--	--	>30%	>30%
0270	350	ND	ND	320	ND	ND
% wt residual	2.45%	--	--	1.52%	--	--
% vol residual	35.19%	--	--	24.95%	--	--
0345	ND	7.8	7.8	65	4 J	4 J
% wt residual	--	>30%	40.37%	7.05%	>30%	--
% vol residual	--	>30%	93.60%	62.08%	>30%	--
0282	180	4.3 J	4.3 J	150	ND	ND
% wt residual	4.66%	>30%	--	3.18%	--	--
% vol residual	51.35%	>30%	--	41.50%	--	--
0347	530	1.40	1.40	110	ND	ND
% wt residual	1.63%	>30%	--	4.29%	--	--
% vol residual	26.39%	>30%	--	49.17%	--	--
0332	ND	6.3 J	6.3 J	190	43	43
% wt residual	--	>30%	--	2.53%	28.65%	10.94%
% vol residual	--	>30%	--	35.90%	>30%	72.61%
0291	260	1.80	1.80	ND	1.30	1.30
% wt residual	3.27%	>30%	--	--	>30%	--
% vol residual	42.22%	>30%	--	--	>30%	--
0214	18.0	1.60	1.60	ND	0.54 J	0.54 J
% wt residual	32.84%	>30%	--	--	--	--
% vol residual	91.35%	>30%	--	--	--	--
0189	120	4.00	4.00	ND	2.50	2.50
% wt residual	6.83%	>30%	--	--	>30%	--
% vol residual	61.29%	>30%	--	--	>30%	--

Table 2-3. Solid/Oil Separation Calculations. (3 Pages)

Drum No. (300A-98- prefix)	Oil Concentration (mg/L)					
	PCB Aroclor-1254	Trichloroethene (TCE)		Naphthalene	Tetrachloroethene (PCE)	
	LDR Calculation	Designation Calculation ^a	LDR Calculation	LDR Calculation	Designation Calculation ^a	LDR Calculation
0106	18.0	ND	ND	ND	ND	ND
% wt residual	32.84%	--	--	--	--	--
% vol residual	91.35%	--	--	--	--	--
0123	ND	0.87	0.87	ND	ND	ND
% wt residual	--	>30%	--	--	--	--
% vol residual	--	>30%	--	--	--	--
0115	ND	300	300	ND	ND	ND
% wt residual	--	2.93%	1.73%	--	--	--
% vol residual	--	>30%	27.54%	--	--	--
0351	86	2.10	2.10	ND	1.10	1.10
% wt residual	9.28%	>30%	--	--	--	--
% vol residual	68.84%	>30%	--	--	--	--
0016	150	ND	ND	43	99.00	99.00
% wt residual	5.54%	--	--	--	12.44%	5.06%
% vol residual	55.88%	--	--	--	>30%	53.52%
0196	55	0.18 J	0.18 J	ND	ND	ND
% wt residual	13.79%	--	--	--	--	--
% vol residual	77.55%	--	--	--	--	--
0232	540	ND	ND	400	ND	ND
% wt residual	1.60%	--	--	1.22%	--	--
% vol residual	26.03%	--	--	21.01%	--	--
0256	250	10 J	10 J	300	ND	ND
% wt residual	3.40%	>30%	--	1.62%	--	--
% vol residual	43.18%	>30%	--	26.18%	--	--
0261	29	0.88	0.88	ND	0.78 J	0.78 J
% wt residual	23.28%	>30%	--	--	>30%	--
% vol residual	86.76%	>30%	--	--	>30%	--
0243	460	2000	2000	ND	ND	ND
% wt residual	1.88%	0.44%	0.26% ^b	--	--	--
% vol residual	29.23%	8.71%	5.39% ^b	--	--	--
0267	170	0.58 J	0.58 J	ND	0.97	0.97
% wt residual	4.92%	>30%	--	--	>30%	--
% vol residual	52.78%	>30%	--	--	>30%	--

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Table 2-3. Solid/Oil Separation Calculations. (3 Pages)

Drum No. (300A-98- prefix)	Oil Concentration (mg/L)					
	PCB Aroclor-1254	Trichloroethene (TCE)		Naphthalene	Tetrachloroethene (PCE)	
	LDR Calculation	Designation Calculation ^a	LDR Calculation	LDR Calculation	Designation Calculation ^a	LDR Calculation
0054	46	1,000	1,000	ND	ND	ND
% wt residual	16.06%	0.88%	0.53%	--	--	--
% vol residual	80.51%	16.09%	10.23%	--	--	--
0036	48	ND	ND	61	ND	ND
% wt residual	15.49%	--	--	7.47%	--	--
% vol residual	79.83%	--	--	63.56%	--	--
0045	18.00	2.2 J	2.2 J	30	ND	ND
% wt residual	32.84%	>30%	--	14.11%	--	--
% vol residual	91.35%	>30%	--	78.01%	--	--
Designation criteria (mg/L)	NA	0.5	NA	NA	0.7	NA
LDR Treatment standard (mg/kg)	10	NA	6.0	5.6	NA	6.0

^a The maximum percent of oil that could remain with the depleted uranium chips after a phase separation, with the separated solids being redesignated. Note that to redesignate, the solids would need to pass the paint filter test. For the redesignation calculations, values greater than 30% are noted rather than displaying the calculated value.

^b Indicates most conservative or lowest residual oil percentage.

-- = Calculation is not needed because the oil concentration is below the treatment standard.

J = Detected concentration below the analytical practical quantitation limit.

NA = Not applicable.

ND = Analyte was not detected.

% residual is the percent of residual oil either on a weight or volume basis that would be allowed to remain on the uranium chips in order for the chips to meet the designation criteria or the treatment standard at the bottom of the table. Note that this calculation does not account for the lack of free liquid requirements.

The analysis indicates that for a majority of the drums, if a phase-separation process resulted in solids material that was free of liquid (as determined by the paint filter test), then the solids could potentially be redesignated. The correlation between the percent of residual oil and passing the paint filter test for this waste is not known. The lowest percent of residual oil for redesignation of the solids from Table 2-3 on a volume basis is 8.7%. For comparison purposes, sand with a moisture content of 9% by weight on a volume basis would have a moisture content of 12.9%. A soil moisture content of 9% is generally fairly dry and is typical of near-surface Hanford Site soils and would easily pass the paint filter test. The implications are that where the percent residual volumes shown in Table 2-3 are low, the solids would likely need to be relatively free of oil to successfully redesignate the solids as nondangerous. This comparison is difficult, however, because the uranium metal is not likely analogous to sand since the uranium metal has a much smaller surface area than sand and thus does not have the same liquid-holding ability.

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Also included in the Table 2-3 are percent residual oil calculations for meeting the LDR standards. The analysis demonstrates that even for the most highly contaminated oil, the uranium solids could contain over 5% by volume oil and still meet the LDR treatment standards. For most of the drums, a substantially greater volume of residual oil could remain with the uranium solids.

3.0 TREATMENT OBJECTIVES

Treatment and disposition of the uranium chip and oil waste must be conducted in a manner that is protective of human health and the environment. The principal threats to be addressed are radioactive and nonradioactive hazardous substances contained in the waste.

The specific objectives of this action are as follows:

- Reduce or eliminate the potential for exposure to hazardous substances above levels that are protective of the workers, the public, and the environment
- Reduce or eliminate the potential for a future release of contaminants.

4.0 DEVELOPMENT AND DESCRIPTION OF DRUM TREATMENT/DISPOSAL ALTERNATIVES

4.1 SCREENING OF TECHNOLOGIES

Drum treatment technologies identified in *Technology Alternatives Baseline – Nondestructive Characterization and Treatment of Drummed Depleted Uranium Chips/Shavings in Oil* (BHI 2002b) were screened to identify potential treatment/disposal options that could be applied to the uranium chip and oil waste.

Specific companies and/or potentially proprietary names are identified in this section and throughout the remainder of this document. Identification of specific company and proprietary names does not preclude the possibility that other companies may offer the same or similar technologies. Solicitation of services and subsequent placement of any commercial contracts to support treatment and/or disposal of the uranium chip and oil waste will be performed within all applicable federal procurement regulations.

A large number of technologies were screened to form potential treatment alternatives for detailed assessment. Screening was performed based on effectiveness, implementability, and cost of the technology. The technology screening is summarized in Tables 4-1 and 4-2. Table 4-1 lists technologies that were eliminated from further consideration along with a brief explanation. Table 4-2 lists the technologies that were retained to form potential treatment alternatives.

Table 4-1. Technologies Eliminated Through Screening Process. (2 Pages)

Category	Method	Comments for Elimination
Phase separation	Chip wringer	Many unresolved technical questions; has not been used for mixed waste applications.
	Thermal desorption	Does not appear to be effective for phase separation.
	Filtration	Many unresolved questions; would not remove dissolved metals from oil. Would not likely allow radiological “free-release” of liquids. Removal of fines and suspended solids is not necessary for many of the liquid treatment technologies.
Whole drum	Molten aluminum bath	Some metals may sublime into the offgas. Some potential operational problems were identified during treatability testing of a uranium chip and organic waste test material. Technology has never been applied outside of laboratory testing.
	Gasification/vitrification	Primary provider of technology for application to these drums has declared bankruptcy.

Table 4-1. Technologies Eliminated Through Screening Process. (2 Pages)

Category	Method	Comments for Elimination
Whole drum (cont.)	Molten salt	Liquid waste poses potential explosion hazard from super-heated vapor. There are currently no treatment providers identified for this technology.
	Solvated electron technology	Many unresolved technical questions. BHI (2002b) authors unsure of technology claims of producing a friable nonpyrophoric solid. No treatment of heavy metals.
Liquids	Incineration at nonradiological TSCA incinerator	Separation process to achieve free release of liquids is not likely.
	Steam reformer	Generates secondary wastes requiring additional treatment including offgases, first-stage evaporation, and waste material from fluidized bed systems. Unclear disposition of metal contaminants. No steam reformer facilities were identified in BHI (2002b).
	Radiolysis	Many technical and regulatory implementation questions. The technology is currently in the development stage.
	Mediated electrochemical oxidation	Very high cost compared to other alternatives. The technology is currently in the development stage.
	Supercritical water oxidation	Very high cost compared to other alternatives. The technology is currently in the development stage.
Solids	Calcination/scintering	Similar to oxidation treatment, with significantly higher cost. Identified facility cannot accept RCRA- or TSCA-regulated waste or uranium chips with organics.
	Chemical oxidation	Los Alamos National Laboratory developed and built this treatment system, but it was never tested and has since been dismantled.

Table 4-2. Technologies Retained Through Screening Process. (2 Pages)

Category	Method	Comments for Retention
Phase separation	Decanting	Simple phase separation. Also necessary as first step of more thorough phase separation.
	Solvent washing	Thorough phase separation of the oil from the uranium chips. Successful bench-scale testing completed. Full-scale testing completed; preliminary results appear positive. Final results pending.
Whole drum	Vitrification	Would provide complete onsite treatment of all waste phases. Successful bench-scale testing completed.
	Stabilization/encapsulation	Uses a material that forms a monolith with petroleum hydrocarbons.

Table 4-2. Technologies Retained Through Screening Process. (2 Pages)

Category	Method	Comments for Retention
Liquids	Incineration at radiological TSCA incinerator	DOE low-level radiological TSCA incinerator located in Tennessee.
	Dechlorination treatment followed by incineration in radiological oil burner	Single vendor located in Tennessee capable of both treatment steps.
Solids	Encapsulation	Capabilities for conducting either on site or off site.
	Oxidation	Capabilities for conducting either on site or off site. Well-known technology that is routinely used at depleted uranium milling facilities.

DOE = U.S. Department of Energy

Treatment/disposal technologies that were determined to be viable options were assembled into alternatives in this report. The alternatives are described in the following sections along with a summary of the associated limitations and issues. For each treatment alternative presented, it is assumed that the treated waste product would be disposed of at the ERDF unless otherwise specified.

4.2 DESCRIPTION OF ALTERNATIVES

4.2.1 No Action

The no action alternative, which is required to be analyzed by the “National Oil and Hazardous Substances Contingency Plan” (40 CFR 300), is included as a baseline for comparison with the other alternatives and to determine the appropriateness of conducting drum treatment. In this analysis, no action represents a situation where the drums continue to be stored at the ERDF staging area under the current storage conditions, but without further action to facilitate their disposition. Selection of the no action alternative as the preferred alternative would require that the drums pose no unacceptable risk to human health or the environment.

4.2.2 Vitrification

Vitrification is a process that uses heat to convert waste into a glass-like solid. This alternative would involve mobilizing a temporary vitrification facility within the ERDF, mixing the drums and their contents with soil, vitrifying the mixture, and disposing of the resulting glass monolith at the ERDF.

Vitrification would be done inside a standard roll-off box (typically 15 m³ [20 yd³]), lined with a refractory liner and sand. Because there are potential treatment problems with liquid wastes such as boiling and melt disturbances and disruptions, free liquids would be minimized by mixing with soil. It is anticipated that the drums would be placed into the box, breached, and crushed,

and the liquids soaked up by the soil prior to vitrification. Pyrophoric reactions of the uranium metal are not anticipated because the drums would be covered in a layer of soil prior to and following drum crushing.

Vitrification would be accomplished by inserting electrodes into the waste/soil mixture and heating to temperatures from 1,600°C to 2,000°C. The vitrification process would take place within a fully contained and ventilated hood to control gaseous emissions. Offgas treatment would include gas cooling, scrubbing, possible activated carbon filtration, and thermal oxidation.

The process could be performed sequentially with removal of the box and vitrified monolith between treatment batches. Disposal could include either removing the vitrified monolith from the box for disposal in the ERDF or disposing of the box and vitrified monolith together in the ERDF. Some oxidation of the uranium chips would be expected from the vitrification process, but oxidation throughout the metal pieces may not be complete. Because oxidation may be incomplete, the ERDF disposal would need to be conducted in a manner that maintains the integrity of the vitrified monolith so that unoxidized uranium would not be exposed to the atmosphere.

The end product of the vitrification process would be a glass-like material that immobilizes the uranium and RCRA metals. The organic constituents (including PCBs) would be thermally destroyed during the process either through the actual vitrification process or through the offgas thermal oxidation system. Organic treatment is estimated at a 99.9999% destruction removal efficiency.

Vitrification is a proven treatment technology for a wide range of organic and inorganic contaminants. This proposed mobile process has been implemented at other sites, primarily on contaminated soils. The process has been applied to heterogeneous wastes such as soils with debris. The process has not been applied directly to a predominant liquid waste similar to the uranium chip/oil mixture. However, as discussed above, the proposed vitrification treatment approach involves addition of soil to the waste to soak up the liquid and to provide for a vitrifiable matrix prior to vitrification. A bench-scale treatability test has been conducted on a small (3.8-L [1-gal]) batch of the uranium chip and oil waste. Results of the treatability test are included in *Treatability Study for the GeoMelt Planar-ISV Remediation of Buried Drums Containing Depleted Uranium Chips and Oil Waste* (Geosafe 1999). The test successfully vitrified the 3.8-L (1-gal) canister containing 1.4 L of oil, 0.9 kg of depleted uranium chips, and soil during 8 hours of operation. The material for the bench-scale test was taken from a drum containing elevated levels of the primary contaminants of concern. PCBs were at a concentration of 480 mg/L and trichloroethene at a concentration of 2,000 mg/L. Following vitrification, the vitrified product was analyzed for PCBs and for RCRA metals using the TCLP. Laboratory analytical results indicated that all analytes, with the exception of barium, were below the laboratory detection limits of 61 µg/kg for PCBs and 0.1 to 50 µg/L for the TCLP RCRA metals. Barium was detected at a concentration of 309 µg/L. All concentrations were well below the required treatment standards for disposal. Offgas sampling and analysis results were within acceptable parameters (Geosafe 1999).

As indicated in BHI (2002b), prior to implementation, additional larger scale treatability testing may be required to verify performance of the actual treatment system and to optimize the process design. However, at the time of the bench-scale vitrification testing, the vendor indicated that additional treatability testing might not be needed. Mobile vitrification systems are currently available from several vendors. A system used by AMEC Earth and Environmental's Geomelt Division was used for purposes of costing this alternative.

The vitrification system would be completely contained under a large-scale fume hood that would be plumbed to an offgas treatment system; therefore, essentially no air emissions or worker inhalation exposures would be associated with the vitrification process. Worker exposure to the waste using the vitrification process would be minimal. Workers would be required to place the drummed waste into the treatment box and would be required to operate machinery such as a trackhoe or other equipment to crush the drums of waste placed into the box. The vitrification process would require a large electrical supply, so electrical controls and safety requirements would be associated with the process.

Because this alternative may require additional treatability testing and extensive equipment mobilization, its implementation could take treatment past the scheduled ERDF drum disposition schedule of October 2004. It is anticipated that with treatability testing, full-scale mobilization, and equipment testing, treatment would begin during the third or fourth quarter of fiscal year 2004 (June – September 2004) and would be completed within approximately 10 months. It is anticipated that without additional treatability testing treatment could begin during the second quarter of fiscal year 2004 (January 2004) and could potentially meet the drum disposition schedule of mid-October 2004.

The cost for this alternative would be \$2.8 million. A cost summary of all treatment alternatives is provided in Section 4.3.

4.2.3 Whole-Drum Stabilization

Stabilization is a process in which stabilizing reagents are added to waste to chemically interact with and/or encapsulate contaminants and thus reduce their mobility. This alternative would involve mobilizing a temporary stabilization process within the ERDF, mixing the uranium chip and oil waste with stabilizing reagents, and disposing of the resulting solid at the ERDF.

Because the liquid component of the drum waste is a petroleum hydrocarbon-based organic, whole-drum stabilization would require a material specifically designed for petroleum hydrocarbon stabilization. An example of a product in wide use is the trade-named Petroset (a trademark of Fluid Tech Inc.) solidification technology, which has been used previously at the ERDF for treating waste petroleum hydrocarbons. Other polymer-based organic solidification materials include products under the trade names Enviro-bond (a trademark of Petroleum Environmental Technologies, Inc.) and Nochar.

The technologies are based on the addition of a chemical to a mixture of waste material and oil to form a stabilized waste. The Petroset technology forms a stabilized waste monolith with compressive strength similar to a low-strength concrete (up to 345 kPa [50 lb/in²]). The Enviro-bond material forms a stabilized waste monolith that is similar to a hard rubber. The Nochar material forms a foam rubber-like stabilized material with little structural strength. Therefore, the Nochar technology alone does not appear to be capable of encapsulating or stabilizing the uranium chips. For application to the uranium chip and oil waste, the drum contents (oil and uranium chips) and the chemical activator would be added to a mixer or would be mixed within the drum. This process would be done in a temporary mobile structure erected at the ERDF. The mixing process would break up and suspend the uranium chips in the oil. Some additional oil may be added during the process to optimize the solids-to-oil ratio. If mixed outside of the original drum, the mixture would be transferred into drums or steel boxes for solidification.

Using the Petroset or Enviro-bond technologies, the end product would be a solid monolith that encapsulates the uranium, immobilizes RCRA metals, and contains the organic compounds, including the PCBs and chlorinated solvents. The process would not oxidize the uranium. Because of this, the ERDF disposal would need to be conducted in a manner that maintains the integrity of the solid monolith so that unoxidized uranium is not exposed to the atmosphere. Current ERDF practices for drums of solidified oil include compressing and mixing the stabilized drum with soil during disposal. This is done because of concerns regarding organic decomposition over time leaving a potential subsidence void (BHI 2002b). This practice likely would not be appropriate for maintaining the pyrophoric uranium metal in a nonpyrophoric state.

Stabilization is a proven treatment technology for immobilizing inorganic constituents such as the RCRA metals found in the uranium chip and oil waste. However, stabilization is not a common treatment technology for organic constituents (including PCBs), and the RCRA waste treatment standards for organics are based on destruction or removal technologies. However, some stabilization reagents have chemical properties that can immobilize certain organic constituents and a demonstration of immobilization can be made on a case-by-case basis. The demonstration requires a total waste analysis of the stabilized waste using organic solvents and aggressive conditions to show that actual immobilization of the organic constituents has occurred. Stabilization also is not a common treatment technology for PCBs, and a similar demonstration likely would be required to meet TSCA requirements.

Stabilization processes are available from several vendors. However, none of the stabilization technologies considered to be applicable for the uranium chip and oil waste have undergone testing for immobilization of organic constituents. The Petroset method, available from Fluid Tech, Inc., was used for purposes of costing the alternative. It is not known whether the Petroset material would have the strong adsorptive properties and irreversible properties for organics necessary to make a successful demonstration of immobilization. From discussions with the developers of the Enviro-bond material, the extraction solvents used in the total waste analysis would dissolve or depolymerize the stabilized polymer material, and thus a demonstration of immobilization could not be made.

The period of time required to mobilize and implement this alternative on site would be relatively short. However, time required for the additional treatability testing to demonstrate the effectiveness of the alternative is uncertain given the lack of information on applications to organic constituents. If early testing were to be successful, it is likely that this alternative could meet the ERDF drum disposition schedule of mid-October 2004.

The total cost for this alternative would be \$1.6 million.

4.2.4 Phase Separation/Liquid Incineration/Solids Stabilization

This alternative would consist of three technologies formed into a single alternative. The technologies are phase separation, incineration (liquid phase), and stabilization (solids phase). The alternative is also considered under onsite and offsite options in order to assess the preference between onsite versus offsite treatment. The technologies would be the same for both the onsite and offsite options. The primary differences between the two options are discussed in greater detail in Sections 4.2.4.4 and 4.2.4.5 and include mobilization of an onsite treatment facility within the ERDF versus transportation of the drums to an offsite treatment facility. Under both options, the stabilized solids would be disposed of in the ERDF.

4.2.4.1 Phase Separation. The first step in this alternative would involve separation of the liquid oil phase from the solid uranium chip phase of the waste. Phase separation would serve two purposes. First, several of the solids stabilization technologies being considered would require removal of most of the oil prior to stabilizing the uranium chips. Second, as discussed in Section 4.2.3, the regulatory requirements for treating the hazardous organic constituents and PCBs may not be met by stabilization, so these constituents would need to be segregated for treatment by other methods. For purposes of developing this alternative, it is assumed that phase separation would consist of decanting followed by a washing process using a petroleum hydrocarbon solvent followed by drying of the solids.

Based on recently completed bench-scale treatability testing, the proposed phase separation process would be viable and effective (BHI 2002a). Full-scale testing has been completed; however, the final results are pending. Treatability testing was performed by the East Tennessee Materials and Energy Corporation located in Oak Ridge, Tennessee (BHI 2002a), using a uranium chip and oil waste from the Rocky Flats U.S. Department of Energy (DOE) site located in Colorado. The Materials and Energy Corporation is a wholly owned subsidiary of Perma-Fix Environmental Services, Inc. Perma-Fix also owns a subsidiary company in Kingston, Tennessee (Diversified Scientific Services). The Diversified Scientific Services facility may also be used in this alternative (discussed in Section 4.2.4.2). Kingston is 31 km (19 mi) from Oak Ridge. For purpose of discussion, both of these subsidiary companies will be referred to as Perma-Fix throughout this document. Where the location difference is relevant it will be noted. The Rocky Flats waste was analogous to the Hanford Site waste in that it consisted of depleted uranium chips and turnings from milling operations stabilized in oil with similar organic and metal contaminants including PCBs, trichloroethene, and tetrachloroethene. Contaminant concentrations of the oil ranged up to 22 mg/kg for PCBs, 14,300 mg/kg for trichloroethene, and 12,200 mg/kg for tetrachloroethene. Both bench-scale and full-scale phase separation treatability

testing have been completed. During testing the uranium chips were analyzed for contaminants of interest during various steps in the phase separation process.

Results from the full-scale testing are pending. The discussion presented here is based on the bench-scale testing.

Following decanting, the uranium chips were analyzed for PCBs with a resulting concentration of 6.6 mg/kg. Given the initial PCB oil concentration of 22 mg/kg, this means that about 30% of the PCBs remained with the solid phase. These results suggest that a simple decant alone may not be sufficient for meeting PCB disposal requirements for waste that contains higher initial concentrations of PCBs. The decanted uranium chips were not analyzed for organics other than PCBs, so implications for other organic constituents are not known.

Following decanting, batches of chips were rinsed using different solvents including kerosene, mineral oil, hexane, and mineral spirits. During the first battery of tests, chips were rinsed twice. Following rinsing, the chips were grouted prior to laboratory analysis. Results from the first battery of tests indicated that the LDR treatment standards were not met in any of the samples for trichloroethene, tetrachloroethene, and some volatile organics. None of the grouted samples were analyzed for PCBs.

During the second battery of tests, the chips were rinsed from three to five times using d-limonene and turpentine in separate tests. Chip samples from the second battery of tests were not grouted prior to analysis. Rinsed chip sample results from both solvents indicated that the organic LDR treatment standards would be met for the separated solids. The results also indicated that if the solids were redesignated, they would no longer be a toxicity characteristic hazardous waste for organics. None of the organics analyzed for in the turpentine-rinsed solids sample were detected using a total waste analysis. Trichloroethene was detected at a concentration of 1.8 mg/kg in the d-limonene-rinsed solid sample. The samples were not analyzed for PCBs.

The simplest method for separation of the liquid and solid phases would be a simple decanting process in which the oil would be drained, pumped, or poured from the drums to the extent possible. However, concentrations of organic constituents remaining in the solids phase would need to meet LDR treatment standards. Based on maximum organic concentrations in the worst-case drum sample, this would require a separation efficiency of greater than 99.76% by weight or 94.6% by volume. Simple decanting would not likely achieve this high degree of phase separation. A simple decant may be sufficient to meet the treatment standards where initial contaminant concentrations are lower, as discussed in Section 2.2. A similar situation exists with respect to PCBs and TSCA regulation. For drums where the PCB concentration in the oil exceeds 50 ppm, phase separation would need to be sufficient to ensure that the resulting solids do not contain a separable liquid phase. It is uncertain whether a simple decant would achieve this. The phase separation process may be evaluated further during remedial design to determine whether a simple decant would be appropriate for some drums. However, a drum-by-drum determination would likely require additional characterization of drums that have not been sampled.

For a greater degree of phase separation, it is assumed that decanting would be followed by a washing process for the solids and then followed by a solids drying process in an inert atmosphere as conducted during full-scale treatability testing. Oil and sludge would be further separated from the solid material using a solvent wash method for solids contaminated with PCBs and chlorinated volatile/semivolatile organic compounds. The solvent wash would include a series of solvent extractions as necessary to separate the oil from the uranium chips. The solvent wash process as conducted by Perma-Fix during treatability testing would involve rolling a drum with uranium chips and extraction solvent into a horizontal position on a drum-rolling apparatus. This process would be repeated for a second solvent rinse by draining the initial solvent and replacing it with new solvent. If additional rinsing were to be necessary, the uranium chips would be placed in a basket and placed in a vertical drum where additional solvent rinses would be pumped through the basket and drum. Following the final rinse, the solvent would be drained from the chips, the chips placed in a drum, and the drum sparged using an inert gas until the chips are dry. Following drying, the chips are covered with a clean mineral oil to maintain them in an oxygen-free state.

During and following phase separation, the pyrophoric property of the solid phase (uranium chips) would have to be addressed through appropriate administrative and engineering controls to maintain stability during subsequent movement, treatment, and/or storage. The solvent wash process as conducted by Perma-Fix during treatability testing considered the length of time of uranium metal exposure to air, submersion of the uranium chips in oil and/or extraction solvent, and use of inert gas as appropriate controls for the pyrophoric property of the uranium chips. Administrative and engineering controls would be developed and provided based on appropriate and relevant design and procedural criteria for operations at the Hanford Site.

Assuming that solvent washing were to be used, the products from the phase separation process would be uranium chips that are no longer designated as a hazardous waste or meet the RCRA treatment standards and that would not be regulated under TSCA; the retrieved oil; and the spent solvent solution.

4.2.4.2 Incineration (RCRA/TSCA, Low-Level Radioactive). Incineration is a process that destroys organic constituents through high-temperature treatment. In this alternative, the liquid phase, consisting of the contaminated oil and spent solvent, if any, would be treated via incineration. Currently two options are available or nearing availability nationwide for incineration of oil/solvent waste designated as a RCRA/TSCA/radioactive waste. One option would be incineration at the DOE's RCRA/TSCA low-level radioactive waste permitted facility in Oak Ridge, Tennessee. Organic compounds, including PCBs, are thermally destroyed during the incineration process, and the final waste form is incinerator ash containing oxidized uranium fines and RCRA metals. Incinerator ash is disposed of at the Envirocare landfill facility in Utah. Stabilization of the ash for RCRA metals is generally conducted as necessary using cement grout. Incineration is a well-established technology for treatment of organic constituents including PCBs, and the Oak Ridge incinerator has been permitted and used successfully for several years. If phase separation was conducted outside of the State of Tennessee, permission to treat Hanford Site waste at the Oak Ridge facility would be required from the State of

Tennessee. There is also the potential option of using the waste oil and solvent as incinerator fuel. The end result is the same (i.e., incineration of the waste).

The second incineration option would involve treating the oil/solvent waste at the Perma-Fix facility in Oak Ridge, Tennessee, followed by burning of the treated waste in an industrial boiler at the Perma-Fix facility in Kingston, Tennessee. The Oak Ridge facility would apply a treatment process to the PCB/organic waste where the oil/solvent waste is mixed with reagent (sodium hydroxide) in a thermal reactor vessel. Through this process the chlorinated contaminants would be dehalogenated or otherwise chemically altered, forming less-toxic compounds that are acceptable for burning in the low-level radioactive waste oil burner. Next, the waste would be burned in a high-temperature burner to destroy the remaining organic constituents.

Dechlorination is a proven technology for organic constituents including PCBs (EPA 1993), as is high-temperature burning for nonchlorinated organic constituents for fuel. The Perma-Fix boiler is permitted under RCRA for mixed waste applications and has been used successfully for over 10 years. Perma-Fix has completed installation of the dechlorination system at its facility in Oak Ridge and is currently obtaining the appropriate permits for the system. Perma-Fix anticipates that the treatment system will be permitted and in operation by the end of calendar year 2003.

Either option would be very effective, and they are generally equivalent. Both options are included in this alternative to provide flexibility and to provide additional certainty for the treatment of the oil/solvent waste. If a treatment alternative that includes incineration of the liquid waste component were to be identified as the preferred alternative, the options would be evaluated in greater detail during remedial design to determine which would provide the timeliest and most cost-effective treatment.

4.2.4.3 Solids Stabilization. Stabilization would involve adding reagents to the uranium chips to immobilize and/or encapsulate the chips. Stabilization would be implemented following phase separation, and the uranium metal would be stabilized in a monolith in a large box (B-12 box or similar). Chip pyrophoricity mitigation will likely be necessary using an uncontaminated mineral oil or inert gas between the chip drying step and the final grout stabilization step. The mineral oil could be incorporated in the chip stabilization monolith using the Perma-Fix proprietary or similar grout recipe. The Perma-Fix grout formulation uses gypsum to soak up free mineral oil for incorporation into the grout monolith. Alternatively, the stabilization material could be used to displace the mineral oil and the mineral oil removed prior to complete stabilization. Depending on the need for the solvent wash portion of phase separation, displacement of the oil using the chip stabilization material could be used as the initial simple oil decant. Uranium chip encapsulation in a Portland cement grout is anticipated. The stabilization step would likely involve mixing the phase-separated uranium chips with grout in a drum followed by placement of the uncured grout and uranium chip mixture into a larger box type-container for final curing. A layer of the cement grout material would be placed at the bottom of the larger box-type container and allowed to partially cure in order to prevent the uranium chips from potentially settling to the bottom of the box container.

The end product of stabilization would be a cement grout monolith that encapsulates the uranium. Following curing, the monolith would be disposed of at the ERDF. The stabilization process would not oxidize the uranium. Because of this, the ERDF disposal would need to be conducted in a manner that maintains the integrity of the monolith so that unoxidized uranium is not exposed to the atmosphere.

4.2.4.4 Onsite Treatment. Onsite treatment would involve setting up a temporary treatment facility within the ERDF. Only the phase separation and uranium chip stabilization treatment steps would be conducted on site. Because of the technical and regulatory complexities, incineration is not considered for onsite treatment. The liquids would likely be transported to the incineration facility using a tanker-type truck. It is anticipated that the phase separation and stabilization steps would be performed inside a sprung tent-like structure on a concrete pad. The structure would be equipped with utilities (e.g., water, electrical), a spill- containment system, and a fire-suppression system. Extensive air emission engineering controls for the treatment system are not anticipated. Workers conducting treatment activities would likely need to wear personal protective equipment such as gloves, boots, splash-resistant overalls, a face shield, and possibly air-purifying respirators. The footprint of the structure would be about 6 m by 15 m.

The implementation schedule for this option appears to meet the mid-October 2004 ERDF drum disposition schedule. Bench-scale and full-scale treatability testing have been completed for this alternative at an offsite facility. Results from the full-scale treatability testing are pending. Results of the bench-scale phase separation are discussed in Section 4.2.4. The liquid wastes would be transported to the incinerator facility in Tennessee in a tanker-type truck. Transportation of the liquid waste is anticipated to be straightforward and not involve complex transportation issues. Vendor procurement and completion of the necessary work plans and assessments would require about seven months. Based on discussion with one vendor (i.e., Perma-Fix), an onsite treatment facility could be mobilized in three months with completion of solids stabilization in another three months. Offsite incineration of the liquids could potentially take longer. If the Oak Ridge incinerator were to be used, the process for placing waste on the incinerator burn plan schedule takes at least 6 months, although alternative approaches are being explored including the use of the waste as a fuel for the incinerator. Using the waste as fuel for the incinerator may not require that the waste be placed on the burn plan schedule. If the Perma-Fix thermal treatment facility were to be used, treatment of the liquid phase could be delayed until the dechlorination process is permitted and operational.

The total cost for the onsite option of this alternative would be \$3.8 million.

4.2.4.5 Offsite Treatment. This option would involve transportation of the drummed oil and uranium chip waste to an offsite treatment facility. The processes of phase separation, incineration of the liquid phase, and stabilization of the solids would be the same as for the onsite option. At least one such facility with the appropriate permits is currently available to perform this treatment, the Perma-Fix facility in Oak Ridge, Tennessee. In addition, Perma-Fix currently has a basic ordering agreement (BOA) in place with the DOE for treating uranium chip and oil wastes. Therefore, the time for procurement for the offsite option would be relatively short.

The waste would need to be transported in compliance with U.S. Department of Transportation (DOT) requirements. A transportation package of sufficient size that is certified in accordance with the requirements is not currently available. Three options are available for compliance. One option would be to apply for a formal DOT exemption to ship the drums as is. Another option would be to conduct an engineering study to establish compliance with the requirements based on a comparison to other transportation packages that have been DOT-certified. Finally, a new package could be designed and tested in accordance with DOT requirements specifically for the uranium chip and oil waste.

Following chip stabilization in the grout, the stabilized monoliths would be transported back to the ERDF for disposal.

The implementation schedule for this option would be relatively short and appears to easily meet the mid-October 2004 ERDF drum disposition schedule. Treatability testing has been completed for this option. This option would involve transportation issues that are anticipated to take 6 months to a year to resolve. However, once the drums left the ERDF, the schedule requirement would be met and would not be linked to completion of treatment as is the onsite option.

The total cost for the offsite option of this alternative would be \$3.6 million.

4.2.5 Phase Separation/Incineration/Uranium Oxidation

This alternative would consist of three technologies formed into a single alternative. The technologies are phase separation, incineration (liquid phase), and thermal oxidation (solids phase). The phase separation and incineration components of the alternative would be identical to the treatment alternative discussed in Section 4.2.4 and will not be repeated here. However, for the thermal oxidation step described below, the solvent rinse and chip drying phase separation would be necessary for all drums regardless of the contaminant concentration of the oil. A thorough cleaning of the uranium chips is necessary because the soot from incineration of organics prematurely clogs the high-efficiency particulate air (HEPA) filtration system necessary for thermal oxidation.

The difference between this alternative and the one discussed previously is that the pyrophoricity of the uranium chips would be controlled through thermal oxidation rather than encapsulation. As with the previous alternative, this alternative has been subdivided into onsite and offsite options in order to assess the preference between onsite versus offsite treatment. The primary differences between the two options are discussed in greater detail in Sections 4.2.5.1 and 4.2.5.2 and include mobilization of an onsite treatment facility within the ERDF versus transportation of the drums to an offsite treatment facility. Under the offsite option, the oxidized solids would be returned to the ERDF for disposal.

Thermal oxidation is a process in which the uranium metal is heated in an oxygen-rich atmosphere, resulting in oxidization of metal constituents. In this alternative, a chip oxidizer would be used to oxidize the uranium metal. Uranium oxidation would involve allowing the uranium to undergo a pyrophoric reaction in a controlled oxidation chamber or oven. The end

product would be a uranium oxide powder that no longer would be pyrophoric and that would be suitable for disposal to the ERDF. Phase separation including chip drying prior to oxidation would be necessary because soot from incineration of organics tends to clog the oxidizer's offgas filtration systems. If the chips were to be stored temporarily between phase separation and oxidation, they would need to be stabilized. Because mineral oil would not be compatible with the oxidation treatment, the pyrophoricity of the chips would need to be mitigated with another material such as an inert gas, sand, or water. Although not likely as effective as oil, sand has reportedly been used to mitigate the pyrophoric property of uranium chips. Water also has been used to temporarily mitigate the pyrophoric property of uranium chips until oxidation occurs. Temporary stabilization using water is currently in use at the DOE Y-12 depleted uranium milling facility in Tennessee. However, the uranium chips produce hydrogen in water and cannot be kept in airtight containers.

4.2.5.1 Onsite Treatment. Onsite treatment would involve setting up a treatment facility within the ERDF. The phase separation and oxidation treatment steps would be conducted on site. Because of the technical and regulatory complexities, incineration is not considered for onsite treatment. The liquid wastes would be transported to the incinerator facility in Tennessee in a tanker-type truck. Transportation of the liquid waste is anticipated to be straightforward and not involve complex transportation issues. Phase separation would be performed as described in Section 4.2.4.1. From discussions with the DOE contractor that currently operates the DOE-owned uranium oxidation facility at the Y-12 facility in Tennessee, the oxidation process could be mobilized on site. However, the oxidation process has not been developed as a turn-key mobile activity such as the vitrification system. Because of this and because the oxidation process is a thermal process using a controlled burn, oxidation would not likely be suitable for conducting in a temporary tent-type structure. A more permanent-type building with more robust ventilation system (i.e., HEPA filtration) and more robust fire-suppression equipment and controls than that which a tent structure could provide would likely be needed.

The implementation schedule for this alternative appears to be able to meet the mid-October 2004 ERDF drum disposition schedule. The schedule for this alternative would be longer than the onsite phase separation/incineration/solids stabilization alternative because the oxidation treatment would likely require construction of a more permanent-type building with additional ventilation and fire controls.

The total cost for the onsite option of this alternative would be \$4.2 million.

4.2.5.2 Offsite Treatment. This option would involve transportation of the drummed oil and uranium chip waste to an offsite treatment facility. The processes of phase separation, incineration of the liquid phase, and oxidation of the solids would be the same as for the onsite option.

No single facility capable of performing both phase separation and oxidation has been identified, so use of multiple offsite facilities might be required. The Perma-Fix facility in Tennessee has the capability and has conducted the treatability testing for the phase separation component of this alternative. However, the Perma-Fix facility is not capable of treating the uranium chips

through oxidation. The DOE uranium oxidation facility in Tennessee has the oxidation capability but does not currently have the capability for phase separation. For purposes of developing this alternative, it is assumed that the Perma-Fix facility would conduct the phase separation component and stabilize the uranium chips using a dry inert material such as sand. The stabilized chips in sand would be shipped a short distance to the uranium oxidation facility for oxidation. Following oxidation the uranium oxide powder would be shipped to the ERDF for final disposal.

Thermal oxidation is a well-established technology for treatment of reactive metals, and the Y-12 oxidation facility has been used successfully for several years. However, to date the facility has only oxidized chips generated at its facility and has not treated uranium from any of the other DOE sites. Permission to treat Hanford Site waste at the Y-12 facility could be required from the State of Tennessee.

As with the previous alternative, the waste would need to be transported in compliance with DOT requirements. A transportation package of sufficient size that is certified in accordance with the requirements is not currently available. Three transportation options are available for compliance. One option would be to apply for a formal DOT exemption to ship the drums as is. Another option would be to conduct an engineering study to establish compliance with the requirements based on a comparison to other transportation packages that have been DOT certified. Finally, a new package would be designed and tested in accordance with DOT requirements specifically for the uranium chip and oil waste.

The implementation schedule for this offsite treatment option appears to be able to meet the mid-October 2004 ERDF drum disposition schedule. This alternative does involve complex transportation issues that are anticipated to take six months to a year to resolve. However, once the drums left the ERDF, the disposition schedule would be met and would not be linked to completion of treatment as is the onsite alternative.

The total cost for the offsite option of this alternative would be \$4.0 million.

4.3 ALTERNATIVE COST SUMMARY

This section presents summary-level cost information for each treatment alternative presented in Section 4.2. Summary-level cost information was obtained by revising cost estimates from *Treatment/Disposal Plan for Drummed Waste from the 300-FF-1 Operable Unit, 618-4 Burial Ground* (BHI 1999b) and through telephone conversations with vendors. Cost estimates from BHI (1999b) were revised for the number of drums and to reflect current costs. For consistency among alternative costs, subcontractor cost multipliers and Environmental Restoration Contractor (ERC) oversight costs were applied to the recently acquired cost information received during telephone conversations.

The estimates were developed using the following common assumptions:

- Population of 520 drums containing depleted uranium metal chips and oil
- Mean weight of 84 kg (185 lb) for drum contents, including 28 kg (62 lb) of depleted uranium solid material and 56 kg (123 lb) (64 L [17 gal] assuming specific gravity of 0.88) of oil per drum based on characterization information from August 1998
- 2002 wage rates for ERC labor
- Performance of onsite work under a hazard classification of “Radiological”
- Inclusion of all adders as applicable (e.g., sales tax, subcontract overhead and profits, direct distributable charges, and General and Administrative).

For the offsite treatment alternatives, the cost estimate includes a DOT-compliant shipping package for the drummed waste.

Cost estimates are summarized in Table 4-3 and are intended to include all applicable material, labor, and subcontract costs for treatability testing, construction, treatment, transportation, disposal, and project management.

Table 4-3. Treatment/Disposal Alternatives Cost Summary. (2 Pages)

Treatment Alternative		Total Cost (\$M)	Comments
No action		0	No treatment.
Vitrification		2.8 ^a	Onsite.
Whole-drum stabilization		1.6 ^a	Petroleum hydrocarbon stabilization using Petroset or similar material.
Phase separation/ incineration/solids stabilization	Onsite Option	3.8 ^b	Offsite incineration. Oil/solvent transportation only.
	Offsite Option	3.6 ^b	Offsite incineration. Transportation and packaging of drummed waste off site. Transportation of stabilized solids to ERDF.
Phase separation/ incineration/solids oxidation	Onsite Option	4.2 ^c	Offsite incineration. Oil/solvent transportation only.
	Offsite Option	4.0 ^c	Offsite incineration. Transportation and packaging of drummed waste off site. Transportation of oxidized uranium to ERDF.

^a The vitrification and whole drum stabilization cost estimates were revised from BHI (1999b) to reflect the current number of drums of waste and to reflect current costs.

^b The phase separation/incineration/solids stabilization cost estimates are based on the Perma-Fix DOE BOA for waste treatment and on telephone conversations with Perma-Fix.

^c For cost estimating purposes, transportation costs were assumed to be the same as the phase separation/incineration/solids stabilization alternative.

5.0 DETAILED ANALYSIS OF ALTERNATIVES

This section uses the CERCLA evaluation criteria to present a detailed analysis of the waste treatment alternatives described in Section 4.0.

5.1 DESCRIPTION OF EVALUATION CRITERIA

The *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988) identifies nine criteria to address statutory requirements and evaluate technical, institutional, and cost considerations for the CERCLA planning process:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance.

These criteria are described in the following sections.

5.1.1 Overall Protection of Human Health and the Environment

This criterion addresses whether the alternative, as a whole, achieves and maintains protection of human health and the environment. The overall assessment draws on results of the other evaluation criteria to make a final conclusion with respect to protectiveness. It is considered a threshold criterion. Alternatives that do not achieve overall protection of human health and the environment are eliminated from further consideration.

5.1.2 Compliance with ARARs

The assessment against this criterion describes how the alternative complies with the ARARs identified in Appendix A. Like overall protection of human health and the environment, compliance with ARARs is a threshold criterion that must be met for each alternative. If compliance with ARARs is not achieved, justification for a waiver must be provided if the alternative is to be included for further consideration.

Detailed Analysis of Alternatives

5.1.3 Long-Term Effectiveness and Permanence

Assessment against this criterion evaluates the long-term effectiveness in maintaining protection of human health and the environment after the treatment objectives have been met. The criterion includes the following components:

- Magnitude of residual risk from treatment products
- Adequacy and reliability of controls used to manage and provide continued protection from treatment products.

5.1.4 Reduction of Toxicity, Mobility, and Volume Through Treatment

This criterion addresses the anticipated ability of specific treatment technologies to permanently and significantly reduce toxicity, mobility, or volume of the hazardous substances. This criterion can be satisfied through destruction of toxic contaminants, reduction of the total mass of toxic contaminants, irreversible reduction of contaminant mobility, and/or reduction of the total volume of contaminated media. The criterion includes the following factors:

- Amount of hazardous materials destroyed or treated
- Degree to which treatment is irreversible
- Type and quantity of residual material after treatment.

5.1.5 Short-Term Effectiveness

The assessment against this criterion examines the effectiveness of protecting human health and the environment during the implementation phase until the treatment objectives have been met. The criterion includes the following factors:

- Protection of the community during treatment (e.g., air quality impacts)
- Protection of workers and reliability of protective measures
- Environmental impacts
- Estimate of time until treatment objectives are achieved.

For the purpose of this study, protection of workers, environmental impacts, and estimated project durations are based on activities performed within the Hanford Site boundaries. Potential exposure to the community during transportation to or from offsite treatment facilities is also considered under this criterion. Protection of the community, protection of workers, environmental impacts, and treatment durations are excluded from evaluation once waste is received at an offsite facility, as those facilities are assumed to have the proper controls in place to ensure safe operation and protection of human health and the environment.

Detailed Analysis of Alternatives

5.1.6 Implementability

The assessment against this criterion describes the technical and administrative feasibility of the alternative and the availability of services, including the following factors:

- Ability to construct and operate the technology and potential difficulties or unknowns
- Reliability of the technology and likelihood of technical problems
- Coordination and/or approvals needed from other agencies
- Availability of services and materials.

5.1.7 Cost

This assessment presents the total cost of each alternative. Summary-level cost information is provided in Section 4.3.

5.1.8 State/Community Acceptance

State acceptance and community acceptance will be evaluated following review and comment of the proposed action by regulatory agencies and the public.

5.2 NO ACTION ALTERNATIVE

The no action alternative is retained for detailed analysis as a baseline description of the effects of taking no action and is required by CERCLA regulations.

5.2.1 Overall Protection of Human Health and the Environment

The no action alternative would fail to provide overall protection of human health and the environment because hazardous substances would remain untreated and stored indefinitely. In the untreated condition, the waste poses a risk to human health and the environment because of the potential for ultimate degradation of the waste containers and a release of contaminants. Such degradation could occur relatively quickly in the absence of a weather-protected storage facility, which represents the current storage condition at the ERDF. Therefore, this alternative would fail to meet this threshold criterion under CERCLA.

5.2.2 Compliance with ARARs

The ARARs requiring ultimate treatment prior to disposal would not be met by this alternative. Because this alternative would fail to satisfy the threshold criteria of overall protection and compliance with ARARs, further evaluation against the CERCLA criteria is not warranted.

5.3 VITRIFICATION

5.3.1 Overall Protection of Human Health and the Environment

The vitrification alternative would provide overall protection of human health and the environment by destroying organic constituents, immobilizing inorganic constituents, and substantially reducing risks associated with the pyrophoricity of the uranium chips.

5.3.2 Compliance with ARARs

Compliance with ARARs and to-be-considered (TBC) guidance for this alternative is addressed in Appendix A. This alternative would comply with all ARARs and TBCs.

5.3.3 Long-Term Effectiveness and Permanence

The vitrification alternative would be very effective and permanent in the long term. Organic constituents, including PCBs, would be destroyed during the vitrification and offgas treatment processes. Inorganic constituents and the uranium would be immobilized within the resulting glass monolith. The uranium chips would be encapsulated, effectively preventing exposure to oxygen that could result in a pyrophoric reaction. The glass monolith produced by vitrification has been demonstrated in other applications to be permanent and durable, so the likelihood that contaminants would be remobilized would be minimal. The resulting waste would be disposed in the ERDF, an engineered disposal facility that would provide an additional degree of protection.

The only concern would be fracturing of the monolith that could result in exposing unoxidized uranium to the air. This concern would be addressed through special controls used to place the glass monolith in the ERDF such that loads from subsequent placement of waste would be unlikely to cause fracturing.

5.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The vitrification alternative would achieve a substantial reduction in toxicity and mobility through treatment. The total quantity of organic contaminants in the waste would be reduced by greater than 99.9999% through vitrification and offgas treatment. Inorganic contaminants would be substantially immobilized in the glass matrix. The surfaces of the uranium chips would be oxidized to a limited extent during vitrification, thereby reducing the amount of waste exhibiting the characteristic of pyrophoricity. However, the uranium would not be fully oxidized by the vitrification process. The risks associated with unoxidized uranium chips would be reduced by encapsulation of the uranium in the glass matrix, which would preclude contact with oxygen and reduce the mobility of the uranium.

This alternative would satisfy the statutory preference for treatment as a principal element of the remedy.

Detailed Analysis of Alternatives

5.3.5 Short-Term Effectiveness

The vitrification alternative likely would be effective in the short term. The high temperatures associated with vitrification would present potential issues related to air emissions and worker safety, but these issues could be addressed through implementation of appropriate controls.

Onsite vitrification would be conducted within an engineered hood that would provide confinement and ventilation. Offgas treatment would include gas cooling, scrubbing, possible activated carbon filtration, and thermal oxidation of organic constituents such that there would be essentially no air emissions.

The vitrification system would be completely contained under a fume hood that would be plumbed to the offgas treatment system, so there would be essentially no worker inhalation exposures associated with the vitrification process. Worker exposure to the waste using the vitrification process would be minimal. Workers would be required to place the drummed waste into the treatment cell and would be required to operate machinery such as a trackhoe or other equipment to crush the drums of waste placed into the cell. The vitrification process would require a large electrical supply, which would require electrical controls and safety requirements associated with standard industrial processes.

5.3.6 Implementability

The vitrification alternative would be relatively straightforward to implement, although further treatability testing would likely be required.

Vitrification is a proven technology for treatment of radioactive and hazardous wastes, and mobile units have been used in a variety of applications nationwide. However, the drums contain a heterogeneous waste (chunks of metal in oil) that could pose a challenge in ensuring the complete vitrification throughout the waste/soil mixture. Initial testing using a small batch of waste has been successful, but additional treatability testing would likely be required to confirm formation of a cohesive glass matrix. Because vitrification has not yet been conducted on a large scale at the Hanford Site and entails high-temperature operations, the necessary approvals would likely involve substantial scrutiny of safety measures and air emissions controls, which could potentially delay implementation.

5.3.7 Cost

The cost for the vitrification alternative is summarized in Section 4.3. The total cost would be \$2.8 million.

Detailed Analysis of Alternatives

5.4 WHOLE-DRUM STABILIZATION

5.4.1 Overall Protection of Human Health and the Environment

It is uncertain whether the whole-drum stabilization alternative would provide overall protection of human health and the environment. Inorganic constituents would be immobilized and risks associated with the pyrophoricity of the uranium chips would be substantially reduced. However, it is unknown whether stabilization would reduce the mobility of organic constituents and thus mitigate their release to the environment. Specific applications for the uranium chip and oil waste would need to be evaluated and tested. The stabilized waste would be disposed in the ERDF, which would provide some containment for the organic constituents regardless of the effectiveness of stabilization.

5.4.2 Compliance with ARARs

Compliance with ARARs and TBC guidance for this alternative is addressed in Appendix A. It is unknown whether this alternative would comply with all ARARs and TBCs. Specifically, stabilization might not achieve LDR standards for organic constituents. In addition, stabilization would not meet the performance-based standards for PCBs, and there are insufficient data to develop a justification for a TSCA risk-based approach for disposal. Additional treatability testing would need to be conducted to determine the compliance status and obtain regulatory approvals.

If compliance cannot be demonstrated, other potential avenues for implementing this alternative would be a treatability variance under RCRA or a waiver under CERCLA. However, given precedents at the Hanford Site and elsewhere, these options would have a low likelihood of success.

5.4.3 Long-Term Effectiveness and Permanence

The whole-drum stabilization alternative would be effective and permanent in the long term with respect to immobilizing inorganic constituents and mitigating the pyrophoricity of the uranium chips. The solid matrix produced by stabilization has been demonstrated in other applications to be permanent and durable, so there would be little likelihood that inorganic constituents would be remobilized. However, it is unknown whether a stabilization process is available that would reduce the mobility of organic contaminants. The stabilized waste would be disposed in the ERDF, an engineered disposal facility that would provide a degree of protection in preventing the release of organic contaminants that might leach from the stabilized waste.

Fracturing of the solid matrix could result in exposing unoxidized uranium to the air. This concern would be addressed through special controls used to place the solids in the ERDF such that loads from subsequent placement of waste would be unlikely to cause fracturing.

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5.4.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The whole-drum stabilization alternative would achieve some reduction in mobility through treatment. Inorganic constituents would be virtually immobilized in the solid matrix. It is unknown whether there would be any reduction in the mobility of organic constituents. Stabilization would not oxidize the uranium chips and thus would not eliminate the characteristic of pyrophoricity. The risks associated with the unoxidized uranium chips would be reduced by encapsulation of the uranium in the solidified matrix, which would preclude contact with oxygen and reduce the mobility of the uranium.

This alternative would satisfy the statutory preference for treatment as a principal element of the remedy.

5.4.5 Short-Term Effectiveness

In some respects, the whole-drum stabilization alternative would be effective in the short term. The stabilization would be a fairly simple, low-temperature operation that would be unlikely to present undue risks to workers or a significant potential for air emissions. Workers would employ standard personal protective equipment in handling the waste. However, because it is unknown whether the whole-drum stabilization would ever achieve the treatment objectives, short-term effectiveness cannot be fully assessed.

5.4.6 Implementability

In some respects, the whole-drum stabilization alternative would be relatively easy to implement from a technical standpoint, but there would be technical challenges. Stabilization is a well-established, low-complexity technology that has been used in a variety of applications. At the Hanford Site, stabilization has been used to treat contaminated sludge and soil prior to disposal at the ERDF, and no significant problems have been encountered. However, the heterogeneous nature of the uranium chip and oil waste could cause considerable difficulty in achieving adequate mixing. Many of the depleted uranium mill turnings are twisted and matted, and rolling the drums may not allow the stabilizing agents and oil to mix completely before the mixture begins to set. A variety of mixing technologies have been considered, but there would be drawbacks to each, especially when used in an environment (submerged in oil) where there would be no visual confirmation of their effectiveness.

In addition, as described previously, the effectiveness of stabilization in reducing the mobility of organic constituents is unknown. A demonstration of immobilization would likely be required by the regulatory agencies before they would approve stabilization alone as a treatment for the RCRA-regulated organic constituents or approve a risk-based approach under TSCA. Without satisfactory results from additional testing, it would likely be very difficult to obtain regulatory approval for this alternative. The likelihood of obtaining approvals would be dependent on the effectiveness of stabilization as a means of reducing the mobility of organic constituents.

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5.4.7 Cost

The cost for the whole-drum stabilization alternative is summarized in Section 4.3. The total cost would be \$1.6 million.

5.5 LIQUID INCINERATION/SOLIDS STABILIZATION

5.5.1 Overall Protection of Human Health and the Environment

The liquid incineration/solids stabilization alternative would provide overall protection of human health and the environment. Most organic constituents would be destroyed, the mobility of inorganic constituents would be substantially reduced, and the risks associated with the pyrophoricity of the uranium chips would be substantially reduced.

5.5.2 Compliance with ARARs

Compliance with ARARs and TBC guidance for this alternative is addressed in Appendix A. This alternative would comply with all ARARs and TBCs.

5.5.3 Long-Term Effectiveness and Permanence

This alternative would be very effective and permanent in the long term. Most organic constituents (including PCBs) contained in the liquid phase of the waste would be destroyed during the incineration process. The resulting ash, which would contain the residual inorganic constituents, would be stabilized as necessary prior to disposal. The uranium chips would be encapsulated, effectively preventing exposure to oxygen that could result in a pyrophoric reaction. The solid matrix produced by stabilization has been demonstrated in other applications to be permanent and durable. The resulting waste would be disposed in the ERDF, an engineered disposal facility that would provide an additional degree of protection.

A potential concern associated with this alternative is that fracturing of the solid matrix could result in exposing unoxidized uranium to the air. This concern would be addressed through special controls used to place the solid in the ERDF such that subsequent placement of waste would not cause fracturing of the matrix. Stabilized waste would be disposed in the ERDF, an engineered disposal facility that would provide an additional degree of protection in preventing the release of contaminants that might leach from the stabilized waste.

5.5.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The liquid incineration/solids stabilization alternative would achieve a substantial reduction in toxicity and mobility through treatment. Most of the organic constituents would be removed during phase separation and would be destroyed with an efficiency of greater than 99.99% through the incineration process. The mobility of inorganic constituents in the incinerator residue would be substantially reduced through stabilization of the ash. Stabilization would not

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oxidize the uranium chips and thus would not eliminate the characteristic of pyrophoricity. However, the risks associated with the pyrophoricity of the unoxidized uranium chips would be substantially reduced by encapsulation of the uranium in the solidified matrix, which would preclude contact with oxygen and reduce the mobility of the uranium.

This alternative would satisfy the statutory preference for treatment as a principal element of the remedy.

5.5.5 Short-Term Effectiveness

The liquid incineration/solids stabilization alternative would be very effective in the short term with implementation of appropriate controls.

The primary risk to workers would be industrial safety risks associated with the treatment processes. Workers conducting treatment activities would likely need to wear personal protective equipment such as gloves, boots, splash-resistant overalls, a face shield, and possibly air-purifying respirators. Because of the pyrophoricity of the uranium chips, there would be some potential for fire associated with the phase separation process. The treatment facility would be equipped with spill-containment and fire-suppression systems.

5.5.6 Implementability

The liquid incineration/solids stabilization alternative would be relatively easy to implement, although there are some uncertainties related to phase separation and transportation.

The viability of the phase separation technology in reducing RCRA constituent concentrations to meet LDR treatment standards has been demonstrated through treatability testing. The vendor who conducted the testing has indicated that additional steps can be taken to dry the solid phase to the extent required to pass the paint filter test under TSCA. At least one offsite facility (i.e., Perma-Fix) would be available to perform phase separation. If onsite treatment were to be selected, a temporary phase separation process could be designed, constructed, and mobilized at the ERDF.

There are three offsite facilities that would be options for treating the liquid phase. The Oak Ridge incinerator is well established and fully permitted to treat RCRA/TSCA/low-level radioactive waste, but would require specific approval from the State of Tennessee to treat the Hanford Site waste if phase separation were conducted onsite. It is anticipated that such approval would be granted. Another potential option would be to burn the oil/solvent waste in the incinerator as a fuel. Perma-Fix operates two thermal units that can treat RCRA organic constituents, but would require a RCRA permit for the dechlorination unit that would be used to pretreat the liquid for PCBs. The company is actively seeking the permit and anticipates being granted one by the end of 2003.

The technical feasibility of the stabilization process has been proven through testing using a similar waste. The heterogeneous nature of the uranium chips as discussed in the whole-drum

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stabilization alternative would not be an issue with this solids-only stabilization step. The whole-drum stabilization alternative includes stabilization of the oil and would require thorough and complete mixing. For the solids-only stabilization, the oil has been removed and only the solids are stabilized or encapsulated and would not require thorough mixing as long as the solids are completely encapsulated. At least one offsite facility (i.e., Perma-Fix) would be available to perform stabilization. If onsite treatment were to be selected, a temporary stabilization system could be designed, constructed, and mobilized at the ERDF using standard industrial practices. Stabilization has already been used to treat other waste types at the ERDF, although stabilization into a solid form and disposal of the solid mass would be a new approach.

The onsite phase separation process would likely involve substantial scrutiny of safety measures and air emissions controls, which could potentially delay implementation and impact cost. However, it is anticipated that the necessary approvals would be granted as long as phase separation were to meet the LDR treatment standards under RCRA and the TSCA requirements for PCBs.

5.5.7 Cost

The cost for the liquid incineration/solids stabilization alternative is summarized in Section 4.3. The total cost would be \$3.8 million for the onsite option and \$3.6 million for the offsite option.

5.6 LIQUID INCINERATION/SOLIDS OXIDATION

5.6.1 Overall Protection of Human Health and the Environment

The liquid incineration/solids oxidation alternative would provide overall protection of human health and the environment by destroying organic contaminants and eliminating the characteristic of pyrophoricity associated with the uranium chips.

5.6.2 Compliance with ARARs

Compliance with ARARs and TBC guidance for this alternative is addressed in Appendix A. This alternative would comply with all ARARs and TBCs.

5.6.3 Long-Term Effectiveness and Permanence

This alternative would be very effective and permanent in the long term. Organic constituents including PCBs contained in the liquid phase of the waste would be destroyed during the incineration process. The resulting ash, which would contain the residual inorganic constituents, would be stabilized as necessary prior to disposal. The uranium chips would be fully oxidized, eliminating the risks associated with the pyrophoricity of the unoxidized metal. The incineration, stabilization, and oxidation processes would be permanent, and there would be little likelihood that the uranium chips could revert to a state where they are pyrophoric or that inorganic constituents would be remobilized. The stabilized ash from incineration would be

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disposed at an offsite permitted disposal facility and the oxidized uranium would be disposed at the ERDF, which would provide an additional degree of protection.

5.6.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The liquid incineration/solids oxidation alternative would achieve a substantial reduction in toxicity and mobility through treatment. Most of the organic constituents would be removed during phase separation and would be destroyed with an efficiency of greater than 99.99% during the incineration process. The mobility of inorganic constituents in the incinerator residue would be substantially reduced through stabilization. The uranium chips would be fully oxidized during the oxidation process, thereby eliminating the characteristic of pyrophoricity.

This alternative would satisfy the statutory preference for treatment as a principal element of the remedy.

5.6.5 Short-Term Effectiveness

This alternative would be effective in the short term. The high temperatures associated with oxidation would present potential issues related to air emissions and worker safety, but these issues would be addressed through implementation of appropriate controls.

The primary risk to workers would be industrial safety risks associated with the treatment processes. Because of the pyrophoricity of the uranium chips, there would be some potential for fire associated with the phase separation process. There also would be a fire risk associated with the oxidation process because of the high temperatures involved. To address fire concerns associated with oxidation, treatment would be conducted in a more permanent-type building with robust fire-suppression equipment and controls. Air emissions would be controlled using HEPA filtration.

5.6.6 Implementability

This alternative could be implemented, although there are uncertainties related to the oxidation process and the offsite treatment option.

The viability of phase separation in reducing RCRA constituent concentrations to meet LDR treatment standards has been demonstrated through treatability testing. The vendor who conducted the testing has indicated that additional steps can be taken to dry the solid phase to the extent required to pass the paint filter test under TSCA. At least one offsite facility (i.e., Perma-Fix) would be available to perform phase separation. If onsite treatment were to be selected, a temporary phase separation process could be mobilized at the ERDF without difficulty using standard industrial practices.

There are three offsite facilities that would be options for treating the liquid phase. The Oak Ridge incinerator is well established and fully permitted to treat RCRA/TSCA/low-level radioactive waste, but would require specific approval from the State of Tennessee to treat the

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Hanford Site waste if phase separation were conducted onsite. It is anticipated that such approval would be granted. Another potential option would be to use the oil/solvent waste as fuel for the incinerator. Perma-Fix operates two thermal units that can treat RCRA organic constituents, but would require a RCRA permit for the dechlorination unit to pretreat the waste for PCBs. The company is actively seeking the permit and anticipates being granted one by the end of 2003.

The solids oxidation process would present the greatest uncertainties, at least for onsite treatment. A mobile oxidation system has not been identified from any vendor. The technology is proven, but onsite treatment would require the design, construction, and mobilization of an oxidation unit, and it is uncertain whether these activities could meet the mid-October 2004 schedule for disposition of the waste. Offsite treatment would present fewer uncertainties assuming that the DOE Y-12 uranium oxidation facility in Tennessee could be used. However, the Y-12 facility does not have the capability to perform phase separation, so offsite treatment would require either onsite phase separation or offsite phase separation at another facility, with the uranium chips then transported to the Y-12 facility. The multiple handling steps would require greater coordination among all parties.

Another implementability issue is related to the offsite treatment option. In the absence of a certified package to transport either the uranium chip and oil waste or washed uranium chips, DOE would need to obtain a DOT exemption or a determination of equivalency, or design and test a new package.

Both the onsite phase separation process and onsite thermal oxidation would likely involve substantial scrutiny of safety measures and air emissions controls, which could potentially delay implementation and impact cost.

5.6.7 Cost

The cost for the liquid incineration/solids oxidation alternative is summarized in Section 4.3. The total cost would be \$4.2 million for the onsite option and \$4.0 million for the offsite option.

6.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

This section presents a comparative analysis of the waste treatment alternatives to identify their relative advantages and disadvantages. This comparison is based on the seven CERCLA evaluation criteria discussed in Section 5.0. The results of this analysis provide a basis for identifying a preferred treatment alternative or combination of alternatives.

In accordance with EPA guidance, the no action alternative has been retained in this analysis for comparison with the other alternatives. However, as described in the detailed analysis (Section 5.0), the no action alternative would not satisfy the threshold criteria of overall protection and compliance with ARARs. Therefore, it is not a viable alternative for disposition of the uranium chip and oil waste.

6.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

With the exception of the no action alternative and possibly the whole-drum stabilization alternative, all alternatives would protect human health and the environment by destroying or immobilizing hazardous constituents and treating the uranium chips to reduce risks associated with pyrophoricity. The whole-drum stabilization alternative may not be considered protective unless testing demonstrates effective immobilization of organic constituents. The other three treatment alternatives would all result in the destruction of most or all organic constituents and the immobilization of inorganic contaminants.

6.2 COMPLIANCE WITH ARARS

The no action alternative would not comply with ARARs. The compliance status for the whole-drum stabilization alternative is unknown and would require additional testing. The remaining three alternatives would comply with ARARs.

6.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

The no action alternative would not afford long-term effectiveness or permanence. The whole-drum stabilization alternative may be effective and permanent in the long term, but this would have to be determined through further testing.

The three remaining alternatives would be protective of human health and the environment in the long term and much more effective than the no action alternative and possibly the whole-drum stabilization alternative. The liquid incineration/solids oxidation alternative performs slightly better for this criterion because it would result in full oxidation of the uranium chips. However,

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with proper waste management to maintain the integrity of the treated waste form during disposal, both the vitrification alternative and the liquid incineration/solids stabilization alternative would be very effective and permanent in the long term.

6.4 REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

No treatment would occur with the no action alternative.

Of the other four alternatives, all would provide some degree of treatment. The vitrification and liquid incineration/solids stabilization alternatives would perform best in reducing the toxicity and mobility of contaminants because they would essentially eliminate the toxicity of the organic constituents and effectively immobilize inorganic constituents. The liquid incineration/solids oxidation alternative would also eliminate the toxicity of organic constituents. The majority of inorganic constituents would not be immobilized. However, this alternative would perform best in eliminating the characteristic of pyrophoricity, a primary hazard associated with the waste. The whole-drum stabilization alternative would provide the least reduction in toxicity and mobility. The mobility of inorganic constituents would be reduced, but there would be no oxidation of uranium chips or destruction of organic constituents. Any reduction in the mobility of the organic constituents is unknown.

6.5 SHORT-TERM EFFECTIVENESS

The no action alternative would not involve any remedial actions; therefore, there would be no short-term impacts to workers, the public, or natural and cultural resources.

All of the remaining alternatives would be expected to be effective in protecting human health and the environment in the short term.

In some respects, the whole-drum stabilization alternative would be the most effective in the short term because it would involve no phase separation process and no offsite transportation, both of which carry inherent risks. The stabilization process would pose minimal risk to workers or the environment during implementation. However, one element of short-term effectiveness is the time until treatment objectives are met. Because it is unknown whether the whole-drum stabilization would ever achieve these objectives, short-term effectiveness cannot be fully assessed or compared to the other alternatives.

Of the remaining three alternatives, all would involve potential risks to workers, the public, and the environment, although the risks can be minimized through engineering and administrative controls. The vitrification and liquid incineration/solids oxidation alternatives pose risks associated with high-temperature operations including the potential for fires or airborne releases of contaminants. The liquid incineration/solids oxidation and the liquid incineration/solids stabilization alternatives also pose risks associated with phase separation of a potentially

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pyrophoric material, primarily the potential for fires. Both onsite and offsite options would also pose risks associated with the offsite transportation of wastes (either liquids only or the entire waste). Of the three alternatives, the liquid incineration/solids stabilization alternative is judged somewhat more effective in the short term than the other two alternatives because it would not involve conducting high-temperature operations for the entire waste stream.

6.6 IMPLEMENTABILITY

In the near term, the no action alternative would be easy to implement. However, it would not be consistent with DOE's need to dispose of the 300 Area drummed waste.

The whole-drum stabilization alternative would present few technical difficulties for implementation, but would be unlikely to gain the necessary regulatory approvals unless immobilization of the organic constituents were to be demonstrated.

All of the other alternatives are considered to be implementable based on available information. The liquid incineration/solids stabilization alternative is judged to perform best against this criterion based on proven performance. The viability of the phase separation and solids stabilization processes has been demonstrated through preliminary full-scale treatability testing using a very similar waste stream. Based on testing, phase separation would reduce RCRA constituent concentrations to meet LDR treatment standards in the solids phase, and it would be feasible to dry the solids such that they would pass the paint filter test under TSCA. A vendor is available to perform both processes either on or off of the Hanford Site. The liquid phase would be treated at existing offsite facilities of proven effectiveness. This alternative would be likely to be the most acceptable because it is proven for this waste.

The liquid incineration/solids oxidation alternative also would perform very well against this criterion. The liquid phase would be treated at existing offsite facilities of proven effectiveness, and the uranium chips could be treated either on or off site. Finally, although the drummed waste has undergone small-scale vitrification tests, it has not undergone large-scale testing, so there are greater uncertainties regarding the technical implementability of the vitrification alternative. Therefore, it is considered more difficult to implement than the other two alternatives.

6.7 COST

The no action alternative would require no funding in the near term. However, if the authorization period for the ERDF staging area expires with no prospect for dispositioning the waste, there would be a cost associated with potential fines for noncompliance. Of the remaining four alternatives, the whole-drum stabilization alternative would be the least costly, followed by the vitrification alternative and the liquid incineration/solids stabilization alternative. Liquid incineration/solids oxidation would be the most costly.

7.0 PREFERRED ALTERNATIVE AND IMPLEMENTATION BARRIER ASSESSMENT

This section presents the preferred treatment alternative, identifies potential barriers to implementing the preferred alternative, and presents the preferred treatment alternative option for either on- or offsite treatment.

7.1 PREFERRED ALTERNATIVE

Based on the CERCLA evaluation, the preferred treatment alternative is the liquid incineration/solids stabilization alternative. This alternative has the ability to be performed on the Hanford Site or at an offsite facility. This alternative would satisfy the criteria of overall protection and compliance with ARARs. The liquid incineration/solids stabilization alternative would also be effective in the long term and would provide a substantial reduction in toxicity, mobility, and volume through treatment. Finally, this alternative would perform better than other alternatives on the bases of implementability and short-term effectiveness. The phase separation and solids stabilization processes have undergone successful bench- and full-scale treatability testing and have been proven to be effective (BHI 2002a). Final results from the full-scale testing are pending; however, preliminary results are positive. At least one vendor is available who could mobilize a treatment system onsite in the near future or could transport and treat the waste at their facility in Tennessee in the near future.

Table 7-1 summarizes the selection of the preferred treatment alternative through the comparative assessment in Section 6.0.

Table 7-1. Summary of Alternative Comparative Analysis for Selection of Preferred Alternative. (2 Pages)

Comparison Criteria	No Action	Whole-Drum Stabilization	Vitrification	Phase Separation/ Incineration/Solids Stabilization	Phase Separation/ Incineration/Oxidation
Protection of Human Health and the Environment	Fails to meet criterion.	May be protective; determination dependant on additional testing.	Protective with destruction of organics and immobilization of inorganics.	Protective with destruction of organics and immobilization of inorganics.	Protective with destruction of organics and immobilization of inorganics.
Compliance with ARARs	Fails to meet criterion.	May comply; determination dependent on additional testing.	Compliant.	Compliant.	Compliant.
Long-Term Effectiveness	Not effective in the long term.	May be effective; determination dependant on additional testing.	Very effective and permanent with proper waste management to maintain waste form.	Very effective and permanent with proper waste management to maintain waste form.	Very effective and permanent; performs slightly better because of full uranium oxidation.
Reduction in Toxicity, Mobility, or Volume Through Treatment	No treatment occurs.	Provides least reduction in toxicity, reduces contaminant mobility.	Performs well; organics destroyed, inorganics immobilized, and pyrophoric property controlled.	Performs well; organics destroyed, inorganics immobilized, and pyrophoric property controlled.	Performs well; organics destroyed, and pyrophoric property fully eliminated.
Short-Term Effectiveness	No short-term impacts.	Most effective in some respects. Minimal risk to workers. Effectiveness for meeting objectives is uncertain; determination dependent on additional testing.	Poses risks associated with high-temperature operations.	Does not involve onsite high-temperature operations and therefore performs better than the onsite high-temperature alternatives.	Poses risks associated with high-temperature operations.

Table 7-1. Summary of Alternative Comparative Analysis for Selection of Preferred Alternative. (2 Pages)

Comparison Criteria	No Action	Whole-Drum Stabilization	Vitrification	Phase Separation/ Incineration/Solids Stabilization	Phase Separation/ Incineration/Oxidation
Implementability	Near term easy. Not consistent with need for disposal.	Few technical implementation difficulties. However, demonstration of adequate reduction in organic mobility provides large implementation uncertainty.	Greater implementation uncertainties; only small-scale testing completed.	Performs best based on proven performance. Single vendor capable of entire treatment.	Performs well, however, implementation more difficult because of high-temperature operations and multiple vendor treatment.
Cost (\$M)	0 (Near term)	1.6	2.8	Onsite: 3.8 – includes offsite transportation of liquids. Offsite: 3.6 – includes offsite transportation of entire waste.	Onsite: 4.2 – includes offsite transportation of liquids. Offsite: 4.0 – includes offsite transportation of entire waste.

7.2 PREFERRED ALTERNATIVE IMPLEMENTATION BARRIER ASSESSMENT

The purpose of the implementation barrier assessment was to identify potential barriers to implementing the preferred alternative. Related to the onsite option of the preferred alternative, a single potential barrier to implementation was identified. The potential barrier is fire protection for the onsite phase separation activities.

According to Hanford Site fire safety personnel, the DOE fire safety control requirements are more stringent than those for commercial practices. Because of this, an onsite phase separation process may require more robust fire protection and suppression controls than the same process implemented at an offsite facility. Specifically, a conservative interpretation of the fire safety control requirements may require an inert atmosphere for the phase separation activities, which was not an element of the treatability test plan (BHI 2002a), with the exception of the drying step, or incorporated into the cost analysis for the onsite option of the preferred alternative. If an inert atmosphere were to be required, the cost of onsite phase separation could be significantly higher than the cost of offsite phase separation.

Because the actual impacts of the fire safety control requirements are unknown, the potential difference in onsite and offsite costs is not reflected in the cost analysis presented in this document. Rather, the cost for the onsite phase separation activity is based on input provided by a potential vendor and is generally assumed to be the same as the offsite phase separation activity. Therefore, there is a greater level of uncertainty associated with implementing phase separation onsite compared to offsite phase separation performed during treatability testing.

7.3 PREFERRED TREATMENT OPTION (ONSITE OR OFFSITE)

The preferred treatment option is the offsite option of the liquid incineration/solids stabilization alternative. As discussed previously, the capability exists for conducting the preferred treatment alternative either onsite or offsite. The onsite option includes onsite phase separation, onsite solids stabilization, and offsite liquid incineration. The offsite option includes performance of the same treatment steps but entirely off of the Hanford Site.

For the offsite option, the identified vendor has a BOA in place with the DOE for treatment of similar waste at their facility in Tennessee. Using this BOA would simplify procurement and reduce procurement time for the offsite option over the onsite option. An incinerator authorized to accept waste similar to the oil is already operational and available in Tennessee for both options. The onsite option would involve transportation of the liquid waste to the incineration facility. The primary difference between the offsite and onsite options includes additional waste transportation for the offsite option and facility design and mobilization for the onsite option. As discussed in the barrier assessment section, there is uncertainty associated with an onsite treatment facility involving the level of required fire protection and the implications to an onsite facility design and cost.

Without considering a more robust fire protection system for the onsite treatment, the cost of the onsite and offsite options are generally equal with the offsite option being slightly less than the onsite option. Table 7-2 provides a detailed cost summary of the onsite and offsite options of the preferred treatment alternative and also includes costs for the necessary engineering documents and oversight.

Between the onsite and offsite options of the preferred alternative, the offsite option has the least amount of uncertainty associated with it and is judged to perform better against the criterion of implementability.

Table 7-2. Cost Comparison of Offsite and Onsite Options of the Preferred Treatment Alternative.

Activity	Offsite Option Cost (\$1,000)	Onsite Option Cost (\$1,000)
Procurement	29	49
DOT-compliant waste package	169	
Air monitoring plan		15
ERDF ASA		58
Radiation work permit	3	3
ALARA Plan		3
EPHA		28
SSWMI	8	8
Waste profile	5	5
Transportation EPHA	7	7
Field activities		233
Repackaging and shipment	307	
Perma-Fix waste treatment	2,936	2,936
Mobilization		323
Liquid transportation		84
Shipment to ERDF	101	
Stabilized solids handling	30	52
Total	\$3,595	\$3,804

8.0 IMPLEMENTATION PLAN

This section presents a detailed implementation plan for the preferred treatment and disposal alternative. The preferred uranium chip and oil treatment and disposal alternative is phase separation of the oil and uranium chips followed by encapsulation or stabilization of the uranium chips. The stabilized chips will be disposed of at the ERDF and the oil and solvent waste incinerated at a facility in Tennessee.

The logic for implementation of the preferred treatment alternative begins with treatment contractor procurement activities. Perma-Fix has been identified as the only company capable of performing the preferred alternative in its entirety (BHI 2002b) and is the only identified company capable of meeting the mid-October 2004 drum disposition schedule for the preferred alternative. In addition, Perma-Fix has a BOA with the DOE for treatment of similar waste at their facility in Tennessee. The existing BOA will simplify waste treatment procurement. The initial implementation activities include procurement of Perma-Fix and an engineering study for determining a DOT-compliant waste transportation container. Following completion of the engineering study identifying a DOT-compliant waste container, procurement activities for the container will begin. Also following the engineering study, the level of waste repackaging will be known and the radiation work permit, the site-specific waste management instructions, the waste profile, and the transportation emergency preparedness hazard assessment concurrently begin. The waste is repackaged and shipped to the Perma-Fix facility in Tennessee, and, therefore, complies with the drum disposition schedule requirement of the ERDF staging area. Following treatment, the stabilized solids are shipped to the ERDF, unloaded, and placed within an ERDF cell for final disposal.

Table 8-1 presents a summary of costs for the preferred treatment alternative. A more detailed plan and schedule for the implementation of this alternative are included in Appendix B. Key assumptions made in preparation of costs include the following:

- The regulatory agency has concurred with the preferred treatment alternative presented in this document.
- Waste treatment will be performed by Perma-Fix at their facilities in Tennessee.
- Perma-Fix will transport, manifest, and profile (as necessary) the uranium chip and oil waste.
- Procurement of Perma-Fix will be done using the existing BOA between Perma-Fix and the DOE.
- The engineering study will identify a readily-available package for transportation of the waste. Design, fabrication, and testing of a new waste package will not be required.
- Waste repackaging will not require opening of the inner drum containing the uranium chip and oil waste.

Implementation Plan

- No additional samples of drummed waste are required; therefore, a data quality objectives process and sampling and analysis plan are not included in this estimate. Perma-Fix will perform additional characterization as needed for acceptability of incineration of the liquid waste either at the Oak Ridge Tennessee low-level radiological TSCA incinerator or at its own facility. Perma-Fix will perform additional characterization as needed for acceptability of disposal of the stabilized solids to the ERDF, including the preparation of necessary data quality objectives and necessary sampling and analysis plans.
- Perma-Fix will be responsible for all offsite shipping, including coordination with Fluor Hanford, Inc., as required.
- The phase separation/solids stabilization process can treat a minimum of five drums per day.

Table 8-1. Summary of Drum Treatment Costs to the Environmental Restoration Contractor for the Preferred Alternative. (2 Pages)

Activity	Justification	Impact (if work not performed)	Cost (\$1,000)
Waste treatment procurement	Procurement of Perma-Fix using the BOA.	Subcontract for waste treatment would be delayed. Failure to meet October 2004 removal requirement.	\$29
DOT-compliant waste package	DOT-compliant waste package needed for transportation of waste.	Waste treatment would be delayed. Failure to meet October 2004 removal requirement.	\$169
Radiation work permit	Required to support drum treatment activities	Noncompliance with radiation work requirements.	\$3
Prepare site-specific waste management instruction	Required to initiate waste repackaging activities.	Repackaging for transportation would be delayed. Failure to meet October 2004 removal requirement.	\$8
Prepare ERDF waste profile	Required prior to disposal of stabilized solids at ERDF.	Stabilized solids would need to be stored on site. Failure to meet October 2004 removal requirement.	\$5
Transportation emergency preparedness hazards assessment for liquids	Required for transportation of the waste.	Waste would need to be stored on site. Failure to meet October 2004 removal requirement.	\$7
Repackaging and shipment	Required for transportation of the waste.	Failure to meet October 2004 removal requirement.	\$307
Waste treatment and disposal	Necessary for treatment of waste.	Failure to meet October 2004 removal requirement.	\$3,067
TOTAL			\$3,595

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Resource Conservation and Recovery Act of 1976, 42 U.S.C. 6901, et seq.

Toxic Substances Control Act of 1976, 15 U.S.C. 2601, et seq.

WAC 173-303, “Dangerous Waste Regulations,” *Washington Administrative Code*, as amended.

APPENDIX A
APPLICABLE OR RELEVANT AND
APPROPRIATE REQUIREMENTS

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ACRONYMS

ARAR	applicable or relevant and appropriate requirement
BARCT	best available radionuclide control technology
CERCLA	<i>Comprehensive Environmental Response, Compensation, and Liability Act</i>
CFR	<i>Code of Federal Regulations</i>
DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
LDR	land disposal restriction
PCB	polychlorinated biphenyl
RCRA	<i>Resource Conservation and Recovery Act</i>
TBC	to be considered
TSCA	<i>Toxic Substances Control Act of 1976</i>
UHC	underlying hazardous constituent
WAC	<i>Washington Administrative Code</i>

APPENDIX A

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

A.1 INTRODUCTION

Section 121 of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), as amended, requires, in part, that any applicable or relevant and appropriate standard, requirement, criteria, or limitation under any federal environmental law, or any more stringent state requirement promulgated pursuant to a state environmental statute, be met (or a waiver justified) for any hazardous substance, pollutant, or contaminant that will remain on site after completion of remedial action. Also, 40 *Code of Federal Regulations* (CFR) 300.435(b) requires that all applicable or relevant and appropriate requirements (ARARs) be met (or waived) during the course of the remedial action. Administrative requirements such as permitting are waived for onsite actions, but such actions are still subject to the substantive requirements of ARARs.

To-be-considered (TBC) information is nonpromulgated advisories or guidance issued by federal or state governments that are not legally binding and do not have the status of potential ARARs. In some circumstances, TBCs will be considered along with ARARs to determine the remedial action necessary for protection of human health and the environment. The TBCs complement ARARs in determining what is protective at a site or how certain actions should be implemented.

The ARARs that specifically drive the need for waste treatment are the State of Washington Dangerous Waste Regulations, the *Resource Conservation and Recovery Act of 1976* (RCRA) land disposal restrictions (LDRs), and the *Toxic Substances Control Act of 1976* (TSCA). Other ARARs that are important in implementing treatment are requirements related to air emissions and hazardous materials transportation. Lists of potential federal and state ARARs/TBCs are presented in Tables A-1 and A-2, respectively. The following sections contain a discussion of how each treatment alternative presented in this study would comply with key ARARs/TBCs.

A.2 RCRA/STATE DANGEROUS WASTE STANDARDS

RCRA regulates the generation, transportation, storage, treatment, and disposal of solid and hazardous waste. Authority to implement much of RCRA has been delegated to the state and is implemented via *Washington Administrative Code* (WAC) 173-303 (for dangerous waste) and WAC 173-304 (for solid nondangerous waste). Authority for LDRs has been delegated to the state through reference to the federal regulations contained in 40 CFR 268, other than state-only LDRs.

Concentrations of both metal and organic constituents in the oil phase of the drummed waste exceed the toxicity characteristic dangerous waste designation criteria of WAC 173-303-090.

Thus, the oil must be managed as a dangerous waste and is subject to the LDR treatment standards for purposes of disposal. Contaminant concentrations in the uranium solids alone do not exceed the designation criteria. In some instances, the U.S. Environmental Protection Agency (EPA) views phase separation of characteristic hazardous waste as acceptable pretreatment and allows the separated waste streams to be considered individually for purposes of waste designation provided that the remaining material that exhibits the characteristic is treated to meet LDR standards (55 *Federal Register* 22544). A phase that no longer exhibits a hazardous waste characteristic (and which is not a listed waste) would not be subject to hazardous waste standards such as the LDR treatment standards. Although the cited reference focuses on organic recovery, it is assumed to be applicable to pretreatment of the uranium/oil mixture. Therefore, if phase separation were to be performed as pretreatment and the resulting solids phase does not exceed the dangerous waste designation criteria, the solids phase would not be subject to the LDR treatment standards.

Onsite waste treatment systems for waste streams designated as dangerous waste (e.g., the oil/uranium mixture) would need to be designed and operated in accordance with the substantive standards of the dangerous waste requirements. Key requirements would include secondary containment, leak detection, and leak collection/removal capabilities. Onsite treatment systems would be exempted from administrative requirements such as permitting because treatment would be performed within the Environmental Restoration Disposal Facility (ERDF) area of contamination. Offsite treatment systems for dangerous waste streams would be subject to all applicable administrative and substantive requirements. Prior to disposal, the waste would need to be treated to meet numeric treatment standards established in the LDRs. The standards would apply both to the constituents for which the waste was originally designated and to any underlying hazardous constituents (UHCs). Of note, polychlorinated biphenyls (PCBs), which are contaminants in the waste, are UHCs and thus subject to regulation under both RCRA and TSCA.

The following sections provide an analysis of how each alternative is anticipated to comply with the ARARs and TBCs for the dangerous waste standards.

A.2.1 Vitrification

Vitrification would satisfy the dangerous waste ARARs. The onsite vitrification system would be designed to meet substantive requirements for dangerous waste treatment systems. Hazardous organic constituents in the waste would be removed or destroyed with a removal efficiency of 99.9999%, thus meeting the LDR treatment standards. Metal constituents would be immobilized within the glass matrix to a degree that would meet the standards.

A.2.2 Whole-Drum Stabilization

It is unknown whether stabilization of the combined uranium chip and oil waste would satisfy the dangerous waste ARARs. A variety of stabilization technologies have proven successful in meeting the LDR treatment standards for metals. However, stabilization technologies that would be appropriate for the uranium chip and oil waste are not commonly used to immobilize organic

constituents, and none that would be appropriate for this waste matrix were specifically identified during this evaluation.

The EPA addresses the issue of stabilization for hazardous organic constituents in recent draft guidance (EPA 2001). RCRA requires that treatment substantially reduce the mobility or toxicity of hazardous constituents. Because stabilization is not a widely effective method of reducing the mobility of organic constituents, it is often viewed as a form of impermissible dilution (by the stabilization reagent) rather than treatment, violating 40 CFR 268.3. The LDR treatment standards do not specifically prohibit the use of stabilization to treat hazardous wastes containing organic constituents, but meeting the standards through dilution alone is not allowed. However, the EPA acknowledges that dilution that is a necessary part of the treatment process, which otherwise destroys, removes, or immobilizes the hazardous constituents, is normally permissible.

For hazardous organic constituents, the LDR treatment standards are based on the performance of treatment technologies like combustion or aggressive distillation, which destroy or remove the hazardous organics from the waste. The EPA's determination is that compliance is demonstrated by showing, via a total waste analysis, that the standard is satisfied. The EPA does not interpret compliance with the rule as requiring only treatment that destroys or reduces the organic constituents. A total waste analysis of a nonwastewater involves exposing a representative sample of the waste to an aggressive extractant, normally some type of solvent that would be expected to extract the "total" amount of hazardous organics from the waste. Further, EPA's draft guidance states that some types of stabilization reagents (e.g., clays, silica, alumina, and activated carbon) have strong adsorptive and bonding properties that may reduce mobility.

Treatability testing would be required to demonstrate that whole-drum stabilization would satisfy the LDR treatment standards for the organic constituents (including PCBs as a UHC). Testing would require a total waste analysis using an aggressive solvent before and after treatment to demonstrate that effective immobilization has occurred. If the demonstration were to be successful, the EPA might accept that the inability to extract the hazardous organic constituents in the stabilized residues is an expected result of excess adsorptive capacity and satisfies the treatment requirements. The EPA would also consider any site-specific conditions (e.g., co-disposal with other wastes) that might affect leachability.

If a demonstration of immobilization were not successful, one of two other mechanisms would be required to implement this alternative. The first would be a treatability variance pursuant to 40 CFR 268.44. This regulation allows for a variance in situations where "treatment to the specified level or by the specified method is technically inappropriate" or, for remediation waste, in situations where treatment "is environmentally inappropriate because it would discourage aggressive remediation." An example (see 62 *Federal Register* 64506) where the EPA may grant a variance based on the former criterion includes "when media is contaminated with metal contaminants and also contains low levels of organic constituents. In such a case, it may be inappropriate to require combustion treatment of the organic contaminants because it may be inappropriate to combust media generally and because it may be inappropriate to combust wastes where metals are the chief hazardous constituent." In this particular example, however, the EPA

cautions that “it is often routine and obviously appropriate to combust organic-contaminated hazardous wastes and to stabilize the combustion residues to reduce metal mobility.” Thus, the conclusion that it may be inappropriate to combust wastes where metals are the chief hazardous constituent is not unequivocal, but instead is based on a case-by-case determination.

The variance provision for situations where treatment to LDR standards could “discourage aggressive remediation” may be applied where federal rules allow the option of leaving waste in place (e.g., within an area of contamination), but a more beneficial option would be to excavate the waste for disposal elsewhere. The latter option could include some form of treatment, but might not be sufficient to meet LDR standards.

The first variance provision could be considered in conjunction with the uranium chip and oil waste. The chief hazard associated with the waste appears to be the pyrophoric property of the depleted uranium and the organic contamination is secondary, so it might be argued that treatment beyond that necessary to address the uranium may not be warranted. However, it can also be argued that separation of the phases is not unduly difficult or costly, and that the chief hazard associated with the separated oil phase is the organic contamination. The second provision, where compliance could discourage aggressive remediation, would not apply because obtaining the variance would actually result in less aggressive remediation. Based on these considerations, an LDR treatability variance is unlikely to be justified.

The second mechanism for alternative ARAR compliance would be to seek an ARAR waiver. However, the only waiver that might potentially be appropriate would be the waiver in cases where compliance would result in greater harm to human health or the environment. Other waivers would not be applicable because waste disposition is not an interim measure, stabilization would not provide an equivalent level of performance, and it is not technically impracticable to treat the waste by another method. A “greater harm” argument potentially could be developed based on the fact that phase separation, which would be required to treat the oil, presents a risk to workers and the potential to generate excessive quantities of additional waste in the form of solvent. However, initial discussions with the regulatory agencies suggest that a waiver would be difficult to obtain.

A.2.3 Liquid Incineration/Solids Stabilization

The liquid incineration/solids stabilization alternative would satisfy the dangerous waste ARARs. The onsite phase separation process would be designed to meet substantive requirements for dangerous waste treatment systems. The offsite phase separation process would meet the substantive and administrative requirements of RCRA. Phase separation would produce a solids phase (uranium chips) that would not exceed the dangerous waste designation criteria. The destruction efficiency of the incineration process used to treat the oil and spent solvent would be expected to meet the LDR treatment standards for the hazardous organic constituents and UHCs. Metal constituents remaining in the ash would be immobilized via stabilization sufficient to meet the standards.

A.2.4 Liquid Incineration/Solids Oxidation

The liquid incineration/solids oxidation alternative would satisfy the dangerous waste ARARs. The onsite phase separation process would be designed to meet substantive requirements for dangerous waste treatment systems. The offsite phase separation process would meet the substantive and administrative requirements of RCRA. Phase separation would produce a solids phase (uranium chips) that would not exceed the dangerous waste designation criteria. The destruction efficiency of the incineration process used to treat the oil and spent solvent would be expected to meet the LDR treatment standards for hazardous organic constituents. Metal constituents remaining in the ash would be immobilized via stabilization sufficient to meet the standards.

A.3 RADIOACTIVE WASTE STANDARDS

The *Atomic Energy Act of 1954* establishes standards for the management of radioactive wastes. Regulations pertaining to the management and land disposal of low-level radioactive waste at U.S. Nuclear Regulatory Commission-licensed facilities are contained in 10 CFR 61. These regulations include barrier design requirements that include protection of humans from inadvertent contact with waste above acceptable levels at any time after the loss of active institutional controls.

Radioactive waste would be disposed under all of the alternatives. All waste residues except ash from the liquid incineration process would be disposed at the ERDF. The ERDF meets all requirements for low-level radioactive waste disposal. The stabilized ash from incineration would be disposed in a licensed commercial low-level waste disposal facility.

A.4 PCB STANDARDS

The TSCA and its implementing regulations (40 CFR 761) govern the storage, treatment, and disposal of materials containing PCBs. The 1998 amendments to TSCA added specific provisions for PCB/radioactive waste and PCB remediation waste. As defined in 40 CFR 761.61.3, “PCB remediation waste” is any waste containing PCBs as a result of a spill release, or other unauthorized disposal at specific date-dependent concentrations. For material disposed prior to April 18, 1978 (such as the uranium chip and oil waste), the concentration that results in regulation as a PCB remediation waste is ≥ 50 ppm in the waste. As specified in 40 CFR 761.1(b)(3), provisions that apply to PCBs at concentrations >50 ppm would also apply to contaminated surfaces at PCB concentrations $>10 \mu\text{g}/100 \text{ cm}^2$. The regulation establishes three methods for disposing of PCB remediation waste: self-implementing standards, performance-based standards, and a risk-based approach.

For purposes of determining the regulatory status under TSCA, the individual phases of multi-phasic waste must be analyzed separately for PCB concentration (40 CFR 761.1[b][4][iii]). Liquid phases must be analyzed on a wet weight basis, and nonliquid phase must be analyzed on

a dry weight basis. If the phases will be disposed together, the mixture must be managed in accordance with the concentration of the most contaminated phase. Alternately, the regulation allows multi-phasic waste to be separated and disposed based on the disposal requirements that apply to each separated, single-phase material (40 CFR 761.1[b][4][iv]). The demonstration that phase separation has resulted in a nonliquid waste stream is made by using the paint filter test (40 CFR 761.3).

The uranium chip and oil mixture meets the definition of a PCB remediation waste because it is derived from a cleanup action and concentrations of PCBs in the oil exceed 50 ppm or 10 $\mu\text{g}/100\text{ cm}^2$. Although the uranium solids were not analyzed separately for PCBs, it is anticipated that the PCBs reside primarily with the oil and that the solids alone would not contain PCBs at concentrations greater than 50 ppm. If this assumption is correct and the solids are sufficiently separated from the oil to pass the paint filter test, they would not be regulated for purposes of disposal as a PCB remediation waste. Solids that do not pass the paint filter test would need to be disposed in accordance with the requirements for multi-phasic PCB remediation waste. A definitive statement regarding the regulatory status of the solids would require further sampling and analysis.¹ The following sections provide an analysis of how each alternative is anticipated to comply with the ARARs and TBCs for the PCB standards.

A.4.1 Vitrification

Vitrification would satisfy the ARARs for PCBs. The vitrification process would provide a PCB destruction efficiency equivalent to incineration and thus would satisfy the performance-based requirements of 40 CFR 761.61(b)(1). Several mobile vitrification units have demonstrated satisfactory performance as alternative treatment systems and been permitted under TSCA for use in treating PCBs.

A.4.2 Whole-Drum Stabilization

Under the whole-drum stabilization alternative, the uranium chips and oil would not be separated, so the mixture would need to be disposed in accordance with the PCB concentration in the liquid, which generally is greater than 50 ppm and in 2 of the 31 drums tested greater than 500 ppm. Whole-drum stabilization would not satisfy the PCB self-implementing or performance-based standards of TSCA. The only avenue for compliance would be the risk-based approach for which additional testing likely would be required.

Under the self-implementing approach (40 CFR 761.61[a][5]), nonaqueous liquid PCB remediation waste must meet the requirements of 40 CFR 761.79(b)(2), which requires the liquid to be decontaminated to a PCB concentration of less than 2 ppm. Under the performance-based approach (40 CFR 761.61[b][1]), liquid PCB remediation waste must be disposed in accordance with 40 CFR 761.60(a) or (e) (which requires incineration, a high-efficiency boiler, or an

¹ The uranium solids range in size from fines to large pieces of metal. A total PCB analysis (e.g., analysis to determine ppm) would likely be inappropriate for substantive pieces of uranium metal. Sampling and analyzing for the surface concentration would be more appropriate.

alternate method equivalent to incineration) or decontaminated in accordance with 40 CFR 761.79.

The TSCA risk-based approach for disposal of PCB remediation waste is flexible. It requires that anyone wishing to dispose of PCB remediation waste in a manner other than prescribed under the self-implementing or performance-base standards provide information on the alternative method to the EPA (40 CFR 761.61[c]). The EPA then considers whether the method will not pose an unreasonable risk to human health or the environment in issuing an approval. Use of the risk-based approach for this alternative may be feasible if it could be demonstrated that stabilization immobilizes the PCBs such that the potential for a release to the environment would be substantially reduced. It is unknown whether the stabilization technologies considered appropriate for this waste would reduce the mobility of PCBs. Additional testing would likely be required to support this approach.

A.4.3 Liquid Incineration/Solids Stabilization

The liquid incineration/solids stabilization alternative would satisfy the ARARs for PCBs.

Following the decant and solvent washing steps of the phase separation process, the uranium solids would be dried under an inert atmosphere to the extent necessary to pass the paint filter test. Without a separable liquid phase, the solids would be managed in accordance with the PCB concentration of the solids. In the absence of data on the PCB concentration in the solids, TSCA regulations would allow DOE to assume that the concentration exceeds 50 ppm and that the solids must be managed as a PCB remediation waste. This assumption would be adequate for the onsite treatment option because the onsite stabilization process would meet the substantive requirements for treatment under TSCA. If the offsite treatment option were to be selected, the solids would be analyzed to confirm that they do not exceed a PCB concentration of 50 ppm (or $10 \mu\text{g}/100 \text{ cm}^2$), and thus, would not be regulated as a PCB remediation waste, or the solids would be treated at a TSCA-authorized facility. The stabilized solids would be disposed at the ERDF, which is authorized to receive nonliquid PCB waste at any concentration for disposal.

The oil/solvent phase would be treated via incineration or a combination of dechlorination/incineration. Either process would satisfy the performance-based requirements of 40 CFR 761.61(b)(1). Both the Oak Ridge incinerator and the Perma-Fix dechlorination unit have been authorized for PCB treatment under TSCA.

A.4.4 Liquid Incineration/Solids Oxidation

The liquid incineration/solids oxidation alternative would satisfy the ARARs for PCBs and, in terms of PCB ARARs, is identical to the situation in the liquid incineration/solids stabilization alternative.

Following the decant and solvent washing steps of the phase separation process, the uranium solids would be dried under an inert atmosphere to the extent necessary to pass the paint filter test. Without a separable liquid phase, the solids would be managed in accordance with the PCB

concentration of the solids. In the absence of data on the PCB concentration in the solids, TSCA regulations would allow DOE to assume that the concentration exceeds 50 ppm and that the solids must be managed as a PCB remediation waste. This assumption would be adequate for the onsite treatment option because the onsite oxidation process would meet the substantive requirements for treatment under TSCA. If the offsite treatment option were to be selected, the solids would be analyzed to confirm that they do not exceed a PCB concentration of 50 ppm (or 10 $\mu\text{g}/100 \text{ cm}^2$), and thus, would not be regulated as a PCB remediation waste, or the solids would be treated at a TSCA-authorized facility. The oxidized solids would be disposed at the ERDF, which is authorized to receive nonliquid PCB waste at any concentration for disposal.

The oil/solvent phase would be treated via incineration or a combination of dechlorination/incineration. Either process would satisfy the performance-based requirements of 40 CFR 761.61(b)(1). Both the Oak Ridge incinerator and the Perma-Fix dechlorination unit have been authorized for PCB treatment under TSCA.

A.5 AIR EMISSION STANDARDS

The *Clean Air Act of 1977* establishes standards for the control of air emissions. Authority has partially been delegated to Washington State. Under 40 CFR 61 (Subpart H) and WAC 246-247, radionuclide airborne emissions from all combined operations at the Hanford Site may not exceed 10 mrem/yr effective dose equivalent to the hypothetical offsite maximally exposed individual. These regulations require verification of compliance through monitoring.

“General Regulations for Air Pollution Sources” (WAC 173-400) and “Controls for New Sources of Toxic Air Pollutants” (WAC 173-460) establish air emission requirements for new or modified sources of air pollutants. These regulations establish new source review requirements, general emissions standards (e.g., control of fugitive dust), and technology requirements.

The radionuclide emission limits would apply to all fugitive, diffuse, and point-source air emissions of radionuclides generated by any of the removal or ex situ alternatives. If there were to be the potential for any nonzero radioactive emissions, best available radionuclide control technology (BARCT) would be required. If the alternative would generate an increase of toxic air pollutants to the atmosphere above the small quantity emission rates, implementation of BARCT would be required.

All of the alternatives that involve onsite treatment would have the potential for air emissions. Treatment systems would be designed, operated, and monitored to control emissions as required to meet ARARs. Potential emission quantities and associated doses (for radioactive emissions) would be calculated to ensure compliance. The offsite treatment options would be conducted at facilities that are currently permitted and meet applicable air emission standards for their location.

A.6 TRANSPORTATION STANDARDS

The *Hazardous Materials Transportation Act of 1974* (49 U.S.C. 1801, et seq.) establishes standards for transporting hazardous materials and is implemented via 49 CFR 171 and 172. Transportation of hazardous material is prohibited unless the material is properly classed, described, packaged, marked, labeled, and in condition for shipment. Tables in the regulation are provided to identify requirements for labeling, packaging, and transportation based on categories of waste types. Specific performance requirements are established for packages used for shipping and transport of hazardous materials. If a transportation package that has been certified in accordance with the regulation is not available, a transporter may request an exemption through the U.S. Department of Transportation (DOT).

The following sections provide an analysis of how each alternative is anticipated to comply with the ARARs for the transportation standards.

A.6.1 Vitrification

Vitrification would not require any offsite transportation; therefore, there are no transportation ARARs for this alternative.

A.6.2 Whole-Drum Stabilization

The whole-drum stabilization alternative would not require any offsite transportation; therefore, there are no transportation ARARs for this alternative.

A.6.3 Liquid Incineration/Solids Stabilization

The liquid incineration/solids stabilization alternative would require offsite transportation of hazardous materials. In the onsite treatment option, the oil and spent solvent would be transported to an offsite incinerator. A certified package is available, and transportation would be conducted in compliance with all DOT requirements.

In the offsite treatment option, the uranium chip and oil waste or washed uranium chips would be transported to a treatment facility. A transportation package of sufficient size that is certified in accordance with the requirements is not currently available. For purposes of developing the alternative, it is assumed that an exemption or a determination of compliance can be made to satisfy the DOT requirements. If neither pathway proves satisfactory, a new package would undergo testing and certification in accordance with the requirements.

A.6.4 Liquid Incineration/Solids Oxidation

The liquid incineration/solids oxidation alternative would require offsite transportation of hazardous materials. In the onsite treatment option, the oil and spent solvent would be transported to an offsite incinerator. A certified package is available, and transportation would be conducted in compliance with all DOT requirements.

In the offsite treatments option, the uranium chip and oil waste would be transported to a treatment facility. A transportation package of sufficient size that is certified in accordance with the requirements is not currently available. For purposes of developing the alternative, it is assumed that an exemption or a determination of equivalency can be made to satisfy the DOT requirements. If neither pathway proves satisfactory, a new package would undergo testing and certification in accordance with the requirements.

A.7 REFERENCES

10 CFR 61, "Licensing Requirements for the Land Disposal of Radioactive Waste," *Code of Federal Regulations*, as amended.

10 CFR 835, "Occupational Radiation Protection," *Code of Federal Regulations*, as amended.

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WAC 173-304, “Minimum Functional Standards for Solid Waste Handling,” *Washington
Administrative Code*, as amended.

WAC 173-400, “General Regulations for Air Pollution,” *Washington Administrative Code*,
as amended.

WAC 173-460, “Controls for New Sources of Toxic Air Pollutants,” *Washington Administrative
Code*, as amended.

WAC 173-480, “Ambient Air Quality Standards and Emission Limits for Radionuclides,”
Washington Administrative Code, as amended.

WAC 173-490, “Emission Standards and Controls for Sources Emitting Volatile Organic
Compounds (VOCs),” *Washington Administrative Code*, as amended.

WAC 246-221, “Radiation Protection Standards,” *Washington Administrative Code*, as amended.

WAC 246-247, “Radiation Protection - Air Emissions,” *Washington Administrative Code*, as
amended.

Table A-1. Identification of Potential Federal ARARs and TBCs.

ARAR Citation	Applicable, Relevant and Appropriate, or To Be Considered	Requirement	Rationale for Use
<p>Resource Conservation and Recovery Act of 1976, 42 U.S.C. 6901, et seq.</p> <p>Land Disposal Restrictions, 40 CFR 268</p>	<p>Applicable where authority not otherwise delegated to state</p>	<p>This section prohibits the placement of restricted RCRA hazardous wastes in land-based units until treated to specific standards considered protective for disposal.</p>	<p>This section is applicable to the treatment and disposal of RCRA hazardous waste.</p>
<p>Clean Air Act of 1977, as amended, 42 U.S.C. 7401, et seq.</p> <p>National Emission Standards for Hazardous Air Pollutants (NESHAP), 40 CFR 61</p>	<p>Applicable</p>	<p>Establishes emission standards for hazardous air pollutants including radionuclides, other than radon, and asbestos. Subpart H sets emission limits from the entire facility to ambient air that are not to cause any member of the public to receive an effective dose equivalent of 10 mrem/yr.</p>	<p>These requirements are applicable because onsite treatment systems are a potential source of emissions.</p>
<p>Toxic Substances Control Act (TSCA) of 1976, 15 U.S.C. 2601 et seq.</p> <p>Regulation of PCBs, 40 CFR 761</p>	<p>Applicable</p>	<p>These requirements identify standards applicable to the handling and disposal of PCBs and PCB remediation waste.</p>	<p>The requirements are applicable because PCBs have been detected in the uranium chip and oil waste.</p>
<p>Atomic Energy Act of 1954, as amended, 42 U.S.C. 2011, et seq.</p> <p>Licensing Requirements for the Land Disposal of Radioactive Waste, 10 CFR 61</p> <p>Department of Energy Occupational Radiation Protection, 10 CFR 835</p>	<p>Relevant and appropriate</p> <p>Applicable</p>	<p>Requires that disposal systems be designed to limit the annual dose equivalent beyond the facility boundary below 25 mrem to the whole body, 75 mrem to the thyroid, or 25 mrem to any other organ. Relevant and appropriate to remedial actions that include land disposal.</p> <p>These requirements set occupational dose limits for adults. Total effective dose equivalent is equal to 5 rem/yr.</p>	<p>Relevant and appropriate because radioactive waste would be disposed as part of the action.</p> <p>Applicable for worker protection during management of the uranium chip and oil waste.</p>
<p>Hazardous Materials Transportation Act of 1974, 49 U.S.C. 1801, et seq.</p> <p>Hazardous Materials Regulation, 49 CFR 171</p> <p>Hazardous Materials Tables, Hazardous Materials Communications Requirements, and Emergency Response Information Requirements, 49 CFR 172</p>	<p>Applicable</p> <p>Applicable</p>	<p>Prohibits transportation of hazardous material unless the material is properly classed, described, packaged, marked, labeled, and in condition for shipment.</p> <p>Tables are used to identify requirements for labeling, packaging, and transportation based on categories of waste types. Specific performance requirements are established for packages used for shipping and transport of hazardous materials.</p>	<p>Applicable because hazardous material would be sent offsite as part of the action.</p> <p>Applicable because hazardous material would be sent offsite as part of the action.</p>

Table A-2. Identification of Potential State ARARs and TBCs. (3 Pages)

ARAR Citation	Applicable, Relevant and Appropriate, To Be Considered	Requirement	Rationale for Use
<p>Dangerous Waste Regulations, Ch. 70.105 RCW</p> <p>Dangerous Waste Regulations, WAC 173-303</p> <p>Designation of Waste, WAC 173-303-070 through 110</p> <p>Land Disposal Restrictions, WAC 173-303-140</p> <p>Spills and Discharges Into the Environment, WAC 173-303-145</p> <p>Requirements for Generators of Dangerous Waste, WAC 173-303-170 through 230</p> <p>Siting Criteria, WAC 173-303-282(6) and (7)</p> <p>General Requirements for Dangerous Waste Management Facilities, WAC 173-303-280 through 395</p> <p>Use and Management of Containers, WAC 173-303-630</p>	<p>Applicable</p> <p>Applicable</p> <p>Applicable</p> <p>Applicable</p> <p>Applicable</p> <p>Applicable</p> <p>Applicable</p>	<p>Establishes the methods and procedures to determine if solid waste requires management as dangerous waste.</p> <p>Identifies dangerous wastes that are restricted from land disposal, describes requirements for state-only restricted wastes, and defines the circumstances under which a prohibited waste may be disposed.</p> <p>Sets forth the requirements that apply when any dangerous waste or hazardous substances are intentionally or accidentally spilled or discharged into the environment such that human health and the environment are threatened, regardless of the quantity of dangerous waste or hazardous substance.</p> <p>Requirements defined under this section include a 90-day waste accumulation period, specific levels of training, emergency preparedness, and record keeping.</p> <p>Establishes siting criteria that serve as an initial screen for consideration of sites for dangerous waste management.</p> <p>General requirements include siting standards and procedures for permitting, training, emergency preparedness, security, inspections, contingency planning, waste analysis, and management of containers.</p> <p>Specifies requirements for the use and management of containers.</p>	<p>Applicable because the uranium chip and oil waste has been designated as a dangerous waste.</p> <p>Applicable to the disposal of dangerous waste.</p> <p>Applicable should any dangerous waste or hazardous substances be spilled or discharged into the environment during the treatment or disposition of the waste.</p> <p>Applicable to storage of the waste.</p> <p>Applicable to siting waste treatment systems that might be considered.</p> <p>Applicable to management of the uranium chip and oil waste.</p> <p>Applicable to the management and transportation of drums containing the uranium chip and oil waste.</p>
<p>State Radiation Protection Requirements, 70.98 RCW</p> <p>Radiation Protection Standards, WAC 246-221</p>	<p>Relevant and appropriate</p>	<p>Washington State radiation protection requirements are implemented under specific sections of WAC 246.</p> <p>Chapter 246-221-290 establishes annual average concentration limits for radioactive releases in gaseous and liquid effluent released to unrestricted areas.</p> <p>Occupational dose to adults and minors are set in these requirements. Dose limits that individual members of the public may receive in unrestricted areas from external sources are also set.</p>	<p>This regulation is not applicable because it does not apply to federal agencies under the Atomic Energy Act. However, it is considered relevant and appropriate because it establishes standards for acceptable levels of exposure to radiation.</p>

Table A-2. Identification of Potential State ARARs and TBCs. (3 Pages)

ARAR Citation	Applicable, Relevant and Appropriate, To Be Considered	Requirement	Rationale for Use
<p>Washington Clean Air Act of 1967, Ch. 70.94 RCW and Ch. 43.21A RCW</p> <p>Radiation Protection - Air Emissions, WAC 246-247</p>	<p>Applicable</p>	<p>Establishes air-emission limits for airborne radionuclide emissions as defined in WAC 173-480 and 40 CFR 61 Subparts H and I. The ambient air standards under WAC 173-480 require that the most stringent standard be enforced. Ambient air standards under 40 CFR 61 Subparts H and I are not to exceed amounts that result in an effective dose equivalent of 10 mrem/yr to any member of the public. The ambient standard in WAC 173-480 specifies that emission of radionuclides to the air must not cause a dose equivalent of 25 mrem/yr to the whole body or 75 mrem/yr to any critical organ. These standards specify emission monitoring requirements and the application of best available radionuclide technology requirements.</p>	<p>Applicable because it sets emission limits and use of BARCT for airborne radionuclides.</p>
<p>General Regulations for Air Pollution, WAC 173-400</p>	<p>Applicable</p>	<p>Requires that all sources of air contaminants meet emission standards for visible, particulate, fugitive, odors, and hazardous air emissions. Requires that all emission units use reasonably available control technology, which may be determined for some source categories to be more stringent than the emission limitations listed in this chapter. Requires that source testing and monitoring be performed. A new source would include any process or source that may increase emissions or ambient air concentration of any contaminant for which federal or state ambient or emission standards have been established.</p>	<p>Applicable to alternatives that might generate such emissions.</p>
<p>Ambient Air Quality Standards and Emission Limits for Radionuclides, WAC 173-480</p>	<p>Relevant and appropriate</p>	<p>These requirements establish that the most stringent federal or state ambient air quality standard for radionuclides are enforced. The WAC 173-480 standard defines the maximum allowable level for radionuclides in the ambient air, which shall not cause a maximum accumulated dose equivalent of 25 mrem/yr to the whole body or 75 mrem/yr to any critical organ. However, ambient air standards under 40 CFR 61 Subparts H and I are not to exceed amounts that result in an effective dose equivalent of 10 mrem/yr to any member of the public. Emission standards for new and modified emission units shall utilize best available radionuclide control technology.</p>	<p>Requirements of this state-authorized standard are relevant and appropriate to remedial actions performed at the site that may emit radionuclides to the air.</p>

Table A-2. Identification of Potential State ARARs and TBCs. (3 Pages)

ARAR Citation	Applicable, Relevant and Appropriate, To Be Considered	Requirement	Rationale for Use
Emission Standards and Controls for Sources Emitting Volatile Organic Compounds (VOC), WAC 173-490	Relevant and appropriate	Establishes technically feasible and attainable standards for sources emitting VOCs.	Probably not applicable because the source of potential VOC emissions generated by treatment most likely does not meet the definition of emission sources specified under WAC 173-490-03. However, may be considered relevant and appropriate if remedial actions have the potential to emit VOCs into the air.

APPENDIX B
IMPLEMENTATION RESOURCES AND SCHEDULE

**Appendix B -
Implementation Resources and Schedule**

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Rev. 0

FY03 - CA/COA/ACT Burden W/ESC - ADK PAGE NO. 1

Project Name: DWT7 START DATE 01OCT02

REPORT DATE 18MAR03 DATA DATE 01APR03
14:55

ACTIVITY BGT QTY BUDGET
TASK ID DESCRIPTION (HOURS) COST

Waste Treatment Procurement

RPB	A0770	Prepare and Issue PMMR	1476.20
RPB	A0790	Form BHI Subcontract Utilizing BOA	
RPB	A1130	Award Subcontract for Offsite Treatment	27949.60

			29425.80

DOT Compliant Waste Package

DOT	A0780	Engineering Study	5361.30
DOT	A0800	Prepare and Issue PMMR	2824.90
DOT	A01140	Prepare and Issue RFP	2824.90
DOT	A1300	Subcontractor Prepares Bid	
DOT	A1450	Negotiate/Award Subcontract	1859.15
DOT	A1460	Delivery of Drums (Subcontractor)	156000.00

			168870.25

RWP (Radiation Work Permit)

RWP	A01660	RWP Request	1948.40
RWP	A01670	RWP Preparation	974.20

			2922.60

Prepare Site Specific Waste Mgmt Instructions

SSW	A01020	Prepare Draft SSWMI	4396.86
SSW	A01030	Internal Review	2298.72
SSW	A01040	Incorporate Comments and Tech Edit	1257.40
SSW	A01060	Issue SSWMI	346.96

			8299.94

**Appendix B -
Implementation Resources and Schedule**

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FY03 - CA/COA/ACT Burden W/ESC - ADK PAGE NO. 2
 Project Name: DWT7 START DATE 01OCT02
 REPORT DATE 18MAR03 DATA DATE 01APR03
 14:55

TASK ID	ACTIVITY DESCRIPTION	BGT QTY (HOURS)	BUDGET COST

Prepare Waste Profile			
PWP A01130	Prepare ERDF Waste Profile		4595.40
PWP A01160	Issue Waste Profile		245.80

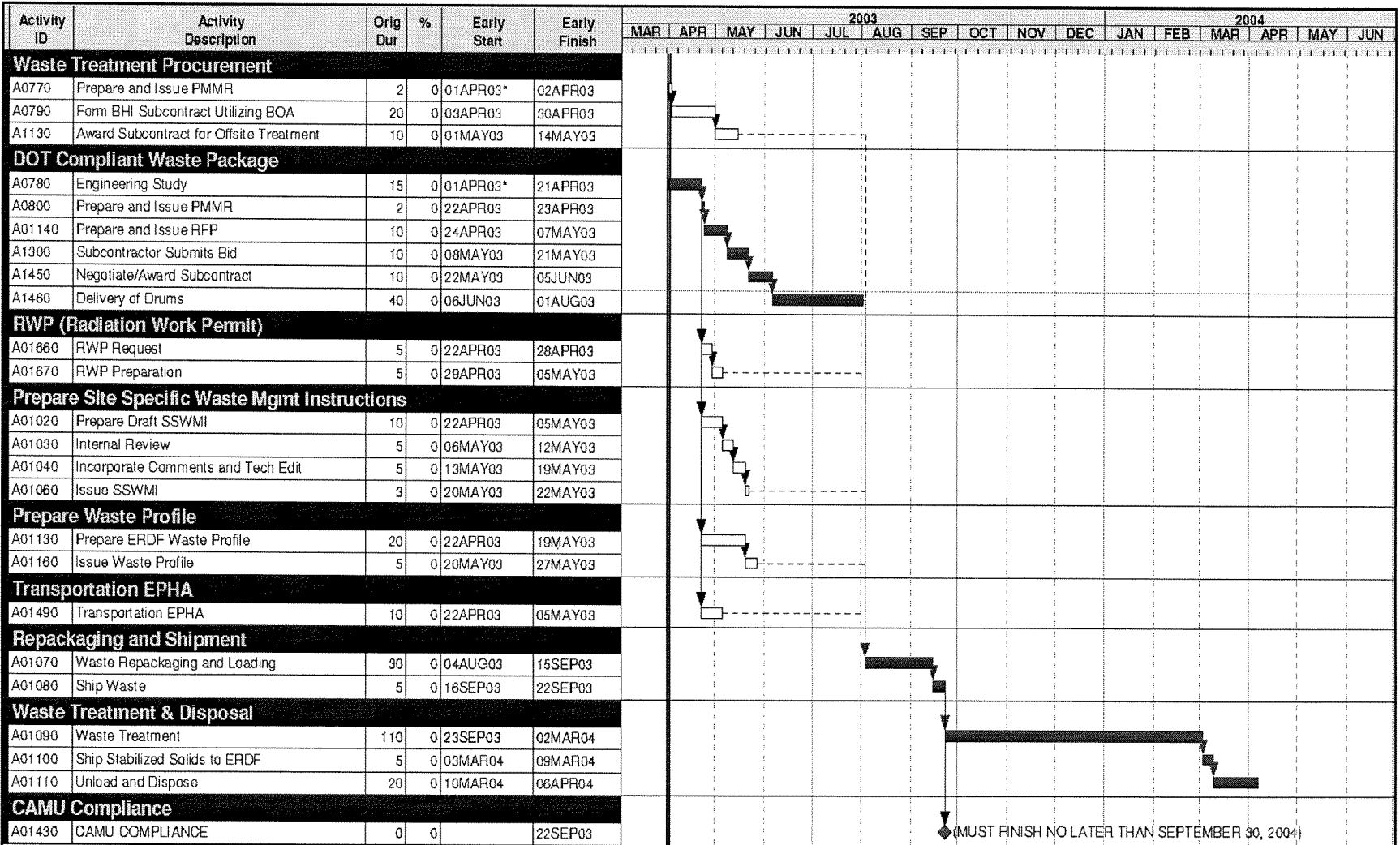
			4841.20
Transportation EPHA for Liquids			
TEL A01490	Transportation EPHA for Liquids		6602.90

			6602.90
Repackaging and Shipment			
RAS A01070	Waste Repackaging and Loading		207338.40
RAS A01080	Ship Waste (Subcontractor)		100050.00

			307388.40
Repackaging and Shipment			
WTD A01090	Waste Treatment (Subcontractor)		2936300.00
WTD A01100	Ship Stabilized Solids to ERDF Subcontractor)		100050.00
WTD A01110	Unload and Dispose		30342.00

			3066692.00
CAMU Compliance			
CAM A01430	CAMU COMPLIANCE		

			=====
			3,595,043.09



Start Date	01OCT02	Early Bar
Finish Date	06APR04	Progress Bar
Date Date	01APR03	Critical Activity
Run Date	27MAR03 10:22	

DWT8

Sheet 1 of 1

Treatment of Uranium Chips in Oil
Field Schedule for Offsite Drummed Treatment

Date	Revision	Checked	Approved

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