REPORT ON
DOE HANFORD TANK WASTE CLASSIFICATION

Prepared for

Nuclear Regulatory Commission
Contract NRC-02-93-005

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Introduction and Background

Hanford Site tank radioactive and hazardous chemical wastes were produced from 1944 through 1988 by reprocessing irradiated nuclear fuel. Aqueous wastes resulting from these reprocessing operations were stored in underground double-shell (DST) and single-shell tanks (SST). The wastes have been treated to reduce volume and to remove some of the radionuclides. The Nuclear Regulatory Commission (NRC) has regulatory responsibility for disposal of high-level radioactive waste (HLW) generated at Hanford, but does not have authority for regulating disposal of U.S. Department of Energy (DOE) low-level radioactive waste (LLW) from that site.

The DOE has requested NRC to concur in a Hanford Site tank waste management plan presented in Technical Basis for Classification of Low-Activity Waste Fraction from Hanford Site Tanks for the Tank Waste Remediation System (hereafter referred to as the TBR) that would classify certain wastes as incidental. These incidental wastes would be disposed onsite in a LLW facility.

The NRC has applied three criteria to classification of Hanford Site tank wastes as incidental:

- Criterion One: Wastes have been processed (or will be further processed) to remove key radionuclides to the maximum extent that is technically and economically practical
- Criterion Two: Wastes will be incorporated in a solid physical form at a concentration that does not exceed the applicable concentration limits for Class C LLW as set out in 10 CFR Part 61
- Criterion Three: Wastes are to be managed, pursuant to the Atomic Energy Act, so that safety requirements comparable to the performance objectives set out in 10 CFR Part 61, Subpart C are satisfied.

This report provides a Center for Nuclear Waste Regulatory Analyses (CNWRA) assessment of the DOE TBR with respect to whether the waste management plan described therein would result in a low-activity waste (LAW) fraction that could be classified as incidental waste. It also includes an assessment of the DOE Hanford Site tank waste characterization.

Evaluation of the Characterization of the Hanford Site Tank Wastes

The Hanford Site liquid radioactive and hazardous chemical wastes from several different waste streams were subjected to a variety of treatment processes. The wastes have also been concentrated to reduce volume and have been mixed in 177 DSTs and SSTs. Available records do not accurately trace the sources, quantities, and current locations of the radionuclides. Consequently, there is uncertainty in the characterization of the constituents and quantities of the wastes in each of the tanks. However, the DOE is confident that the quantities of radionuclides used to support the TBR represent an upper bound. The following assumptions were used in the CNWRA assessment.

- Hanford Site tank waste inventories used for the material balance in the TBR are representative of the upper bound of these inventories, given the uncertainties in existing records of tank contents.

- If continuing characterization of tank wastes results in a determination that radionuclide inventory values should be significantly increased, classification of the wastes will be re-evaluated.

- If waste classification must be reevaluated in response to increases in the estimated inventory, privatization contract specifications for the waste form will continue to require that all solidified waste be classified as Class C or less as defined in 10 CFR Part 61.

- Any re-evaluation of waste classification in response to increased estimates of tank inventories will be conducted using the three criteria currently defined or other criteria concurred in by the NRC staff.

In conclusion, the material balance used for the TBR is consistent with available records and models of tank waste radionuclide inventories.

Evaluation of Compliance with Criterion One

The DOE waste management plan for the Hanford Site tanks proposes the use of processes that will remove all but 8.5 MCi of the key radionuclides (approximately 2–5 percent of the total site inventory). This 8.5 MCi would be the waste considered to be incidental. CNWRA reviewers evaluated DOE analyses of the technical and economic practicality of methods available for radionuclide removal, considering NRC guidance to DOE on requirements for classifying waste as incidental. To some extent, the evaluation was constrained by availability of references and the subjectivity of the analyses. The following assumptions were used in this evaluation.

- Results of the DOE assessments of the technical and economic practicalities of radionuclide removal processes for the Hanford Site tank wastes represent a reasonable effort to perform such assessments considering inherent subjectivity.

- Privatization contract specifications provide flexibility in the use of radionuclide removal processes consistent with producing a waste form that would be classified as Class C or less.

- A LAW fraction from processing both DST and SST wastes that results in a lower waste volume and total waste activity at the lower end of the range than previously expected considering only the DSTs, supports a determination that radionuclide removal would be completed to the extent technically and economically practical, consistent with the same determination made by the NRC in 1989 for the DST wastes.

In conclusion, Criterion One for classifying the Hanford Site LAW fraction as incidental waste will be met if a waste management plan similar to the one presented in the TBR is placed in effect and if privatization contractors meet the contract waste form specifications.

Evaluation of Compliance with Criterion Two

In section 2 of this report, CNWRA reviewers conclude that the DOE characterization of the key radionuclides and their quantities represents a realistic estimate. Using this waste characterization data, CNWRA reviewers assessed the DOE estimates of key radionuclide concentrations in the probable solidified waste form. This assessment included an examination of the contract specifications for the privatization contractors. Privatization contract specifications require that the radionuclide concentration in the waste form be less than Class C limits. The following assumptions were used in this assessment.

- The radionuclide inventory has been adequately characterized in the TBR. If the inventory is found to be significantly larger, the NRC will re-evaluate its determination of waste classification.

- Privatization contractors will be able to produce a waste form complying with contract specifications that require that the solidified product meets the limits for Class C waste or less as defined in 10 CFR Part 61. If privatization contractors are unable to meet waste form contract specifications, the NRC will re-evaluate its determination of waste form classification.

In conclusion, Criterion Two for classifying the Hanford Site LAW fraction as incidental waste will be met if privatization contractors meet the contract waste form specifications.

Evaluation of Compliance with Criterion Three

The CNWRA reviewers conducted an independent assessment of the comparability of performance objectives from DOE Order 5820.2A and Subpart C of 10 CFR Part 61. The primary differences between the NRC and DOE performance objectives that would be applicable to the Hanford Site disposal facility are (i) lack of a technical requirement for waste classification in the DOE system (compensated by a specific performance objective dose limit for intruder protection), (ii) lack of a stability performance objective in the DOE framework (addressed through system performance assessments), (iii) absence of a specific performance objective for protection of individuals during operations (addressed by a required safety analysis report), and (iv) absence of an NRC groundwater protection performance objective (compensated by a requirement in 10 CFR 61.41).

In addition, to meet Criterion Three a performance assessment must demonstrate that the disposal facility will meet the performance objectives. In reviewing the TBR, the CNWRA considered the results of an interim performance assessment (IPA) for the disposal facility conducted by Westinghouse Hanford Company. This interim performance assessment is the first of three required and was conducted prior to selection of a disposal facility site, completion of a disposal facility design, or selection of a LAW fraction solidification process. However, the interim performance assessment incorporates the requirements of the three criteria for incidental waste classification.

The following assumptions were used in this assessment.

- The absence of a DOE waste classification system is compensated by a performance objective dose limit for intruder protection.

- The lack of a DOE performance objective for site stability can be addressed through system performance assessments that incorporate processes affecting the site.

- Absence of a DOE performance objective for protection of individuals during operations can be mitigated through the completion of the required site safety analysis report.

- Although NRC has no specific performance objective for protection of groundwater, DOE and NRC application of "as low as reasonably achievable" (ALARA) requirements will provide protection of groundwater resources.

- Proposed changes to DOE site performance objectives will not result in significant inconsistencies with NRC performance objectives.

- Uncertainties and concerns identified with respect to the interim performance assessment can be satisfactorily addressed in the subsequent preliminary and final performance assessments required by DOE Order 5820.2A. Many of these concerns result from lack of specificity because a site, design, or solidification process have not yet been selected.

In conclusion, for Criterion Three, performance objectives from DOE Order 5280.2A are comparable to those contained in 10 CFR Part 61, and disposal of the LAW fraction as proposed in the TBR will meet applicable performance objectives.

Summary

The results of the CNWRA review of the TBR and a number of associated references support the conclusion that if Hanford Site tank wastes are managed using a program compatible with the one presented in the TBR, the NRC can consider the resulting solidified LAW fraction to be incidental waste. Such waste could then be disposed onsite in near-surface vaults not subject to NRC regulatory control. If the management plan presented in the TBR changes significantly, NRC may find it necessary to re-examine waste classification.

The CNWRA review identified a number of uncertainties and concerns that should be addressed by the DOE through its continuing implementation of the tank waste remediation system (TWRS) program. Specifically, the CNWRA reviewers found that assessing compliance with Criterion Three identified several areas of significant uncertainty and technical concern. To some extent, these uncertainties and concerns may be resolved as site, design, and process selection are completed. Some of the concepts used in the IPA for assessing disposal system performance may need to be refined. These items have been identified in this report. Continuing concurrence in the DOE incidental waste classification for the Hanford Site tank wastes requires that these issues be adequately resolved in the preliminary and final performance assessments. The NRC has the responsibility and authority to conduct any such re-evaluation under its existing statutory and regulatory roles.

1 INTRODUCTION AND BACKGROUND

Hanford Site tank radioactive and hazardous chemical wastes were produced from 1944 through 1988 by reprocessing irradiated nuclear fuel. Aqueous wastes resulting from these reprocessing operations were stored in underground double-shell (DST) and single-shell tanks (SST). The wastes have been treated to reduce volume and to remove some of the radionuclides (Westinghouse Hanford Company, 1996a, pp. ES-i and 1-1). In managing Hanford Site tank wastes, high-level radioactive waste (HLW) is considered to be "...those aqueous wastes resulting from the operation of the first cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuel" (Nuclear Regulatory Commission, 1956). The Nuclear Regulatory Commission (NRC) has regulatory responsibility for disposal of HLW generated at Hanford, but does not have authority for regulating disposal of U.S. Department of Energy (DOE) low-level radioactive waste (LLW) from that site (Westinghouse Hanford Company, 1996a, p. 2-1).

In September 1988, the DOE proposed a management plan for the Hanford DST wastes during a meeting with NRC staff. This plan incorporated the preferred alternative in the Environmental Impact Statement for the Disposal of Hanford Defense, High-Level, Transuranic, and Tank Wastes (U.S. Department of Energy, 1987). The plan addressed only the waste in the DSTs, and required removal of ^{137}Cs from neutralized current acid waste and complexant concentration waste supernatants. Transuranic wastes (TRU) were also to be removed from the neutralized cladding removal waste and from the plutonium finishing plant sludges. The wastes from liquid remaining after removal of these radionuclides were to be solidified as a grout for disposal in near-surface vaults. SST wastes were not addressed in this 1988 plan, since the DOE required further study on appropriate means for their disposal (Westinghouse Hanford Company, 1996a, p. ES-i). The plan also proposed developing a DOE/NRC consensus on a source-based approach to classification of the wastes (Bell, 1988).

In response to the 1988 DOE plan for management of DST wastes, the NRC provided general concurrence and offered comments intended to improve the Hanford Site tank waste management and classification. These comments (i) recommended disregarding specific individual waste streams based on radionuclide activity rather than on volume as had been recommended by the DOE, (ii) provided improved criteria for classification of waste as incidental, (iii) requested an opportunity to review the characteristics of specific tank wastes prior to grouting, and (iv) rejected a DOE suggestion to establish a DOE/NRC task force to develop a risk-based definition for HLW. Concerned that the proposed DOE plan would require a tank-by-tank waste classification effort, the NRC staff suggested an alternative approach using a material balance of the tank wastes at Hanford Site and the existing source-based definition of HLW. With this approach, if the DOE could demonstrate that at least 90 percent (the largest practical amount) of the first cycle solvent extraction wastes had been removed, the NRC would concur that the residual small fraction of moderately radioactive material would not be subject to NRC licensing and could be disposed by the DOE onsite in near-surface vaults. The NRC response also included criteria for classifying decontaminated salts as incidental wastes (Bell, 1988).

In March 1989, the DOE completed the material balance recommended by the NRC and reported the results. The material balance indicated that only 3–5 percent of the key radionuclides estimated to be in the DST wastes would be incorporated in the grouted waste. According to the DOE analysis, all of these wastes would be Class C or less as defined in 10 CFR Part 61 (Nuclear Regulatory Commission, 1982a). The DOE also proposed removing additional ^{137}Cs to reduce the grouted portion of the key radionuclides to 2–3 percent of the DST radioactive wastes. In response to an NRC concern that the grouted vaults would contain more Class C waste than other similar facilities, the DOE noted that multiple barriers and the well-established institutional controls at the Hanford Site would provide mitigation of the effects of

the large waste quantity. In conclusion, the DOE stated that the material balance demonstrated that residual radionuclides were not HLW and therefore not subject to NRC licensing (Rizzo, 1989). In September 1989, the NRC concurred that the low-activity waste (LAW) fraction resulting from processing the DST wastes as proposed in the DOE waste management plan could be considered incidental LLW and could be disposed in a grout facility not subject to NRC licensing (Bernero, 1989).

Subsequent to these activities, Washington State and others petitioned for a rulemaking that would establish a procedural framework for determining classification of Hanford Site tank wastes (Husseman, 1990). This petition was ultimately denied (Nuclear Regulatory Commission, 1993). The discussion of the standard for waste classification in the denial includes the NRC conclusion that "any radioactive material from the DSTs that is deposited in the grout facility would not be high-level waste subject to NRC licensing jurisdiction." These wastes would be "...'incidental' wastes because of DOE assurances that they: (1) have been processed (or will be further processed) to remove key radionuclides to the maximum extent that is technically and economically practical; (2) will be incorporated in a solid physical form at a concentration that does not exceed the applicable concentration limits for Class C low level waste as set out in 10 CFR Part 61; and (3) are to be managed, pursuant to the Atomic Energy Act, so that safety requirements comparable to the performance objectives set out in 10 CFR Part 61 are satisfied" (Nuclear Regulatory Commission, 1993). These three criteria were transmitted by letter to the DOE with the direction that they be considered in any re-evaluation of tank waste remediation options by the DOE (Bernero, 1993).

Subsequent to development of the plan for processing DST wastes, DOE determined that it is possible to process SST waste in the same manner (Washington State Department of Ecology et al., 1994). Concerns about the suitability of grout as a waste form have resulted in decision to use a vitrification or solidification process (Westinghouse Hanford Company, 1996a, p. 2-4). More recently, DOE has decided that the waste treatment and immobilization will be privatized, and the selected private contractors will define the processes for waste treatment and immobilization in their proposals. The associated facilities will be contractor owned and operated (Kinzer, 1996). Contract specifications for these private contractors (U.S. Department of Energy, 1996a,b) require that radionuclide separation processes and the immobilized waste form be consistent with the technical basis provided in Revision 2 to Technical Basis for Classification of Low-Activity Waste Fraction from Hanford Site Tanks for the Tank Waste Remediation System (Westinghouse Hanford Company, 1996a); hereafter referred to as the Technical Basis Report (TBR). The DOE notes that the radioactivity remaining in the LAW fraction from all 177 SSTs and DSTs (if the contractors can meet the specifications) will be less than that initially proposed for the LAW fraction from the DSTs (Kinzer, 1996). In consideration of this activity level, and noting that the NRC previously concurred in classifying the DST LAW fraction as incidental waste, the DOE has requested that the NRC concur that the combined DST and SST LAW fractions be considered incidental waste. The DOE also has requested that this waste be disposed onsite in a solidified form not subject to NRC licensing authority (Kinzer, 1996).

This report provides a Center for Nuclear Waste Regulatory Analyses (CNWRA) assessment of the DOE TBR. It includes the assumptions that must be met for the NRC to accept the DOE proposal for classification of DST and SST LAW fractions as incidental waste. Section 2 evaluates the DOE characterization of the Hanford Site tank wastes provided in the TBR, considering other published data on tank wastes. Sections 3, 4, and 5 assess compliance with the three NRC-specified criteria for classification of the LAW fraction as incidental waste. Section 6 summarizes conclusions, and section 7 provides references. Uncertainties regarding the Hanford tank waste inventory are outlined in Appendix A.

2 EVALUATION OF THE CHARACTERIZATION OF THE HANFORD SITE TANK WASTES

2.1 DISCUSSION

Processing of irradiated nuclear fuel at the Hanford Site began in 1944. The resulting liquid radioactive and hazardous chemical wastes from several different waste streams were subjected to a variety of treatment processes. Also, the wastes have been concentrated to reduce volume and have been mixed in 177 DSTs and SSTs. Available records do not accurately trace the sources, quantities, and current locations of the radionuclides (Westinghouse Hanford Company, 1996a, pp. 1-1; Rizzo, 1989, enclosure 1, p. 4). Consequently, there is uncertainty in the characterization of the constituents and quantities of the wastes in each of the tanks. However, the DOE is confident that the quantities of radionuclides used to support the TBR represent an upper bound.[1] Specific evaluations of individual radionuclide uncertainties are provided in appendix A (reproduced from the TBR).

Figure 2-1, reproduced from the TBR (Westinghouse Hanford Company, 1996a, p. 3-2, figure 3-1), provides the estimated material balance for the Hanford Site tank waste radionuclide inventory. Figure 2-1 indicates that 243 MCi of the original tank waste radionuclide content of 422 MCi will have decayed by the year 1999. This value reflects the relatively short half lives of ^{137}Cs and ^{90}Sr. The material balance also indicates that approximately 87 MCi are accounted for as (i) leaks or deliberate discharges, (ii) encapsulation of ^{137}Cs and ^{90}Sr, (iii) other offsite shipments, or (iv) residual tank inventories. The remaining 91.6 MCi consists of 55.6 MCi insoluble waste to be disposed in a geologic repository as HLW and 36 MCi that comprises the soluble radionuclides that will be further treated to produce what DOE proposes to classify as incidental waste. This 36 MCi contains most of the ^{137}Cs and ^{99}Tc and almost all of the ^{79}Se, ^{129}I, ^{14}C, and ^{3}H (Westinghouse Hanford Company, 1996a, p. 4-1). After further treatment, 8.5 MCi will remain as incidental waste with 27.5 MCi being added to the HLW stream.

The tank waste inventory for selected radionuclides (decayed to December 31, 1999) that formed the basis for the material balance used data from the Integrated Data Base Report—1994 (U.S. Department of Energy, 1994a). In table 2-1, values of total tank waste inventory are compared for ^{90}Sr, ^{137}Cs, ^{99}Tc, and TRU taken from the TBR (Westinghouse Hanford Company, 1996a, p. 3-3, Table 3-1), from Shelton (1995), and from Goldberg and Guberski (1995). Values from the different references are consistent, except for the TRU inventory. The TRU inventory value in the TBR is lower by 63 percent when compared to Shelton (1995) and to Goldberg and Guberski (1995)—most likely because ^{241}Am was not included in the TRU inventory listed in the TBR. However, the difference in the total radionuclide inventory is within the uncertainties recorded in the reported values. The effect of a larger value for the TRU inventory will be addressed in section 4. This comparison indicates that various sources of tank waste inventory data are consistent. All inventories used for the comparison were compiled by DOE contractors. No non-DOE sources of Hanford Site tank waste inventory are known to be available.

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[1] During briefings to the NRC and CNWRA staffs at the DOE facilities in Richland, Washington, January 15, 1997, Mr. D. Wodrich noted that although individual tank inventories may be uncertain, the total radionuclide inventory in the material balance used to develop the TBR is considered to adequately represent the upper bound.

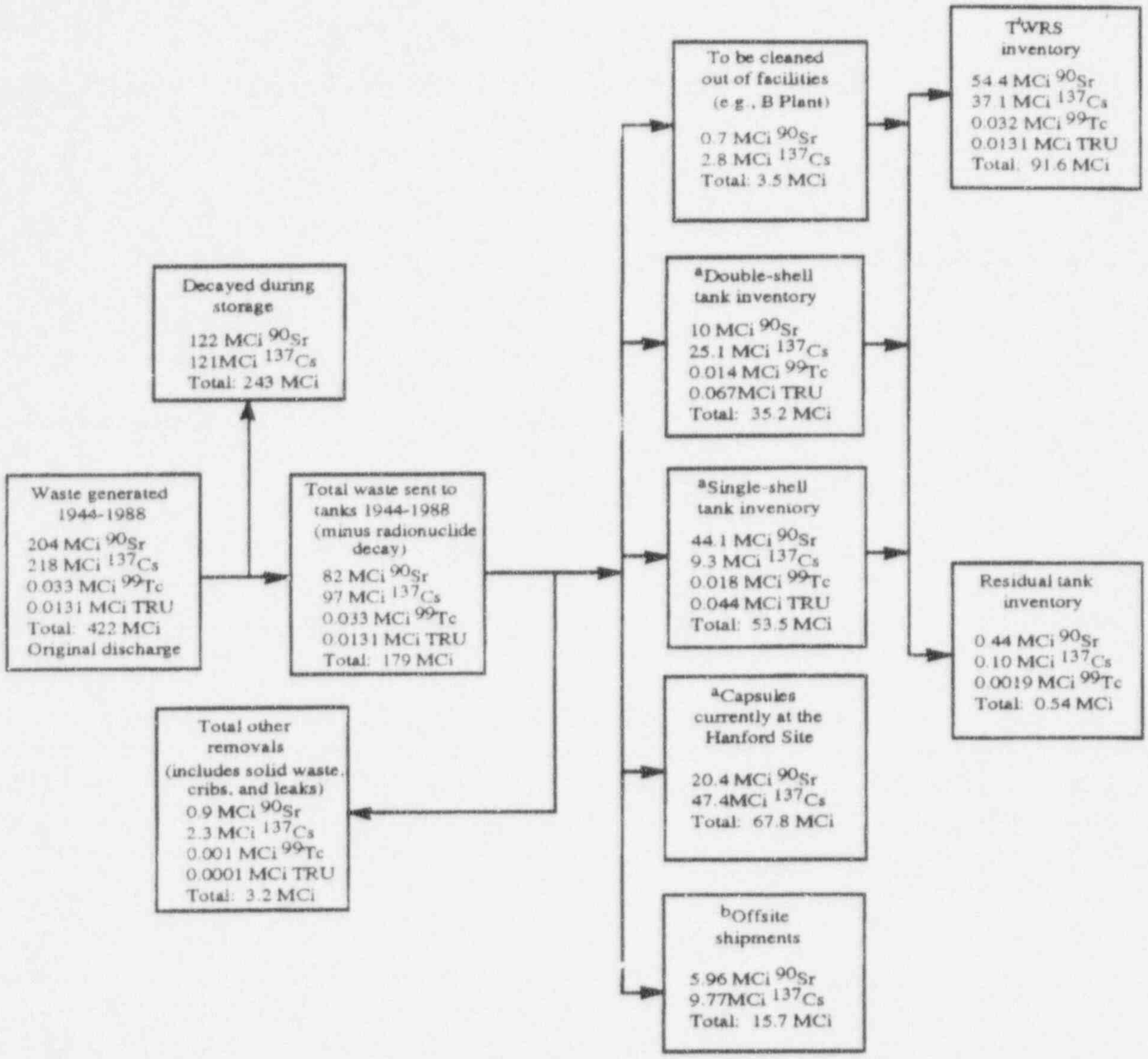

Figure 2-1. Estimate Hanford Site Tank Waste Radionuclide Inventory[c,d]

[a]Curie values are based on the Integrated Data Base Report—1994, rev. 11, table 2.11 decayed to December 31, 1999.

[b]The "offsite shipments" inventory is not expected to return to the Hanford Site for treatment.

[c]Decay products are not listed. Some radionuclides, such as ^{137}Cs and ^{90}Sr, have daughters with relatively short half-lives and are present in concentrations associated with the normal decay chain of the radionuclide.

[d]Inventories of other key radionuclides (i.e., ^{3}H, ^{129}I, ^{14}C, ^{79}Se, uranium isotopes, and ^{126}Sn) are not shown on the material balance. These radionuclides have small inventories that do not significantly affect the total curies in the material balance.

Table 2-1. Comparison of Hanford Site tank waste radionuclide inventory data

Radionuclide	Total (Double- and Single-Shell) Tank Waste Inventory, MCi (decayed to December 31, 1999)		
	Technical Basis Report	Shelton, 1995	Goldberg and Guberski, 1995
^{90}Sr	54.1	53.6	53.7
^{137}Cs	34.4	34.9	34.9
^{99}Tc	0.0321	0.0321	0.0321
TRU	0.131	0.214	0.213
TOTAL	88.66	88.75	88.85

2.2 ASSUMPTIONS

Following are the assumptions made in assessing the TBR waste characterization.

- Hanford Site tank waste inventories used for the material balance in the TBR are representative of the upper bound of these inventories, given the uncertainties in existing records of tank contents.
- If continuing characterization of tank wastes results in a determination that radionuclide inventory values should be significantly increased, classification of the wastes will be re-evaluated.
- If waste classification must be re-evaluated in response to increases in the estimated inventory, privatization contract specifications for the waste form will continue to require that all solidified waste be classified as Class C or less as defined in 10 CFR Part 61.
- Any re-evaluation of waste classification in response to increased estimates of tank inventories will be conducted using the three criteria currently defined or other criteria concurred in by the NRC staff.

2.3 CONCLUSION

The material balance used for the TBR is consistent with available records and models of tank waste radionuclide inventories.

3 EVALUATION OF COMPLIANCE WITH CRITERION ONE

WASTES HAVE BEEN PROCESSED (OR WILL BE FURTHER PROCESSED) TO THE MAXIMUM EXTENT THAT IS TECHNICALLY AND ECONOMICALLY PRACTICAL

3.1 DISCUSSION

The NRC provided initial guidance to the DOE on classification and disposal of incidental waste from DSTs in a letter from M.J. Bell to R.E. Gerton (1988). This guidance stated "...we suggest that DOE attempt an overall material balance of HLW at the Hanford Site using the source-based meaning of HLW. ...Under this approach, if DOE could demonstrate that the largest practical amount of the total site activity attributable to 'first-cycle solvent extraction' wastes has been segregated for disposal as HLW, then the NRC would view the residual as a non-HLW. We would anticipate that at least 90 percent of the activity would have been separated in this way. Thus, if it can be shown that DOE has processed the waste with the intent to dispose of the HLW in a repository or other appropriate licensed facility, leaving behind only a small fraction of only moderately radioactive material, then the goals stated in 10 CFR Part 50 appendix F and incorporated in the Energy Reorganization Act would have been satisfied; and the disposal of the residual would accordingly not be subject to NRC licensing (Bell, 1988)."

In response to this cited NRC 1988 guidance, DOE conducted a radionuclide balance and concluded that 3–5 percent of the key radionuclides that entered the tanks would be disposed as LLW in near-surface vaults. DOE proposed additional radionuclide removal that would reduce this value to 2–3 percent of the key radionuclides. The classification of this waste would be Class C or less (Rizzo, 1989). The NRC concurred that if the DOE processed the waste in this manner, the low-activity fraction would not be considered HLW. In forwarding this concurrence, the NRC noted similar evaluations made for incidental wastes at the West Valley Demonstration Project and the Savannah River Site, and acknowledged the complications resulting from mixing various waste sources at the Hanford Site. The NRC also noted that the Hanford Site waste material balance was based on estimates from computer models and that actual samples taken prior to solidification would be used to confirm waste inventories (Bernero, 1989).

In forwarding to the DOE its denial of a rulemaking petition from Washington and Oregon on the subject of radioactive waste classification, the NRC stated that key radionuclide removal must be completed to the maximum extent technically and economically practical (Bernero, 1993). In so doing, the NRC did not rescind its concurrence in the DOE plan for onsite disposal of the LAW fraction for DST wastes.

As shown in figure 2-1 of this report, 91.6 MCi comprises the Hanford Site tank waste inventory that will be processed for disposal as HLW or LLW. Approximately 99.9 percent of this waste is ^{137}Cs or ^{90}Sr. Initially, a simple solids-liquids separation will be performed on this waste to yield a low-activity liquid fraction containing the bulk of the nonradioactive materials, including about 3 percent solids carryover, and a high-activity fraction containing most of the solids. This solids-liquids separation process is expected to be relatively simple to complete and will remove approximately 55.6 MCi, consisting primarily of ^{90}Sr and TRU radionuclides (Westinghouse Hanford Company, 1996a, pp 3-2, 4-1, 4-2). Chapter 5 of the TBR concludes that, with the additional selective removal of transuranic wastes from three complexant concentrate tanks, and single-cycle ion exchange removal of ^{137}Cs from certain wastes,

the waste concentrations presented in the Supernatant Inventory after Pretreatment column of table 3-1 (reproduced from the TBR) (Westinghouse Hanford Company, 1996a, p. 5-2, table 5-2), are those to be incorporated in the incidental waste.[1] The evaluation of the DOE assessment of economic and technical practicality for radionuclide removal processes was made using available references and considering the subjectivity of the analyses in the TBR.[2]

Table 3-1. Solidified waste radionuclide concentrations after supernatant separations versus 10 CFR Part 61 limits

Radionuclide	Supernatant Inventory after Pretreatment[a] (Ci/m^3)	Average Concentration in Low-Activity Waste Glass (Ci/m^3)[b,c]	Class A Limit (Ci/m^3)	Class B Limit (Ci/m^3)	Class C Limit (Ci/m^3)
^{137}Cs	5	32	1	44	4,600
^{90}Sr	3.4	22	0.04	150	7,000
^{99}Tc	0.32	0.2	0.3	–	3.0
^{79}Se	0.000103	<0.006	NLE	NLE	NLE
^{14}C	0.0053	<0.03	0.8	NLE	8.0
^{129}I	0.000051	<0.0003	0.008	NLE	0.08
^{3}H	0.01	0.06	40	NLE	NLE
^{126}Sn	0.0016	<0.01	N/A	N/A	N/A
Uranium	0.001	<0.006	NLE	NLE	NLE
Transuranics	0.01nCi/g	25 nCi/g	10 nCi/g	NLE	100 nCi/g

NLE=No limit established.

[a]To be conservative, it is assumed that 100 percent of the ^{99}Tc, ^{79}Se, ^{14}C, ^{3}H, ^{129}I, and ^{126}Sn inventories (soluble and insoluble fractions) are incorporated into the immobilized low-activity waste.

[b]The sum of the fractions rule for mixtures of radionuclides has been applied.

[c]The low-activity waste volume is estimated to be 158,000 m^3 of glass.

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[1] The column titled Supernatant Inventory after Pretreatment includes dissolved species in existing tank supernatant, dissolved salt cake, and liquids from treatment of sludge (Westinghouse Hanford Company, 1996a, p. 3-1)

[2] During briefings to the NRC and CNWRA staffs at the DOE facilities in Richland, Washington, January 15, 1997, Mr. D. Wodrich, in response to a comment that relevant reference materials had not yet been obtained by the reviewers, noted that the assessments of economic and technical practicality were somewhat subjective.

The TBR states that "economic practicality is determined by the total life-cycle cost per curie removed" and that "the economically practical limit is selected...as the point where additional removal costs increase significantly" (Westinghouse Hanford Company, 1996a, p. 2-9). However, the TBR examines only one of the key radionuclides, ^{137}Cs, with respect to these criteria: a cost per curie removed curve is provided only for ^{137}Cs (Westinghouse Hanford Company, 1996a, p. 4-7). The TBR examined the economic practicality of radionuclide removal processes only if they were determined to be technically practical. Processes were determined to be technically practical only if they had been tested on a plant scale or exhibited a high probability of success (Westinghouse Hanford Company, 1996a, pp. 2-7, 2-9).

The TBR did not consider duplicative costs. Chapter 4 of the TBR examines removal of ^{137}Cs, ^{99}Tc, and ^{79}Se through volatilization as an intrinsic part of the vitrification process. In each case, the TBR concludes that such volatilization is technically impractical because the process has not been demonstrated at a plant scale [this is consistent with the definition of technical practicality used in the TBR (Westinghouse Hanford Company, 1996a, p. 2-7)]. Consequently, no economic analysis is provided for this process. However, section B5.0 of the report assesses the cost of ^{79}Se removal through volatilization as \$1.00 per Ci. Considering this low cost compared to other radionuclide removal processes, further examination of volatilization as a radionuclide removal technique might be appropriate, and the costs could be distributed among relevant radionuclides.

Table 3-2 has been reproduced in part from the TBR (Westinghouse Hanford Company, 1996a, p. 4-26, table 4-4). An examination of the cost per curie column from table 3-2 indicates that some removal options considered not economically practical have costs very close to others deemed economically practical. For example, costs for hydroxide precipitation for TRU and ^{90}Sr, evaluated as being economically practical, are higher than those for one category of single-cycle cation ion exchange, which is viewed as being economically impractical. No criteria are provided for evaluating these economic practicality judgments or costs, other than for ^{137}Cs.

There was limited reference material available for assessing DOE evaluations of economic and technical practicality. However, the DOE is allowing the privatization contractors flexibility in selection of radionuclide removal and treatment processes so long as solidified product specifications and performance objectives are met.[3] These contract specifications (U.S. Department of Energy, 1996a,b) require that the solidified product radionuclide concentrations meet Class C or less requirements as defined in 10 CFR Part 61 (Nuclear Regulatory Commission, 1982a) and as described in the Branch Technical Position on Concentration Averaging and Encapsulation (Nuclear Regulatory Commission, 1995).[4,5]

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[3] During briefings to the NRC and CNWRA staffs at the DOE facilities in Richland, Washington, January 15, 1997, the DOE staff stated that the Tank Waste Remediation System privatization contractors had the option to select radionuclide removal and treatment procedures so long as the solidified product met the contract specifications.

[4] Contract specification 2, Immobilized Low-Activity Waste (ILAW), Product Requirement 2.2.2.8 for both privatization contracts states "The radionuclide concentration of the ILAW form shall be less than Class C limits as defined in 10 CFR 61.55 and as described in *Branch Technical Position on Concentration Averaging and Encapsulation*. In addition, the average concentrations of ^{137}Cesium (^{137}Cs), ^{90}Strontium (^{90}Sr), and ^{99}Tc shall be limited as follows: $^{137}Cs < 3\ Ci/m^3$, $^{90}Sr < 20\ Ci/m^3$, and $^{99}Tc < 0.3\ Ci/m^3$. The average concentrations shall be calculated by adding the inventories of each of the above radionuclides in the packages that have been presented to date for acceptance and dividing by the total volume of waste in these packages."

[5] Contract specifications 4, 5, and 6 (^{137}Cs, ^{99}Tc, and ^{90}Sr and TRU) state that for these specific radionuclides, "The contractor shall determine the degree of...removal required to comply with the requirements of specification 2, *Immobilized Low-Activity Waste*" as discussed in footnote 3.

Table 3-2. Summary of costs for technically practical radionuclide removal technology options

Technically Practical Technology Option	Economically Practical	Cost $/Ci
Single-Cycle Cation Ion Exchange, Selective Removal (^{137}Cs concentrations >0.05 Ci/L)	Yes	25
Single Cycle Cation Ion Exchange, Selective Removal (^{137}Cs concentrations <0.05 Ci/L)	No	65
Single Cycle Cation Ion Exchange	No	30
Second Cycle Cation Ion Exchange	No	420
Hydroxide Precipitation for TRU and ^{90}Sr, Selective Treatment	Yes	63–128
Ferric Hydroxide Precipitation for TRU and ^{90}Sr, Selective Treatment	No	140–570
Solvent Extraction, TRUEX, PUREX	No	800,000

The CNWRA reviewers examined the radionuclide removal processes discussion in chapter 4 of the TBR in conjunction with the Tank Waste Remediation Process Flowsheet (Orme, 1995). This examination supports the conclusion that the TBR presents a reasonable assessment of the types of processes available to conduct radionuclide removal. The radionuclide removal processes examined in the TBR, in conjunction with the process flowsheet and the requirements of the privatization contract provide a substantial framework for economical, technically practical radionuclide removal.

Both DST and SST wastes are considered in the TBR waste management plan. Table 3-3 [taken from the TBR (Westinghouse Hanford Company, 1996a, p. 5-4, table 5-3)] reflects that the DOE plan to process both SST and DST wastes, including additional radionuclide removal after pretreatment, will result in a smaller waste volume with a total Curie content near the low end of the range previously proposed for only the DST wastes. This revised Curie content (8.5 MCi) represents approximately 2 percent of the estimated activity generated at the Hanford Site (8.5 MCi/422 MCi × 100% = 2.01%). If the original total waste inventory is decayed until the 1999, the 8.5 MCi represents approximately 5 percent of the

remaining inventory (8.5 MCi/179 MCi × 100% = 4.74%). This value is consistent with the NRC requirement that at least 90 percent of the activity be removed (Bell, 1988).

Table 3-3 Comparison of previous and proposed determinations of Hanford Site tank waste classification[b,c]

Parameter	Previous NRC Determination[a]	Proposed NRC Determination[b]
Scope, Number of waste tanks	28 DSTs	28 DSTs and 149 SSTs
LAW form	Grout	Glass
LAW volume, m^3	233,000	158,000
Radionuclides in LAW (MCi)		
^{137}Cs	6 to 7	5
^{90}Sr	1 to 8	3.4
Transuranics	0.002 to 0.01	0.01
^{99}Tc	0.016 to 0.028	<0.03[c]
^{79}Se	—	<0.001
^{14}C	0.0027	<0.0053
^{129}I	0.000033	<.000051
^{3}H	—	<0.01
^{126}Sn	—	<0.0016[c]
Uranium	—	<0.001[c]
Total (without daughters)	7 to 15	8.5

— = No value established
[a]Decay date December 31, 1995
[b]Decay date December 31, 1999
[c]And as required by the performance assessment

3.2 ASSUMPTIONS

The following assumptions were made in assessing compliance with Criterion One.

- Results of the DOE assessments of the technical and economic practicalities of radionuclide removal processes for the Hanford Site tank wastes represent a reasonable effort to perform such assessments, considering inherent subjectivity.

- Privatization contract specifications provide flexibility in use of radionuclide removal processes consistent with producing a waste form that would be classified as Class C or less.

- A LAW fraction from processing both DST and SST wastes that results in a lower waste volume and total waste activity at the lower end of the range previously expected considering only the DSTs, supports a determination that radionuclide removal would be completed to the extent technically and economically practical, consistent with the same determination made by the NRC in 1989 for the DST wastes.

3.3 CONCLUSION

Criterion One for classifying the Hanford Site LAW fraction as incidental waste will be met if a waste management plan similar to the one presented in the TBR is placed in effect and if privatization contractors meet the contract waste form specifications.

4 EVALUATION OF COMPLIANCE WITH CRITERION TWO

WASTES WILL BE INCORPORATED IN A SOLID PHYSICAL FORM AT A CONCENTRATION THAT DOES NOT EXCEED THE APPLICABLE LIMITS FOR CLASS C LOW-LEVEL WASTE AS SET OUT IN 10 CFR PART 61

4.1 DISCUSSION

Table 3-1 supports the analysis for this criterion. Assuming that the DOE assessment of the waste inventory is correct, table 3-1 indicates that the waste form will comply with 10 CFR Part 61 requirements for Class C waste or less.

In section 2, the CNWRA reviewers examined the validity of the waste inventory as presented in the TBR. This examination indicated that the TBR may have underestimated the quantity of TRU radionuclides by a factor of about 63 percent compared to other assessments of the radionuclide inventory. Assuming that the waste form would contain 63 percent more TRU than indicated in table 3-1, the average TRU concentration in LAW glass would increase to approximately 41 nCi/g (1.63×25 nCI/g), at least a factor of two less than the Class C limit.

Privatization contract specifications require that the radionuclide concentration in the ILAW form be less than Class C limits (Kinzer, 1996; U.S. Department of Energy, 1996a,b).[1] If the quantities of the radionuclides in the inventory are within reasonable bounds of those estimated in the TBR, and if the privatization contractors can meet the contract specifications, then Criterion Two will be met.

4.2 ASSUMPTIONS

The following assumptions were made in assessing compliance with Criterion Two.

- The radionuclide inventory has been adequately characterized in the TBR (this issue was evaluated in section 2.1). If the inventory is found to be significantly larger, the NRC will re-evaluate its determination of waste classification.

- Privatization contractors will be able to produce a waste form complying with contract specifications that require that the solidified product meets the limits for Class C waste or less as defined in 10 CFR Part 61. If privatization contractors are unable to meet waste form contract specifications, the NRC will re-evaluate its determination of waste form classification.

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[1] Contract specification 2, Immobilized Low-Activity Waste (ILAW), Product Requirement 2.2.2.8 for both privatization contracts states "The radionuclide concentration of the ILAW form shall be less than Class C limits as defined in 10 CFR 61.55 and as described in *Branch Technical Position on Concentration Averaging and Encapsulation*. In addition, the average concentrations of ^{137}Cesium (^{137}Cs), ^{90}Strontium (^{90}Sr), and ^{99}Tc shall be limited as follows: ^{137}Cs < 3 Ci/m^3, ^{90}Sr < 20 Ci/m^3, and ^{99}Tc < 0.3 Ci/m^3. The average concentrations shall be calculated by adding the inventories of each of the above radionuclides in the packages that have been presented to date for acceptance and dividing by the total volume of waste in these packages."

4.3 CONCLUSIONS

Criterion Two for classifying the Hanford Site LAW fraction as incidental waste will be met if waste inventory estimates are reasonably accurate and if privatization contractors meet the contract waste form specifications.

5 EVALUATION OF COMPLIANCE WITH CRITERION THREE

WASTES ARE TO BE MANAGED, PURSUANT TO THE ATOMIC ENERGY ACT, SO THAT SAFETY REQUIREMENTS COMPARABLE TO THE PERFORMANCE OBJECTIVES SET OUT IN 10 CFR PART 61 ARE SATISFIED

5.1 DISCUSSION

The DOE requirements for LLW disposal are presented in DOE Order 5820.2A Radioactive Waste Management, chapter III, section 3.a (U.S. Department of Energy, 1988). The NRC performance objectives in 10 CFR Part 61 are at §61.40 through §61.44 (Nuclear Regulatory Commission, 1982a).

Appendix D of the TBR contains a DOE comparison of the performance requirements from DOE Order 5820.2A and 10 CFR Part 61. This comparison also incorporates the results of Hanford Low-Level Tank Waste Interim Performance Assessment (IPA) (Westinghouse Hanford Company, 1996b) and Performance Objectives of the Tank Waste Remediation System Low-Level Waste Disposal Program (Westinghouse Hanford Company, 1996c). In the latter document, DOE assesses LLW disposal facility performance objectives from DOE, the U.S. Environmental Protection Agency, NRC, and Washington State regulations. This assessment indicates that the performance objectives contained in DOE Order 5820.2A are comparable to the requirements of these other agencies. The TBR notes that the performance objectives from DOE Order 5820.2A were sent to members of the Hanford Advisory Board and that the resulting comments required no changes to the performance objectives. (Westinghouse Hanford Company, 1996a, appendix D). CNWRA reviewers conducted an independent assessment of the comparability of performance objectives from DOE Order 5820.2A and 10 CFR Part 61. This assessment is described in the following subsection.

5.1.1 Assessment of the Comparability of Nuclear Regulatory Commission and U.S. Department of Energy Low-Level Waste Disposal Site Performance Objectives

In addition to the performance objectives at §61.40 through §61.44, 10 CFR Part 61 includes several prescriptive technical requirements that are intended to help ensure that the performance objectives are met. These technical requirements are specified in Subpart D of 10 CFR Part 61 and include requirements for (i) disposal site design, §61.51; (ii) waste classification, §61.55; and (iii) institutional ownership and control, §61.59.

Taken together, the technical requirements establish a system that is intended to provide long-term disposal with reasonable assurance of meeting the performance objectives of Subpart C. No single element of the system is assumed to be sufficient to provide assurance that the performance objectives are realized for near surface land disposal facilities, and it is unlikely that the performance objectives can be met if the facility is significantly deficient with respect to any one element of the technical requirements. In the 10 CFR Part 61 framework for LLW disposal, it is the combination of technical requirements that reasonably assures that the performance objectives will be met.

DOE performance objectives and technical requirements for LLW disposal contained in chapter III of DOE Order 5820.2A include requirements for (i) protection of public health and safety in

accordance with standards specified in applicable EH Orders and other DOE orders, (ii) protection of the public from releases of radioactive material, (iii) protection of inadvertent intruders, and (iv) protection of groundwater resources. DOE Order 5820.2A chapter III also contains various supporting technical requirements addressing factors such as (i) waste form requirements, 3.i.(5); (ii) site selection criteria, 3.i.(7); (iii) facility and site design, 3.i.(8); (iv) operations, 3.i.(9); (v) closure and post closure operations, 3.i.(j); and (vi) environmental monitoring, 3.i.(k).

10 CFR Part 61 is primarily a performance-based regulation, and the technical requirements of Subpart D contribute to establish an integrated system that addresses all parameters that can affect facility performance. The DOE LLW disposal requirements are not as explicitly integrated, and DOE Order 5820.2A covers other aspects of LLW management in addition to disposal. The DOE system relies on the results of performance assessments to determine the factors requiring adjustment to meet the performance objectives. These factors can include waste forms, waste classification, and facility design. Although the NRC framework provides the ability to make similar adjustments based on results of performance assessments, the requirements of Subpart D of 10 CFR Part 61 independently provide some degree of assurance that the facility will meet the performance objectives of Subpart C.

Following are comparisons and evaluations of performance objectives and requirements from 10 CFR Part 61 with corresponding requirements from DOE Order 5820.2A.

(1) **10 CFR 61.40** "General Requirement. Land disposal facilities must be sited, designed, operated, closed, and controlled after closure so that reasonable assurance exists that exposures to humans are within the limits established in the performance objectives in §§ 61.41 through 61.44."

DOE 5820.2A, III.3.a.(1). "Protect health and safety in accordance with standards specified in applicable EH Orders and other DOE orders."

Comparison

The NRC statement is more prescriptive in requiring that specific facility lifecycle parameters be examined to provide reasonable assurance that performance objectives will be met. However, both documents require conformity with standards to protect public health and safety.

Evaluation

These requirements are comparable.

(2) **10 CFR 61.41** "Protection of the general population from releases of radioactivity. Concentrations of radioactive material which may be released to the general environment in groundwater, surface water, air soil, plants, or animals must not result in an annual dose exceeding an equivalent of 25 mrems to the whole body, 75 mrems to the thyroid, and 25 mrems to any other organ of any member of the public. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as reasonably achievable."

The 25 mrem/yr limit applies throughout the operating and post-closure periods of a disposal facility. The other radiological control limits of 10 CFR Part 20 (Nuclear Regulatory Commission, 1991) apply during facility operation, except for the 25 mrem limit from the pathways defined above.

DOE 5820.2A, III.3.a.(2). "Assure that external exposure to the waste and concentrations of radioactive material which may be released into surface water, groundwater, soil, plants and animals results in an effective dose equivalent that does not exceed 25 mrem/yr to any member of the public. Releases to the atmosphere shall meet the requirements of 40 CFR 61. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable."

Comparison

10 CFR 61.41 requirements for protection of the public from releases to the general environment and DOE performance objective 5280.2A III.3.a.(2) are essentially equivalent for most release pathways. However, the DOE requirement is stated in more current dose measurement standards of effective dose equivalent rather than whole body dose.

10 CFR 61.41 does not specify meeting National Emission Standards for Hazardous Air Pollutants (NESHAPS) atmospheric release limits promulgated by EPA in 40 CFR Part 61 (U.S. Environmental Protection Agency, 1989). NRC has a "constraint level" of 10 mrem/yr for air emissions from NRC licensed facilities in 10 CFR Part 20. The constraint level is viewed as a means of implementing as low as reasonably achievable (ALARA) requirements.

Both DOE and NRC impose ALARA requirements.

Evaluation

Considering that the release limit objectives of the two agencies are essentially equivalent for most pathways, and that the air emissions limit in the DOE objective is consistent with NRC constraints for operating facilities, these performance objectives are comparable.

(3) **10 CFR 61.42** "Protection of individuals from inadvertent intrusion. Design, operation, and closure of the land disposal facility must ensure protection of any individual inadvertently intruding into the disposal site and occupying the site or contacting the waste at any time after active institutional controls over the disposal site are removed."

Although a particular dose limit is not specified in this performance objective, compliance with the technical requirements of 10 CFR Part 61 and, in particular, with the classification system of 10 CFR 61.55, is considered to provide adequate protection to intruders at a near surface land disposal facility. In the draft environmental impact statement for the 10 CFR Part 61 rulemaking (Nuclear Regulatory Commission, 1981), NRC used a 500 mrem/yr dose limit to an inadvertent intruder to establish the concentration limits and other aspects of the waste classification system. In addition, 10 CFR Part 61 does not specify a time limit for institutional controls in the performance objectives, but does require in 10 CFR 61.59(b) that "...institutional controls may not be

relied upon for more than 100 years following transfer of control of the disposal site to the owner."

DOE 5820.2A, III.3.a.(3). "Assure that the committed effective dose equivalents received by individuals who inadvertently may intrude into the facility after the loss of active institutional control (100 years) will not exceed 100 mrem/yr for continuous exposure or 500 mrem for a single acute exposure."

Comparison

The requirements for intruder protection are similar. Although the NRC classification system is based on a 500 mrem/yr intruder exposure limit, the corresponding 10 CFR Part 61 performance objective does not specify a dose limit.

The DOE performance objective explicitly states a 100 mrem/yr limit for continuous exposure and a 500 mrem limit for a single acute exposure. These limits are consistent with and more conservative than the intent of 10 CFR Part 61. The DOE limits for intruders are also consistent with current NRC radiation protection standards in 10 CFR 20.1301 for dose limits to individual members of the public (Nuclear Regulatory Commission, 1991).

Evaluation

The DOE acute exposure limit of 500 mrem to an intruder is more conservative than the basis for 10 CFR Part 61.

DOE Order 5820.2A does not incorporate a waste classification system such as that in 10 CFR 61.55. However, the specification of intruder dose limits in the DOE performance objectives would likely cause the activity concentration limits of any waste classification system derived from a site specific performance assessment to be controlled to levels similar to those contained in NRC regulations.

(4) **10 CFR 61.43** "Protection of individuals during operations. Operations at the land disposal facility must be conducted in compliance with the standards for radiation protection set out in Part 20 of this chapter, except for releases of radioactivity in effluents from the land disposal facility, which shall be governed by §61.41 of this part. Every reasonable effort shall be made to maintain radiation exposures as low as reasonably achievable."

This performance objective applies to both the public and to LLW disposal facility workers. No performance objective is specified in DOE Order 5820.2A that corresponds to this NRC performance objective with respect to protection of workers (Westinghouse Hanford Company, 1996a, p. D-6).

Comparison

DOE Order 5820.2A performance objectives do not explicitly establish requirements for protection of workers and the general public during facility operations. NRC invokes the

radiation protection standards of 10 CFR Part 20 (Nuclear Regulatory Commission, 1991) (except that the more restrictive 25 mrem/yr limit of 10 CFR Part 61 applies for radionuclide releases) as an explicit disposal facility performance objective.

DOE 5820.2A provides in III.3.i.(9) that, "Field organizations shall develop and implement operating procedures for low-level waste disposal facilities that protect the environment, health and safety of the public."

Requirements for LLW disposal should make clear the distinction between operating and post-operating phases. Radiation exposures during operations (handling, processing, emplacement of waste, skyshine, etc.) could be significantly higher than for post-operating conditions when the waste will be covered. Radiation protection standards applicable to the public and radiation workers should be specified for the disposal facility operations that are consistent with radiation protection standards that apply for other operating facilities that impose similar risks. In general, these should be consistent with 10 CFR Part 20 and with corresponding DOE Orders. A draft revision to DOE 5820.2A, (DOE 5820.2B [Department of Energy, 1994b]) proposes that these DOE orders be incorporated into the performance objectives for LLW disposal (Westinghouse Hanford Company, 1996c, pp. A-2, A-3). DOE should consider amending performance objectives in DOE Order 5820.2A to explicitly incorporate radiation protection standards. The DOE plans to address worker protection through the safety analysis report that will be prepared for the disposal system (Westinghouse Hanford Company, 1996b, p. 1-11; 1996c, p. 3).

Evaluation

Although DOE performance objectives are not explicit with respect to protection of individuals during operations, the requirement for a disposal facility safety analysis report should assure adequate worker protection and the performance objective can be considered comparable.

(5) **10 CFR 61.44** "Stability of the disposal site after closure. Disposal facilities must be sited, designed, used, operated, and closed to achieve long-term stability of the disposal site and to eliminate to the extent practicable the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required."

The stability performance objective is consistent with a major premise of 10 CFR Part 61 that the facility must be sited, designed, used, operated, and closed with the intention of providing permanent disposal. A disposal facility should not require long-term maintenance and care. Stability is particularly important considering the requirements in 10 CFR 61.59(b) that "...institutional controls must not be relied upon for more than 100 years following transfer of control of the disposal site to the owner."

No DOE performance objective corresponds to this NRC performance objective.

Comparison

DOE performance objectives do not include a requirement for long-term facility stability as specified in 10 CFR 61.44. However, DOE has included some waste stability requirements in 5820.2A.III.3.i.(5) and site stability considerations in 5820.2A.III.3.i.(7)(d), respectively.

NRC notes that long-term stability is important to meeting performance objectives in several ways, including reducing (i) water infiltration and the potential for migration, (ii) uncertainty and the need for long-term maintenance and care costs, (iii) likelihood and results of inadvertent intrusion, and (iv) occupational exposures and potential off-site releases in the event of an accident (Nuclear Regulatory Commission, 1982b).

The stability performance objective is supported by a number of specific technical requirements for near-surface disposal in 10 CFR 61.50. These include stability criteria for avoiding site locations (i) that are susceptible to flooding [10 CFR 61.50(a)(5)]; (ii) that have areas where upstream drainage could cause erosion or inundation of disposal units [10 CFR 61.50(a)(6)]; (iii) that are susceptible to tectonic processes such as faulting, folding, seismic activity, or volcanism [10 CFR 61.50(a)(9)]; and (iv) where there is significant potential for surface geologic processes such as mass wasting, erosion, slumping, landslides, or weathering [10 CFR 61.50(a)(10)].

DOE Order 5820.2A, while referencing site suitability factors, does not provide these same constraints and detailed guidance on site selection and suitability [DOE, 1988, section III.3.1(7)].

NRC Regulatory Guide 4.19 (Nuclear Regulatory Commission, 1988) states that, "...NRC staff considers the long-term contribution of the natural conditions of the site essential in protecting the general population against releases of radioactive material. The effectiveness of other measures such as design features, waste form, waste packaging, and institutional controls is assumed to decrease with time after site closure."

Evaluation

Although a stability requirement is different in nature from other performance objectives that relate directly to protection of health and safety, stability is nonetheless important to site performance. Assessments of performance need to incorporate site stability evaluations. So long as DOE performance assessments for the LLW disposal facility adequately evaluate processes affecting site stability, there is no need for DOE to explicitly define a site stability performance objective.

(6) **Groundwater Protection**

NRC does not have a performance objective for groundwater protection, although 10 CFR 61.41 provides protection for groundwater resources.

DOE 5820.2A, III.3.a.(4). "Protect groundwater resources, consistent with Federal, State and local requirements."

Comparison

NRC has considered that the release limits of 10 CFR Part 61.4' adequately protect the public and environment. EPA plans to promulgate a groundwater protection standard for LLW disposal sites in its proposed regulation, 40 CFR Part 193 (Environmental Protection Agency, 1994). NRC (Bernero, 1990) and DOE (Pelletier, 1991) have opposed the issuance of a groundwater protection standard. However, the DOE performance objective is consistent with the proposed 40 CFR Part 193.

There is not a consensus among DOE, NRC, and the Environmental Protection Agency on groundwater protection requirements. However, NRC (10 CFR 61.41) and DOE [5820.2A, III.3.a.(2)] both prescribe application of ALARA requirements to releases of radioactivity in effluents to the general environment, including groundwater.

Evaluation

Although NRC has no specific performance objective for protection of groundwater, DOE and NRC application of ALARA requirements regarding radioactive effluents will provide protection of groundwater resources.

Summary of Evaluations

10 CFR Part 61 presents a performance-based regulatory framework combined with several prescriptive requirements considered important to providing reasonable assurance that the performance objectives can be achieved. DOE Order 5820.2A, Chapter III prescribes a more loosely structured performance-based framework for LLW management and disposal at DOE facilities.

DOE Order 5820.2A provides performance criteria for protecting the health and safety of the public (environmental release limits and intruder protection) and for environmental protection (groundwater resource protection). Various technical criteria address waste characterization, waste form, treatment, and disposal to help ensure compliance with performance and other health and safety objectives.

While the NRC requirements for LLW disposal comprise a system of well defined elements that are integrated to ensure that performance objectives will be attained, the DOE requirements allow greater flexibility in attaining performance objectives. This difference in approach may account for the specific differences in the performance objectives. The primary differences are (i) lack of a technical requirement for waste classification in the DOE system (compensated by a specific performance objective dose limit for intruder protection), (ii) lack of a stability performance objective in the DOE framework (addressed through system performance assessments), (iii) absence of a DOE specific performance objective for protecting individuals during operations (addressed by required safety analysis report), and (iv) absence of an NRC groundwater protection performance objective (compensated by requirements at 10 CFR 61.41).

Proposed Changes to DOE Performance Objectives

DOE has proposed changes to the performance objectives for the LLW disposal facility so that "the Hanford stakeholders can help determine the performance objectives to be used in the assessment of long-term impact of the disposal of low-level waste from the Hanford tanks (Westinghouse Hanford

Company 1996c, p. iii)." The proposed performance objectives in that document include (i) a 25 mrem/yr effective dose equivalent exposure limit from all pathways for protection of the general public, (ii) the same limit for workers as for the general public, (iii) a 500 mrem one-time and 100 mrem/yr continuous exposure limit for inadvertent intruders, (iv) National Primary Drinking Water Regulation limits for groundwater (4 mrem/yr), (v) 1.0 mrem/yr surface water dose limits, and (vi) a 10 mrem/yr limit from airborne emissions.

DOE has also proposed a revision to DOE Order 5820.2A (i.e., 5820.2B) and issuance of a directive from the Richland Operations Office (RL-5820.2A), both of which contain performance objectives different from those in DOE Order 5820.2A (Westinghouse Hanford Company, 1996c, pp. A-2 to A-4). The CNWRA reviewers did not conduct a detailed review of these proposed documents. However, the summaries of their content provided in Performance Objectives of the Tank Waste Remediation Systems Low-Level Waste Disposal Program (Westinghouse Hanford Company, 1996c) indicated that these documents may not contain the same set of four performance objectives that are specified in 10 CFR Part 61, and may not be mutually consistent.

The draft of the revised DOE Order 5820.2B adds specific requirements for (i) protection of public health and safety in accordance with DOE Order 5400.5, (ii) protection of worker safety in accordance with DOE Order 5480.11 and other applicable regulations, (iii) protection of the environment in accordance with DOE Order 5400.1, (iv) restrictions on atmospheric emissions to be in compliance with 40 CFR Part 61, and (v) application of ALARA requirements (Westinghouse Hanford Company, 1996c, pp. A-2, A-3). However, this proposed revision to DOE Order 5820.2A appears to contain no provision for protection of inadvertent intruders.

The proposed Richland Operations Office supplement to 5820.2A (RL 5820.2A) would provide for (i) protection of the public from releases from all exposure pathways, (ii) groundwater protection, (iii) application of ALARA requirements, (iv) intruder protection, and (v) mixed waste regulation (Westinghouse Hanford Company, 1996c, pp. A-3, A-4).

NRC should monitor the development of these documents to ensure that DOE performance objectives for LLW disposal remain comparable to 10 CFR Part 61 performance objectives.

5.1.2 Assessment of the U.S. Department of Energy Interim Performance Assessment for the Hanford Site Tank Wastes

Assuring that performance objectives applicable to the Hanford Site LLW disposal facility are comparable to those in 10 CFR Part 61 is not sufficient for compliance with Criterion Three. A performance assessment must also demonstrate that the disposal facility will meet the performance objectives. In reviewing the TBR, the CNWRA considered the results of the DOE IPA (Westinghouse Hanford Company, 1996b).

The IPA is the first of three performance assessments required by DOE Order 5820.2A (Westinghouse Hanford Company, 1996b, p. iv). The IPA has been conducted prior to selection of a disposal facility site, completion of a disposal facility design, or selection of a LAW solidification process. However, the IPA incorporates the requirements of the three criteria for incidental waste classification (Westinghouse Hanford Company, 1996b, p. 2-44).

The following ten items are observations and concerns from the CNWRA review of the IPA.

- The IPA provides a value of an initial fractional radionuclide release rate of 4.4×10^{-6} for all radionuclides except ^{99}Tc which has a rate of 8.8×10^{-7} (Westinghouse Hanford Company, 1996, pp. iv and 3-32). These values for the fractional radionuclide release rate may be unrealistically low for the disposal facility. The IPA assumes that the fractional radionuclide release rates are limited by the fractional bulk dissolution rate of the glass. It is not clear how the fractional release rate for ^{99}Tc, a highly soluble nuclide, could be much smaller than those for the other isotopes in the glass. These values should be justified. For example, Kerrisk (1984) presents a detailed model for calculating fractional radionuclide release rates for vitrified pressurized water reactor HLW for ten important radionuclides expected in the waste based on nuclide solubilities, recharge rates, background concentrations of silica, and other factors. A similar evaluation would be appropriate for the Hanford Site tank wastes. Additionally, the bulk dissolution rate for glass does not necessarily determine the dissolution rate for high solubility fission products in the glass (such as ^{99}Tc and ^{129}I), because many of these nuclides may have the ability to diffuse out of the glass, therefore having higher release rates. These processes are not included in the IPA.

- The K_d value for ^{129}I (Westinghouse Hanford Company, 1996b, p. 3-27, table 3-5) appears to be non-conservative. As standard practice, ^{129}I is generally considered to be unretarded, that is, K_d=0 (Sheppard and Thibault, 1990). The value presented in the IPA (3 L/kg) is higher. This difference is expected to significantly affect the results. The value should be altered or justified.

- Some of the all-pathways dose conversion factors (DCF) in the IPA (Westinghouse Hanford Company, 1996b, p. B-56, table B-3) appear to be low compared with DCFs for other arid sites (LaPlante et al., 1995). The IPA should include a more detailed technical justification for selection of DCFs, because evaluations of disposal facility performance are expected to be very sensitive to the values selected.

- The derivation of the relative radionuclide release rate (Westinghouse Hanford Company, 1996b, pp. 3-33 and 3-34) may require modification. The equation in the center of page 3-33 describes the absolute radionuclide release rate (in Ci/yr) for the waste form as

$$\boldsymbol{RRR}(t) = C * S(t) * I(t) / V(t) \tag{5-1}$$

where

$\boldsymbol{RRR}(t)$ = the radionuclide release rate (Ci/unit time)
C = the constant corrosion rate (L/unit time)
$S(t)$ = the surface area of the waste as a function of time (L^2)
$I(t)$ = the radionuclide inventory as a function of time (Ci)
$V(t)$ = the volume of the waste as a function of time (L^3).

Assuming that this equation is correct, the relative (or fractional) radionuclide release rate $\boldsymbol{FRRR}(t)$, that is, the fraction of radionuclide inventory release rate per unit of time, would be given by

$$FRRR(t) = RRP(t)/I(t) = C * S(t)/V(t) \tag{5-2}$$

The waste area to volume ratio is expected to increase with time due to corrosion of the waste form and cracking due to formation of corrosion products. Since ***FRRR*(*t*)** is directly proportional to the waste area to volume ratio, this quantity would be expected to increase with time. In contrast, on page 3-34 there is an expression for ***FRRR*(*t*)** that decreases with time. These considerations should be included in the IPA, because performance is likely to be highly sensitive to radionuclide release rate.

- The IPA methodology is deterministic and single values (sometimes best values) of parameters are used in the analysis. The reviewers are concerned that if the range of measured parameter values were to be incorporated into the IPA, some performance limits might be exceeded. Uncertainty analyses are required in addition to the sensitivity analyses presented in the IPA.

- There is insufficient justification for the assumption that the capillary barrier will be intact for 1,000 yr. The performance of this barrier will degrade with time. Similarly, the IPA assumes that the concrete vaults will be intact for 500 yr. This assumption seems to be based on an NRC branch technical position that specifies that the maximum credit that can be allowed for concrete structures is 500 yr. A site specific justification must be provided for this assumption, since occurrence of earthquakes and other natural events must be considered.

- The infiltration rate of 0.5 mm/yr for the first 1,000 yr and 3 mm/yr thereafter has not been adequately justified. These values may be unrealistically low, and contribution from lateral subsurface flow during storms has been neglected.

- The release rate calculation appears unrealistic in that the dissolution time for the entire inventory is based on dissolution in still water. In flowing water, waste dissolution will be faster because the fresh water will provide for continuous attack on the waste form. The IPA acknowledges that performance results are dependent on release rate (Westinghouse Hanford Company, 1996b, pp. 3-32 and 3-35). The dissolution time calculations should be justified or altered.

- The IPA uses an equation that appears to consider that the quantity of radionuclides transported to the base of the vadose zone is dissolved in a volume of water equal to the annual recharge (Westinghouse Hanford Company, 1996b, p. 3-61). This would be unrealistic and non-conservative, particularly for the second design option in which the vaults are interspersed by soil. The volume of water will be the portion of annual recharge that actually flows over the waste. The concentration calculated by the flow and transport code would appear to be more justifiable.

- Flow and transport modeling neglects heterogeneity within layers, thereby omitting consideration of spatially distributed flow.

Preliminary DOE responses to these comments on the IPA are included as Appendix B. These preliminary responses provide a basis for further discussion and interaction between NRC and DOE on the results of the IPA.

5.2 ASSUMPTIONS

The following assumptions were made in assessing compliance with Criterion Three.

- The absence of a DOE waste classification system is compensated by a performance objective dose limit for intruder protection.
- The lack of a DOE performance objective for site stability can be addressed through system performance assessments that incorporate processes affecting the site.
- Absence of a DOE performance objective for protection of individuals during operations can be mitigated through the completion of the required site safety analysis report.
- Although NRC has no specific performance objective for protection of groundwater, DOE and NRC application of ALARA requirements will provide protection of groundwater resources.
- Proposed changes to DOE site performance objectives will not result in significant inconsistencies with NRC performance objectives.
- Uncertainties and concerns identified with respect to the IPA can be satisfactorily addressed in the subsequent preliminary and final performance assessment required by DOE Order 5820.2A. Many of these concerns result from lack of specificity because a site, design, or solidification process have not yet been selected.

5.3 CONCLUSIONS

The following conclusions were reached in assessing compliance with Criterion Three.

- Performance objectives from DOE Order 5280.2A are comparable to those contained in 10 CFR Part 61.
- Disposal of the LAW fraction as proposed in TBR will meet applicable performance objectives.

6 SUMMARY OF CONCLUSIONS

The results of the CNWRA review of the TBR and a number of associated references support the conclusion that if Hanford Site tank wastes are managed using a program compatible with the one presented in the TBR, the NRC can consider the resulting solidified LAW fraction to be incidental waste. Such waste could then be disposed onsite in near-surface vaults not subject to NRC regulatory control. If the management plan presented in the TBR changes significantly, NRC may find it necessary to re-examine waste classification.

The CNWRA review identified a number of uncertainties and concerns that should be addressed by the DOE through its continuing implementation of the TWRS program. Specifically, the CNWRA reviewers found that assessing compliance with Criterion Three identified several areas of significant uncertainty and technical concern. To some extent, these uncertainties and concerns may be resolved as site, design, and process selection are completed. Classification of wastes as incidental will require that privatization contractors meet waste form specifications. Proposed changes to site performance objectives must not result in incompatibility with NRC performance objectives in Subpart C of 10 CFR Part 61. Some of the concepts used in the IPA for assessing disposal system performance may need to be refined. These items have been identified in this report. Continuing concurrence in the DOE incidental waste classification for the Hanford Site tank wastes requires that these issues be adequately resolved in the preliminary and final PAs. The NRC has the responsibility and authority to conduct any such reevaluation under its existing statutory and regulatory roles.

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APPENDIX A

HANFORD SITE TANK WASTE INVENTORY UNCERTAINTIES

HANFORD SITE TANK WASTE INVENTORY UNCERTAINTIES

This appendix has been abstracted from the Technical Basis Report (TBR) (Westinghouse Hanford Company, 1996, pp. 3-3, 3-4) to document the U.S. Department of Energy (DOE) assessment of uncertainties associated with the quantities of key radionuclides contained in the Hanford Site double-shell (DSTs) and single-shell tanks (SSTs). The Center for Nuclear Waste Regulatory Analyses (CNWRA) considers these uncertainty assessments to be adequate considering the available technical data on the characterization of the tank wastes. Specifically, Shelton (1995) and Goldberg and Guberski (1995) corroborate the TBR assessment of radionuclide inventories.

Cesium and Strontium Inventories: The reported inventories for ^{137}Cs and ^{90}Sr are expected to have small uncertainties (less than 10 percent).

Transuranics (includes ^{239}Pu, ^{240}Pu, ^{241}Am, and ^{237}Np) Inventory: The inventory uncertainty for transuranics is primarily associated with the quantities in the insoluble fraction. This uncertainty does not affect an analysis of removal from the soluble fraction. The tank waste processing inventory of transuranics used for this analysis is consistent with the Integrated Data Base Report, Rev. 11. (U.S. Department of Energy, 1994).

Technetium Inventory: The ^{99}Tc inventories are based on the assumption there will be no removal of ^{99}Tc by previous processing. Previous ^{99}Tc removals include cribbing as supernatants from the tanks, cribbing of process wastes during B Plant ^{90}Sr and ^{137}Cs recovery campaigns, ^{99}Tc recovery demonstration and shipment offsite, and removal from the Hanford Site as a contaminant in shipments of uranium oxide product. These previous removals may reduce the ^{99}Tc tank inventory by 25–50 percent (Colby and Petersen, 1995). Analysis of the ^{99}Tc inventory is ongoing.

Selenium Inventory: The ^{79}Se inventories assume no removal of ^{79}Se by previous processing. Previous ^{79}Se removals include cribbing as supernatants from the tanks and cribbing or process wastes during B Plant ^{90}Sr and ^{137}Cs recovery campaigns. These previous removals may reduce the ^{79}Se tank inventory by up to a factor of two. Analysis of previous ^{79}Se removals is in progress.

Carbon Inventory: Because of the poorly known chemistry of ^{14}C in the fuel reprocessing operations that generated the Hanford Site tank wastes, the assumed inventory is conservative and the actual inventory may be a factor of 2–10 lower. The assumed inventory is 0.0053 MCi, representing 120 kg of ^{14}C diluted by approximately 1,800,000 kg of natural carbon. The chemistry of carbon results in its distribution in the supernatants and solids of all tanks. If no ^{14}C is removed, offgas during the vitrification process will result in a maximum offsite 50-yr dose of less than 7 mrem/yr (Westinghouse Hanford Company, 1996, p. 4-21).

Tritium Inventory: Tritium (^{3}H) contained in the tank wastes is estimated to be 10,000 Ci (Colby, 1994). ^{3}H will be discharged to a state-approved disposal site from the pretreatment and waste vitrification facilities in the process condensates as tritiated water. Analysis of the ^{3}H inventory is ongoing.

Tin Inventory: Some ^{126}Sn is expected to be solubilized in the alkaline solutions, but inventory values have not yet been specified. No significant quantity of ^{126}Sn is expected in the low-activity waste that would affect the waste classification. Therefore, ^{126}Sn is not considered for additional radionuclide removal. For performance assessment studies, incorporation of some ^{126}Sn in the low-level radioactive waste (LAW) fraction is assumed to ensure continued consideration of ^{126}Sn for intruder dose consequences.

Uranium Inventory: The reactor discharges of the major uranium isotope, ^{238}U, are well established using the ORIGEN2 model. The production estimates of higher actinides, including other uranium and plutonium isotopes, are more difficult to calculate. Further analysis is needed to refine the values for ^{234}U, ^{236}U, and ^{241}Am.

Other-Sodium Inventory: The impact of a potential reduction in the tank sodium inventory was not quantitatively determined in this study. Qualitatively, the costs for ^{137}Cs ion exchange will not change significantly with a reduction in the sodium inventory. Agnew (1995) indicates that the total sodium inventory in the tank wastes may be approximately 60 percent of the current reported values. This would decrease the predicted volume of the immobilized LAW form since sodium is the major constituent in the LAW, but will not affect Class C concentration limits.

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APPENDIX B

PRELIMINARY U.S. DEPARTMENT OF ENERGY RESPONSES TO COMMENTS ON HANFORD LOW-LEVEL TANK WASTE INTERIM PERFORMANCE ASSESSMENT

PRELIMINARY U.S. DEPARTMENT OF ENERGY RESPONSES TO COMMENTS ON HANFORD LOW-LEVEL TANK WASTE INTERIM PERFORMANCE ASSESSMENT

The U.S. Department of Energy (DOE) provided the following responses to an informal Nuclear Regulatory Commission (NRC) request for additional information (RAI) regarding the Hanford Low-Level Tank Waste Interim Performance Assessment (IPA) (Westinghouse Hanford Company, 1996b). The RAI forwarded the IPA comments documented in section 5.1.2 of this report. These DOE responses provide a basis for further discussion and interaction between NRC and DOE on the results of the IPA.

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Response to Specific Comments from the Review of the
"Hanford Low-Level Tank Waste Interim Performance Assessment",
WHC-EP-0884, Revision 0
(Comments contained in letter from Michael J. Bell, NRC)

1a. *The comments suggest that the initial fractional release rate of $4.4 x 10^{-6}$ for all radionuclides except ^{99}Tc, which has a rate of $8.8 x 10^{-7}$ may be unrealistically low.* The actual waste form to be disposed is undergoing negotiation between the Department of Energy and two private vendors selected for phase 1 immobilization. Since the waste form is unknown, the base case of the interim performance assessment used the specifications that were included in the request for proposal [RFP] (and now included in the contracts). Please note that for the base case, the release rate for Tc is taken as $4.4x10^{-6}$.

Although this release rate is very low, experiments at the Argonne and Pacific Northwest National Laboratories have shown for a variety of low-level radioactive glass waste forms, this rate can be achieved for the temperatures and pHs expected in the disposal facility.

The initial rate will be determined by a 7 day PCT test and hence should be indicative of the forward rate of glass dissolution. Multi-year experiments at Argonne and Pacific Northwest Laboratories on LD6-5413, a typical low-level waste glass, show that the initial rate is indeed conservative for both Stage II and III of the glass dissolution process.

In addition, to using the release rate specifications, computer simulations based on experimental data for LD6-5412 were performed. These calculations show that the predicted release rate is much lower than required in the RFP.

1b. *The comments state that the release rate for Tc may not be lower than for other components.* For the base case of the interim performance assessment, the release rate for Tc was assumed to be the same as for other elements. The lower rate for Tc release in the RFP could be met in a variety of ways. The most likely way is to separate the Tc from the waste to be immobilized, as the specifications require the release rate calculated relative to the amount of material supplied to the vendor and not to the amount in the waste form. However, from the perspective of a performance assessment, the effect is the same as shown by the sensitivity cases.

1c. *The comments note that some components of the glass may come out at different rates.* This is true. The sensitivity case in which computer simulations were used showed that the release rate did depend on species. However, until the actual waste form is known, no calculations can be made. Recent experiments at Argonne National Laboratory suggest that Tc may be bound in some of the secondary phases that are formed from dissolution of LD6-5412 and FLLW-1.

2. *The comments note that the Kd for iodine is usually taken to be 0 and that the interim performance assessment used 3 L/kg.* Kd values for the important elements are based on

experiments using Hanford soils (see "Distribution Coefficient Values Describing Iodine, Neptunium, Selenium, Technicium, and Uranium Sorption to Hanford Sediments" by D.I Kaplan and R.J. Serne, PNL-10379, Sup. 1 - March 1995. This document as well as others forming the data base for the interim performance assessment are contained in "Data Packages for the Hanford Low-Level Tank Waste Interim Performance Assessment", WHC-SD-WM-RPT-166, Rev. 0 - August 1995). Subsequent measurements and reanalysis confirmed that a non-zero Kd is appropriate for Hanford soils, although the value of 3 may be a bit too high.

Argonne National Laboratory is measuring Tc release from LD6-5412 glass this year. Both Argonne and Pacific Northwest National Laboratories will measure release rates of actual vendor glasses made using actual Hanford tank waste starting next year.

3. *The comments state that dose conversion factors in the interim performance assessment appear to be low compared to other arid sites and should be documented.* The dose conversion factors are documented in "Data and Assumptions for Estimates of Radiation Doses for the Glass Low-Level Waste Interim Performance Assessment, P.D. Roadman, WHC-SD-WM-TI-707 - June 1995. This document as well as others forming the data base for the interim performance assessment are contained in "Data Packages for the Hanford Low-Level Tank Waste Interim Performance Assessment", WHC-SD-WM-RPT-166, Rev. 0 - August 1995). The values used are consistent with the values used in other Hanford risk assessments. Both the values and methods used were reviewed by the Hanford Environmental Dose Oversight Panel.

4. *The comments note that the surface area to volume of the waste form should increase with time due to corrosion and cracking.* As noted in the performance assessment, the simple assumption of uniform decrease in dimensions were used. As more is known about the waste form and its processing, cracking and other events will be included into the performance assessments.

5. *The comments note that interim performance assessment used point values and provided sensitivity studies. The comments suggest that an uncertainty analysis be performed.* The interim performance assessment was produced into order to provide confidence that the disposal of Hanford low-activity tank waste could be performed. Because it was produced so early in the project, many items (waste form, disposal facility location and design) were not known. Reasonable assumptions based on other projects were used for the estimation of values for the base case. Sensitivity cases were defined to determine the impact of these assumptions. For the performance assessments to be submitted for regulatory review, uncertainty analyses will be done.

6. *The comments note that the surface barrier is assumed to be intact for 1,000 years and that the concrete structure for 500 years.* Neither the surface barrier nor the concrete structures have been designed. Sensitivity studies assuming no credit for such structures are very little different than the base case where such structures are present. The parameters (including design life) for the surface barrier come from work on the Hanford

barrier ("Prototype Hanford Surface Barrier: Design Basis Document", D.R. Myers and D.A. Duranceau, BHI-0007 - November 1994). Research on the Hanford surface barrier is continuing. As the design of the disposal facility progresses, analyses to determine the degradation of the structure will occur. However, until design does start, assumptions based on other projects were thought suitable for the interim performance assessment.

7. *The comments feel that the infiltration rates are not adequately justified. The effect of lateral subsurface flow during storms has been neglected.* The rates were taken from "Estimate of the Natural Ground Water Recharge for the Performance Assessment of a Low-Level Waste Disposal Facility at the Hanford Site" by M.L. Rockhold, M.J. Fayer, C.T. Kincaid, and G.W. Gee, PNL-10508, March 1995. (This document as well as others forming the data base for the interim performance assessment are contained in "Data Packages for the Hanford Low-Level Tank Waste Interim Performance Assessment", WHC-SD-WM-RPT-166, Rev. 0 - August 1995). The value for the first 1,000 years is based on the design specifications of the Hanford surface barrier. Testing of this surface barrier is continuing at Hanford and so far is meeting its specifications (even under precipitation rates of three times normal). The long-term infiltration rates are based on an extensive program at Hanford which has been very favorable reviewed by outside groups. The results of a program including long-term tracer measurements, lysimetrer measurements, and computer simulations will be used in the performance assessments created for regulatory review.

   The cause of infiltration at the Hanford Site has been extensively studied. The cause of infiltration below the root zone is predominately the melting of large snow packs cause by rains. Melting caused by sudden increase in temperatures is unimportant because of the very low air humidity. The effect of lateral subsurface flow during storms has not been detected during the decades-long measurement program at Hanford.

8. *The comments feel that the release calculations are unrealistic because they are based on dissolution is still water.* Because of the low infiltration rates, the waste if not in still water is in an environment in which the water hardly moves. The base analysis case assumes the forward rate of glass dissolution which based on experiment provides the maximum rate since it is based on fresh water. Moreover, the simulations of glass dissolution do assume flowing water but at rate consistent with water infiltration.

9. *The comments note that the contaminants are assumed to be diluted using the area of the disposal facility, not of the waste packages.* The computer model used in the base analysis case was a full facility model. The results of these simulations clearly show that the water and contaminants do spread laterally enough to cover the gaps between vaults in the alternate layout design. In fact, the calculations are conservative, since the lateral dispersion will extend beyond the area of the disposal facility.

10. *The comments note that the vadose zone modeling neglects heterogeneity within layers.* This is true. The site of the disposal action not yet been determined. Once the site(s) have been determined, then site characterization will be performed. The effect of any preferred flow paths will be determined.