Safety Issue Resolution Strategy Plan for Inactive Miscellaneous Underground Storage Tanks

O. S. Wang

T. B. Powers

Date Published
September 1994

Prepared for the U.S. Department of Energy
Office of Environmental Restoration and
Waste Management

**Westinghouse
Hanford Company**

P.O. Box 1970
Richland, Washington

Hanford Operations and Engineering Contractor for the
U.S. Department of Energy under Contract DE-AC06-87RL10930

Approved for Public Release

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RELEASE AUTHORIZATION

Document Number: WHC-EP-0775

Document Title: Safety Issue Strategy Plan for Inactive
Miscellaneous Underground Storage Tanks

Release Date: 9/26/94

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Kara Broz

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Document Title:

**SAFETY ISSUE RESOLUTION STRATEGY
PLAN FOR INACTIVE MISCELLANEOUS
UNDERGROUND STORAGE TANKS**

Prepared by:

T. B. Powers,
Risk Management Function

9/21/94
Date

Approved by:

O. S. Wang,
Waste Tank Safety Program

9/21/94
Date

Approved by:

M. N. Islam,

9/21/94
Date

Waste Tank Safety Assurance

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**SAFETY ISSUE RESOLUTION STRATEGY PLAN
FOR INACTIVE MISCELLANEOUS
UNDERGROUND STORAGE TANKS**

EXECUTIVE SUMMARY

The purpose of this strategy plan is to identify, confirm, and resolve safety issues associated with inactive miscellaneous underground storage tanks (MUSTs) using a risk-based priority approach. Assumptions and processes to assess potential risks and operational concerns are documented in this report. Safety issue priorities are ranked based on a number of considerations including risk ranking and cost effectiveness. This plan specifies work scope and recommends schedules for activities related to resolving safety issues, such as collecting historical data, searching for authorization documents, performing Unreviewed Safety Question (USQ) screening and evaluation, identifying safety issues, imposing operational controls and monitoring, characterizing waste contents, mitigating and resolving safety issues, and fulfilling other remediation requirements consistent with the overall Tank Waste Remediation System (TWRS) strategy. Recommendations for characterization and remediation are also recommended according to the order of importance and practical programmatic consideration.

Fifty MUSTs have been identified. All tanks are associated with past Hanford Site operations. Of the 50 tanks, 18 are catch tanks, 20 are vault tanks, 3 are neutralization tanks, 7 are settling tanks, 1 is an experimental tank, and 1 is a waste handling tank. The 50 MUSTs represent approximately 1% of the total waste in the existing 149 single-shell

tanks (SSTs) and 28 double-shell tanks (DSTs). It is important to proactively deal with the risks imposed by these 50 tanks, and at the same time not jeopardize the existing commitments and schedules for mitigating and resolving identified safety issues related to the 177 SSTs and DSTs. All of the existing key commitments and schedules are associated with Tri-Party Agreement and DOE safety initiatives.

According to a set of criteria consistent with the safety screening Data Quality Objective (DQO) process, six tanks are ranked high related to the hydrogen generation potential safety issue, six tanks are ranked high related to the flammability potential safety issue, and twenty-five tanks are ranked high related to the vapor emissions potential safety issue.

Access controls have been placed on all MUSTs with potentially high risk safety issues or operational concerns. An accelerated effort to identify authorization documents and perform USQ screening is also being scheduled. These are identified as short-term tasks (i.e., less than 6 months). For long-term activities, tasks such as leak-detection monitoring, safety screening characterization, and safety issue confirmation and resolution are identified along with recommended schedules in this plan. The recommended schedules will be reevaluated at a later date to be consistent with the entire TWRS task plan and strategy.

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LIST OF TERMS

DOE	U.S. Department of Energy
DQO	Data Quality Objective
ERMC	Environmental Remediation Management Contractor
LFL	Lower Flammability Limit
MUST	Inactive Miscellaneous Underground Storage Tank
PHA	Preliminary Hazard Analysis
SAR	Safety Analysis Report
SST	Single-Shell Tank
TOC	Total Organic Carbon
TWRS	Tank Waste Remediation System
USQ	Unreviewed Safety Question
WHC	Westinghouse Hanford Company
WT	Waste Type
WTSP	Waste Tank Safety Program

1.0 INTRODUCTION

1.1 PURPOSE

There are 50 inactive miscellaneous underground storage tanks (MUSTs) located in the 200 East and 200 West areas on the Hanford Site. The purpose of this strategy plan is to identify, confirm, and resolve safety issues associated with these MUSTs. This strategy plan makes recommendations for collecting historical data, searching for authorization documents, performing Unreviewed Safety Question (USQ) screening and evaluation, identifying safety issues, imposing operational controls and monitoring, characterizing waste contents, mitigating and resolving safety issues, and fulfilling other remediation requirements consistent with the overall Tank Waste Remediation System (TWRS) strategy. The plan also outlines and schedules the key tasks necessary to confirm potential safety issues and to identify resolutions of identified safety issues related to MUSTs. The tasks and recommended schedules are prioritized based on a number of considerations including risk ranking and cost effectiveness.

1.2 BACKGROUND

The MUSTs were used in the past for the following functions associated with plutonium and uranium separations and waste management activities in the 200 East and 200 West areas of the Hanford Site:

- Settling solids before disposal of supernate in cribs and a reverse well
- Neutralizing acidic process wastes before crib disposal
- Receiving and processing of single-shell tank waste for uranium recovery operations
- Collecting water that intruded into diversion boxes and transfer pipeline encasements and any leakage that occurred during waste transfer operations
- Waste handling and process experimentation.

Most of the MUSTs contain some amount of wastes and are interim isolated and interim stabilized. Interim isolated means the tanks are isolated from facilities by sealing all inlet and outlet connections to the tanks. Interim stabilized means that all liquid that is technically and economically practical to remove has been removed.

To gain a proper perspective related to the priority the miscellaneous tanks should have, it is important to consider the comparison of nominal capacities and the volume of solids and liquids between the 149 single shell tanks (SSTs) and the MUSTs as represented in

Figure 1-1. The MUSTs contain wastes that are similar in composition to those in the single-shell tanks (SSTs) and therefore the risks are believed to be bounded by the safety analyses for the SSTs. The sum of the nominal capacities of single shell tanks is 94.1 million gallons whereas the sum of the nominal capacities for the MUSTs is only 1.3 million gallons.

Thus, the MUSTs have approximately 1 percent of the nominal capacity of the single shell tanks. The single shell tanks contain 35.6 million gallons of solids and 0.6 million gallons of supernate liquids whereas the MUSTs contain 0.2 million gallons of solids and 0.04 million gallons of supernate liquids. Thus, the MUSTs have approximately 0.6 percent and 7 percent of the single shell tank solids and supernate liquids, respectively. Therefore the priority of addressing the MUSTs should not impact major commitments associated with the 177 double and single shell tanks unless some MUST has a safety issue which potentially presents a legitimate safety concern.

1.3 GENERAL ASSUMPTIONS

This strategy plan discusses identification, mitigation, and resolution of safety issues; Waste Tank Safety Program (WTSP) is responsible to carry out this plan. Recommendations will be made to Characterization, Retrieval, Operations, Upgrades, and Plant Engineering to facilitate the completion of this plan, and for their respective responsibilities to be consistent with the overall TWRS strategy. All the identified tasks described in this plan are designed to identify, mitigate, and resolve potential safety issues such as hydrogen and vapor emission.

1.4 SUMMARY

This strategy plan has been developed to address the potential safety issues related to the MUSTs. Methods for prioritizing the MUSTs according to potential safety issues and associated tasks are discussed.

Section 2.0 discusses the prioritization process of the potential safety issues and operational concerns. The criteria for prioritization and the priorities and the logic diagram for the plan are discussed in this section. Section 3.0 describes the major tasks in relation to the logic associated with MUSTs. Section 4.0 lists planned schedules for the major tasks. Section 5.0 is the reference section for the main body of the report. Appendix A discusses the bases for various Priority 1 safety issue criteria. Appendix B discusses the bases for various Priority 2 safety issue criteria. Appendix C discusses the bases for leak potential (Priority 3 safety

Figure 1-1. Comparison of Waste Volumes Between SSTs and MUSTs.

177 SST & DST Tanks

125.9 Million Gallons Capacity

40.4 Million Gallons Solids

21.3 Million Gallons Supernate

149 SST Tanks

94.1 Million Gallons Capacity

35.6 Million Gallons Solids

0.6 Million Gallons Supernate

MUST Tanks

1.3 Million Gallons Capacity

0.2 Million Gallons Solids

0.04 Million Gallons Supernate

≈ 1.0% of SSTs

≈ 0.6% of SSTs

≈ 7.0% of SSTs

issue) criteria. Appendix D discusses the bases for radiological hazards (operational concern) criteria. Appendix E lists the justification for the priority ranking for each MUST on a potential safety issue or operational concern basis. Appendix F duplicates selected pages from a waste tanks administration manual regarding unreviewed safety questions.

2.0 PRIORITIZATION OF MUST

An engineering study (WHC 1994a) compiles all available information on the inactive miscellaneous underground storage tanks and evaluates the information to determine the following:

- Potential safety issues in the current configuration
- Data needs and recommendations for resolving these issues
- Potential methods of monitoring the tanks and characterizing wastes
- Priorities for resolving safety issues and/or investigation and closure (or remediation) of the tanks
- Other operational concerns.

The engineering study prioritized the 50 MUSTs according to the risks associated with the various potential safety issues. The criteria for the priorities in this study were not quantitatively defined and thus the priorities were assumed to be based on subjective judgment. A quantitative approach to developing priorities is developed for this strategy plan. This approach results in some differences in priorities from the engineering study.

The original identification and prioritization of Hanford Site high-level waste tank safety issues was based on criteria specified by the U.S. Department of Energy (DOE) (Duffy 1990). These criteria are qualitative in nature and are quoted below as background information for the new quantitative criteria discussed in Section 2.1.

- Priority 1* Issues/situations that contain most necessary conditions that could lead to worker (onsite) or offsite radiation exposure through an uncontrolled release of fission products (e.g., tank 101-SY).
- Priority 2* Issues/situations that have presented (or contain) some conditions that could lead to an uncontrolled release of fission products under extreme assumptions (e.g., ferrocyanide* or seismic issues).
- Priority 3* Issues/situations that could lead to the future release of fission products if tanks are viewed as intermediate storage (5 to 30 years) of high-level waste (HLW) (e.g., corrosion/leakage, operating practices, buried single wall transfer lines).

*The Westinghouse *Hanford* Company has prioritized potential explosive mixture of ferrocyanide in tanks as Priority 1.

The italicized words were added to the quote for clarification purposes.

The Priority 1 safety issues are hydrogen generation, ferrocyanide* reactivity, organic salt reactivity, and high heat generation. The Priority 2 safety issues are criticality, flammable gases, and noxious vapors. The only Priority 3 safety issue considered is tank leakage.

2.1 QUANTITATIVE PRIORITIZATION FOR ASSESSING SAFETY ISSUES

The quantitative approach in developing priorities of potential safety issues for each MUST was based on the data provided in the engineering study (WHC 1994a). Existing numerical criteria (same as in the Safety Screening Data Quality Objective [Babad 1994]) served as the basis for the following potential safety issues: hydrogen generation and buildup, ferrocyanide reactivity, organic salt reactivity, criticality, and flammability.

The following is a listing of the MUSTs that are considered empty of waste (but may contain radionuclide contamination) for this prioritization assessment:

241-S-302B
241-TY-302B
241-CX-70
244-UR-004
244-WR-001
244-WR-002
244-WR-003
244-WR-004
244-WR-005
244-WR-005, sump
244-WR-006
244-WR-007
244-WR-008

All MUSTs will need to be examined to verify whether the tank is empty before turning the tank over for closure and environmental remediation.

The quantitative criteria for confirming each potential safety issue are discussed in the sections below. Criteria for a safety issue do not have to include all the necessary conditions to cause a release of fission products (otherwise it would be called an accident).

*The Westinghouse *Hanford* Company has prioritized potential explosive mixture of ferrocyanide in tanks as Priority 1.

2.1.1 Quantitative Criteria for Priority 1 Safety Issues

2.1.1.1 Hydrogen Generation and Buildup

Hydrogen generation and buildup is a potential safety issue for the MUSTs because radiolysis of water and other chemicals can produce hydrogen. Hydrogen can also be produced by chemical reactions not affected by radiation. If the MUSTs are well isolated, hydrogen can buildup to flammable concentrations in the tanks. Flammable concentrations of hydrogen and oxygen can be ignited if an ignition source is present. The criteria given below are less than the minimum conditions for hydrogen ignition, but they are consistent with the numerical criteria in the safety screening DQO and provide a basis for relative rankings.

The criteria for determining the priority rank of high, moderate, or low with regard to hydrogen generation and buildup as a potential safety issue are listed as follows:

Priority Rank	Criterion
High	Hydrogen accumulation reaches more than 1 volume percent of the tank vapor space [25 percent of the lower flammability limit (LFL)] within 10 years or less.
Moderate	Hydrogen accumulation reaches more than 1 volume percent of the tank vapor space within 10 to 25 years.
Low	A tank is either empty, or hydrogen accumulation reaches more than 1 volume percent of the tank vapor space in more than 25 years.

If there is no data to calculate hydrogen generation, and there is less than a 50 percent void space ratio, the tank is ranked moderate. If there is no data related to the amount of waste in the tank, assume the void space ratio is less than 50 percent. The basis for the hydrogen generation criterion is discussed in Appendix A.1.

According to the engineering study, four tanks (241-A-302B, 240-S-302, 241-S-302A, 241-TX-302B) are monitored daily and one tank (241-CX-70) is monitored monthly. The monthly status report (Hanlon 1994) indicates that two tanks (241-A-302B and 241-TX-302B) are monitored for liquid level using a manual tape and two tanks (240-S-302 and 241-S-302A) are monitored with FIC level detectors in the intrusion mode. Subsequent discussions with monitoring personnel indicate the frequencies of tank monitoring vary from daily to 3 times a week to weekly and possibly to monthly. Tank 241-CX-70 is monitored with a Trace Tek leak detection system. Nevertheless, these are the only known possible

spark sources for any of the 50 MUSTs. These instruments, based on previous instrumentation failure analysis, would require at least one component failure to yield a spark sufficient to ignite a flammable mixture of hydrogen. Some of the monitoring activities require opening of the tank riser. This tends to reduce the hydrogen accumulation level. The overall risk will be evaluated in a risk assessment for fiscal year 1995 (see Chapter 3.0).

2.1.1.2 Ferrocyanide Reactivity

Ferrocyanide reactivity is a potential safety issue for the MUSTs that were connected to the ferrocyanide process flowpath. If the right concentration of ferrocyanide compounds and a high enough temperature exist in a MUST, an explosive chemical reaction is possible. The criteria given below are less than the minimum conditions for an explosive chemical reaction but they are consistent with the numerical criteria in the safety screening DQO and provide a basis for relative rankings.

The criteria listed below is based on information found in WHC-EP-0691 (Postma et al. 1994). The criteria for determining the priority rank of high, moderate, or low with regard to ferrocyanide reactivity as a potential safety issue are listed as follows:

Priority Rank	Criterion
High	The potential ferrocyanide content of a tank must be estimated to be at least 8 weight percent of the solids and the calculated center line temperature must be at least 90 °C (194 °F).
Moderate	The potential ferrocyanide content of a tank must be estimated to be at least 8 weight percent of the solids and the calculated center line temperature is less than 90 °C (194 °F).
Low	The tank is either empty or the potential ferrocyanide content of a tank must be estimated to be less than 8 weight percent of the solids.

If there is no data to estimate the ferrocyanide content, the tank is ranked moderate. The basis for these criteria is discussed in Appendix A.2.

2.1.1.3 Organic Salt Reactivity

Organic salt reactivity is a potential safety issue for the MUSTs that could contain organic salts. If the right concentration of organic salts and a high enough temperature exist in a MUST, an explosive chemical reaction is possible. The criteria given below are less than

the minimum conditions for an explosive chemical reaction but they are consistent with the numerical criteria in the safety screening DQO and provide a basis for relative rankings.

The criteria for determining the priority rank of high, moderate, or low with regard to organic salt reactivity as a potential safety issue are listed as follows:

Priority Rank	Criterion
High	The potential total organic carbon content of a tank must be estimated to be at least 3 weight percent of the solids and the calculated center line temperature must be above 180 °C (356 °F).
Moderate	The potential total organic carbon content of a tank must be estimated to be at least 3 weight percent of the solids and the calculated center line temperature must be less than 180 °C (356 °F).
Low	The tank is either empty or the potential total organic carbon content of a tank is estimated to be less than 3 weight percent of the solids.

If there is no data to estimate the weight percent of total organic carbon in the tank, the tank is ranked moderate. If there are indications of organics in a tank but there is not enough information to judge that there is less than 3 weight percent total organic carbon, then assume more than 3 weight percent total organic carbon. The basis for these criteria is discussed in Appendix A.3.

2.1.1.4 High Heat

High heat is an independent safety concern for tanks within concrete vaults (22 tanks), tanks on a concrete foundation pad (4 tanks), and tanks constructed of concrete (5 tanks). The rest of the tanks (19 tanks) are direct buried steel tanks. If the temperature of the concrete exceeds 350 °F, the concrete could be damaged. The criteria given below are less than the minimum conditions for guaranteed concrete damage but they provide a basis for relative rankings.

The criteria for determining the priority rank of high, moderate, or low with regard to high heat as a potential safety issue are listed as follows:

Priority Rank	Criterion
High	The center line temperature calculation exceeds 350 °F.
Moderate	The center line temperature calculation is greater than 250 °F but less than 350 °F.
Low	The tank is either empty or the center line temperature calculation is less than 250 °F.

A discussion related to waste temperature is in Appendix A.2.

2.1.2 Quantitative Criteria for Priority 2 Safety Issues

2.1.2.1 Criticality

Criticality is a potential safety issue for the MUSTs that could contain fissile materials. The right concentration and amount of fissile materials in the right configuration with optimum moderation and a lack of neutron poisons in a MUST could cause a criticality event. The criteria given below are less than the minimum conditions for a criticality event but they are consistent with the numerical criteria in the safety screening DQO and provide a basis for relative rankings.

The criteria related to criticality are based on information in the criticality unreviewed safety question resolution report (Braun et al. 1994). The criteria are also based on the concentration of plutonium from sample analyses and the subsequent calculation of estimated total quantity of plutonium in a tank.

The criteria for determining the priority rank of high, moderate, or low with regard to criticality as a potential safety issue are listed as follows:

Priority Rank	Criterion
High	The plutonium concentration is more than 2.6 gram/liter.
Moderate	The plutonium concentration is more than 1 gram/liter but less than 2.6 gram/liter.
Low	The tank is either empty or the plutonium concentration is less than 1 gram/liter.

The basis for the criticality calculations is discussed in Appendix B.1. If no sample data exists for a tank and the tank is not empty, then the tank is ranked the same as the majority of the other MUSTs (the majority of the other MUSTs were ranked low).

2.1.2.2 Flammability

Flammability of gas mixtures in the MUST vapor spaces is a potential safety issue for the MUSTs that could produce flammable gases. If flammable gases are produced and buildup to the optimum concentration, they can be ignited if an ignition source is present. The criteria given below are less than the minimum conditions for flammable gas ignition but they are consistent with the numerical criteria in the safety screening DQO and provide a basis for relative rankings.

MUSTs are ranked high, moderate, or low in relation to the potential flammability safety issue based on the higher rank for that tank under the hydrogen generation or the organic salt reactivity potential safety issues. It is recognized that hydrogen is a flammable gas and many of the organics forming organic salts can contribute to a flammable gas mixture. A waste temperature that is elevated above ambient is required for the organics of concern to evaporate sufficiently to form a flammable gas mixture. To be consistent with the safety screening DQO for flammable gases, data is necessary to predict 25 percent of the lower flammability limit of the flammable gases. Because this data is not available for tanks containing organics, the rankings for organic salt tanks was used for the flammable gas evaluation. Thus, all flammable gas rankings will be represented by the higher ranking of hydrogen generation or organic salt reactivity.

2.1.2.3 Noxious Vapor Emissions

Noxious vapor emissions from MUSTs is a potential safety issue for the MUSTs that could produce these vapors. If enough noxious vapors are produced and released from the tank, they can produce a hazardous environment for the tank farm workers. The criteria given below are less than the minimum conditions for a noxious vapor hazardous environment but they provide a basis for relative rankings.

The criteria for determining if vapor emissions is ranked high, moderate, or low as a potential safety issue are a combination of parts of the criteria from hydrogen generation, ferrocyanide reactivity, and organic reactivity potential safety. Vapor emissions are related to hydrogen generation, the possible degradation of ferrocyanide compounds, and the existence of organics in the MUSTs. Vapor emissions are related to hydrogen generation because the chemical reactions that produce hydrogen also produce noxious gases in the waste tanks. Thus, the vapor emission criteria are listed as follows:

Priority Rank	Criterion
High	Hydrogen reaches more than 1 volume percent of the tank vapor space within 10 years or less, or the potential ferrocyanide content of a tank must be estimated to be at least 8 weight percent of the solids, or the potential total organic carbon content of a tank must be estimated to be at least 3 weight percent of the solids.
Moderate	Hydrogen reaches more than 1 volume percent of the tank vapor space within 10 to 25 years, or the potential ferrocyanide content of a tank must be estimated to be less than 8 weight percent of the solids, or the potential total organic carbon content of a tank is estimated to be less than 3 weight percent of the solids.
Low	A tank is either empty or hydrogen reaches greater than 1 volume percent of the tank vapor space in more than 25 years.

If there is no data to calculate hydrogen generation and there is less than 50 percent void space ratio, the tank is ranked moderate. If there is no data related to the amount of waste in the tank, assume the void space ratio is less than 50 percent. Other gases that may be produced along with hydrogen are considered harmful vapors.

If there is no data to estimate the ferrocyanide content in the tank, the tank is ranked moderate. If there is no data to estimate the weight percent of total organic carbon in the tank, the tank is ranked moderate.

Further information on the basis for the vapor emission potential safety issue ranking is found in Appendix B.2.

2.1.3 Quantitative Criteria for Priority 3 Safety Issues

2.1.3.1 Leak Potential

The only Priority 3 safety issue under consideration in the MUST safety program is the potential for tank leakage, which is an environmental concern. The criteria for determining the priority rank of high, moderate, or low with regard to leak potential are listed as follows:

Priority Rank	Criterion
High	The tank contains more than 5,000 gallons of supernate.
Moderate	The tank contains less than 5,000 gallons but more than 400 gallons of supernate.
Low	The tank is either empty or the tank contains less than 400 gallons of supernate.

The basis for the 5,000 and the 400 gallon supernate limits in the criteria is that those are the levels at which MUSTs were considered to be interim stabilized when they were being isolated in the mid-1980s. The 5,000 and 400 gallon values for interim stabilization are discussed in a 1984 supporting document (Beil 1984). If liquid was too highly radioactive to be pumped to a tank truck without dilution, then overground piping was used. Supernate volumes of 5,000 gallons or less were considered to be economically and technically nonpumpable through the overground piping. If liquid was of low enough radioactivity to be pumped to a tank truck, then supernate volumes of 400 gallons or less were considered to be economically and technically nonpumpable to tank trucks.

If there is no data for the amount of supernate, it is assumed to be less than 5,000 gallons. The basis for the supernate volume is discussed in Appendix C.

2.2 QUANTITATIVE PRIORITIZATION FOR ASSESSING RADIOLOGICAL HAZARDS

Radiological hazard is an operational concern to workers rather than a safety issue. The measurable criteria for radiological hazards are developed and summarized in this section. These criteria and related data will be transmitted to Operations for survey and monitoring when tank entry is needed.

The criteria related to radiological hazards are based on estimated ^{137}Cs content of the tanks. The criteria for determining the priority rank of high, moderate, or low with regard to radiological hazards as an operational concern are listed as follows:

Priority Rank	Criterion
High	A tank contains more than 1,000 curies of ^{137}Cs .
Moderate	A tank contains more than 100 curies but less than 1,000 curies of ^{137}Cs .
Low	A tank contains less than 100 curies of ^{137}Cs .

The decision to use 100 and 1,000 curies as the criteria is an arbitrary decision used to show order of magnitude differences. If a tank is empty of waste, it could still have surface radiological contamination. The basis for the ^{137}Cs content calculations is discussed in Appendix D. If there is no analytical data for ^{137}Cs in a tank or the quantities of waste as supernate and sludge is not well known, then the tank is ranked moderate until it can be surveyed and posted to prevent unacceptable exposures when an entry to a tank is planned.

2.3 SUMMARY OF SAFETY ISSUE PRIORITIES

The priorities of each potential safety issue for each inactive miscellaneous underground storage tank are listed in Table 2-1. These priorities were made based on the criteria given in Section 2.1 of this strategy plan. Additional notes explaining priority ranks of certain tanks are outlined in Appendix E. The tanks that had high ranks for Priority 1 safety issues, such as hydrogen, are listed first; then the tanks ranked high for Priority 2 safety issues, such as vapor emission, and a Priority 3 safety issue, such as leak potential, are listed next.

Six tanks related to the hydrogen generation potential safety issue are ranked high. These tanks (241-T-361, 244-BXR-003, 241-U-361, 241-B-361, 244-BXR-001, and 244-BXR-011) are calculated to generate enough hydrogen for a 1 percent vapor space concentration [25 percent of lower flammability limit (LFL)] in less than 10 years.

No tanks related to the ferrocyanide reactivity potential safety issue are ranked high. Two tanks are ranked moderate. These tanks (244-TY-302A and 244-TX-302B) are two of the possible eight tanks on the ferrocyanide flow path that are estimated to potentially have an 8 weight percent ferrocyanide content or there is insufficient data to refute that supposition. These tanks are assumed to have waste temperatures of less than 90°C based on the preliminary results of a more realistic temperature calculation (to be issued in November 1994).

Table 2-1. Priorities of the Miscellaneous Tanks Given Resolution Action Is Occurring. (5 pages)

Tank Row #	TANK	Tank Type [a]	Relative Ranking on Potential Safety Issues [b][c]									Sludge Volume (gal) [d]	Liquid Volume (gal) [d]	Total Volume (gal) (d)	NOTES
			H ₂	FeCN	Org	Heat	Crit	Flam	Vap	Leak	Rad				
	Priority 1, 2, 3, or Operational Concern →		1	1	1	1	2	2	2	3	OC				
1	241-T-361	S	H	L	M*	L	L	H	H	M	H	24,500	0	24,500	
2	244-BXR-003	V	H	L	M* [g]	L	L	H	H	M	L	1,450	360	1,810	Est. 8,300 gal. soft sludge in sump
3	241-U-361	S	H	L	M*	L	L	H	H	M	H	27,700	100	27,800	Little or no liquid
4	241-B-361	S	H	L	M	L	L	H	H	M	M	20,678	0	20,678	No pumpable liquids
5	244-BXR-001	V	H	L	M*	L	L	H	H	M	M	7,200	0	7,200	Minimum sludge in sump
6	244-BXR-011	V	H	L	L	L	L	H	H	M	M	7,000	100	7,100	Est. 4,200 gal. soft sludge in sump
7	241-TY-302A	C	L	M	M*	M	L	M	H	M	M	450	0	450	
8	241-TX-302B [f]	C	L	M	M*	M	L	M	H	M	M	- [e]	-	1,320	Monitored by leak detector.
9	241-A-302B	C	L	L	M*	M	L	M	H	M	M	-	-	3,600	Monitored by leak detector.
10	241-B-301	C	L	L	M*	L	L	M	H	M	L	21,660	590	22,250	
11	241-B-302B	C	L	L	M*	M	L	M	H	M	M	690	4,240	4,930	
12	241-BX-302B	C	L	L	M*	M	L	M	H	M	M	950	90	1,040	
13	241-BX-302C	C	L	L	M*	M	L	M	H	M	M	640	230	870	
14	241-C-301	C	L	L	M*	L	L	M	H	M	L	9,000	1,470	10,470	

Table 2-1. Priorities of the Miscellaneous Tanks Given Resolution Action Is Occurring. (5 pages)

Tank Row # ↓	TANK	Tank Type [a]	Relative Ranking on Potential Safety Issues [b][c]									Sludge Volume (gal) [d]	Liquid Volume (gal) [d]	Total Volume (gal) [d]	NOTES
			H ₂	FeCN	Org	Heat	Crit	Flam	Vap	Leak	Rad				
	Priority 1, 2, 3, or Operational Concern →		1	1	1	1	2	2	2	3	OC				
15	240-S-302	C	L	L	M*	M	L	M	H	M	M	-	-	2,276	Monitored by leak detector. Est. 100 gal. interstitial liquid
16	241-S-302A	C	L	L	M*	M	L	M	H	M	M	-	-	5,130	Monitored by leak detector. 2 ft grout over 1 ft sand
17	241-SX-302	C	L	L	M*	M	L	M	H	M	M	1,050	300	1,350	
18	241-T-301B	C	L	L	M*	L	L	M	H	M	L	21,660	590	22,250	
19	241-TX-302A	C	L	L	M*	L	L	M	H	M	L	2,450	30	2,480	
20	241-TX-302XB	C	L	L	M*	M	L	M	H	M	M	110	250	360	
21	241-CX-71	N	L	L	M*	L	L	M	H	M	L	930	0	930	Grout over 4 ft limestone and 2.35 ft sludge
22	244-BXR-002	V	L	L	M*	L	L	M	H	M	L	1,800	380	2,180	Est. 280 gal. sludge in sump
23	244-UR-001	V	L	L	M*	L	L	M	H	M	L	1,850	390	2,240	Liquid and sludge in sump
24	244-UR-002	V	L	L	M*	L	L	M	H	M	L	2,300	570	2,870	Conflicting liquid level data (214 or 570 gal.)
25	244-UR-003	V	L	L	M*	L	L	M	H	M	M	1,570	0	1,570	Liquid and sludge in sump

Table 2-1. Priorities of the Miscellaneous Tanks Given Resolution Action Is Occurring. (5 pages)

Tank Row #	TANK	Tank Type [a]	Relative Ranking on Potential Safety Issues [b][c]									Sludge Volume (gal) [d]	Liquid Volume (gal) [d]	Total Volume (gal) [d]	NOTES
			H ₂	FeCN	Org	Heat	Crit	Flam	Vap	Leak	Rad				
	Priority 1, 2, 3, or Operational Concern →		1	1	1	1	2	2	2	3	OC				
26	244-WR-009	V	L	L	M	M	L	M	M	H	M	0	23,000	23,000	Conflicting volume data (may be empty)
27	270-B-1	N	M	L	M	M	L	M	M	M	M	3,800	0	3,800	Possible 1,400 gal. interstitial liquid
28	270-W	N	L	L	M	M	L	M	M	M	M	-	-	-	contents unknown
29	241-Z-361	S	L	L	L	M	L	M	M	M	M	20,000	200	20,200	Layered "mud-like" sludge
30	241-Z-8	S	L	L	M	M	L	M	M	M	M	500	0	500	Liquid removed 10-19-74
31	241-CX-72	B	L	L	M	M	L	M	M	M	M	650	0	650	Filled with grout over sludge
32	244-TXR-003	V	L	L	M	L	L	M	M	M	M	6,500	0	6,500	Minimum sludge in sump
33	231-W-151-001	S	L	L	M	M	L	M	M	M	L	0	1,430	1,430	
34	231-W-151-002	S	L	L	M	L	L	M	M	M	L	10	950	960	
35	244-TXR-001	V	L	L	M	L	L	M	M	M	L	2,300	50	2,350	Minimum sludge in sump
36	244-TXR-002	V	L	L	M	L	L	M	M	M	M	2,950	0	2,950	Minimum sludge in sump
37	241-TX-302BR [f]	C	L	L	L	M	L	L	L	M	M	-	-	-	contents unknown
38	241-BX-302A	C	L	L	L	L	L	L	M	M	M	840	0	840	

Table 2-1. Priorities of the Miscellaneous Tanks Given Resolution Action Is Occurring. (5 pages)

Tank Row #	TANK	Tank Type [a]	Relative Ranking on Potential Safety Issues [b][c]									Sludge Volume (gal) [d]	Liquid Volume (gal) [d]	Total Volume (gal) (d)	NOTES
			H ₂	FeCN	Org	Heat	Crit	Flam	Vap	Leak	Rad				
	Priority 1, 2, 3, or Operational Concern →		1	1	1	1	2	2	2	3	OC				
39	241-S-302B	C	L	L	L	L	L	L	L	L	M	0	0	0	Emptied
40	241-TY-302B	C	L	L	L	L	L	L	L	L	M	0	0	0	Emptied
41	241-CX-70	WH	L	L	L	L	L	L	L	L	M	0	0	0	Flushed and emptied
42	244-WR-001	V	L	L	L	L	L	L	L	L	M	-	-	12,000	Tank believed empty; est. 12,000 gal. in sump
43	244-WR-002	V	L	L	L	L	L	L	L	L	M	-	-	35,000	Tank believed empty; est. 35,000 gal. in sump
44	244-WR-003	V	L	L	L	L	L	L	L	L	M	-	-	0	Believed empty; unknown sump waste volume
45	244-WR-004	V	L	L	L	L	L	L	L	L	M	-	-	0	Believed empty; unknown sump waste volume
46	244-WR-005	V	L	L	L	L	L	L	L	L	M	-	-	-	Value unknown (may be empty)
47	244-UR-004	V	L	L	L	L	L	L	L	L	L	min.	min.	min.	minimum heel
48	244-WR-006	V	L	L	L	L	L	L	L	L	L	-	-	min.	Minimum heel of thorium solution
49	244-WR-007	V	L	L	L	L	L	L	L	L	L	-	-	0	Believed empty

Table 2-1. Priorities of the Miscellaneous Tanks Given Resolution Action Is Occurring. (5 pages)

Tank Row # ↓	TANK	Tank Type [a]	Relative Ranking on Potential Safety Issues [b][c]									Sludge Volume (gal) [d]	Liquid Volume (gal) [d]	Total Volume (gal) (d)	NOTES
			H ₂	FeCN	Org	Heat	Crit	Flam	Vap	Leak	Rad				
	Priority 1, 2, 3, or Operational Concern →		1	1	1	1	2	2	2	3	OC				
50	244-WR-008	V	L	L	L	L	L	L	L	L	L	-	-	0	Believed empty

NOTES:

[a] C = catch tank; E = experimental tank; N = neutralization tank; S = settling tank; V = vault tank; WH = waste handling tank

[b] Relative rankings: H = high; M = moderate; M* = see Note g. below; L = low

[c] Issue abbreviations:

H ₂	Hydrogen generation and buildup	Flam	Flammability
FeCN	Ferrocyanide reactivity	Vap	Emission of radioactive or toxic vapors
Org	Organic salt reactivity	Leak	Leak Potential
Heat	High heat	Rad	Radioactivity
Crit	Criticality		

[d] Volumes have been rounded to the nearest 10 gallons.

[e] - = No Data

[f] There is confusion in the reference information about whether there are two or three tanks with the following designations: tank 241-TX-302B or tank 241-TX-302BR. One version says tank 241-TX-302B replaced tank 241-TX-302BR because 241-TX-302BR was damaged by acid. The other version indicates that 241-TX-302B was the first tank, it was replaced by 241-TX-302BR which subsequently failed and then was replaced by a tank designated 241-TX-302B.

[g] Under the organic salt reactivity potential safety issue column a moderate ranking with an asterisk (M*) means it has > 3 wt% TOC but the temperature analysis makes it moderate.

No tanks related to the organic salt reactivity potential safety issue are ranked high. One tank (244-BXR-003) is ranked moderate. Indications are that this tank could have at least 3 weight percent total organic carbon and is assumed to have a waste temperature of less than 180°C based on the preliminary results of a more realistic temperature calculation (to be issued in November 1994).

No tanks related to the high heat potential safety issue are ranked high. This is based on a preliminary thermal assessment to be issued in November 1994.

The highest rank any tank received is low for the criticality potential safety issue.

The same six tanks that were ranked high for the hydrogen generation potential safety issue are also ranked high for the flammability potential safety issue.

Twenty-five tanks are ranked high related to the vapor emissions safety issue. These tanks include the six high hydrogen generation tanks and the two moderate ferrocyanide tanks as well as many of the organic tanks that are estimated to contain more than 3 weight percent total organic carbon.

One tank is ranked high for the leakage safety issue. This tank is ranked high because it contains more than 5,000 gallons of supernate. The 5,000 gallon limit of supernate was the criteria used in the mid-1980s at which MUSTs were considered to be interim stabilized. This 5,000 gallon value for interim stabilization is discussed in a 1984 supporting document (Bell 1984).

Two tanks are ranked high for the radiological hazards by direct exposure potential operational concern. These tanks (241-T-361 and 241-U-361) contain over 1,000 curies of ¹³⁷Cs. One tank, 241-T-361, is estimated to contain over 15,000 curies and tank 241-U-361 is estimated to contain about 1,400 curies. But there are 32 tanks ranked moderate because they contain between 100 and 1,000 curies or because of insufficient information. Radiological hazards are not related to safety issues; however, attention should be addressed to protect workers during planned entries to MUSTs.

A summary of the number of MUSTs having a given rank for each potential safety issue or operational concern is shown in Table 2-2.

Table 2-2. Summary of Priorities of the Miscellaneous Tanks
Given Resolution Action Is Occurring.

Potential Safety Issues (SI) or Operational Concerns (OC)		Number of MUSTs in Each Ranking Category		
Priority of SIs or Designation as OC		High	Moderate	Low
1	Hydrogen generation and buildup	6	1	43
1	Ferrocyanide reactivity	0	2	48
1	Organic salt reactivity	0	34*	16
1	High heat	0	18	32
2	Criticality	0	0	50
2	Flammability	6	30	14
2	Emission of radioactive or toxic vapors	25	12	13
3	Leak Potential	1	37	12
OC	Radioactivity	2	32	16

* 23 of the 34 have > 3 wt% TOC but the temperature analysis makes it moderate as indicated in Table 2-1 by the M^c.

2.4 SAFETY ISSUE RESOLUTION LOGIC

A logic diagram to resolve relevant safety issues for the MUST safety program is displayed in Figure 2-1. The logic at the initial stage emphasizes tank identification, historical data collection, safety documentation, and potential safety issue verification. The numerical notations at the upper right of the logic boxes in Figure 2-1 represent the section numbers of the associated tasks described in Section 3.0. As soon as relevant safety issues are verified for all MUSTs, SAIC logic* will be used for the revised strategy plan to resolve specific

*SAIC logic is a report, *Planning Exercise for the Resolution of High-Level Waste Tank Safety Issues*, issued on December 23, 1991 by Science Applications International Corporation (SAIC) for DOE-HQ.

safety issues. If no safety issues can be verified, this safety program will then be terminated and the 50 MUSTs will be remediated according to the overall TWRS strategy plan.

The logic starts with tank identification (3.1). Most of the MUSTs cannot be identified from above ground because of a tank isolation project implemented in the 1980s. The isolation project cut off most risers below grade. Only the MUSTs with risers above grade, such as tank 241-T-361, can be readily identified. Otherwise, a special device like ground penetrating radar (GPR) technique must be deployed to identify and verify the location and orientation of the tanks.

The next logic step is to collect historical data and relevant information (3.2) about the MUSTs. This step is essential for the identification of potential safety issues (3.3.1) and applicable authorization basis documents (3.4.1). Based on the potential safety issues, a risk assessment (3.3.2) can be performed and some interim controls may be imposed to protect onsite workers (3.5.1). After authorization bases are identified, discovery USQ (unreviewed safety question) screening (3.4.2), PHA (preliminary hazard analysis) evaluation (3.4.3), and USQ evaluation (3.4.4) will be needed to complete safety assessment and analysis. At that time, additional controls may be identified and established as preventive measures to protect workers and the environment (3.5.2).

All MUSTs will be verified regarding their status of being empty or leaking, and the amount of wastes (3.10) using state-of-the-art techniques. For tanks verified to be empty, they will be transferred to Environmental Restoration for proper closure (3.12). The criteria use to define a tank as empty are yet to be determined. The rest of the MUSTs will then be characterized (3.6) and verified for specific safety issues (3.7). Those MUSTs without safety issues can be transferred to other TWRS programs for retrieval and remediation (3.11). In the mean time, some selected tanks should be considered for monitoring to detect tank leaking and flammable gas buildup (3.9).

If there are no identifiable safety issues, the safety program for MUSTs can be terminated at that time. Otherwise, a revised strategy/program plan will be drafted for the resolution of specific safety issues (3.8).

Figure 2-1. Logic Diagram for the Inactive Miscellaneous Underground Storage Tank Strategy Plan

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3.0 MAJOR TASKS OF STRATEGY PLAN

Figure 2-1 shows the safety issue resolution logic for the Inactive Miscellaneous Underground Storage Tank Strategy Plan. Each of the major tasks of this strategy plan is represented by a block corresponding to each section number below and is shown in Figure 2-1. The scope of these major tasks are discussed below. This plan and the status of all major tasks will be updated annually.

3.1 IDENTIFY TANKS

The first task is to identify all the inactive miscellaneous underground storage tanks (MUSTs). This task is complete and has identified 50 MUSTs. All tanks are associated with past Hanford Site operations. Of the fifty tanks, 18 are catch tanks, 20 are vault tanks, 3 are neutralization tanks, 7 are settling tanks, 1 is an experimental tank, and 1 is a waste handling tank. All of these tanks have contained radioactive waste except for five of the tanks in the WR Vault. Because these "cold" tanks are in a vault with tanks that have contained radioactive waste and the walls between the "cold" and "hot" sides of the vault have leaked contamination, these five tanks are also considered radioactive MUSTs. These 50 MUSTs are identified and documented in an engineering study (WHC 1994a).

Status: Completed in May 1994. Effort to identify more tanks is ongoing.

3.2 OBTAIN HISTORICAL DATA

This task is to obtain all historical data and relevant information that is available on the 50 MUSTs already identified. This task is documented in the same engineering study (WHC 1994a).

Status: Completed in May 1994. Effort to collect more information is ongoing.

3.3 SAFETY ISSUES AND RISK ASSESSMENT

3.3.1 Identify Potential Safety Issues

After the second task, there are two parallel paths. The only task in the right-hand path is a task to identify the potential safety issues. This task is essentially complete and is documented in Section 2.0 of this report. These first three tasks (3.1 through 3.3) represent an active document to be updated on an annual basis as more information is discovered or developed.

Status: To be completed by 9/30/94. Document will be updated annually.

3.3.2 Risk Assessment

The risk assessment is to evaluate the overall risks of the safety program based on identified potential safety issues. The assessment includes risks resulting from related activities and alternatives, such as the no action alternative.

Status: To be completed by 9/30/95.

3.4 SAFETY ASSESSMENT

The other parallel path in the left-hand side of Figure 2-1 is related to safety assessment and documentation. This major task consists of four subtasks as described below.

3.4.1 Identify Applicable "Authorization Basis Documents"

The first subtask in the left-hand path is to identify applicable "authorization basis documents." The following steps will be taken:

The AUTHORIZATION BASIS documents listed in Appendix G of WHC-IP-0042, Revision 3 (WHC 1994b) and any safety basis documents identified by cognizant plant and safety personnel will be reviewed for applicability to the MUSTs.

WHC-IP-0842, Revision 3, Appendix G, identifies the following three documents as the current AUTHORIZATION BASIS documents for the Waste Tank Farm:

- a. 242-A Evaporator, WHC-SD-WM-SAR-023, Revision 1.
- b. LERF, WHC-SD-W105-SAR-01, Revision 0-B.
- c. Waste Tanks, WHC-SD-WM-ISB-001, Revision 1.

A search for additional safety basis and AUTHORIZATION BASIS documents will be conducted by contacting cognizant plant and safety personnel.

It is probable that some of these MUSTs may already be included in one or more of these documents.

Status: To be completed by 9/30/94.

3.4.2 Perform Discovery USQ Screening

The second subtask in the left-hand path is to perform Discovery USQ Screening related to the potential safety issues associated with the MUSTs. The following steps will be taken:

- WHC-IP-0842, Revision 3, will be applied to the MUSTs in order to determine if the MUST "occurrence" is indeed a USQ "discovery."
- This process involves answering the three questions shown in Figure B-2, Appendix B, WHC-IP-0842, Revision 3. A copy of the page (page 19) from WHC-IP-0842 that contains these questions is in Appendix F.
- MRP 5.12 (WHC-CM-1-3), Revision 2, will also be consulted as needed.

Status: To be completed by 10/31/94.

3.4.3 Perform Additional Preliminary Hazard Analysis

The third subtask in the left-hand path is to perform a safety evaluation to answer the eight questions in Figure B-3, Appendix B, WHC-IP-0842, Revision 3. The safety evaluation for the MUST will be a Preliminary Hazard Analysis (PHA). A copy of the pages (pages 20 & 21) from WHC-IP-0842 that contain these questions is in Appendix F.

The results of the PHA will be compared to appropriate safety analyses for similar, "bounding" facilities. The results of these comparisons will be used to evaluate potential accidents in the MUST and their potential risks.

Status: To be completed by 10/31/94.

3.4.4 Complete USQ Evaluation if required

The fourth subtask in the left-hand path is to complete a USQ Evaluation if it is required. If any of the eight questions in Figure B-3, Appendix B, WHC-IP-0842, Revision 3, are not answered satisfactorily, even after the safety evaluation is performed, then additional safety analyses must be undertaken to close this process.

Status: To be completed by 5/30/95.

3.5 ESTABLISH PREVENTIVE CONTROLS

3.5.1 Short-Term

In the short-term, some access control will be implemented to restrict access to various MUSTs ranked high for H₂/Flammable gas, vapor emission, or radiological hazards. These forms of access control may be as simple as posting signs indicating the location of these MUSTs; or the access controls may require fencing off the surface area above the MUSTs.

Status: 10 high priority tanks to be completed by 9/30/94. 40 other tanks to be completed by 12/31/94.

3.5.2 Based on USQ Evaluation

Based on the results of the USQ Evaluation subtasks, some additional forms of access control may be implemented, or additional MUSTs may require access controls.

Status: To be completed by 9/30/95, if needed.

3.6 CHARACTERIZATION

All MUSTs, except the confirmed empty tanks, will have their contents characterized according to a screening process. Following analyses of the waste, a judgment will be made to determine if a safety issue exists. If a tank is judged to have no safety issues, then it is ready for retrieval/remediation and eventually environmental restoration and closure. If a tank is judged to have a safety issue(s), the safety issue(s) will be resolved before retrieval/remediation. Table 3-1 lists the priority of the MUSTs for characterization purposes. The MUSTs that should be characterized first are the ones ranked high according to potential safety issue concerns, then the remaining tanks that have the most total waste are characterized. The assumed empty MUSTs will be verified first, and characterization may not be needed.

Table 3-1. Priorities of the Miscellaneous Tanks For Characterization Purposes. (3 pages)

Tank Row # ↓	Tank	Highest Safety Issue Rank	Sludge Volume (gal) [a]	Liquid Volume (gal) [a]	Total Volume (gal) [a]	Notes
1	241-T-361	H	24,500	0	24,500	
2	244-BXR-003	H	1,450	360	1,810	Est. 8,300 gal. soft sludge in sump
3	241-U-361	H	27,700	100	27,800	Little or no liquid
4	241-B-361	H	20,678	0	20,678	No pumpable liquids
5	244-BXR-001	H	7,200	0	7,200	Minimum sludge in sump
	244-BXR-011	H	7,000	100	7,100	Est. 4,200 gal. soft sludge in sump
7	241-TY-302A	H	450	0	450	
8	241-TX-302B (0)	H	- [b]	-	1,320	Monitored by leak detector.
9	241-A-302B	H	-	-	3,600	Monitored by leak detector.
10	241-B-301	H	21,660	590	22,250	
11	241-B-302B	H	690	4,240	4,930	
12	241-BX-302B	H	950	90	1,040	
13	241-BX-302C	H	640	230	870	
14	241-C-301	H	9,000	1,470	10,470	
15	240-S-302	H	-	-	2,276	Monitored by leak detector. Est. 100 gal. interstitial liquid
16	241-S-302A	H	-	-	5,130	Monitored by leak detector. 2 ft grout over 1 ft sand
17	241-SX-302	H	1,050	300	1,350	
18	241-T-301B	H	21,660	590	22,250	
19	241-TX-302A	H	2,450	30	2,480	
20	241-TX-302XB	H	110	250	360	
21	241-CX-71	H	930	0	930	Grout over 4 ft limestone and 2.35 ft sludge

Table 3-1. Priorities of the Miscellaneous Tanks For Characterization Purposes. (3 pages)

Tank Row #	Tank	Highest Safety Issue Rank	Sludge Volume (gal) [a]	Liquid Volume (gal) [a]	Total Volume (gal) [a]	Notes
22	244-BXR-002	H	1,800	380	2,180	Est. 280 gal. sludge in sump
23	244-UR-001	H	1,850	390	2,240	Liquid and sludge in sump
24	244-UR-002	H	2,300	570	2,870	Conflicting liquid level data (214 or 570 gal.)
25	244-UR-003	H	1,570	0	1,570	Liquid and sludge in sump
26	244-WR-009	H	0	23,000	23,000	Conflicting volume data (may be empty)
27	244-WR-002	M	-	-	35,000	Tank believed empty; est. 35,000 gal. in sump
28	241-Z-361	M	20,000	200	20,200	Layered "mud-like" sludge
29	244-WR-001	M	-	-	12,000	Tank believed empty; est. 12,000 gal. in sump
30	244-TXR-003	M	6,500	0	6,500	Minimum sludge in sump
31	270-E-1	M	3,800	0	3,800	Possible 1,400 gal. interstitial liquid
32	244-TXR-002	M	2,950	0	2,950	Minimum sludge in sump
33	244-TXR-001	M	2,300	50	2,350	Minimum sludge in sump
34	231-W-151-001	M	0	1,430	1,430	
35	231-W-151-002	M	10	950	960	
36	241-BX-302A	M	840	0	840	
37	241-CX-72	M	650	0	650	Filled with grout over sludge
38	241-Z-8	M	500	0	500	Liquid removed 10-19-74

Table 3-1. Priorities of the Miscellaneous Tanks For Characterization Purposes. (3 pages)

Tank Row #	Tank	Highest Safety Issue Rank	Sludge Volume (gal) [a]	Liquid Volume (gal) [a]	Total Volume (gal) [a]	Notes
39	270-W	M	-	-	-	contents unknown
40	241-TX-302BR (f)	M	-	-	-	contents unknown
41	244-UR-004	L	min.	min.	min.	minimum heel
42	244-WR-006	M	-	-	min.	Minimum heel of thorium solution
43	244-WR-003	M	-	-	0	Believed empty; unknown sump waste volume
44	244-WR-004	M	-	-	0	Believed empty; unknown sump waste volume
45	244-WR-005	M	-	-	-	Value unknown (may be empty)
46	244-WR-007	L	-	-	0	Believed empty
47	244-WR-008	L	-	-	0	Believed empty
48	241-S-302B	M	0	0	0	Emptied
49	241-TY-302B	M	0	0	0	Emptied
50	241-CX-70	M	0	0	0	Flushed and emptied

NOTES:

[a] Volumes have been rounded to the nearest 10 gallons.

[b] - = No Data

3.6.1 Safety Screening Data Quality Objective/Sampling

The safety screening process is described in a document titled *Tank Safety Screening Data Quality Objective* (Babad 1994). This process addresses decision rules used to classify a tank as "safe" or "not safe," decision variables used for safety status classification, and the number and type of samples required for safety screening. Use of this module will help classify MUSTs into specific categories for safety issues dealing with the presence of ferrocyanide, organics, and flammable gases, as well as criticality.

Status: To be discussed with the Characterization Program on specific schedules.

3.6.2 Vapor Sampling

Vapor sampling will be performed according to ongoing industrial hygiene programs and procedures to determine if noxious vapors are a safety issue.

Status: To be discussed with the Characterization Program on specific schedules.

3.6.3 Criticality Evaluation

Criticality concerns are dealt with in part by safety screening sampling. The concerns of different geometries other than the larger 50,000 gallon Single-Shell Tanks (SSTs) must also be evaluated.

Status: Effect of geometry on criticality to be completed by 4/15/95.

3.7 SAFETY ISSUE CONFIRMATION/VERIFICATION

Once the sampling and evaluation subtasks above are performed, then safety issues can be confirmed or it can be verified that there are no safety issues.

Status: To be consistent with results from 3.6.

3.8 SAFETY ISSUE RESOLUTION

If a safety issue is confirmed, a plan will be developed and implemented to resolve the issue.

Status: A safety issue resolution plan will be developed after 3.7 is completed.

3.9 MONITORING

Certain MUSTs may be monitored if safety concerns or operational/environmental concerns dictate.

3.9.1 Leak detection

For MUSTs that have more than 5,000 gallons of supernate, some form of leak detection system will be implemented. This may involve the installation of a liquid level gauge into those MUSTs.

Status: In-tank video effect and leak detection devices will be implemented immediately after characterization work is done.

3.9.2 H₂/Flammable Gas Monitoring

If certain MUSTs are confirmed as H₂/flammable gas safety issue tanks, then some form of flammable gas monitoring system will be implemented.

Status: To be determined.

3.10 VERIFICATION OF EMPTY TANKS

All MUSTs will be checked to verify whether the tank is empty, leaking, and how much waste is in the tank. If a tank is verified empty, it will be considered ready for environmental restoration and closure. A set of "empty" criteria will be developed and agreed upon by all stakeholders as soon as practicable.

Status: In-tank video or other noninvasive device will be used to verify empty tanks. At least one tank will be verified in fiscal year 1995.

3.11 WASTE RETRIEVAL RECOMMENDATION

Table 3-2 lists the priority of the MUSTs for waste retrieval purposes. The MUSTs that should be retrieved first are the ones with the most supernate liquid, then those MUSTs ranked high according to potential safety issue concerns, then the remaining tanks.

Status: Recommendations made by 9/30/95.

3.12 ENVIRONMENTAL RESTORATION AND CLOSURE

After the MUSTs are verified as empty in accordance with a set of criteria to be developed by TWRS and Environmental Remediation Management Contractor (ERMC), these tanks will be transferred to ERMC for environmental restoration and closure. This procedure is similar to a procedure for the 149 SSTs and will be in accordance to an agreed schedule by all stakeholders.

Status: To be determined.

Table 3-2. Priorities of the Miscellaneous Tanks For Retrieval Purposes. (3 pages)

Tank Row # †	TANK	Highest Safety Issue Rank	Sludge Volume (gal) [a]	Liquid Volume (gal) [a]	Total Volume (gal) [a]	NOTES
1	244-WR-009	H	0	23,000	23,000	Conflicting volume data (may be empty)
2	241-B-302B	H	690	4,240	4,930	
3	241-C-301	H	9,000	1,470	10,470	
4	231-W-151-001	M	0	1,430	1,430	
5	231-W-151-002	M	10	950	960	
6	241-B-301	H	21,660	590	22,250	
7	241-T-301B	H	21,660	590	22,250	
8	244-UR-002	H	2,300	570	2,870	Conflicting liquid level data (214 or 570 gal.)
9	244-UR-001	H	1,850	390	2,240	Liquid and sludge in sump
10	244-BXR-002	H	1,800	380	2,180	Est. 280 gal. sludge in sump
11	244-BXR-003	H	1,450	360	1,810	Est. 8,300 gal. soft sludge in sump
12	241-SX-302	H	1,050	300	1,350	
13	241-TX-302XB	H	110	250	360	
14	241-BX-302C	H	640	230	870	
15	241-Z-361	M	20,000	200	20,200	Layered "mud-like" sludge
16	241-U-361	H	27,700	100	27,800	Little or no liquid
17	244-BXR-011	H	7,000	100	7,100	Est. 4,200 gal. soft sludge in sump
18	241-BX-302B	H	950	90	1,040	
19	244-TXR-001	M	2,300	50	2,350	Minimum sludge in sump
20	241-TX-302A	H	2,450	30	2,480	
21	244-UR-004	L	min.	min.	min.	minimum heel
22	270-W	M	-	-	-	contents unknown
23	241-TX-302BR (f)	M	-	-	-	contents unknown
24	244-WR-002	M	-	-	35,000	Tank believed empty; est. 35,000 gal. in sump

Table 3-2. Priorities of the Miscellaneous Tanks For Retrieval Purposes. (3 pages)

Tank Row #	TANK	Highest Safety Issue Rank	Sludge Volume (gal) [a]	Liquid Volume (gal) [a]	Total Volume (gal) [a]	NOTES
25	244-WR-001	M	-	-	12,000	Tank believed empty; est. 12,000 gal. in sump
26	270-E-1	M	3,800	0	3,800	Possible 1,400 gal. interstitial liquid
27	240-S-302	H	-	-	2,276	Monitored by leak detector. Est. 100 gal. interstitial liquid
28	244-UR-003	H	1,570	0	1,570	Liquid and sludge in sump
29	241-T-361	H	24,500	0	24,500	
30	241-B-361	H	20,678	0	20,678	No pumpable liquids
31	244-BXR-001	H	7,200	0	7,200	Minimum sludge in sump
32	241-TY-302A	H	450	0	450	
33	241-TX-302B (f)	H	- [b]	-	1,320	Monitored by leak detector.
34	241-A-302B	H	-	-	3,600	Monitored by leak detector.
35	241-S-302A	H	-	-	5,130	Monitored by leak detector. 2 ft grout over 1 ft sand
36	241-CX-71	H	930	0	930	Grout over 4 ft limestone and 2.35 ft sludge
37	244-TXR-003	M	6,500	0	6,500	Minimum sludge in sump
38	244-TXR-002	M	2,950	0	2,950	Minimum sludge in sump
39	241-BX-302A	M	840	0	840	
40	241-CX-72	M	650	0	650	Filled with grout over sludge
41	241-Z-8	M	500	0	500	Liquid removed 10-19-74
42	244-WR-006	L	-	-	min.	Minimum level of thorium solution
43	244-WR-003	M	-	-	0	Believed empty; unknown sump waste volume
44	244-WR-004	M	-	-	0	Believed empty; unknown sump waste volume

Table 3-2. Priorities of the Miscellaneous Tanks For Retrieval Purposes. (3 pages)

Tank Row #	TANK	Highest Safety Issue Rank	Sludge Volume (gal) [a]	Liquid Volume (gal) [a]	Total Volume (gal) [a]	NOTES
45	244-WR-005	M	-	-	-	Value unknown (may be empty)
46	244-WR-007	L	-	-	0	Believed empty
47	244-WR-008	L	-	-	0	Believed empty
48	241-S-302B	M	0	0	0	Emptied
49	241-TY-302B	M	0	0	0	Emptied
50	241-CX-70	M	0	0	0	Flushed and emptied

NOTES:

[a] Volumes have been rounded to the nearest 10 gallons.

[b] - = No Data

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4.0 SCHEDULES

The implementation schedules for major tasks identified in this strategy plan are summarized in Table 4-1. The task identification is consistent with the section number in Section 3. A number of tasks, such as characterization activities, require coordinated effort with other program elements or organizations. The status of the tasks and revised schedules will be updated annually.

Table 4-1. MUST Safety Issue Resolution Strategy Plan Schedule

TASK ID	TASK DESCRIPTION	COMPLETED BY
3.1	Identify Tanks	May 31, 1994
3.2	Obtain Historical Data	May 31, 1994
3.3.1	Identify Potential Safety Issues	September 30, 1994
3.3.2	Risk Assessment	September 30, 1995
3.4.1	Identify Applicable Authorization Basis Documents	September 30, 1994
3.4.2	Perform Discovery USQ Screening	October 31, 1994
3.4.3	Perform Additional Preliminary Hazard Analysis	October 31, 1994
3.4.4	USQ Evaluation (if required)	May 30, 1995
3.5.1 (a)	Establish Short-Term Preventive Controls for 10 High Priority Tanks	September 30, 1994
3.5.1 (b)	Establish Short-Term Preventive Controls for 40 Other Tanks	December 31, 1994
3.5.2	Establish Additional Preventive Controls based on USQ Evaluation (if needed)	September 30, 1995
3.6.1	Safety Screening DQO and Sampling	TBD
3.6.2	Vapor Sampling	TBD
3.6.3	Criticality Evaluation	April 15, 1995
3.7	Safety Issue Confirmation/Verification	TBD
3.8	Safety Issue Resolution	TBD
3.9	Monitoring	TBD

TASK ID	TASK DESCRIPTION	COMPLETED BY
3.9.1	Leak Detection	TBD
3.9.2	Hydrogen and Flammable Gas Monitoring	TBD
3.10	Verification of Empty Tanks	TBD
3.11	Waste Retrieval Recommendations	September 30, 1995
3.12	Environmental Restoration and Closure Recommendations	TBD

5.0 REFERENCES

- Babad, H., 1994, *Tank Safety Screening Data Quality Objective*, WHC-SD-WM-SP-004, Westinghouse Hanford Company, Richland, Washington.
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- Braun, D. J., L. D. Muhlestein, T. B. Powers, and M. D. Zentner, 1994, *High-Level Waste Tank Subcriticality Safety Assessment*, WHC-SD-WM-SARR-003, Westinghouse Hanford Company, Richland, Washington.
- Duffy, L., 1990, *DOE High-Level Waste Tanks' Task Force Work Plan*, (internal correspondence from L. Duffy (DOE) to J. Tseng (DOE), November 1990), Department of Energy, Washington, D.C.
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- Postma, A. K., J. E. Meacham, G. S. Barney, G. L. Borsheim, R. J. Cash, M. D. Crippen, D. R. Dickinson, J. M. Grigsby, D. W. Jeppson, M. Kummerer, J. M. McLaren, C. S. Simmons, and B. C. Simpson, 1994, *Ferrocyanide Safety Program: Safety Criteria for Ferrocyanide Watch List Tanks*, WHC-EP-0691, Westinghouse Hanford Company, Richland, Washington.
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- WHC, 1994a, *Engineering Study of 50 Miscellaneous Inactive Underground Radioactive Waste Tanks Located at the Hanford Site, Washington*, WHC-SD-EN-ES-040, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- WHC, 1994b, *Waste Tanks Administration*, WHC-IP-0842, Section 15.9, Rev. 3, Westinghouse Hanford Company, Richland, Washington.

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APPENDIX A

BASES RELATED TO POTENTIAL PRIORITY 1 SAFETY ISSUES

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APPENDIX A

BASES RELATED TO POTENTIAL PRIORITY 1 SAFETY ISSUES

A.1 BASIS FOR HYDROGEN GENERATION CRITERIA

To develop a quantitative basis for the hydrogen generation criteria, the analyst performed a spreadsheet calculation of how many years it would take each inactive miscellaneous underground storage tank to generate a 1 volume percent hydrogen concentration in the tank vapor space. The concentrations of ^{137}Cs and ^{90}Sr were the basis for calculating the hydrogen generation from radiolysis. The analyst recognized that the concentrations of radionuclides change over time, and that this was a conservative calculation of hydrogen from that viewpoint. Key assumptions related to the concentrations affect the calculations significantly. The first assumption is that ^{137}Cs is only considered to be in the supernate unless sample analysis shows it in the solids. If there is no supernate sample for a tank but there is a solid sample, then the ^{137}Cs concentration is assumed to be a factor of ten lower in the supernate than in the solids. If there is no solids sample for a tank but there is a supernate sample, then ^{90}Sr concentration assumed for the solids is a factor of ten higher than for the supernate. The formula used in the spreadsheet for calculating years until 1 volume percent hydrogen concentration in a tank vapor space is as follows:

$$A/(B \cdot C) = \text{Years to reach 1\% hydrogen in vapor space of MUST}$$

A = Volume of hydrogen required for 1% hydrogen in the vapor space in gallons

B = Heat rate in BTU/hr

C = Conversion of heat rate to gallons of hydrogen generated per year

A, B, and C are further defined as follows:

A = Tank vapor space in gallons * 0.01 (fraction of volume to yield 1%)

B = $[(\text{Sr-sol} \cdot \text{Sol} + \text{Sr-sup} \cdot \text{Sup}) \cdot \text{SR}] + [(\text{Cs-sol} \cdot \text{Sol} + \text{Cs-sup} \cdot \text{Sup}) \cdot \text{CS}] / 1,000,000$

NOTE: Division by 1,000,000 converts μCi to Ci

Sr-sol = ^{90}Sr concentration in solids in $\mu\text{Ci/gal}$

Sol = volume of solids in gallons

Sr-sup = ^{90}Sr concentration in supernate in $\mu\text{Ci/gal}$

Sup = volume of supernate in gallons

SR = 0.0229 BTU/hr-Ci (heat rate per Ci for ^{90}Sr)

Cs-sol	=	^{137}Cs concentration in solids in $\mu\text{Ci/gal}$
Cs-sup	=	^{137}Cs concentration in supernate in $\mu\text{Ci/gal}$
CS	=	0.0161 BTU/hr-Ci (heat rate per Ci for ^{137}Cs)

$$C = d * e * f * g * h * i * j * k \div l$$

d	=	0.293 Watt-hr/BTU
e	=	1 Joule/Watt-sec
f	=	0.8 [F factor (fraction of energy absorbed)]
g	=	100 Electron Volts/1.6E-17 Joules
h	=	0.45 molecules/100 Electron Volts [G(H ₂) {gas generation per unit of energy absorbed}]
i	=	1 liter of gas/2.7E+22 molecules at standard temperature (0 °C) and pressure (760 millimeters of mercury)
j	=	3,600 sec/hr
k	=	8760 hr/year
l	=	3.785 liters/gallon

The above calculations for all the tanks is represented in Table A-1. Where there are blanks in the "Yrs to 1%" column, no data were available for performing the calculation.

The sources for the ^{90}Sr and ^{137}Cs concentration numbers in Table A-1 are shown in Table A-2.

Table A-1. Spreadsheet Results of Hydrogen Generation Calculations. (3 pages)

MUST-HYD.WQ1		Assumptions: 1 % hydrogen of concern 0.0229 Sr-90 heat rate per Ci (BTU/hr-Ci) 0.0161 Cs-137 heat rate per Ci (BTU/hr-Ci)									
	Yrs to 1%	Normal Capacity (gal.)	Solids Volume (gal.)	Supernatant Volume (gal.)	Total Waste Volume (gal.)	Vapor Space Volume (gal.)	Vapor Space Void %	Sr-90-sol ($\mu\text{Ci/gal.}$)	Sr-90-sup ($\mu\text{Ci/gal.}$)	Cs-137-sol ($\mu\text{Ci/gal.}$)	Cs-137-sup ($\mu\text{Ci/gal.}$)
241-A-302B		13500	no data	no data	3600	9900	73				
241-B-301	631	36000	21660	590	22250	13750	38				11400
241-B-302B		17684	690	4240	4930	12754	72				
241-BX-302A	609	17684	835	0	835	16849	95	7190	719		358
241-BX-302B		11389	950	94	1044	10345	91				
241-BX-302C		11378	635	228	863	10515	92				
241-C-301	30	36000	9016	1470	10486	25514	71	17000	1700		25500
240-S-302		17684	no data	no data	2276	15408	87				
241-S-302A		17684	no data	no data	5130	12554	71				
241-S-302B		14314	0	0	0	14314	100				
241-SX-302		17684	1050	305	1355	16329	92				
241-T-301B	45	36000	21658	588	22246	13754	38	3040	304		1600
241-TX-302A	296	17684	2450	30	2480	15204	86	4540	454		48
241-TX-302BR		12000	no data	no data	0	12000	100				
241-TX-302B		17684	no data	no data	1320	16364	93				
241-TX-302XB		14314	108	245	353	13961	98				
241-TY-302A		17684	450	0	450	17234	97				

Table A-1. Spreadsheet Results of Hydrogen Generation Calculations. (3 pages)

MUST-HYD.WQ1		Assumptions: 1 % hydrogen of concern 0.0229 Sr-90 heat rate per Ci (BTU/hr-Ci) 0.0161 Cs-137 heat rate per Ci (BTU/hr-Ci)									
	Yrs to 1%	Normal Capacity (gal.)	Solids Volume (gal.)	Supernate Volume (gal.)	Total Waste Volume (gal.)	Vapor Space Volume (gal.)	Vapor Space Void %	Sr-90-sol (μ Ci/gal.)	Sr-90-sup (μ Ci/gal.)	Cs-137-sol (μ Ci/gal.)	Cs-137-sup (μ Ci/gal.)
241-TY-302B		14314	0	0	0	14314	100				
270-E-1		4185	3800	0	3800	385	9				
270-W		3780	no data	no data	0	3780	100				
241-B-361	1	36000	20678	0	20678	15322	43	112301		6836	684
241-T-361	0	36000	24500	0	24500	11500	32	1149	115	64734	64734
241-U-361	1	36000	27734	98	27832	8168	23	27634	2763	49629	4963
241-Z-361		40500	20000	200	20200	20300	50				
241-Z-8		15435	500	0	500	14935	97				
231-W-151-001	12148	4000	0	1430	1430	2570	64		32		0.12
231-W-151-002	241361	1000	12	955	967	33	3	0.00 15	0.02 65	0.00 11	0.00 643
241-CX-70		30000	0	0	0	30000	100				
241-CX-71	102	1000	930		930	70	7	160	16		6
241-CX-72		2300	653	0	653	1647	72				
244-BXR-001	4	50000	7215	0	7215	42785	86	348220	34822		38229
244-BXR-002	39	15000	1805	380	2185	12815	85	38270	3827		1964
244-BXR-003	1	15000	1449	356	1805	13195	88	3174480	317448		22824

Table A-1. Spreadsheet Results of Hydrogen Generation Calculations. (3 pages)

MUST-HYD.WQ1		Assumptions: 1 % hydrogen of concern 0.0229 Sr-90 heat rate per Ci (BTU/hr-Ci) 0.0161 Cs-137 heat rate per Ci (BTU/hr-Ci)									
	Yrs to 1 %	Normal Capacity (gal.)	Solids Volume (gal.)	Supernate Volume (gal.)	Total Waste Volume (gal.)	Vapor Space Volume (gal.)	Vapor Space Void %	Sr-90-sol (μ Ci/gal.)	Sr-90-sup (μ Ci/gal.)	Cs-137-sol (μ Ci/gal.)	Cs-137-sup (μ Ci/gal.)
244-BXR-011	6	50000	7020	98	7118	42882	86	183673	18367	72795	7280
244-TXR-001	4480	50000	2291	49	2340	47660	95	750	75		16995
244-TXR-002	2336	15000	2945	0	2945	12055	80	380	38		83270
244-TXR-003		15000	6460	0	6460	8540	57				
244-UR-001	384	50000	1852	390	2242	4775	96	14000	1400		1800
244-UR-002	3338	15000	2304	570	2874	12126	81	220	22		670
244-UR-003	50	15000	1568	0	1568	13432	90	37000	3700		950
244-UR-004		8230	0	0	0	8230	100				
244-WR-001		50000	minimal?	minimal?	0	50000	100	7080	708		6
244-WR-002		50000	minimal?	minimal?	0	50000	100	2170	217		20
244-WR-003		50000	minimal?	minimal?	0	50000	100				
244-WR-004		50000	minimal?	minimal?	0	50000	100				
244-WR-005		50000	minimal?	minimal?	0	50000	100				
244-WR-006		50000	minimal?	minimal?	0	50000	100				
244-WR-007		50000	minimal?	minimal?	0	50000	100				
244-WR-008		50000	minimal?	minimal?	0	50000	100				
244-WR-009		50000	minimal?	23000	23000	27000	54				

Table A-2. Basis for Sr and Cs Hydrogen Generation Calculations. (4 pages)

Tank #	Total β , $\mu\text{Ci/gal}$	Gamma Energy Analysis, $\mu\text{Ci/gal}$	Sr^{90} Sludge Concentration, $\mu\text{Ci/gal}$	Sr^{90} Supernate Concentration, $\mu\text{Ci/gal}$	Cs^{137} Sludge Concentration, $\mu\text{Ci/gal}$	Cs^{137} Supernate Concentration, $\mu\text{Ci/gal}$
241-B-301						11,400 ¹⁾
241-BX-302A		358 ²⁾	7,190 ³⁾	719 ⁴⁾		358 ⁵⁾
241-C-301	1,700 ⁶⁾		17,000 ⁷⁾	1,700 ⁸⁾		25,500 ⁹⁾
241-T-301B	304 ¹⁰⁾		3,040 ¹¹⁾	304 ¹²⁾		1,600 ¹³⁾
241-TX-302A			4,540 ¹⁴⁾	454 ¹⁵⁾		48 ¹⁶⁾
241-B-361			112,301 ¹⁷⁾		6,836 ¹⁸⁾	
241-T-361			1,149 ¹⁹⁾	115 ²⁰⁾	647,341 ²¹⁾	64,734 ²²⁾
241-U-361			27,634 ²³⁾	2,763 ²⁴⁾	49,629 ²⁵⁾	4,963 ²⁶⁾
231-W-151-00 1				32 ²⁷⁾		0.12 ²⁸⁾
231-W-151-00 2			0.0015 ²⁹⁾	0.0265 ³⁰⁾	0.0011 ³¹⁾	0.0064 ³²⁾
241-CX-71			160 ³³⁾	16 ³⁴⁾		6 ³⁵⁾
244-BXR-001	73,051 ³⁶⁾	38,229 ³⁷⁾	348,220 ³⁸⁾	34,822 ³⁹⁾		38,229 ⁴⁰⁾
244-BXR-002	5,791 ⁴¹⁾	1,964 ⁴²⁾	38,270 ⁴³⁾	3,827 ⁴⁴⁾		1,964 ⁴⁵⁾
244-BXR-003	340,272 ⁴⁶⁾	22,824 ⁴⁷⁾	3,174,480 ⁴⁸⁾	317,448 ⁴⁹⁾		22,824 ⁵⁰⁾
244-BXR-011			183,673 ⁵¹⁾	18,367 ⁵²⁾	72,795 ⁵³⁾	7,280 ⁵⁴⁾

Table A-2. Basis for Sr and Cs Hydrogen Generation Calculations. (4 pages)

Tank #	Total β , $\mu\text{Ci/gal}$	Gamma Energy Analysis, $\mu\text{Ci/gal}$	Sr^{90} Sludge Concentration, $\mu\text{Ci/gal}$	Sr^{90} Supernate Concentration, $\mu\text{Ci/gal}$	Cs^{137} Sludge Concentration, $\mu\text{Ci/gal}$	Cs^{137} Supernate Concentration, $\mu\text{Ci/gal}$
244-TXR-001	17,070 ^{3b)}	16,995 & ^{3b)}	750 ^{3b)}	75 ^{3b)}		16,995 ^{2b)}
244-TXR-002			380 ^{3b)}	38 ^{3b)}		83,270 ^{3b)}
244-UR-001	3,200 ^{4b)}			1,400 ^{4b)}		1,800 ^{4b)}
244-UR-002			220 ^{3b)}	22 ^{4b)}		670 ^{4b)}
244-UR-003			37,000 ^{3b)}	3700 ^{4b)}		950 ^{4b)}
244-WR-001			7,080 ^{3b)}	708 ^{4b)}		6 ^{4b)}
244-WR-002			2,170 ^{3b)}	217 ^{4b)}		20 ^{4b)}

- 1) WHC-SD-EN-ES-040, Rev.0, page A-4.
- 2) WHC-SD-EN-ES-040, Rev.0, page A-10, $94.6 \mu\text{Ci/L} * 3.785 \text{ L/gal} = 358 \mu\text{Ci/gal}$.
- 3) If concentration is only given for supernate, then it is assumed that the concentration in the sludge is 10 times larger.
- 4) WHC-SD-EN-ES-040, Rev.0, page A-10, $1.9\text{E}+2 \mu\text{Ci/L} * 3.785 \text{ L/gal} = 719 \mu\text{Ci/gal}$.
- 5) WHC-SD-EN-ES-040, Rev.0, page A-19, Total β of $1.7\text{E}+3 \mu\text{Ci/gal}$ appears to be in conflict with the Cs^{137} concentration of $2.55\text{E}+4 \mu\text{Ci/gal}$ because Cs^{137} gives off a β so the Total β should include the Cs^{137} and thus should be larger than the Cs^{137} concentration (Sr^{90} also gives off a β).
- 6) Assumed to be the same as the Total β concentration for this calculation. See also note 5).
- 7) WHC-SD-EN-ES-040, Rev.0, page A-19.
- 8) WHC-SD-EN-ES-040, Rev.0, page A-33, Total β of $3.04\text{E}+2 \mu\text{Ci/gal}$ appears to be in conflict with the Cs^{137} concentration of $1.6\text{E}+3 \mu\text{Ci/gal}$ because Cs^{137} gives off a β so the Total β should include the Cs^{137} and thus should be larger than the Cs^{137} concentration (Sr^{90} also gives off a β).

Table A-2. Basis for Sr and Cs Hydrogen Generation Calculations. (4 pages)

- 9) Assumed to be the same as the Total β concentration for this calculation. See also note 8).
- 10) WHC-SD-EN-ES-040, Rev.0, page A-33.
- 11) WHC-SD-EN-ES-040, Rev.0, page A-37.
- 12) WHC-SD-EN-ES-040, Rev.0, page A-58, $23.0 \mu\text{Ci/gram} * 1.29 \text{ grams/cm}^3 * 1000 \text{ cm}^3/\text{L} * 3.785 \text{ L/gal} = 112,301 \mu\text{Ci/gal}$.
- 13) WHC-SD-EN-ES-040, Rev.0, page A-58, $1.4 \mu\text{Ci/gram} * 1.29 \text{ grams/cm}^3 * 1000 \text{ cm}^3/\text{L} * 3.785 \text{ L/gal} = 6,836 \mu\text{Ci/gal}$.
- 14) WHC-SD-EN-ES-040, Rev.0, page A-61, $0.12 \mu\text{Ci/gram} * 2.53 \text{ grams/cm}^3 * 1000 \text{ cm}^3/\text{L} * 3.785 \text{ L/gal} = 1,149 \mu\text{Ci/gal}$.
- 15) If concentration is only given for sludge, then it is assumed that the concentration in the supernate is 10 times smaller.
- 16) WHC-SD-EN-ES-040, Rev.0, page A-61, $67.6 \mu\text{Ci/gram} * 2.53 \text{ grams/cm}^3 * 1000 \text{ cm}^3/\text{L} * 3.785 \text{ L/gal} = 647,341 \mu\text{Ci/gal}$.
- 17) WHC-SD-EN-ES-040, Rev.0, page A-64, $4.9 \mu\text{Ci/gram} * 1.49 \text{ grams/cm}^3 * 1000 \text{ cm}^3/\text{L} * 3.785 \text{ L/gal} = 27,634 \mu\text{Ci/gal}$.
- 18) WHC-SD-EN-ES-040, Rev.0, page A-64, $8.8 \mu\text{Ci/gram} * 1.49 \text{ grams/cm}^3 * 1000 \text{ cm}^3/\text{L} * 3.785 \text{ L/gal} = 49,629 \mu\text{Ci/gal}$.
- 19) WHC-SD-EN-ES-040, Rev.0, page A-75, $8.5 \mu\text{Ci/L} * 3.785 \text{ L/gal} = 32 \mu\text{Ci/gal}$.
- 20) WHC-SD-EN-ES-040, Rev.0, page A-75, $3.1\text{E-}2 \mu\text{Ci/L} * 3.785 \text{ L/gal} = 0.12 \mu\text{Ci/gal}$.
- 21) WHC-SD-EN-ES-040, Rev.0, page A-77, $3.9\text{E-}4 \mu\text{Ci/L} * 3.785 \text{ L/gal} = 0.0015 \mu\text{Ci/gal}$.
- 22) WHC-SD-EN-ES-040, Rev.0, page A-77, $0.7\text{E-}2 \mu\text{Ci/L} * 3.785 \text{ L/gal} = 0.0265 \mu\text{Ci/gal}$.
- 23) WHC-SD-EN-ES-040, Rev.0, page A-77, $3.0\text{E-}4 \mu\text{Ci/L} * 3.785 \text{ L/gal} = 0.0011 \mu\text{Ci/gal}$.
- 24) WHC-SD-EN-ES-040, Rev.0, page A-77, $1.7\text{E-}3 \mu\text{Ci/L} * 3.785 \text{ L/gal} = 0.0064 \mu\text{Ci/gal}$.
- 25) WHC-EP-0560, Rev. 0, page 3-6.
- 26) WHC-SD-EN-ES-040, Rev.0, page A-86, $1.93\text{E+}4 \mu\text{Ci/L} * 3.785 \text{ L/gal} = 73,051 \mu\text{Ci/gal}$.
- 27) WHC-SD-EN-ES-040, Rev.0, page A-86, $1.01\text{E+}4 \mu\text{Ci/L} * 3.785 \text{ L/gal} = 38,229 \mu\text{Ci/gal}$.
- 28) Subtracted Gamma Energy Analysis concentration (assumed to be Cs^{137}) from Total β concentration to get Sr^{90} concentration.
- 29) Assumed the Gamma Energy Analysis concentration was the Cs^{137} concentration.
- 30) WHC-SD-EN-ES-040, Rev.0, page A-88, $1.53\text{E+}3 \mu\text{Ci/L} * 3.785 \text{ L/gal} = 5,791 \mu\text{Ci/gal}$.
- 31) WHC-SD-EN-ES-040, Rev.0, page A-88, $5.19\text{E+}2 \mu\text{Ci/L} * 3.785 \text{ L/gal} = 1,964 \mu\text{Ci/gal}$.
- 32) WHC-SD-EN-ES-040, Rev.0, page A-90, $8.99\text{E+}4 \mu\text{Ci/L} * 3.785 \text{ L/gal} = 340,272 \mu\text{Ci/gal}$.

Table A-2. Basis for Sr and Cs Hydrogen Generation Calculations. (4 pages)

- 34) WHC-SD-EN-ES-040, Rev.0, page A-93, $(0.54 + 85.5) \mu\text{Ci/gram} * 0.564 \text{ grams/cm}^3 * 1000 \text{ cm}^3/\text{L} * 3.785 \text{ L/gal} = 183,673 \mu\text{Ci/gal}$.
- 35) WHC-SD-EN-ES-040, Rev.0, page A-93, $(11.1 + 23.0) \mu\text{Ci/gram} * 0.564 \text{ grams/cm}^3 * 1000 \text{ cm}^3/\text{L} * 3.785 \text{ L/gal} = 72,795 \mu\text{Ci/gal}$.
- 36) WHC-SD-EN-ES-040, Rev.0, page A-96, $4.51\text{E}+3 \mu\text{Ci/L} * 3.785 \text{ L/gal} = 17,070 \mu\text{Ci/gal}$.
- 37) WHC-SD-EN-ES-040, Rev.0, page A-96, $4.49\text{E}+3 \mu\text{Ci/L} * 3.785 \text{ L/gal} = 16,995 \mu\text{Ci/gal}$.
- 38) WHC-SD-EN-ES-040, Rev.0, page A-99, $10 \mu\text{Ci/L} * 3.785 \text{ L/gal} = 38 \mu\text{Ci/gal}$.
- 39) WHC-SD-EN-ES-040, Rev.0, page A-99, $22,000 \mu\text{Ci/L} * 3.785 \text{ L/gal} = 83,270 \mu\text{Ci/gal}$.
- 40) WHC-SD-EN-ES-040, Rev.0, page A-105.
- 41) Subtracted Cs^{137} concentration from Total β concentration to get Sr^{90} concentration.
- 42) WHC-SD-EN-ES-040, Rev.0, page A-105.
- 43) WHC-SD-EN-ES-040, Rev.0, page A-108.
- 44) WHC-SD-EN-ES-040, Rev.0, page A-111.
- 45) WHC-SD-EN-ES-040, Rev.0, page A-118, $187 \mu\text{Ci/L} * 3.785 \text{ L/gal} = 708 \mu\text{Ci/gal}$.
- 46) WHC-SD-EN-ES-040, Rev.0, page A-118, $1.5 \mu\text{Ci/L} * 3.785 \text{ L/gal} = 6 \mu\text{Ci/gal}$.
- 47) WHC-SD-EN-ES-040, Rev.0, page A-120, $57.3 \mu\text{Ci/L} * 3.785 \text{ L/gal} = 217 \mu\text{Ci/gal}$.
- 48) WHC-SD-EN-ES-040, Rev.0, page A-120, $5.27 \mu\text{Ci/L} * 3.785 \text{ L/gal} = 20 \mu\text{Ci/gal}$.

A.2 BASIS FOR FERROCYANIDE CRITERIA

Two spreadsheet calculations were performed to develop a quantitative basis for the ferrocyanide criteria. The first calculation defines what fraction of an inactive miscellaneous underground storage tank's (MUST's) capacity would have had to leak to the specific MUST to result in an 8 weight percent ferrocyanide mixture in the MUST. The calculation was performed for only those MUSTs that were identified in the engineering study (WHC 1994) that were in the ferrocyanide process routing path or suspected of containing ferrocyanide. This represented only eight MUSTs (241-C-301, 241-T-301B, 241-TX-302BR, 241-TX-302B, 241-TY-302B, 244-BXR-002, 244-WR-001, and 244-WR-002).

The second calculation is a conservative center line temperature calculation based on an assumed line source of the ^{90}Sr and ^{137}Cs contents estimated to be in a specific MUST. A subsequent calculation is being performed as this plan is released. This calculation is a more realistic waste temperature calculation that considers the dispersion of the radionuclide heat sources throughout the waste. The preliminary result of this calculation indicates that *temperature is not of concern for any of the tanks with radionuclide heat source data*. The documentation of this more realistic waste temperature calculation will be completed by November 1994.

The formula used in the spreadsheet for calculating gallons of ferrocyanide scavenged solution that would have had to leak to create 8 weight percent in the MUST is as follows:

gallons	=	gal
liters	=	L
milliliters	=	ml
grams	=	gm

$$(A \text{ gal})(3.785 \text{ L/gal})(1000 \text{ ml/L})(B \text{ gm/ml})(C)(D)(1 \text{ gm-mole Na}_2\text{NiFe(CN)}_6/317 \text{ gm})/(E \text{ gm-mole/L})(3.785 \text{ L/gal}) =$$

F gallons of leaked ferrocyanide waste solution

A	=	volume of solid waste in the specific MUST
B	=	density of solid waste in the specific MUST
C	=	fraction of solid's weight that is not water
D	=	fraction of solid's weight that is ferrocyanide (0.08) to be potentially reactive
E	=	molarity of ferrocyanide solution used in scavenging
F	=	gallons of ferrocyanide waste solution contributing to 8 weight percent of solids

NOTE: $\text{Cs}_2^{137}\text{NiFe(CN)}_6$ would have precipitated in the tanks but $\text{Na}_2\text{NiFe(CN)}_6$ would also have precipitated. There is probably 1000 times more $\text{Na}_2\text{NiFe(CN)}_6$ than $\text{Cs}_2^{137}\text{NiFe(CN)}_6$.

due to the excess of $\text{Na}_4\text{Fe}(\text{CN})_6$ used in the process, so $\text{Na}_2\text{NiFe}(\text{CN})_6$ should be used to calculate the number of gm-moles represented by 8 wt% of the sludge.

Thus, for a miscellaneous waste tank with 450 gallons of sludge, a sludge density of 1.29 grams/milliliter, 40% free water (60% water free solids), and 0.005 molar concentration of $\text{Na}_4\text{Fe}(\text{CN})_6$, the gallons of solution to yield 8 weight percent ferrocyanide solids is 17,596.

This amount of leakage into a 17,000 gallon capacity miscellaneous tank over about a one year period does not seem incredible.

The formula used in the spreadsheet for calculating the fraction of MUST capacity that is represented by the F gallons ferrocyanide solution is as follows:

$$F \text{ gallons} / (G \text{ gallons, capacity of MUST})$$

The above calculations for the eight tanks suspected to have ferrocyanide waste are represented in Table A-3.

If an MUST suspected of containing ferrocyanide waste was calculated to have a fraction of capacity of less than 2.00 or there was not enough data to perform the calculation, the MUST was considered to have an 8 weight percent ferrocyanide solids content for ranking purposes. The calculated fraction of capacity of less than 2.00 conservatively indicates that the MUST would have had to have been filled to capacity twice to yield an 8 weight percent ferrocyanide solids content. The value of 2.00 was chosen as a conservative value because the catch tank type MUSTs were not expected to ever receive twice their capacity as spillage during ferrocyanide operations.

The formulas used in the spreadsheet to calculate the center line temperature are as follows:

$$\text{B-sol} = [((\text{Sr-sol} * \text{Sol}) * \text{SR}) + ((\text{Cs-sol} * \text{Sol}) * \text{CS})] / 1,000,000$$

$$\text{B-sup} = [((\text{Sr-sup} * \text{Sup}) * \text{SR}) + ((\text{Cs-sup} * \text{Sup}) * \text{CS})] / 1,000,000$$

NOTE: Division by 1,000,000 converts μCi to Ci

B-sol	=	Heat rate of the solids (BTU/hr) due to ^{90}Sr and ^{137}Cs
B-sup	=	Heat rate of the supernate (BTU/hr) due to ^{90}Sr and ^{137}Cs
Sr-sol	=	^{90}Sr concentration in solids in $\mu\text{Ci/gal}$
Sol	=	volume of solids in gallons
SR	=	0.0229 BTU/hr-Ci (heat rate per Ci for ^{90}Sr)
Cs-sol	=	^{137}Cs concentration in solids in $\mu\text{Ci/gal}$
CS	=	0.0161 BTU/hr-Ci (heat rate per Ci for ^{137}Cs)
Sr-sup	=	^{90}Sr concentration in supernate in $\mu\text{Ci/gal}$

Sup = volume of supernate in gallons
 Cs-sup = ¹³⁷Cs concentration in supernate in $\mu\text{Ci/gal}$

The following formula assumes the heat generation is from a line source on the center line of the vertical cylindrical tank. The formula below was derived for application to a hollow cylinder but is used assuming the line source is contained within a hollow cylinder of 0.01 foot radius:

$$\Delta T = q * \Delta r / (k * A_m)$$

- ΔT = difference in temperature between center line temperature and the temperature at the outside of the cylinder (or tank), assuming the temperature at the outside of the tank is 55 °F
- Δr = difference in radius between "hollow cylinder" radius (0.01 foot) and the radius of the outside of the cylinder (or tank)
- k = thermal conductivity of the solid waste (BTU/hr-ft- °F), assumed to be 0.25 BTU/hr-ft- °F for dry solids from Rockwell report (Campbell 1981, page 24)
- A_m = log mean area normal to heat flow, $(A_2 - A_1)/[\ln(A_2/A_1)]$
- A_2 = is the perimeter of the tank times the solid waste height in the tank,
- A_1 = is the perimeter of the 'hollow cylinder' of the line source times the solid waste height in the tank. For tanks that were horizontal cylindrical tanks or rectangular tanks, some modifications were made to the above formula to represent these tanks as if they were vertical cylindrical tanks. The radius of the tank was taken as 1/2 of the longest dimension (either length for horizontal cylinder or length of rectangular tank). The waste heights in horizontal tanks were calculated by dividing the volume of solids in the tank by the planar area of the tank. The planar area is defined as the length times the diameter of a horizontal tank.

The calculations of the conservative (higher than real) center line temperature are represented in Table A-4 as the temperature change above 55 °F. Where there are blanks in the table, no data was available for performing the calculation. Again it is noted that a more realistic waste temperature calculation is being performed that indicates that temperature is of no concern for the MUSTs. This calculation will be documented after this plan has been released therefore it can't be referenced in this report.

Table A-3. Spreadsheet Results of Ferrocyanide Calculations.

MUST-FeC.WQ1	Assumptions:									
	Default Density = 1.29 gm/ml Default % H ₂ O in Solids = 40 % Default Concentration of Na ₄ Fe(CN) ₆ = 0.005 gm-moles/L									
	Nominal Capacity (gal.)	Solids Volume (gal.)	Supernate Volume (gal.)	Total Waste Volume (gal)	Density of Solids (gm/ml)	% H ₂ O in Solids	Moles of Na ₄ NiFe(CN) ₆ (gm-moles)	Concentration of Na ₄ Fe(CN) ₆ (moles/L)	Gallons leaked to get 8 wt% (gal.)	Fraction of capacity to have leaked
241-C-301	36000	9016	1470	10486			6666	0.005	352221	9.78
241-T-301B	36000	21658	588	22246			16012	0.0025	1692194	47.01
241-TX-302BR	12000	no data	no data	0			0	0.0025	0	0.00
241-TX-302B	17684	no data	no data	1320			0	0.0025	0	0.00
241-TY-302A	17684	450	0	450			0		0	0.99
244-BXR-002	15000	1805	380	2185			1334	0.0025	141029	9.40
244-WR-001	50000	minimal?	minimal?	0			0	0.0025	0	0.00
244-WR-002	50000	minimal?	minimal?	0			0	0.0025	0	0.00

Table A-4. Spreadsheet Results of Conservative Center Line Temperature Calculation. (4 pages)

MUST-HEA.WQ1		Assumptions: 0.01 All heat from sludge and supernate is located as a vertical line source in the sludge with radius of 0.01 ft 0.25 Thermal conductivity of solid waste (Btu/hr-ft-F) 0.0229 Sr-90 heat rate per Ci (Btu/hr-Ci) 0.0161 Cs-137 heat rate per Ci (Btu/hr-Ci)													
Tanks	Solids Heat Rate (Btu/hr)	Supernate Heat Rate (Btu/hr)	Total Heat Rate (Btu/hr)	ΔT Above 55 °F	Diameter of vertical tank (ft)	Longest dimension of horizontal or rectangular tank (ft)	Perimeter of horizontal or rectangular tanks (ft)	Planar Area of tank (ft ²)	Solid Volume (gal)	Supernate Volume (gal)	⁹⁰ Sr concentration in solids (μCi/gal)	⁹⁰ Sr concentration in supernate (μCi/gal)	¹³⁷ Cs concentration in solids (μCi/gal)	¹³⁷ Cs concentration in supernate (μCi/gal)	
241-A-302B						30	76.0	240	no data	no data					
241-B-301	0.0	0.1	0.1	0.1	20				21660	390				11400	
241-B-302B						35.79	89.6	322	690	4240					
241-BX-302A	0.1	0.0	0.1	2.4	36		90.0	324	835	0	7190	719		358	
241-BX-302B						18	56.0	180	950	94					
241-BX-302C						18	56.0	180	635	228					
241-C-301	3.5	0.7	4.2	4.8	20				9016	1470	17000	1700		25500	
241-S-302						36	90.0	324	no data	no data					
241-S-302A						35.79	89.4	319	no data	no data					
241-S-302B						32.33	82.7	291	0	0					
241-SX-302						35.79	89.6	322	1050	305					
241-T-301B	1.5	0.0	1.5	0.7	20				21650	588	3040	304		1600	
241-TX-302A	0.3	0.0	0.3	1.5		35.79	89.6	322	2450	30	4540	454		40	
241-TX-302BR						32.79	81.6	262	no data	no data					
241-TX-302B						35.79	89.6	322	no data	no data					

Table A-4. Spreadsheet Results of Conservative Center Line Temperature Calculation. (4 pages)

MUST-HEA.WQ1		Assumptions: 0.01 All heat from sludge and supernate is located as a vertical line source in the sludge with radius of 0.21 ft 0.25 Thermal conductivity of solid waste (Btu/hr-ft-F) 0.0229 Sr-90 heat rate per Ci (Btu/hr-Ci) 0.0161 Cs-137 heat rate per Ci (Btu/hr-Ci)												
Tanks	Solids Heat Rate (Btu/hr)	Supernate Heat Rate (Btu/hr)	Total Heat Rate (Btu/hr)	ΔT Above 55 °F	Diameter of vertical tank (ft)	Longest dimension of horizontal or rectangular tank (ft)	Perimeter of horizontal or rectangular tanks (ft)	Planar Area of tank (ft ²)	Solid Volume (gal)	Supernate Volume (gal)	⁹⁰ Sr concentration in solids (μCi/gal)	⁹⁰ Sr concentration in supernate (μCi/gal)	¹³⁷ Cs concentration in solids (μCi/gal)	¹³⁷ Cs concentration in supernate (μCi/gal)
241-TX-302XB						28.83	73.7	260	108	245				
241-TY-302A						35.79	89.6	322	450	0				
241-TY-302B						32.33	82.7	291	0	0				
270-B-1					9				3800	0				
270-W					9				no data	no data				
241-B-361	55.5	0.0	55.5	27.7	20				20678	0	112301		684	68360
241-T-361	256.0	0.0	256.0	108.0	20				24500	0	1149	115	64734	6473410
241-U-361	39.7	0.0	39.7	14.8	20				27734	98	27634	2763	4963	496290
241-Z-361						26	78.0	338	20000	200				
241-Z-8						40	96.0	320	500	0				
231-W-151-001		0.0	0.0	EBR	9				0	1430		32		0.12
231-W-151-002	0.0	0.0	0.0	0.0	5				12	955	0.0015	0.0065	0.0011	0.00643
241-CX-70				EBR	20				0	0				
241-CX-71	0.0	0.0	0.0	0.0	5				930		160	16		6
241-CX-72					3.33				653	0				

Table A-4. Spreadsheet Results of Conservative Center Line Temperature Calculation. (4 pages)

MDS7-HEA.WQ1		Assumptions: 0.01 All heat from sludge and supernate is located as a vertical line source in the sludge with radius of 0.01 ft 0.25 Thermal conductivity of solid waste (Btu/hr-ft-F) 0.0229 Sr-90 heat rate per Ci (Btu/hr-Ci) 0.0161 Cs-137 heat rate per Ci (Btu/hr-Ci)												
Tanks	Solids Heat Rate (Btu/hr)	Supernate Heat Rate (Btu/hr)	Total Heat Rate (Btu/hr)	ΔT Above 55 °F	Diameter of vertical tank (ft)	Longest dimension of horizontal or rectangular tank (ft)	Perimeter of horizontal or rectangular tanks (ft)	Planar Area of tank (ft ²)	Solid Volume (gal)	Supernate Volume (gal)	⁹⁰ Sr concentration in solids (μCi/gal)	⁹⁰ Sr concentration in supernate (μCi/gal)	¹³⁷ Cs concentration in solids (μCi/gal)	¹³⁷ Cs concentration in supernate (μCi/gal)
244-BXR-001	57.5	0.0	57.5	82.4	20				7215	0	348220	34822		38229
244-BXR-002	1.6	0.0	1.6	4.3	14				1805	380	38270	3827		1964
244-BXR-003	105.3	2.7	108.1	358.1	14				1449	356	3174480	317448		22824
244-BXR-011	37.8	0.1	37.8	55.7	20				7020	94	183673	18367	72795	7280
244-TXR-004	0.0	0.0	0.1	0.2	28				2291	49	750	75		16995
244-TXR-002	0.0		0.0	0.0	14				2945	0	380	38		83270
244-TXR-003	0.0		0.0	0.0	14				6460	0				
244-UR-004	0.6	0.0	0.6	3.4	20				1852	390	14000	1400		1800
244-UR-002	0.0	0.0	0.0	0.0	14				2304	510	220	22		670
244-UR-003	1.3	0.0	1.3	4.1	14				1548	0	37000	3700		950
244-UR-004	0.0	0.0	0.0	ERR	10				0	0				
244-WR-001				ERR	20				minimum?	minimum?	7080	708		6
244-WR-002				ERR	20				minimum?	minimum?	2170	217		20
244-WR-003					20				minimum?	minimum?				
244-WR-004					20				minimum?	minimum?				

Table A-4. Spreadsheet Results of Conservative Center Line Temperature Calculation. (4 pages)

MUST-HEA.WQ1		Assumptions: 0.01 All heat from sludge and supernate is located in a vertical line source in the sludge with radius of 0.01 ft 0.25 Thermal conductivity of solid waste (Btu/hr-ft-F) 0.0229 Sr-90 heat rate per Ci (Btu/hr-Ci) 0.0161 Cs-137 heat rate per Ci (Btu/hr-Ci)												
Tanks	Solids Heat Rate (Btu/hr)	Supernate Heat Rate (Btu/hr)	Total Heat Rate (Btu/hr)	ΔT Above 55 °F	Diameter of vertical tank (ft)	Longest dimension of horizontal or rectangular tank (ft)	Perimeter of horizontal or rectangular tanks (ft)	Planar Area of tank (ft ²)	Solid Volume (gal)	Supernate Volume (gal)	⁹⁰ Sr concentration in solids (μCi/gal)	⁹⁰ Sr concentration in supernate (μCi/gal)	¹³⁷ Cs concentration in solids (μCi/gal)	¹³⁷ Cs concentration in supernate (μCi/gal)
244-WR-005					20				minimal?	minimal?				
244-WR-006					20				minimal?	minimal?				
244-WR-007					20				minimal?	minimal?				
244-WR-008					20				minimal?	minimal?				
244-WR-009					20				minimal?	23000				

A.3 BASIS FOR ORGANIC SALTS CRITERIA

Two spreadsheet calculations were performed to develop a quantitative basis for the organic salts criteria. The first calculation defines the percent of total organic carbon (TOC) in each of the waste types (WT) suspected to have been received by any of the MUSTs as noted in Appendix A of the engineering study (WHC 1994). The composition of the various waste types represented in the engineering study are found in Appendix A of a Westinghouse Hanford report (WHC 1991). The second calculation is a conservative center line temperature calculation based on an assumed line source of the ^{90}Sr and ^{137}Cs contents estimated to be in a specific MUST.

The formulas used in the spreadsheet for first calculation are as follows:

$$\Sigma(X_i * Y_i) = \Sigma Z_i$$

X_i = atomic weight (gm/gm-mole) for each (i) element, ion or molecule in the composition of the waste type

Y_i = concentration (in gm-moles/L) for each (i) element, ion or molecule in the composition of the waste type

Z_i = concentration (gm/L) for each (i) element, ion or molecule in the composition of the waste type

ΣZ_i = total grams in one liter of waste type

$$\{\Sigma(X_c/X_o)(Z_i)\}/\{\Sigma Z_i\} * 100 = V$$

X_c = atomic weight (gm/gm-mole) for the carbon in the organic molecules that were part of the composition of the waste type

V = percentage of carbon in the waste type composition as a measure of percent TOC

The calculations of percent of TOC in each waste type are represented in Table A-5. Table A-6 indicates which MUSTs contain which waste types that could contribute to total organic carbon.

The second calculation of the conservative (higher than real) center line temperature is described in Section A.2 and shown in Table A-4 in the previous section, Section A.2, as the temperature change above 55 °F. Blanks in the table indicate no data was available for performing the calculation. Again it is noted that a more realistic waste temperature calculation is being performed that indicates that temperature is of no concern for the MUSTs. This calculation will be documented after this plan has been released therefore it can't be referenced in this report.

Table A-5. Spreadsheet Results of Total Organic Carbon in Waste Types. (3 pages)

toc-cal.wq1		B-WT		BL-WT		SSW-WT		224-WT		Z-WT	
Element	Atomic Weight	conc. (moles/L)	conc. (grams/L)	conc. (moles/L)	conc. (grams/L)	conc. (moles/L)	conc. (grams/L)	conc. (moles/L)	conc. (grams/L)	conc. (moles/L)	conc. (grams/L)
Al	27	0.079	2.13	0.55	14.85					0.5	13.50
Ba	137	0.000032				0.0002	0.03			0.000003	0.00
Bi	209							0.0062	1.30		
Ca	40	0.0001	0.00	0.000005	0.00	0.0049	0.20			0.00071	0.03
Ce	140					0.0017	0.24				
C2H3O2	59					1.34	79.06				
C6H5O7	189	0.12	22.68	0.92	173.88						
Cl	35.5									0.041	1.46
CO3	60			2.61	156.60						
Cr	52	0.002	0.10					0.0009	0.05	0.0014	0.07
F	19							0.31	5.89	0.047	0.89
Fe	56	0.0029	0.16			0.03	1.68			0.0007	0.04
H2C2O4	90							0.028	2.52		
K	39					0.078	3.04	0.26	10.14	0.0007	0.03
La	139							0.0014	0.19		

Table A-5. Spreadsheet Results of Total Organic Carbon in Waste Types. (3 pages)

toc-cal.wq1		B-WT		BL-WT		SSW-WT		224-WT		Z-WT	
Element	Atomic Weight	conc. (moles/L)	conc. (grams/L)	conc. (moles/L)	conc. (grams/L)	conc. (moles/L)	conc. (grams/L)	conc. (moles/L)	conc. (grams/L)	conc. (moles/L)	conc. (grams/L)
Mg	24									0.000021	0.00
Mn	55	0.00029	0.02	0.0029	0.16			0.0046	0.25	0.0007	0.04
Na	23	1.29	29.67	5.55	127.65	4.9	112.70	1.75	40.25	4	92.00
Ni	59	0.002	0.12	0.0092	0.54					0.00057	0.03
NO2	46									0.014	0.64
NO3	62	1.27	78.74	5.28	327.36	2.1	130.20	1.06	65.72	3.5	217.00
OH	17					1.32	22.44	0.59	10.03	0.0001	0.00
Pb	207			0.014	2.90	0.034	7.04			0.00036	0.07
PO4	95							0.049	4.66	0.00014	0.01
Pu	239	0.000001	0.00	0.00087	0.21						
Re	186					0.0069	1.28				
106Ru	106	0.000003	0.00								
SiO3	76			0.0029	0.22						
SO4	96									0.0014	0.13
Sr	88					0.0005	0.04			0.000021	0.00

Table A-5. Spreadsheet Results of Total Organic Carbon in Waste Types. (3 pages)

toc-cal.wqt		B-WT		BL-WT		SSW-WT		224-WT		Z-WT	
Element	Atomic Weight	conc. (moles/L)	conc. (grams/L)	conc. (moles/L)	conc. (grams/L)	conc. (moles/L)	conc. (grams/L)	conc. (moles/L)	conc. (grams/L)	conc. (moles/L)	conc. (grams/L)
Tc	43	0.000048	0.00								
TOC											3.00
TRU	240									0.00006	0.01
U	238	0.0029	0.69	0.37	88.06					0.00001	0.00
Zr	91	0.000048	0.00								
			134.32		892.43		357.95		141.00		328.98
wt%TOC			6.43		7.42		8.98		0.48		0.91

Table A-6. MUSTs Containing Potential Organic Wastes. (2 pages)

MUST-ORG.W Q1	Waste Types (WT) Containing Organics That Contribute to Total Organic Carbon (TOC)					Analysis Shows TOC < 3%
	WTs with TOC > 3%			WTs with TOC < 3%		
	B-WT	BL-WT	SSW-WT	224-WT	Z-WT	
241-A-302B	X					
241-B-301		X		X		
241-B-302B	X	X				
241-BX-302A						YES
241-BX-302B	X	X				
241-BX-302C		X		X		
241-C-301		X	X			
240-S-302	X	X		X		
241-S-302A	X	X		X		
241-S-302B						empty
241-SX-302	X	X		X		
241-T-301B		X		X		
241-TX-302A	X	X				
241-TX-302BR				X		
241-TX-302B	X	X		X		
241-TX-302XB	X	X				
241-TY-302A		X				
241-TY-302B		X				empty
270-E-1						
270-W						
241-B-361						
241-T-361	Volatiles & semivolatiles indicated					
241-U-361	Semivolatile organics (kerosene, TBP) & volatile organics indicated					
241-Z-361	TBP, DBP & ion exchange resin indicated					YES
241-Z-8						
231-W-151-001						
231-W-151-002						

Table A-6. MUSTs Containing Potential Organic Wastes. (2 pages)

MUST-ORG.W Q1	Waste Types (WT) Containing Organics That Contributes to Total Organic Carbon (TOC)					Analysis Shows TOC < 3%
	WTs with TOC > 3%			WTs with TOC < 3%		
	B-WT	BL-WT	SSW-WT	224-WT	Z-WT	
241-CX-70						empty
241-CX-71	Organic compounds found in tank, salts likely to exist					
241-CX-72						
244-BXR-001	Small amounts of organics exist in tank					
244-BXR-002	Organic salts may exist					
244-BXR-003	Organic salts may exist					
244-BXR-011						YES
244-TXR-001						
244-TXR-002						
244-TXR-003						
244-UR-001	TBP containing waste in this tank					
244-UR-002	TBP containing waste in this tank					
244-UR-003	TBP containing waste in this tank					
244-UR-004						empty
244-WR-001						minimal waste left
244-WR-002						minimal waste left
244-WR-003						minimal waste left
244-WR-004						minimal waste left
244-WR-005						minimal waste left
244-WR-006						minimal waste left
244-WR-007						minimal waste left
244-WR-008						minimal waste left
244-WR-009						

APPENDIX A

REFERENCES

- Campbell, G. D., 1981, *Heat Transfer Analysis for In Situ Disposal of Nuclear Wastes in Single- and Double-Shell Underground Storage Tanks*, RHO-LD-171, Rockwell Hanford Operations, Richland, Washington.
- WHC, 1991, *The Sort On Radioactive Waste Type Model: A Method to Sort Single-Shell Tanks Into Characteristics Groups*, WHC-EP-0449, Westinghouse Hanford Company, Richland, Washington.
- WHC, 1994, *Engineering Study of 50 Miscellaneous Inactive Underground Radioactive Waste Tanks Located at the Hanford Site, Washington*, WHC-SD-EN-ES-040, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

APPENDIX B

BASES RELATED TO POTENTIAL PRIORITY 2 SAFETY ISSUES

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APPENDIX B**BASES RELATED TO POTENTIAL PRIORITY 2 SAFETY ISSUES****B.1 BASIS FOR CRITICALITY CRITERIA**

A spreadsheet calculation represents an estimate of the plutonium concentration in the solid wastes in the MUSTs. The formulas used in the spreadsheet for this calculation really just convert sample analysis data to a consistent basis of grams plutonium per liter. The liter measure represents either solids if just solid sample data exists, supernate if just supernate sample data exists, or total waste if both solid and supernate sample data exist.

If solid sample data exists in the form of $\mu\text{Ci/gm}$, then a density value must exist to convert the sample data to $\mu\text{Ci/ml}$. This value is then converted to gm/L by dividing by the specific activity for Plutonium-239 ($6.13 \times 10^2 \text{ Ci/gm}$) and using conversion factors for μCi to Ci and ml to L .

If solid sample data exists in the form of $\text{gm of plutonium/gm of waste solids}$, then a density value must exist to convert the sample data to g/ml . This value is then converted to gm/L by using the conversion factor for ml to L .

If liquid sample data exists in the form of $\mu\text{Ci/ml}$ or $\mu\text{Ci/L}$, it is then converted to gm/L by dividing by the specific activity for Plutonium-239 ($6.13 \times 10^2 \text{ Ci/gm}$) and using conversion factors for μCi to Ci and ml to L , as necessary.

If liquid sample data exists in the form of gm/gal , then it is converted to gm/L by multiplying by the conversion factor of 1 gal per 3.785 L.

If liquid sample data exists in the form of $\mu\text{gm/L}$, then it is converted by multiplying by 1 gm per 1,000,000 μgm .

The calculations of the plutonium concentration in gm/L from sample data are shown in Table B-1 below. Blanks in the table indicate no sample data was available for performing the calculation.

Table B-1. Spreadsheet Results of Plutonium Concentrations Based on Sample Data. (4 pages)

MUST-CRT.WQ1			Assumptions: 0.0613 Curies of Pu-239 per gram									
Tanks	Total Pu (Kg)	Pu Concen- tion (g/L)	Nominal Capacity (gal)	Solids Volume (gal)	Supernate Volume (gal)	Total Waste (gal)	Vapor Space Volume (gal)	Void %	Pu Concen- tation in Solids	<--Units	Pu Concen- tation in Supernate	<--Units
241-A-302B			13500	no data	no data	3600	13500	100				
241-B-301	3.88E-07	1.74E-07	36000	21660	590	22250	13750	38			6.58E-07	g/gal
241-B-302B			17684	690	4240	4930	12754	72				
241-BX-302A	0.00	6.55E-08	17684	835	0	835	16849	95			6.55E-08	g/L
241-BX-302B			11389	950	94	1044	10345	91				
241-BX-302C			11378	635	228	863	10515	92				
241-C-301	9.67E-07	1.74E-07	36000	9016	1470	10486	25514	71			6.58E-07	g/gal
240-S-302			17684	no data	no data	2276	17684	100				
241-S-302A			17684	no data	no data	5130	17684	100				
241-S-302B			14314	0	0	0	14314	100				
241-SX-302			17684	1050	305	1355	16329	92				
241-T-301B	3.87E-07	1.74E-07	36000	21658	588	22246	13754	38			6.58E-07	g/gal
241-TX-302A			17684	2450	30	2480	15204	86				
241-TX-302B R			12000	no data	no data	0	12000	100				
241-TX-302B			17684	no data	no data	1320	17684	100				

Table B-1. Spreadsheet Results of Plutonium Concentrations Based on Sample Data. (4 pages)

MUST-CRT.WQ1			Assumptions: 0.0613 Curies of Pu-239 per gram									
Tanks	Total Pu (Kg)	Pu Concen- tion (g/L)	Nominal Capacity (gal)	Solids Volume (gal)	Supernat e Volume (gal)	Total Waste (gal)	Vapor Space Volume (gal)	Void %	Pu Concen- ration in Solids	<--Units	Pu Concen- tration in Supernat e	<--Units
241-TX-302X B			14314	108	245	353	13961	98				
241-TY-302A			17684	450	0	450	17234	97				
241-TY-302B			14314	0	0	0	14314	100				
270-E-1			4185	3800	0	3800	385	9				
270-W			3780	no data	no data	0	3780	100				
241-B-361	5.60	0.072	36000	20678	0	20678	15322	43	3.4	$\mu\text{Ci/g}$ @1.29g/ml	6.10E-07	$\mu\text{Ci/ml}$
241-T-361	5.40	0.058	36000	24500	0	24500	11500	32	0.000023	g/g @ 2.53g/ml		
241-U-361	2.53E-06	2.41E-08	36000	27734	98	27832	8168	23	9.97E-07	$\mu\text{Ci/g}$ @1.49g/ml		
241-Z-361	54.50	0.72	40500	20000	200	20200	20300	50	0.72	g/L		
241-Z-8	1.44	0.76	15435	500	0	500	14935	97	0.76	g/L		
231-W-151-00 1	2.56E-07	4.73E-08	4000	0	1430	1430	2570	64			0.0029	$\mu\text{Ci/L}$
231-W-151-00 2	0.23	0.06*	1000	12	955	967	33	3			101	$\mu\text{Ci/g}$ @3.05g/ml

Table B-1. Spreadsheet Results of Plutonium Concentrations Based on Sample Data. (4 pages)

MUST-CRT.WQ1			Assumptions: 0.0613 Curies of Pu-239 per gram									
Tanks	Total Pu (Kg)	Pu Concen- tion (g/L)	Nominal Capacity (gal)	Solids Volume (gal)	Supernate Volume (gal)	Total Waste (gal)	Vapor Space Volume (gal)	Void %	Pu Concen- tation in Solids	<-Units	Pu Concen- tation in Supernate	<-Units
241-CX-70			30000	0	0	0	30000	100				
241-CX-71			1000	930		930	70	7				
241-CX-72	0.20	0.08*	2300	653	0	653	1647	72				
244-BXR-001			50000	7215	0	7215	42785	86				
244-BXR-002			15000	1805	380	2185	12815	85				
244-BXR-003			15000	1449	356	1805	13195	88				
244-BXR-011	0.01	0.00021	50000	7020	98	7118	42882	86	3.78E-07	g/g @0.564g/ml		
244-TXR-001			50000	2291	49	2340	47660	95				
244-TXR-002	8.03E-06	7.20E-07	15000	2945	0	2945	12055	80			0.72	ug/L
244-TXR-003			15000	6460	0	6460	8540	57				
244-UR-001			50000	1852	390	2242	47758	96				
244-UR-002	3.04E-06	0.000001	15000	2304	570	2874	12126	81			0.000005	g/gal
244-UR-003			15000	1568	0	1568	13432	90				
244-UR-004			8230	0	0	0	8230	100				

Table B-1. Spreadsheet Results of Plutonium Concentrations Based on Sample Data. (4 pages)

MUST-CRT.WQ1			Assumptions: 0.0613 Curies of Pu-239 per gram									
Tanks	Total Pu (Kg)	Pu Concen- tion (g/L)	Nominal Capacity (gal)	Solids Volume (gal)	Supernate Volume (gal)	Total Waste (gal)	Vapor Space Volume (gal)	Void %	Pu Concen- tration in Solids	<--Units	Pu Concen- tration in Supernate	<--Units
244-WR-001	0.00	0.000001	50000	minimal?	minimal?	0	50000	100			0.000001	g/L
244-WR-002	0.00	7.22E-07	50000	minimal?	minimal?	0	50000	100			7.22E-07	g/L
244-WR-003			50000	minimal?	minimal?	0	50000	100				
244-WR-004			50000	minimal?	minimal?	0	50000	100				
244-WR-005			50000	minimal?	minimal?	0	50000	100				
244-WR-006			50000	minimal?	minimal?	0	50000	100				
244-WR-007			50000	minimal?	minimal?	0	50000	100				
244-WR-008			50000	minimal?	minimal?	0	50000	100				
244-WR-009			50000	minimal?	23000	23000	27000	54				

NOTES:

*CALCULATED AS "X"kg of Total Pu/gal of Total Waste * 1000g/kg * gal/3.785L = "Y" g/L

B.2 BASIS FOR VAPOR EMISSION CRITERIA

Because the vapor emission criteria consists of parts of the hydrogen generation, ferrocyanide reactivity, and organic reactivity criteria, Table B-2 below shows which parts resulted in the final ranking for each tank related to vapor emissions.

Table B-2. Basis for Vapor Emission Rankings. (5 pages)

Tanks	H ₂ years to 1%	FeCN	Organic	Vapor Emission
		> 8 wt% FeCN	> 3 wt% TOC	Ranking
241-A-302B	no data	not in FeCN flowpath	Y-WT	H
	M	L	H	
241-B-301	631	not in FeCN flowpath	Y-WT	H
	L	L	H	
241-B-302B	no data	not in FeCN flowpath	Y-WT	H
	M	L	H	
241-BX-302A	609	not in FeCN flowpath	No-analysis	M
	L	L	M	
241-BX-302B	no data	not in FeCN flowpath	Y-WT	H
	M	L	H	
241-BX-302C	no data	not in FeCN flowpath	Y-WT	H
	M	L	H	
241-C-301	30	No-9.78	Y-WT	H
	L	M	H	
240-S-302	no data	not in FeCN flowpath	Y-WT	H
	M	L	H	
241-S-302A	no data	not in FeCN flowpath	Y-WT	H
	M	L	H	
241-S-302B	empty	not in FeCN flowpath	empty	L
	L	L	L	
241-SX-302	no data	not in FeCN flowpath	Y-WT	H
	M	L	H	

Table B-2. Basis for Vapor Emission Rankings. (5 pages)

Tanks	H ₂ years to 1%	FeCN	Organic	Vapor Emission
		> 3 wt% FeCN	> 3 wt% TOC	Ranking
241-T-301B	45	No-47.01	Y-WT	H
	L	M	H	
241-TX-302A	296	not in FeCN flowpath	Y-WT	H
	L	L	H	
241-TX-302BR	empty	empty	N-WT	L
	L	L	L	
241-TX-302B	no data	no data	Y-WT	H
	M	M	H	
241-TX-302XB	no data <400 gal	not in FeCN flowpath	Y-WT	H
	L	L	H	
241-TY-302A	no data	Yes-0.99	Y-WT	H
	M	H	H	
241-TY-302B	empty	not in FeCN flowpath	empty	L
	L	L	L	
270-B-1	no data	not in FeCN flowpath	no data	M
	M	L	M	
270-W	no data	not in FeCN flowpath	no data	M
	M	L	M	
241-B-361	1	not in FeCN flowpath	no data	H
	H	L	M	
241-T-361	0	not in FeCN flowpath	Y-indicated	H
	H	L	H	
241-U-361	1	not in FeCN flowpath	Y-indicated	H
	H	L	H	
241-Z-361	no data	not in FeCN flowpath	No-analysis	M
	M	L	M	

Table B-2. Basis for Vapor Emission Rankings. (5 pages)

Tanks	H ₂ years to 1%	FeCN	Organic	Vapor Emission
		> 8 wt% FeCN	> 3 wt% TOC	Ranking
241-Z-8	no data	not in FeCN flowpath	no data	M
	M	L	M	
231-W-151-001	12148	not in FeCN flowpath	no data	M
	L	L	M	
231-W-151-002	241361	not in FeCN flowpath	no data	M
	L	L	M	
241-CX-70	empty	not in FeCN flowpath	empty	L
	L	L	L	
241-CX-71	102	not in FeCN flowpath	Y-indicated	H
	L	L	H	
241-CX-72	no data	not in FeCN flowpath	no data	M
	M	L	M	
244-BXR-001	4	not in FeCN flowpath	Y-indicated	H
	H	L	H	
244-BXR-002	39	No-9.40	Y-indicated	H
	L	M	H	
244-BXR-003	1	not in FeCN flowpath	Y-indicated	H
	H	L	H	
244-BXR-011	5	not in FeCN flowpath	No-analysis	H
	H	L	M	
244-TXR-001	4480	not in FeCN flowpath	no data	M
	L	L	M	
244-TXR-002	2336	not in FeCN flowpath	no data	M
	L	L	M	
244-TXR-003	no data	not in FeCN flowpath	no data	M
	M	L	M	

Table B-2. Basis for Vapor Emission Rankings. (5 pages)

Tanks	H ₂ years to 1%	FeCN	Organic	Vapor Emission
		> 8 wt% FeCN	> 3 wt% TOC	Ranking
244-UR-001	384	not in FeCN flowpath	Y-indicated	H
	L	L	H	
244-UR-002	3338	not in FeCN flowpath	Y-indicated	H
	L	L	H	
244-UR-003	50	not in FeCN flowpath	Y-indicated	H
	L	L	H	
244-UR-004	empty	not in FeCN flowpath	empty	L
	L	L	L	
244-WR-001	empty	empty	empty	L
	L	L	L	
244-WR-002	empty	empty	empty	L
	L	L	L	
244-WR-003	empty	not in FeCN flowpath	empty	L
	L	L	L	
244-WR-004	empty	not in FeCN flowpath	empty	L
	L	L	L	
244-WR-005	empty	not in FeCN flowpath	empty	L
	L	L	L	
244-WR-006	empty	not in FeCN flowpath	empty	L
	L	L	L	
244-WR-007	empty	not in FeCN flowpath	empty	L
	L	L	L	
244-WR-008	empty	not in FeCN flowpath	empty	L
	L	L	L	

Table B-2. Basis for Vapor Emission Rankings. (5 pages)

Tanks	H ₂ years to 1%	FeCN	Organic	Vapor Emission
		> 8 wt% FeCN	> 3 wt% TOC	Ranking
244-WR-009	no data	not in FeCN flowpath	no data	M
	M	L	M	

NOTES:

1. Under the FeCN > 8 wt% FeCN column, a notation like "No-9.78" means that the tank was not considered to have > 8 wt% FeCN because the ratio of leakage to capacity of the tank would have had to have been "9.78" which is greater than the criteria of "2.00".
2. Under the Organic > 3 wt% TOC column, a notation "Y-WT" means that the tank was considered to have > 3 wt% TOC because the waste types potentially received by the tank contained > 3 wt% TOC.
3. Under the Organic > 3 wt% TOC column, a notation "No-analysis" means that the tank was not considered to have > 3 wt% TOC because analysis indicated < 3 wt% TOC.
4. Under the Organic > 3 wt% TOC column, a notation "Y-indicated" means that the tank was considered to have > 3 wt% TOC because reference information indicated organics in the tank.

APPENDIX C

BASES FOR LEAK POTENTIAL (PRIORITY 3 SAFETY ISSUE) CRITERIA

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APPENDIX C

BASES FOR LEAK POTENTIAL (PRIORITY 3 SAFETY ISSUE) CRITERIA

To develop a quantitative basis for the leak potential criteria, information from the engineering study (WHC 1994) was used to tabulate the volume of supernate in each of the tanks. The basis for the 5000 gallon supernate limit in the criteria is that is the level at which MUSTs were considered to be interim stabilized when they were being isolated in the mid-1980's. This 5000 gallon value for interim stabilization is discussed in a 1984 supporting document (Bell 1984). This tabulation is shown in Table C-1 below.

Table C-1. Supernate and Total Waste Volumes of MUSTs. (3 pages)

Tanks	Supernate Volume (gal.)	Total Waste Volume (gal)
241-A-302B	no data	3600
241-B-301	590	22250
241-B-302B	4240	4930
241-BX-302A	0	835
241-BX-302B	94	1044
241-BX-302C	228	863
241-C-301	1470	10486
240-S-302	no data	2276
241-S-302A	no data	5130
241-S-302B	0	0
241-SX-302	305	1355
241-T-301B	588	22246
241-TX-302A	30	2480
241-TX-302BR	no data	0
241-TX-302B	no data	1320
241-TX-302XB	245	353
241-TY-302A	0	450
241-TY-302B	0	0

Table C-1. Supernate and Total Waste Volumes of MUSTs. (3 pages)

Tanks	Supernate Volume (gal.)	Total Waste Volume (gal)
270-E-1	0	3800
270-W	no data	unknown
241-B-361	0	20678
241-T-361	0	24500
241-U-361	98	27832
241-Z-361	200	20200
241-Z-8	0	500
231-W-151-001	1430	1430
231-W-151-002	955	967
241-CX-70	0	0
241-CX-71	no data	930
241-CX-72	0	653
244-BXR-001	0	7215
244-BXR-002	380	2185
244-BXR-003	356	1805
244-BXR-011	98	7118
244-TXR-001	49	2340
244-TXR-002	0	2945
244-TXR-003	0	6460
244-UR-001	390	2242
244-UR-002	570	2874
244-UR-003	0	1568
244-UR-004	0	0
244-WR-001	minimal?	0
244-WR-002	minimal?	0
244-WR-003	minimal?	0

Table C-1. Supernate and Total Waste Volumes of MUSTs. (3 pages)

Tanks	Supernate Volume (gal.)	Total Waste Volume (gal)
244-WR-004	minimal?	0
244-WR-005	minimal?	0
244-WR-006	minimal?	0
244-WR-007	minimal?	0
244-WR-008	minimal?	0
244-WR-009	23000	23000

APPENDIX C

REFERENCES

Bell, N. E., 1984, *Guideline for Declaring Auxiliary Tanks Interim Stabilized*, WHC-SD-WM-TI-129, Rev. 0, Rockwell Hanford Company, Richland, Washington.

WHC, 1994, *Engineering Study of 50 Miscellaneous Inactive Underground Radioactive Waste Tanks Located at the Hanford Site, Washington*, WHC-SD-EN-ES-040, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

APPENDIX D

BASES FOR RADIOLOGICAL HAZARDS (OPERATIONAL CONCERN) CRITERIA

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APPENDIX D**BASES FOR RADIOLOGICAL HAZARDS (OPERATIONAL CONCERN) CRITERIA**

To develop a quantitative basis for the radiological hazards criteria, the analyst performed a spreadsheet calculation. This calculation quantifies the estimated amount of ^{137}Cs in a specific MUST. The formula used in the spreadsheet for this calculation is as follows:

$$B = (\text{Cs-sol} * \text{Sol} + \text{Cs-sup} * \text{Sup}) / 1,000,000$$

NOTE: Division by 1,000,000 converts μCi to Ci.

Cs-sol	=	^{137}Cs concentration in solids in $\mu\text{Ci/gal}$
Sol	=	volume of solids in gallons
Cs-sup	=	^{137}Cs concentration in supernate in $\mu\text{Ci/gal}$
Sup	=	volume of supernate in gallons

The calculations of the estimated amount of ^{137}Cs in a specific MUST is represented in Table D-1 below. Blanks in the table indicate no data was available for performing the calculation.

Table D-1. Spreadsheet Results of ^{137}Cs Contents Based on Sample Data. (3 pages)

MUST-RAD.W Q1	Cesium (Curies)	Nominal Capacity (gal)	Solids Volume (gal)	Supernate Volume (gal)	Total Waste Volume (gal)	^{137}Cs Solids Concentration ($\mu\text{Ci/gal}$)	^{137}Cs Supernate Concentration ($\mu\text{Ci/gal}$)
Tanks							
241-A-302B		13500	no data	no data	3600		
241-B-301	6.73	36000	21660	590	22250		11400
241-B-302B		17684	690	4240	4930		
241-BX-302A	?	17684	835	0	835		358
241-BX-302B		11389	950	94	1044		
241-BX-302C		11378	635	228	863		
241-C-301	37.49	36000	9016	1470	10486		25500
240-S-302		17684	no data	no data	2276		
241-S-302A		17684	no data	no data	5130		
241-S-302B		14314	0	0	0		
241-SX-302		17684	1050	305	1355		
241-T-301B	0.94	36000	21658	588	22246		1600
241-TX-302A	0.00	17684	2450	30	2480		48
241-TX-302BR		12000	no data	no data	0		
241-TX-302B		17684	no data	no data	1320		
241-TX-302XB		14314	108	245	353		
241-TY-302A		17684	450	0	450		
241-TY-302B		14314	0	0	0		

Table D-1. Spreadsheet Results of ^{137}Cs Contents Based on Sample Data. (3 pages)

MUST-RAD.W Q1	Cesium (Curies)	Nominal Capacity (gal)	Solids Volume (gal)	Supernate Volume (gal)	Total Waste Volume (gal)	^{137}Cs Solids Concentration ($\mu\text{Ci/gal}$)	^{137}Cs Supernate Concentration ($\mu\text{Ci/gal}$)
Tanks							
270-E-1		4185	3800	0	3800		
270-W		3780	no data	no data	0		
241-B-361	141.35	36000	20678	0	20678	6836	684
241-T-361	15859.85	36000	24500	0	24500	647341	64734
241-U-361	1376.90	36000	27734	98	27832	49629	4963
241-Z-361		40500	20000	200	20200		
241-Z-8		15435	500	0	500		
231-W-151-001	0.00	4000	0	1430	1430		0.12
231-W-151-002	0.00	1000	12	955	967	0.0011	0.00643
241-CX-70		30000	0	0	0		
241-CX-71	0.00	1000	930		930		6
241-CX-72		2300	653	0	653		
244-BXR-001	?	50000	7215	0	7215		38229
244-BXR-002	0.75	15000	1805	380	2185		1964
244-BXR-003	8.13	15000	1449	356	1805		22824
244-BXR-011	511.73	50000	7020	98	7118	72795	7280
244-TXR-001	0.83	50000	2291	49	2340		16995
244-TXR-002	?	15000	2945	0	2945		83270

Table D-1. Spreadsheet Results of ^{137}Cs Contents Based on Sample Data. (3 pages)

MUST-RAD.W Q1	Cesium (Curies)	Nominal Capacity (gal)	Solids Volume (gal)	Supernate Volume (gal)	Total Waste Volume (gal)	^{137}Cs Solids Concentration ($\mu\text{Ci/gal}$)	^{137}Cs Supernate Concentration ($\mu\text{Ci/gal}$)
Tanks							
244-TXR-003		15000	6460	0	6460		
244-UR-001	0.70	50000	1852	390	2242		1800
244-UR-002	0.38	15000	2304	570	2874		670
244-UR-003	?	15000	1568	0	1568		950
244-UR-004	0.00	8230	0	0	0		
244-WR-001		50000	minimal?	minimal?	0		6
244-WR-002		50000	minimal?	minimal?	0		20
244-WR-003		50000	minimal?	minimal?	0		
244-WR-004		50000	minimal?	minimal?	0		
244-WR-005		50000	minimal?	minimal?	0		
244-WR-006		50000	minimal?	minimal?	0		
244-WR-007		50000	minimal?	minimal?	0		
244-WR-008		50000	minimal?	minimal?	0		
244-WR-009		50000	minimal?	23000	23000		

APPENDIX E

BASIS FOR RANKINGS

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BASIS FOR RANKINGS (7 pages)

Tanks	H ₂ years to 1 %	FeCN		Organic		Heat °P	Crit g/L	Flam	Yap See Appendix A, part 5 for rankings	Leak gallons of supernate	Rad curies cesium
		> 8 wt% FeCN	Temperature > 90 °C	> 3 wt% TOC	Temperature > 180 °C						
241-A-302B	no data void space $\geq$ 50 %	not in FeCN flowpath		Y-WT	no data	no data	no data	Org	H	no data assume < 5000 gal	no data
	L	L		M		M	L-similar	M		M	M
241-B-301	631	not in FeCN flowpath		Y-WT	No-13 °C	13 °C	2B-7	Org	H	590	6.7
	L	L		M		L	L	M		M	L
241-B-302B	no data void space $\geq$ 50 %	not in FeCN flowpath		Y-WT	no data	no data	no data	Org	H	4240	no data
	L	L		M		M	L-similar	M		M	M
241-BX-302A	609	not in FeCN flowpath		No-analysis	No-14.3 °C	14.3 °C	7B-8	Org	M	0	no data
	L	L		L		L	L	L		L	M
241-BX-302B	no data void space $\geq$ 50 %	not in FeCN flowpath		Y-WT	no data	no data	no data	Org	H	94	no data
	L	L		M		M	L-similar	M		L	M
241-BX-302C	no data void space $\geq$ 50 %	not in FeCN flowpath		Y-WT	no data	no data	no data	Org	H	225	no data
	L	L		M		M	L-similar	M		L	M
241-C-301	30	No-9.7%	No-15.7 °C	Y-WT	No-15.7 °C	15.7 °C	2B-7	Org	H	1470	37
	L	L		M		L	L	M		M	L
240-S-302	no data void space $\geq$ 50 %	not in FeCN flowpath		Y-WT	no data	no data	no data	Org	H	no data assume < 5000 gal	no data
	L	L		M		M	L-similar	M		M	M

BASIS FOR RANKINGS (7 pages)

Tank	H ₂ years to 1%	FeCN		Organic		Heat °F	Cris g/L	Flam	Vap See Appendix A, part 5 for rankings	Leak gallons of hydrocarbon	Rad corros condition
		> 8 wt% FeCN	Temperature > 90 °C	> 3 wt% TDC	Temperature > 180 °C						
241-S-302A	no data void space ≥ 50 %	not in FeCN flowpath		Y-WT	no data	no data	no data	Org	H	no data assume < 5000 gal	no data
	L	L		M		M	L-similar	M		M	M
241-S-302B	empty	not in FeCN flowpath		empty	no data	empty	empty	Org	L	empty	no data
	L	L		L		L	L	L		L	M
241-SX-302	no data void space ≥ 50 %	not in FeCN flowpath		Y-WT	no data	no data	no data	Org	H	305	no data
	L	L		M		M	L-similar	M		L	M
241-T-301B	45	No-47.01	No-13.4 °C	Y-WT	No-13.4 °C	13.4 °C	2B-7	Org	H	588	.94
	L	L		M		L	L	M		M	L
241-TX-302A	296	not in FeCN flowpath		Y-WT	No-13.8 °C	13.8 °C	no data	Org	H	30	0.00
	L	L		M		L	L-similar	M		L	L
241-TX-302BR	empty	empty	no data	N-WT	no data	no data	no data	Org	L	no data assume < 5000 gal	no data
	L	L		L		M	L-similar	L		M	M
241-TX-302B	no data void space ≥ 50 %	no data	no data	Y-WT	no data	no data	no data	Org	H	no data assume < 5000 gal	no data
	L	H		M		M	L-similar	M		M	M
241-TX-302CB	no data void space ≥ 50 %	not in FeCN flowpath		Y-WT	no data	no data	no data	Org	H	245	no data
	L	L		M		M	L-similar	M		L	M

BASIS FOR RANKINGS (7 pages)

Tank	H ₂ years to 1%	FeCN		Organic		Heat °F	Cyt g/L	Plant	Vsp See Appendix A, part 5 for rankings	Leak gallons of separators	Rad cures closures
		> 4 wt% FeCN	Temperature > 90 °C	> 3 wt% TOC	Temperature > 180 °C						
241-TY-302A	no data void space ≥ 50 %	Yes-0.99	no data	Y-WT	no data	no data	no data	Org	H	0	no data
	L	H		M		M	L-similar	M		L	M
241-TY-302B	empty	not in FeCN flowpath		empty	no data	empty	empty	Org	L	empty	no data
	L	L		L		L	L	L		L	M
270-B-1	no data void space < 50 %	not in FeCN flowpath		no data	no data	no data	no data	Org	M	0	no data
	M	L		M		M	L-similar	M		L	M
270-W	no data void space ≥ 50 %	not in FeCN flowpath		no data	no data	no data	no data	Org	M	no data assume < 5000 gal	no data
	L	L		M		M	L-similar	M		M	M
241-B-361	1	not in FeCN flowpath		no data	No-28.4 °C	28.4 °C	0.072	H ₂	H	0	141
	H	L		M		L	L	H		L	M
241-T-361	0	not in FeCN flowpath		Y-indicated	No-73 °C	73 °C	0.058	H ₂	H	0	15,860
	H	L		M		L	L	H		L	H
241-U-361	1	not in FeCN flowpath		Y-indicated	No-21.4 °C	21.4 °C	2E-8	H ₂	H	98	1425
	H	L		M		L	L	H		L	H
241-Z-361	no data void space ≥ 50 %	not in FeCN flowpath		No-analysis	no data	no data	0.72	H ₂	M	200	no data
	L	L		L		M	L	M		L	M

BASIS FOR RANKINGS (7 pages)

Tanks	H ₂ years to 1%	FeCN		Organic		Heat °F	Crit g/L	Flam	Vap See Appendix A, part 5 for rankings	Leak gallons of separate	Rad criteria ratings
		> 8 wt% FeCN	Temperature > 90 °C	> 3 wt% TOC	Temperature > 180 °C						
241-Z-8	no data void space $\geq$ 50 %	not in FeCN flowpath		no data	no data	no data	0.76	Org	M	0	no data
	L	L		M		M	L	M		L	M
231-W-151-001	12148	not in FeCN flowpath		no data	no data	no data	58.8	Org	M	1430	0.0
	L	L		M		M	L	M		M	L
231-W-151-002	241361	not in FeCN flowpath		no data	No-13 °C	13 °C	no data	Org	M	955	0.0
	L	L		M		L	L-similar	M		M	L
241-CX-70	empty	not in FeCN flowpath		empty	no data	empty	empty	Org	L	empty	data not conclusive e that no rad
	L	L		L		L	L	L		L	M
241-CX-71	102	not in FeCN flowpath		Y-indicated	No-13 °C	13 °C	no data	Org	H	no data systems < 5000 gal	0.0
	L	L		M		L	L-similar	M		M	L
241-CX-72	no data void space $\geq$ 50 %	not in FeCN flowpath		no data	no data	no data	0.08	Org	M	0	no data
	L	L		M		M	L	M		L	M
244-BXR-001	4	not in FeCN flowpath		Y-indicated	No-58.8 °C	58.8 °C	no data	H ₂	H	0	no data
	H	L		M		L	L-similar	H		L	M
244-BXR-002	39	No-9.40	No-15.4 °C	Y-indicated	No-15.4 °C	15.4 °C	no data	Org	H	380	0.75
	L	L		M		L	L-similar	M		L	L

BASIS FOR RANKINGS (7 pages)

Tanks	H ₂ yours to 1%	FeCN		Organic		Heat °F	Cet g/L	Flam	Vap See Appendix A, part 3 for rankings	Leak gallons of separators	Rad corros coatings
		> 8 wt% FeCN	Temperature > 90 °C	> 3 wt% TOC	Temperature > 180 °C						
244-BXR-008	1	not in FeCN flowpath		Y-indicated	Y-211.9 °C	211.9 °C	no data	Org	H	356	8.1
	H	L		H		H	L-similar	H		L	L
244-BXR-011	5	not in FeCN flowpath		No-methyl	No-44.8 °C	44.8 °C	0.00021	H ₂	H	98	580
	H	L		L		L	L	H		L	M
244-TXR-001	4480	not in FeCN flowpath		no data	No-13.1 °C	13.1 °C	no data	Org	M	49	0.83
	L	L		M		L	L-similar	M		L	L
244-TXR-002	2336	not in FeCN flowpath		no data	No-13 °C	13 °C	7E-7	Org	M	0	no data
	L	L		M		L	L	M		L	M
244-TXR-003	no data void space ≥ 50 %	not in FeCN flowpath		no data	No-13 °C	13 °C	no data	Org	M	0	no data
	L	L		M		L	L-similar	M		L	M
244-UR-001	384	not in FeCN flowpath		Y-indicated	No-14.9 °C	14.9 °C	no data	Org	H	390	0.70
	L	L		M		L	L-similar	M		L	L
244-UR-002	3338	not in FeCN flowpath		Y-indicated	No-13 °C	13 °C	0.000001	Org	H	570	0.38
	L	L		M		L	L	M		M	L
244-UR-003	50	not in FeCN flowpath		Y-indicated	No-15.3 °C	15.3 °C	no data	Org	H	0	no data
	L	L		M		L	L-similar	M		L	M

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BASIS FOR RANKINGS (7 pages)

Tanks	H ₂ years to 1%	FeCN		Organic		Heav °F	Crk g/L	Flam	Vap See Appendix A, part 3 for rankings	Leak gallons of supermate	Rad surface contain
		> 8 wt% FeCN	Temperature > 90 °C	> 3 wt% TOC	Temperature > 180 °C						
244-UR-004	empty	not in FeCN flowpath		empty	no data	empty	empty	Org	L	empty	0.0
	L	L		L		L	L	L		L	L
244-WR-001	empty	empty	no data	empty	no data	empty	empty (0.000001)	Org	L	empty	no data
	L	L		L		L	L	L		L	M
244-WR-002	empty	empty	no data	empty	no data	empty	empty (7E-7)	Org	L	empty	no data
	L	L		L		L	L	L		L	M
244-WR-003	empty	not in FeCN flowpath		empty	no data	empty	empty	Org	L	empty	no data
	L	L		L		L	L	L		L	M
244-WR-004	empty	not in FeCN flowpath		empty	no data	empty	empty	Org	L	empty	no data
	L	L		L		L	L	L		L	M
244-WR-005	empty	not in FeCN flowpath		empty	no data	empty	empty	Org	L	empty	no data
	L	L		L		L	L	L		L	M
244-WR-006	empty	not in FeCN flowpath		empty	no data	empty	empty	Org	L	empty	no data but cold side tank
	L	L		L		L	L	L		L	L
244-WR-007	empty	not in FeCN flowpath		empty	no data	empty	empty	Org	L	empty	no data but cold side tank
	L	L		L		L	L	L		L	L

BASIS FOR RANKINGS (7 pages)

Tank	H_2 years to 1%	FeCN		Organic		Heat °F	Cyt g/L	Flam	Vap See Appendix A, part 5 for rankings	Leak gallons of supermate	Rad curies cesium
		> 8 wt% FeCN	Temperature > 90 °C	> 3 wt% TOC	Temperature > 180 °C						
244-WR-008	empty	not in FeCN flowpath		empty	no data	empty	empty	Org	L	empty	no data but cold side tank
	L	L		L		L	L	L		L	L
244-WR-009	no data void space $\geq$ 50 %	not in FeCN flowpath		no data	no data	no data	no data	Org	M	23,000	no data but cold side tank
	L	L		M		M	L-shelter	M		H	M

NOTES:

- Under the FeCN > 8 wt% FeCN column, a notation like "No-9.75" means that the tank was not considered to have > 8 wt% FeCN because the ratio of leakage to capacity of the tank would have had to have been "9.75" which is greater than the criteria of "2.00".
- Under the Organic > 3 wt% TOC column, a notation "V-WT" means that the tank was considered to have > 3 wt% TOC because the waste types potentially received by the tank contained > 3 wt% TOC.
- Under the Organic > 3 wt% TOC column, a notation "No-analysis" means that the tank was not considered to have > 3 wt% TOC because analysis indicated < 3 wt% TOC.
- Under the Organic > 3 wt% TOC column, a notation "Y-indicated" means that the tank was considered to have > 3 wt% TOC because reference information indicated organics in the tank.
- Under the Cyt column, a notation "L-shelter" means that the majority of tanks with plutonium concentration analyses indicated a Low ranking and therefore all tanks with no analysis were similarly ranked Low.
- Under the Flam and Vap columns, a notation of "Org" or " H_2 " or "FeCN" indicates which of the potential safety categories contributed the highest ranking for the flammability or Vapor Emission potential safety issue ranking.

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APPENDIX F

SELECTED PAGES FROM WHC-IP-0842

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SELECTED PAGE FROM WHC-IP-0842

WASTE YARDS ADMINISTRATION	Manual	WHC-IP-0842
UNREVIEWED SAFETY QUESTIONS	Section	15.9, REV 3
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Figure B-1. Unreviewed Safety Question-Evaluation Form. (2 sheets)

USQ Tracking Number:

AREA: (Circle Those That Apply) EAST WEST

FACILITY: (Circle Those That Apply) 242-A DST SST LERF AGING
WASTE

OTHER (Specify _____)

EQUIPMENT DESCRIPTION:

REFERENCE DOCUMENT: (Circle Those That Apply)

ECN No. _____ PCA No. _____ WORK PKG No. _____ OTHER
(Specify _____)

TITLE:

1. Does the PROPOSED CHANGE or DISCOVERY increase the probability of occurrence of an accident previously evaluated in the AUTHORIZATION BASIS documentation?
No _____ Yes/Maybe _____

Basis: _____

2. Does the PROPOSED CHANGE or DISCOVERY increase the consequences of an accident previously evaluated in the AUTHORIZATION BASIS documentation?
No _____ Yes/Maybe _____

Basis: _____

3. Does the PROPOSED CHANGE or DISCOVERY increase the probability of occurrence of a malfunction of EQUIPMENT previously evaluated in the AUTHORIZATION BASIS documentation?
No _____ Yes/Maybe _____

Basis: _____

4. Does the PROPOSED CHANGE or DISCOVERY increase the consequences of a malfunction of ITS EQUIPMENT previously evaluated in the AUTHORIZATION BASIS documentation?
No _____ Yes/Maybe _____

Basis: _____

SELECTED PAGE FROM WHC-IP-0842

WASTE TANKS ADMINISTRATION	Revised	WHC-IP-0842
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Figure 9-3. Unreviewed Safety Question Evaluation Form. (2 sheets)

USQ Tracking Number: _____

5. Does the PROPOSED CHANGE or DISCOVERY create the possibility of an accident of a different type than any previously evaluated in the AUTHORIZATION BASIS documentation? No ___ Yes/Maybe ___

Basis: _____

6. Does the PROPOSED CHANGE or DISCOVERY create the possibility of a malfunction of EQUIPMENT of a different type than any previously evaluated in the AUTHORIZATION BASIS documentation? No ___ Yes/Maybe ___

Basis: _____

7. Does the PROPOSED CHANGE or DISCOVERY reduce the margin of safety as defined in the basis for any Technical Specification/Operational Safety Requirement? No ___ Yes/Maybe ___

Basis: _____

8. Does the PROPOSED CHANGE or DISCOVERY require a new or revised Technical Safety Requirement/ Operational Safety Requirement or a compensatory measure required by a Compliance Implementation Plan? No ___ Yes/Maybe ___

Basis: _____

(Use additional space if necessary to explain basis.)

USQE #1 _____	USQE #2 _____
Print Name	Print Name
Signature _____	Signature _____
Date _____	Date _____

PRC REVIEW (If Required)

Meeting #: _____ Date _____

PRC Chairman Concurrence: _____

Signature _____ Date _____

SELECTED PAGE FROM WHC-IP-0842

WASTE TANKS ADMINISTRATION	Manual	WHC-IP-0842
UNREVIEWED SAFETY QUESTIONS	Section	15.9, REV 1
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	Effective Date	May 20, 1994

Appendix B (cont'd)
Figure B-2 Unreviewed Safety Question-Occurrence Screening Form (1 sheet)

Occurrence Report Number: _____

TITLE: _____

A. Does the OCCURRENCE have any potential for impacting the AUTHORIZATION BASIS?

N/A _____ NO _____ Yes/Maybe _____

Basis: _____

B. Does the OCCURRENCE possibly call into question any information explicitly relied upon in the AUTHORIZATION BASIS?

N/A _____ NO _____ Yes/Maybe _____

Basis: _____

C. Does the OCCURRENCE introduce any possibility that the margin of safety may be reduced as defined in implemented IOSR's, nonimplemented IOSR's, existing OSR's or compliance implementation plans?

N/A _____ NO _____ Yes/Maybe _____

Basis: _____

USQE #1 _____
Print Name

OSQE #2 _____
Print Name

Signature

Date

Signature

Date

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J.W. Osborne	S7-15
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