ORP-61725
Revision 1

# Waste Incidental to Reprocessing Evaluation -- Test Samples of Treated, Low-Activity Waste from Hanford Tanks for Off-site Disposal

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

Office of River Protection

**P.O. Box 450**
**Richland, Washington 99352**

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# Waste Incidental to Reprocessing Evaluation -- Test Samples of Treated, Low-Activity Waste from Hanford Tanks for Off-site Disposal

# Test Bed Project, Office of River Protection, U.S. Department of Energy

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# ABSTRACT

This *Waste Incidental to Reprocessing Evaluation – Test Samples of Treated, Low-Activity Waste from Hanford Tanks for Offsite Disposal* ("Test Sample WIR Evaluation") evaluates whether approximately five (5) gallons of test samples – consisting of treated, solidified, low-activity waste from six Hanford tanks -- meet the criteria for determining that the waste is incidental to reprocessing and not high-level radioactive waste (HLW), under Section II.B(2)(a) of the U.S. Department of Energy (DOE) Manual 435.1-1, Chg. 2, *Radioactive Waste Management Manual*. This WIR Evaluation demonstrates that those criteria in Manual 435.1-1 will be satisfied.

The test samples consist of low-activity (decanted supernate) waste from six tanks, which contain waste from, in part, the prior reprocessing of spent nuclear fuel for defense-related activities at the Hanford Site. The samples were pretreated in a test bed at the 222-S Laboratory. Following pretreatment at the 222-S Laboratory, the waste will be solidified in a grout matrix, to meet Resource Conservation and Recovery Act and disposal requirements, at Perma-Fix Northwest Richland, Inc. (PFNW), near the Hanford Site. DOE plans to dispose of the treated and solidified waste as low-level radioactive waste (LLW) at the Waste Control Specialists Federal Waste Disposal Facility (WCS FWF), in Andrews, Texas.

This Test Sample WIR Evaluation demonstrates that the criteria in DOE Manual 435.1-1, Section II.B(2)(a), will be met, specifically, that the treated test samples: 1) have been processed to remove key radionuclides to the maximum extent that is technically and economically practical; 2) will be managed to meet safety requirements comparable to the Nuclear Regulatory Commission (NRC) performance objectives for disposal of LLW, set out in 10 CFR Part 61, Subpart C, *Performance Objectives*; and 3) will be managed, pursuant to DOE's authority, in accordance with the LLW provisions in Chapter IV of Manual 435.1-1, and will be incorporated into a solid physical form at a concentration that does not exceed the applicable concentration limits for Class C LLW, as set out in the NRC regulations at 10 CFR 61.55, *Waste Classification*. Therefore, this Test Sample WIR Evaluation would support a Waste Incidental to Reprocessing (WIR) Determination, issued by the Associate Principal Deputy Assistant Secretary for Regulatory and Policy Affairs, Office of Environmental Management, that this waste is incidental to reprocessing, is not HLW, and may be managed and disposed of as LLW.

# CONTENTS

## FIGURES

**TABLES**



**APPENDICES**

# ACRONYMS

| | |
|---|---|
| BBI | Best Basis Inventory |
| DOE | U.S. Department of Energy |
| DST | Double Shell Tank |
| EIS | Environmental Impact Statement |
| HDW | Hanford Defined Waste |
| HLW | High level radioactive waste |
| FWF | Federal Waste Disposal Facility |
| LAW | Low activity waste |
| LAWPS | Low Activity Waste Pretreatment System |
| LLW | Low level radioactive waste |
| MLLW | Mixed low level radioactive waste |
| NEPA | National Environmental Policy Act |
| NRC | Nuclear Regulatory Commission |
| ORP | DOE’s Office of River Protection |
| PFNW | Perma-Fix Northwest Richland, Inc. |
| PNNL | Pacific Northwest National Laboratory |
| PUREX | Plutonium and Uranium Extraction |
| RCRA | Resource Conservation and Recovery Act |
| REDOX | Reduction and Oxidation |
| ROD | Record of decision |
| SNF | Spent nuclear fuel |
| SST | Single Shell Tanks |
| TCEQ | Texas Commission on Environmental Quality |
| TRU | Transuranic waste |
| TWINS | Tank Waste Information Network System |
| WAC | Waste acceptance criteria |
| WCS | Waste Control Specialists |
| WIR | Waste incidental to reprocessing |
| WTP | Waste Treatment and Immobilization Plant |

# 1.0 Introduction

**Section Purpose**

The purpose of this section is to provide introductory information that lays the foundation for detailed discussions in later sections.

**Section Contents**

This section describes the purpose and scope of this evaluation, provides a background of the Hanford site, identifies the technical requirements on which this evaluation is based, and outlines the contents of the rest of the evaluation.

**Key Points**

- This *Waste Incidental-to-Reprocessing Evaluation – Test Samples of Treated, Low-Activity Waste from Hanford Tanks for Offsite Disposal* ("Test Sample WIR Evaluation") evaluates whether approximately five (5) gallons of test samples – consisting of low-activity waste from six Hanford tanks -- meet the criteria for determining that the waste is incidental to reprocessing, and not high-level radioactive waste (HLW), under Section II.B(2)(a) of the U.S. Department of Energy (DOE) Manual 435.1-1, *Radioactive Waste Management Manual*. As demonstrated in this WIR Evaluation, the treated and solidified test samples will satisfy the waste incidental to reprocessing (WIR) criteria in Manual 435.1-1.
- The waste samples consist of low-activity waste (supernate) from six Hanford tanks, which contain waste generated, in part,[1] by the prior reprocessing of spent nuclear fuel for defense-related research, development and production activities.
- DOE conducted a test of the planned pretreatment system using stored tank waste samples at the 222-S Laboratory (also referred to as the test bed project), located on the Hanford site. This test was conducted on approximately 5 gallons of tank waste samples. The samples were pretreated using decanting[2], filtration, and two ion-exchange columns in the 222-S Laboratory. These bench scale methods are planned for use on a larger scale for tank waste in the Low Activity Waste Pretreatment System, currently under construction at the Hanford Site.
- Following pretreatment at the 222-S Laboratory, the test samples will be further treated and solidified (encapsulated in a grout matrix) at Perma-Fix Northwest Richland, Inc. (PFNW) near the Hanford Site, to meet Land Disposal Restrictions under the Resource Conservation and Recovery Act and disposal requirements.
- DOE will to dispose of the treated and solidified waste as LLW at the Waste Control Specialists (WCS) Federal Waste Disposal Facility (FWF), a privately-operated facility, licensed by the Texas Commission on Environmental Quality (TCEQ) and located in Andrews, Texas unless circumstances require alternate disposal location.

## 1.1 Purpose

The purpose of this Test Sample WIR Evaluation is to analyze whether approximately five (5) gallons of treated and solidified test samples – consisting of low-activity waste from six Hanford tanks, generated, in part, by the prior reprocessing of spent nuclear fuel – meet the waste incidental to reprocessing (WIR)

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[1] Tank waste consists of waste generated by reprocessing of spent nuclear fuel and other sources such as wash water from cleaning tanks or equipment. Therefore, in a strict sense, these wastes are not specifically only from reprocessing.

[2] Decanting refers to the process of drawing off liquid without disturbing the sediment or the lower liquid layers. (www.merriam-webster.com/dictionary/decant) Decanting was an integral part of the pretreatment for decreasing the potential, future risk from the tank waste samples. The waste was decanted twice during this test bed project. The first decanting occurred during removal of the liquid from the tanks. This decanting involved removing samples from only the upper low-activity liquid layer (not the salts or solids) in six underground storage tanks at the Hanford Site. The second decanting took place in the 222-S Laboratory by pouring off the liquid layer in the bottles prior to the remaining pretreatment steps (filtration and ion exchange treatment). This is intended to mimic the pretreatment planned in the Low Activity Waste Pretreatment System in order to provide additional pretreatment results on actual tank waste. Most of the actinides and radioactivity (other than some soluble radionuclides) were entrained in the solids.

criteria, are not high-level radioactive waste (HLW), and may be managed as low-level radioactive waste (LLW)[3] pursuant to Section II.B(2)(a) of Department of Energy (DOE) Manual 435.1-1, *Radioactive Waste Management Manual*.

**Waste-Incidental-to-Reprocessing Requirements**

The term WIR refers not to a type of waste but rather to a "process," whereby "certain waste streams produced during the generation of high-level radioactive waste may be determined to be non-high-level waste through the waste incidental to reprocessing determination process" (DOE Guide 435.1-1). DOE Manual 435.1-1 Chg 2 provides two methods for determining whether waste associated with Spent Nuclear Fuel (SNF) reprocessing is incidental to reprocessing and can be managed as low-level radioactive waste (LLW): the citation method and the evaluation method.

The citation process applies to radioactive wastes such as, but not limited to, contaminated job wastes including laboratory items such as clothing, tools, and equipment which have been found to routinely meet the criteria for management as LLW.

Consistent with DOE Guide 435.1-1, the waste addressed in this evaluation does not fall within a category of materials to which DOE considers the citation process can be applied. Therefore, the evaluation method was used for the subject waste as described in this Test Sample WIR Evaluation.

## 1.2 Scope

This Test Sample WIR Evaluation applies to approximately five (5) gallons (combined total) of low-activity samples of Hanford tank waste, that have been identified and are currently stored at the 222-S Laboratory, which is operated by DOE's subcontractor, Wastren Advantage, Inc., at the Hanford Site. This Test Sample WIR Evaluation does not apply to other tank wastes.[4]

## 1.3 Technical Basis for This Evaluation

This Test Sample WIR Evaluation has been prepared in accordance with DOE Manual 435.1-1, "Radioactive Waste Management Manual", following guidance in DOE Guide 435.1 1, "*Implementation Guide for use with DOE M 435.1-1*."

The method used involves evaluating whether the treated test samples of Hanford tank wastes are incidental to reprocessing and may be managed under DOE's authority in accordance with requirements for LLW waste. The criteria in Section II.B(2)(a) of DOE Manual 435.1-1 provide, in relevant part, that the wastes:

> (1) Have been processed, or will be processed, to remove key radionuclides to the maximum extent that is technically and economically practical;

[3] For convenience in this Test Sample WIR Evaluation, throughout this document, the treated and solidified test samples are referred to as simply LLW.

[4] After pretreatment in the 222-S Laboratory, the waste samples will be solidified - incorporated in a solid physical form at a concentration that does not exceed the applicable concentration limits for Class C low-level waste as set out in 10 CFR 61.55, *Waste Classification* - at Perma-Fix Northwest Richland, Inc. (PFNW). DOE plans to dispose of the treated and solidified waste at the Waste Control Specialists (WCS) Federal Waste Disposal Facility (FWF), a commercial facility licensed by the Texas Commission on Environmental Quality and located in Andrews, Texas. This portion of the test bed project will serve as a proof-of-concept test of potential stabilization and offsite disposal capabilities. The scope is intended to be large enough to test the approach but still small enough to require limited resources to be expended.

(2) Will be managed to meet safety requirements comparable to the performance objectives set out in 10 CFR Part 61, Subpart C, *Performance Objectives*; and

(3) Are to be managed, pursuant to DOE's authority under the Atomic Energy Act of 1954, as amended, and in accordance with the provisions of Chapter IV of this Manual, provided the waste will be incorporated in a solid physical form at a concentration that does not exceed the applicable concentration limits for Class C low-level waste as set out in 10 CFR 61.55, *Waste Classification*.

This Test Sample WIR Evaluation focuses on the WIR criteria of DOE Manual 435.1-1, Section II.B(2)(a), which are discussed in Section 3 of this Test Sample WIR Evaluation and addressed in detail in Sections 4, 5, and 6, respectively.

Although the WIR criteria in DOE Manual 435.1-1 are generally similar to the provisions in Section 3116(a) of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005, Public Law 108-375, that Act only applies to waste remaining in South Carolina and Idaho. Nevertheless, as a matter of policy, DOE has considered the Section 3116(a)(1) criteria for perspective and general consistency. This matter is addressed in detail in Appendix C.

## 1.4 Background

The following general information is provided to put this Test Sample WIR Evaluation into context. Section 2 provides more detailed background information on reprocessing of spent nuclear fuel, storage of reprocessing wastes in tanks, tank waste sampling, and Hanford tank waste management plans.

### 1.4.1 The Hanford Site and Its History[5]

The Hanford Site occupies approximately 586 square miles in southeastern Washington State along the Columbia River (Figure 1-1). Hanford's mission included defense-related nuclear research, development, and nuclear weapons production activities from the early 1940s to approximately 1989. Since that time, Hanford's mission has been to clean up the site, especially the radioactive and hazardous wastes from plutonium production that pose a risk to the local environment, including the Columbia River.

[5] This brief history was compiled primarily from the *Final Tank Farm Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington,* TC&WM EIS (DOE 2012) and *A Short History of Hanford Waste Generation, Storage, and Release (PNNL 2003).*

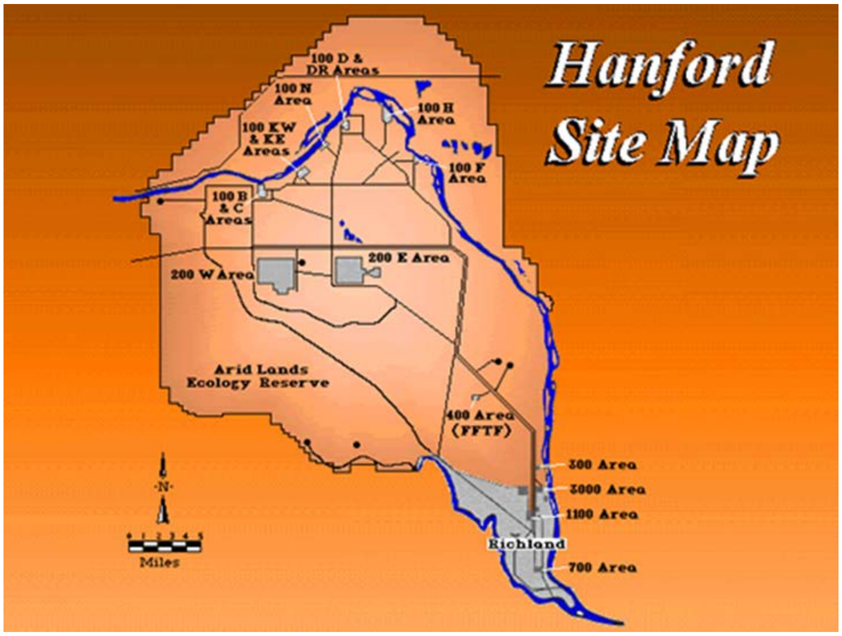


**Figure 1-1 Hanford Site Map**

### 1.4.2 Spent Nuclear Fuel Reprocessing

To support defense-related activities and production of material for nuclear weapons, plutonium and other nuclear materials were separated (reprocessed) from spent (used) nuclear fuel and targets using various chemical precipitation and solvent extraction techniques at the Hanford Site.[6] In 1989, the reprocessing plants were shut down and no new wastes were generated from reprocessing.

The resulting liquid waste from reprocessing was stored in large underground storage tanks. Beginning in the 1960s, some of the tank waste was treated to remove some of the cesium and strontium, and the treated waste was returned to the tanks.[7] Thereafter, additional waste from reprocessing was added to the tanks. Currently, approximately 56 million gallons of liquid, radioactive waste are stored in 177 underground tanks on the Central Plateau at Hanford. Figure 1-2 shows the Central Plateau, which contains the underground storage tanks and their support structures where liquids from reprocessing are stored.

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[6] Starting in late 1944 and 1945, the T and B Plants used a bismuth phosphate batch processing technology. Later, the Reduction and Oxidation (REDOX) and Plutonium and Uranium Extraction (PUREX) plants were brought on line beginning in the 1950s. The Hanford Site reprocessed approximately 96,700 metric tons of irradiated uranium and generated several hundred thousand metric tons of chemical and radioactive waste during its production period. The resulting liquid wastes from these processes were stored in large underground storage tanks. All Hanford tank waste is considered to be mixed radioactive and hazardous waste, regulated under DOE Order 435.1 (and Manual 435.1-1) pursuant to the Atomic Energy Act of 1954, as amended, and the Resource Conservation and Recovery Act (RCRA).

[7] Beginning in the 1960s, some waste was retrieved from single-shell tanks and transferred to the B Plant at Hanford, where cesium and strontium were extracted, placed in capsules, and stored in a separate facility. This process removed approximately 40 percent of the fission product inventory from the tank waste.

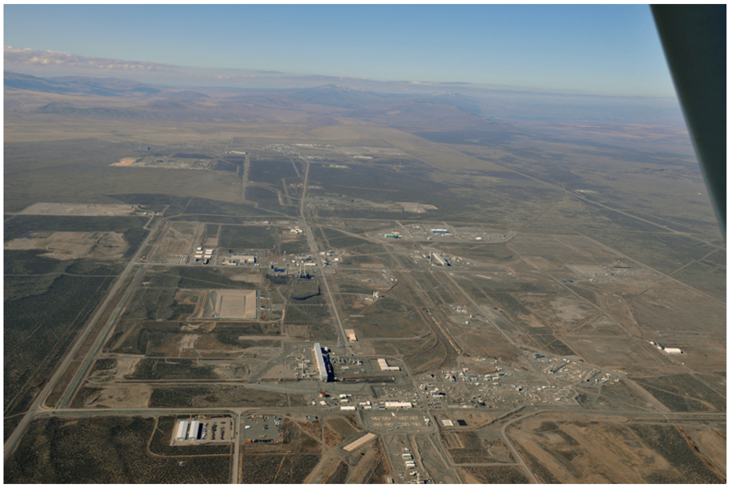

**Figure 1-2. Hanford Central Plateau**

Cleanup and closure of these tanks is the focus of ongoing work by the DOE Office of River Protection (ORP). DOE plans to retrieve the waste from some of the tanks and separate the retrieved waste into a low-activity waste (LAW) fraction and higher-activity waste stream at the Waste Treatment and Immobilization Plant (WTP), currently under construction at the Hanford Site. Prior to completing construction of the WTP Pretreatment facility, some of the tank waste will be pretreated in the Low Activity Waste Pretreatment System (LAWPS) and then transferred to the LAW melters in WTP, where it will be vitrified (converted to a solid, glass-like substance) for disposal at the Integrated Disposal Facility onsite. In contrast, once the WTP is fully constructed, the higher–activity waste will be treated and vitrified in the WTP and stored for eventual disposal offsite as high-level radioactive waste.[8] It will take several decades to complete the construction of the facilities necessary to complete this solidification, empty the tanks, complete the treatment of the wastes, and close the tanks.

The test samples (WRPS 2016) discussed in this Test Sample WIR Evaluation were collected from tanks that contained, in part, waste which was previously treated (beginning in the 1960s) to remove some of the cesium and strontium. The tanks at Hanford typically contain blends of waste from different processes due to historical practices and due to waste retrieval and consolidation activities in the tank farms. The samples consist of liquid waste, specifically supernate – that is, the less-radioactive liquid sitting above the more-radioactive, settled, solid material in the tanks.[9] As explained in more detail later in this Test Sample WIR Evaluation, these samples were pretreated at the 222-S Laboratory using decanting, filtration (to remove insoluble radionuclides) and two ion-exchange columns (primarily for removing cesium-137). The similar pretreatment methods will be used on a larger scale in the LAWPS and WTP.

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[8] The first of several Records of Decision (ROD#1) has been issued for the Tank Closure and Waste Management Environmental Impact Statement (TC&WM EIS, DOE 2012.)

[9] The waste in the tanks generally consists of 3 phases: supernatant, saltcake, and sludge. Some entrained gas can also exist in the solid phases. The supernate is liquid remaining above the solid material that was formed by precipitation of sludge and saltcake in the tanks. The supernate consists of lower activity waste and represents most of the volume of the tank waste, whereas the sludge consists of a lower volume but contains most of the long-lived radionuclides which may persist in the environment. (NAS 2006)

### 1.4.3 Inventory

The test samples at issue in this Test Sample WIR Evaluation consist of low-activity waste (supernate) from six tanks at the Hanford Site, collected from 2010-2014.[10] The samples have been consolidated from containers stored in the hot cell at 222-S Laboratory,[11] and are representative of supernate from those six tanks, rather than a single tank. The waste samples came from tanks 241-AN-101, 241-AN-106, 241-AP-105, 241-AP-106, 241-AP-107, and 241-AY-101 (WRPS 2016) located in the area known as 200 East Area on the Central Plateau. Figure 1-3 shows the 222-S Laboratory hot cells and sample wastes from tanks. These samples were selected for this test for a number of reasons, including: the samples consist of low-activity supernate; the waste was generated, in part, by reprocessing; and the waste is similar to the waste that will be pretreated in LAWPS.

**Figure 1-3 222-S Laboratory Hot Cells**

### 1.4.4 Characterization of the Tank Waste Samples

Hanford maintains the tank waste radionuclide inventory in a database known as the Best-Basis Inventory (BBI)[12]. This inventory includes 46 radionuclides and 24 chemicals. Inventories are provided for each tank using waste sample data and process history modeling, and are updated quarterly. The Best-Basis Inventory process was developed using the best available information to estimate compositions and inventories of the underground waste tank contents. It establishes the inventory of the underground waste storage tanks at Hanford by using sample data, process knowledge, surveillance data, and waste stream composition information from the HDW (Hanford Defined Waste) computer model (WHC 1996). Section 2 of this Test Sample WIR Evaluation provides more detail on the characterization and treatment process.

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[10] Identified in Test Plan for the Preparation of Samples from Hanford Tanks 241-AN-101, 241-AN-106, 241-AP-105, 241-AP-106, 241-AP-107, and 241-AY-101. (WRPS 2016)

[11] Thousands of samples of the tank wastes were collected from the tanks over the years. Many samples were used to identify key constituents in each tank and for treatment demonstrations. Over 800 samples are currently stored in hot cells in the 222-S Laboratory to support characterization and testing for future treatment, stabilization, and disposal activities. (Best-Basis Inventory 2016) The test samples at issue in this Test Sample WIR Evaluation were removed from the tanks between the years 2010-2014. (WRPS 2016)

[12] BBI can be found at http://www.hanford.gov/page.cfm/PHOENIX. It is updated quarterly.

As explained in more detail in Section 6 of this Test Sample WIR Evaluation, the pretreated tank waste samples were characterized for radioactivity based on sample analytical data, where available, as well as information from the BBI. Based on the evaluation in Section 6, the treated and solidified waste samples are well below the Nuclear Regulatory Commission (NRC) concentration limits for Class C LLW set forth in 10 CFR 61.55.

### 1.4.5 Incorporation into a Solid Physical Form

After the liquid low-activity test samples were pretreated at the 222-S Laboratory, they were collected into one-liter plastic bottles. The individual one-liter containers were overpacked into a drum following ATS-LO-100-153 "222-S Laboratory Waste Packaging and Preparation for Shipment", with appropriate absorption pads and padding necessary for this configuration. The drum was then placed into a Department of Transportation (DOT) approved Type A compliant package and will be transported in accordance with DOT requirements.

The pretreated liquid waste samples will be shipped to Perma-Fix Northwest Richland, Inc. (PFNW), located adjacent to the Hanford Site, where the hazardous waste constituents will be immobilized (solidified) to meet Land Disposal Restrictions under the Resource Conservation and Recovery Act (RCRA) and meet requirements for disposal of radioactive waste.[13] The liquid will be mixed with grout in a container and void spaces will be minimized through the process of mixing the liquids and grout. Mixing the grout with the liquids will increase the volume of disposed waste by a 50-100% ratio (ATS-LO-100-153 2016).

### 1.4.6 Waste Disposal Facility

DOE plans to ship the treated, stabilized, and packaged tank waste samples to the Waste Control Specialists (WCS) facility in Texas for disposal.[14] The commercial WCS radioactive waste disposal facility is located in Andrews, Texas on a semi-arid, isolated 1,338-acre site. It is licensed by the State of Texas,[15] Texas Commission on Environmental Quality (TCEQ), for near-surface disposal of Class A, B, and C LLW from Texas Compact waste generators and certain non-compact generators,[16] as well as federal Class A, B, and C LLW and mixed low-level waste. Federal facility waste, which includes LLW owned or generated by DOE, is disposed of in a separate landfill disposal unit at WCS called the Federal Waste Disposal Facility (FWF).

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[13] The sample Hanford tank waste consists of RCRA listed and characteristic waste. Treatment at PFNW will consist of additives to generate a solidified grout matrix that will be designed to immobilize the hazardous constituents such that the waste form will meet the regulatory requirements for disposal at WCS (WRPS 2016).

[14] PFNW will ship the treated and solidified test samples directly to WCS, under a subcontract with DOE's tank waste contractor, Washington River Protection Solutions. PFNW will be the shipper of record. As required by Section I.2.F(4) of DOE Manual 435.1-1, such offsite disposal must be approved by the ORP site manager, and the justification for off-site disposal must be provided to DOE Headquarters. In addition, DOE has consulted with the State of Texas before transport of the treated and solidified test samples to the WCS FWF for disposal.

[15] Texas became an NRC Agreement State in 1963, and as an NRC Agreement State, regulates and licenses certain radioactive materials within its borders, including the disposal of certain LLW. The Texas program is periodically reviewed by the NRC; under the NRC Agreement State Program, NRC evaluates technical licensing and inspection issues from Agreement States, and periodically evaluates State rules for health and safety and compatibility with NRC requirements. Pursuant to applicable law, including Title 30 of the Texas Administrative Code, WCS was issued a license, with conditions, by the Texas Commission on Environmental Quality in 2009 for a federal waste disposal facility. The license was subsequently amended several times.

[16] The Texas compact consists of the states of Texas and Vermont. Waste generators in these states are authorized to dispose of LLW in the WCS Texas Compact disposal facility. The facility is also available for 34 U.S. states that do not have access to a compact disposal facility. Out-of-compact generators must submit a petition to the Texas Compact Commission for approval prior to shipping, and the State of Texas limits the total non-compact waste that may be disposed of at the facility.

A recent change (Amendment 26) to Waste Control Specialists' (WCS's) radioactive materials license was approved by the TCEQ for the WCS FWF. The key change to the license was the removal of the administrative curie limits for technetium-99, iodine-129, and carbon-14.

### 1.4.7 Consultation with the Nuclear Regulatory Commission

DOE Guide 435.1-1, "Implementation Guide for use with DOE Manual 435.1-1," explains that involvement by NRC in WIR evaluations is not required, although consultation with NRC on technical issues is recommended in certain circumstances, where DOE has some question about whether the waste stream is HLW or for waste streams that are expected to be controversial or contentious with other regulators or stakeholders. In DOE's view, such circumstances are not present in this case.

This Test Sample WIR Evaluation concerns a small quantity of waste generated by a laboratory-scale treatment test performed to assess planned pretreatment for certain low-activity waste. DOE conducts treatment tests of this nature in accordance with its authority under the Atomic Energy Act of 1954, as amended, and generally does not consult with the NRC on such tests. This test sample waste stream is not one for which DOE has a question as to whether the waste is HLW or involves a waste stream that is expected to engender controversy or contention with regulators or stakeholders. As demonstrated in this Test Sample WIR Evaluation, the small quantity[17] of test sample, treated and solidified, low-activity waste is well below Class C LLW concentration limits, and meets the requirements for disposal at the WCS FWF in Andrews, Texas. Accordingly, in DOE's view, consultation with the NRC is not warranted under the limited circumstances here.

In the past, DOE has invited the public to review and comment on draft WIR evaluations where DOE had consulted with the NRC and the NRC had conducted consultative reviews. For the reasons stated above, NRC consultation is not indicated here. For similar reasons, DOE has concluded that public review and comment on this Test Sample WIR Evaluation would not be of benefit in this instance and is, therefore, not providing the public with the opportunity to provide review and comment on this draft WIR evaluation.

## 1.5 Organization of this Test Sample WIR Evaluation

Information in the remainder of this draft evaluation is presented as follows:

**Section 2** describes the processes used to generate the tank waste and the origin of the tank waste samples used in this test bed project.

**Section 3** describes DOE Manual 435.1-1 waste incidental to reprocessing waste determination criteria.

**Section 4** describes how key radionuclides have been removed from the tank waste samples to the maximum extent technically and economically practical.

**Section 5** discusses how safety requirements comparable to NRC performance objectives in 10 CFR 61, Subpart C will be met, and how disposal will be in accord with the waste acceptance criteria for the WCS FWF.

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[17] For perspective, this small volume of waste is well below the volumes in the "treatability study samples" exclusion in 40 CFR 261.4(e), promulgated by the Environmental Protection Agency.

**Section 6** explains that the radionuclide concentrations in the packaged and pretreated waste samples will be below Class C LLW concentration limits. Section 6 further explains that the tank waste samples will be managed in accordance with Chapter IV of DOE Manual 435.1-1.

**Section 7** summarizes DOE‘s conclusion that the Test Sample WIR Evaluation demonstrates that the criteria for waste incidental to reprocessing, as set out in Section II.B(2)(a) of Manual 435.1-1, will be satisfied.

**Section 8** identifies the references cited in this Test Sample WIR Evaluation.

**Appendix A** discusses the comparability of DOE, NRC, and State of Texas requirements for LLW disposal.

**Appendix B** discusses the comparability of DOE, NRC, and State of Texas radiation dose standards.

**Appendix C** discusses the criteria in Section 3116 of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005.

# 2. Background

**Section Purpose**

The purpose of this section is to provide detailed background information to support the discussions in the sections that follow.

**Section Contents**

This section describes the spent nuclear fuel reprocessing, the contents of the underground waste storage tanks at the conclusion of reprocessing, the sources of the tank waste samples at issue in this Test Sample WIR Evaluation, radiological characterization of the wastes, and the waste management plans.

**Key Points**

- Several processes were used at Hanford to isolate plutonium from spent nuclear fuel and nuclear targets.
- Reprocessing liquids were sent to 177 underground storage tanks located on the Hanford Central Plateau.
- The test samples were treated in the 222-S Laboratory to remove key radionuclides to the maximum extent technically and economically practical, using physical and chemical treatment through decanting, filtration, and two ion exchange resin columns.
- After treatment in the 222-S Laboratory, the waste was characterized and will be shipped to an offsite commercial treatment facility, PFNW, for treatment (stabilization) in a grout matrix to meet RCRA Land Disposal Restriction limits.
- The solidification will stabilize the waste in a solid form for disposal in an offsite disposal facility, the WCS FWF in Andrews, Texas.

## 2.1 Introduction

This section establishes the context for the evaluations of the tank waste test samples that are described in Sections 4, 5, and 6 by providing the following information:

Section 2.2 provides a brief review of nuclear fuel reprocessing conducted at the Hanford site.

Section 2.3 provides summary information on the tank waste inventory.

Section 2.4 summarizes how the tank waste test samples were pretreated, and will be solidified and disposed.

The descriptions of prior reprocessing activities, the BBI, and the LAWPS are provided here solely for information purposes and are not being evaluated in this Test Sample WIR Evaluation. This Test Sample WIR Evaluation only concerns approximately five (5) gallons of test samples of low-activity waste from six Hanford tanks.

## 2.2 Spent Nuclear Fuel Reprocessing

The waste for this tank waste test bed project resulted in part from prior spent nuclear fuel and reprocessing through several processes at Hanford, as explained previously in this Test Sample WIR Evaluation. The primary actinide separations processes at Hanford were Bismuth-phosphate precipitation, REDOX and PUREX. The actinide separations processes generally used batch processing steps to dissolve the fuel cladding of the irradiated fuel and subsequently, to dissolve the fuel itself. Similarly, the targets were dissolved and processed. Then, both uranium and plutonium were recovered in precipitation or continuous solvent extraction processes. Following initial separation, the uranium-bearing and plutonium-bearing solutions underwent additional purification.

### 2.2.1 The Basic Process

Reprocessing operations were conducted in several facilities. The first step in reprocessing operations involved disassembling fuel assemblies and chopping them into pieces. The small pieces of fuel were transported to vessels where they were dissolved in concentrated nitric acid, which transformed them into an aqueous stream containing uranium nitrate, plutonium nitrate, and fission products.

The largest volume of waste remaining from the normal operation of the plant for reprocessing fuel contained the fission products and was neutralized by the addition of sodium hydroxide prior to transfer to the tank farms. Neutralizing the initially acidic liquid waste prior to transfer caused most of the fission product elements to precipitate out and form sludge at the bottom of the tanks. Therefore, the liquid waste was not homogeneous, but was comprised of supernatant (liquid), and sludge (solids at the bottom of the tank). To conserve storage capacity, the supernatant liquid was boiled down and concentrated in evaporators. The liquids and solids from reprocessing and from the evaporators were transferred to underground storage tanks, located in 18 tank farms (groups of tanks are called “tank farms”) which contain a total of 177 tanks. An example of a tank farm under construction is shown in Figure 2.1. Following construction of the tank farm, soil is replaced to completely cover the tops of the tanks. The tank tops are at varying depths from the surface but average approximately 12 feet, with access to the tank contents via pipes (risers) that connect from the tank top to the ground surface.

**Figure 2-1 Tank Farm Under Construction**

### 2.2.2 Contents of the Waste Storage Tanks

The acidic liquids from reprocessing were neutralized with sodium hydroxide in order to protect the integrity of the carbon steel tank liners. Unlike stainless steel, carbon steel corrodes quickly in the presence of acids and therefore neutralization was imperative, even though this created waste that would be more difficult waste to manage in the future.

The wastes generated from the individual separations processes have been extensively co-mingled over the years. Waste types were historically mixed, based on compatible chemistry, to accommodate actinide recovery processing. More recently, retrieval of wastes from the Single Shell Tanks (SSTs) into the Double Shell Tanks (DSTs) has continued the co-mingling of waste across tank farms.

Information on the contents of the tanks is maintained in a database, the BBI that is based on analytical data from samples and process knowledge. The BBI is documented in the Tank Waste Information Network System (TWINS) maintained by the Pacific Northwest National Laboratory (PNNL) and can be found on this publicly-available webpage, https://twinsweb.labworks.org/twinsdata/Forms/About.aspx?subject=TWINS.

For this Test Sample WIR Evaluation, DOE pretreated a small volume of test samples (approximately 5 gallons, total) to remove key radionuclides to the maximum extent technically and economically practical, and plans to solidify and transport the treated waste for disposal at an off-site LLW disposal facility, the WCS FWF.

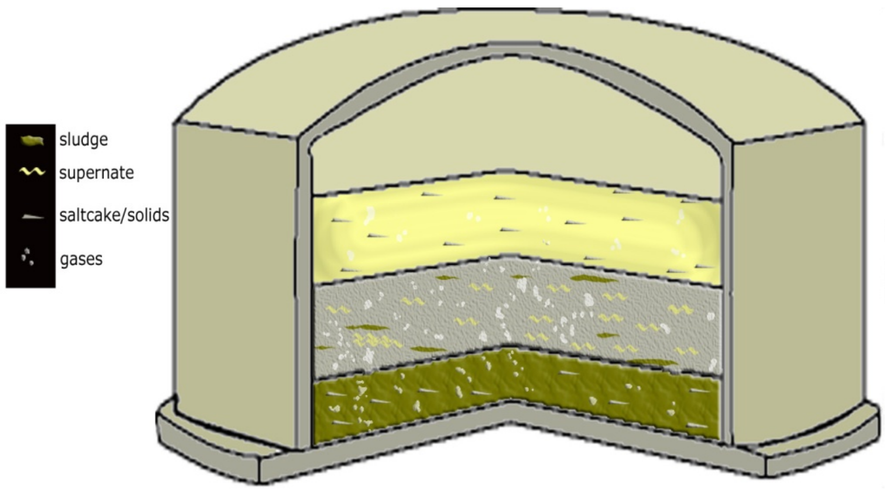


**Figure 2-2. Tank Waste Phases in BBI**

## 2.3 The Tank Waste Inventories from the Best Basis Inventory

Inventory estimates are available for individual waste phases and for all the waste in a tank. The waste phases are: supernatant, saltcake and sludge. For SSTs[18] and DSTs, volumes of supernatant, saltcake, and sludge is updated monthly and published on the web page.

Inventory for each standard BBI analyte (24 chemicals and 46 radionuclides) are provided for every waste phase. Inventories for up to 112 supplemental BBI analytes are included only when sample data are available for all waste phases in a tank or when process knowledge values can be calculated from combined sample results. The standard analytes account for approximately 99-weight percent (wt%) of the chemical inventory (not including percent water, free hydroxide, bound hydroxide or oxygen associated with metallic oxides) and the radionuclides account for over 99 percent of the activity (in curies (Ci)), in terms of short and long-term risk (WHC-SD-WM-TI-731, *Predominant Radionuclides in Hanford Site Waste Tanks*).

[18] Single-shell tanks are tanks without secondary containment to capture potential leaks. The initial underground waste storage tanks constructed at Hanford were single-shell tanks. Double-shell tanks are newer tanks and have secondary containment — essentially a tank-in-a-tank.

## 2.4 Test Sample Treatment, Solidification and Disposal

In general, the waste samples covered by this Test Sample WIR Evaluation will undergo the same processes that have been planned for the pretreatment of the LAW in the LAWPS, as part of preparing waste for treatment at the WTP at Hanford. At the LAWPS, the initial step in the pretreatment will be dilution with water to achieve approximately 5-molar sodium ion concentration. This step will prepare the feed for subsequent processing and result in a more uniform feed and therefore more uniform results from treatment. Supernatant will often be decanted off the solids (either saltcake or sludge), in order to create a uniform feed. The radionuclides remaining in the supernatant are primarily the soluble radionuclides; the insoluble radionuclides remain in the sludge in the tank. For example, essentially all the Cs-137 is in the supernatant; the high concentration of Cs in the supernatant provides the highest dose. Cs-137 is a short-lived radionuclide, and when it is in high enough concentrations it can impact worker safety, which is why it is removed through a separations process in a shielded area, prior to solidification in a final waste form. Once the treated waste is in final waste form with Cs-137 removed, workers can handle the waste packages, safely.

With respect to this Test Sample WIR Evaluation, the test samples have been decanted (liquids were withdrawn from the test samples without disturbing the sediment or lower liquid layer, in order to separate out any solids); that is, the original test samples were waste decanted from the underground storage tanks prior to storing the samples in sample jars.

The third pretreatment step was filtration. This step separated the liquid from the remaining solid fraction. Following filtration, no visibly detectible solids were present and the majority of the radionuclides present in the resulting liquid were those radionuclides that are partially or completely soluble, including Cs-137 and Tc-99.

Following filtration, the liquids in the test samples were processed through a series of two Spherical Resorcinol-Formaldehyde Resin (sRF) ion exchange columns to remove Cs-137. This treatment protocol is described below and shown in Figure 2-3 (NOTE: this is the actual laboratory apparatus used in the test bed project that was assembled outside of the 222-S Laboratory hot cell and later placed inside the hot cell for the sRF ion exchange pretreatment).

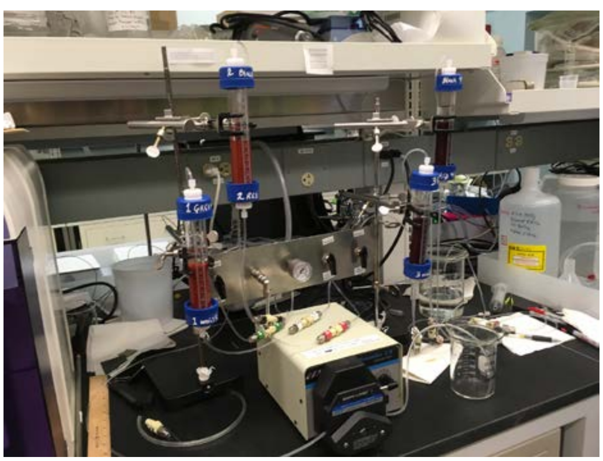

**Figure 2-3. Spherical Resorcinol-Formaldehyde Ion Exchange Columns**

The system consisted of two small columns containing the ion exchange material, a small metering pump, valves, and necessary gauges and/or meters. This resin and the two-column process were used to gain additional resin performance information for the LAWPS. Two small columns were used in order to replicate configuration of the LAWPS process, enabling a better understanding of the performance of the resin to be used in the LAWPS. The two-column configuration is typical of past testing practices and accomplishes both objectives of obtaining lead column performance information while the lag column fully decontaminates the sample for subsequent use. This configuration ensures that only low-activity waste is included in the final waste stream.

Following pretreatment in the 11A Hot Cells at the 222-S Laboratory, the low activity portion of the pretreated waste was packaged in one-liter plastic liquid waste containers in preparation for shipment to PFNW, located adjacent to the Hanford Site, for treatment into a solid physical form to meet RCRA land disposal requirements. The radionuclide inventory and physical characteristics of the supernatant meets the DOT definition for Low Specific Activity materials. The individual one-liter containers have been overpacked into a drum following ATS-LO-100-153 "222-S Laboratory Waste Packaging and Preparation for Shipment", with appropriate absorption pads and padding necessary for this configuration.

PFNW has completed the RCRA notification to the Washington State Department of Ecology of the plan to perform the treatment. PFNW will perform analysis and testing on simulants and a small portion of actual waste to develop a treatment formulation, and will conduct the treatment to ensure the final solid waste meets RCRA Land Disposal Restriction limits and the waste acceptance requirements of the WCS FWF. PFNW will ship the waste to the WCS FWF for disposal as LLW.[19]

### 2.4.1 Waste Characterization

Waste characterization is performed at several different points throughout the process. In order to assess the validity of the assumptions regarding the efficacy of the filtration process (in order to provide additional data points to support LAWPS planning), unfiltered and filtered liquids have been characterized. Because this waste was decanted, little precipitate was expected, although some non-radioactive salts did form upon combining the subsamples.

Following pretreatment with the ion exchange column, the liquids were characterized to verify that Cs had been removed prior to shipping to PFNW. If any portion of the treated waste had not been fully decontaminated based on the treatment protocol, it would have remain in the hot cell at 222-S Laboratory and would not be shipped to PFNW.

PFNW will characterize the treated, solidified waste to ensure it meets the WCS FWF requirements and to support waste profile documentation. This characterization data will be provided to WCS.

### 2.4.2 Waste Solidification and Disposal

Due to the small quantities of waste in this test bed project, the waste will be mixed with a grout matrix at existing facilities at PFNW – no new equipment or containers will be used for the material. Once characterized and demonstrated to meet the acceptance criteria in the WCS *Federal Waste Facility (FWF) Generator Handbook* (WCS 2015), the waste will be drummed and shipped in accordance with DOT requirements to the WCS facility in Andrews, Texas, for disposal in the WCS FWF. Required documentation will be provided to DOE upon emplacement of the waste.[20]

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[19] The pretreated test samples have been characterized for RCRA constituents following pretreatment in the 222-S Laboratory, prior to shipment to PFNW. Currently information indicates that the test samples will be mixed LLW.

[20] As required by DOE disposal contracts, commercial disposal facilities must provide documentation confirming the disposal of shipped waste and provides validation that it conforms with requirements of that facility.

# 3. Waste Determination Criteria

**Section Purpose**

The purpose of this section is to describe the criteria applicable to this Test Sample WIR Evaluation.

**Section Contents**

This section provides brief background information on Department of Energy criteria that apply to this Test Sample WIR Evaluation, providing additional details on this matter beyond that provided in Section 1.

**Key Points**

Applicable criteria appear in Section II.B(2)(a) of the Department of Energy Manual 435.1-1, *Radioactive Waste Management Manual*.

## 3.1 Waste Determination Criteria Background

Section II. B (2)(a) of DOE Manual 435.1-1, Chg. 2, sets forth criteria, using the evaluation method, to determine whether waste from reprocessing is incidental to reprocessing, is not HLW, and may be managed as other than HLW.

## 3.2 Applicable Waste Determination Criteria

Section I.1.C of DOE Manual 435.1-1, Chg. 2 provides that all radioactive waste subject to DOE Order 435.1 shall be managed as HLW, transuranic (TRU) waste, LLW, or mixed LLW. DOE Manual 435.1-1Chg 2, Section II.B, also states, in relevant part, that waste resulting from the reprocessing of spent nuclear fuel (SNF) which is determined to be incidental to reprocessing is not HLW, and shall be managed in accordance with the requirements for LLW. The determination that waste is incidental to spent nuclear fuel reprocessing, and therefore not HLW, is called a "waste incidental to reprocessing determination," which is also referred to in this evaluation as a WIR determination.

DOE Manual 435.1-1 Chg 2, Section II.B(2)(a), lists, in relevant part, three criteria to demonstrate, using the evaluation method, that wastes resulting from SNF reprocessing are not HLW and may be managed as LLW:

(1) Criterion 1 – the wastes have been processed, or will be processed, to remove key radionuclides to the maximum extent that is technically and economically practical;

(2) Criterion 2 – the wastes will be managed to meet safety requirements comparable to the performance objectives set out in 10 CFR Part 61, Subpart C, Performance Objectives; and

(3) Criterion 3 – the wastes are to be managed, pursuant to DOE's authority under the Atomic Energy Act of 1954, as amended, and in accordance with the provisions of Chapter IV of DOE Manual 435.1-1, provided the waste will be incorporated in a solid physical form at a concentration that does not exceed the applicable concentration limits for Class C low-level waste as set out in 10 CFR 61.55, *Waste Classification*.[21]

As demonstrated in the next three sections of this Test Sample WIR Evaluation, DOE has evaluated the waste samples against these criteria, and, for the reasons presented, concludes that the samples, after

[21] DOE is not authorizing or applying alternative requirements for waste classification and characterization in this Test Sample WIR.

treatment and solidification, will meet the applicable criteria and can be managed and disposed of as LLW.

# 4. Criterion 1: The Waste Has Been Processed To Remove Key Radionuclides To The Maximum Extent That Is Technically And Economically Practical

**Section Purpose**

The purpose of this section is to evaluate whether the test samples have been treated to remove key radionuclides to the maximum extent that is technically and economically practical.

**Section Contents**

This section summarizes the radionuclides in the test samples prior to treatment in the 222-S Laboratory, identifies the key radionuclides and describes the process used in determining the key radionuclides. It then describes the technical and economic practicality evaluations that have been performed for the removal of key radionuclides, and their results.

**Key Points**

- The evaluation shows that key radionuclides have been removed from the test samples to the maximum extent that is technically and economically practical.
- The key radionuclides in the test sample wastes are those long-lived and short-lived radionuclides listed in Tables 1 and 2 of the Nuclear Regulatory Commission's regulations in 10 CFR 61.55 and the Texas Administrative Code, and those radionuclides which are important to the most recent performance assessment for the WCS FWF.
- Evaluation of potential methods of removing key radionuclides showed that decanting, filtration to remove any undissolved radionuclides, and ion exchange to remove Cs-137 are the most technically practical methods to remove key radionuclides from this waste.
- Treatment of the decanted test samples, using filtration and ion exchange, has removed approximately 99.9% of the Cs-137 as well as other key radionuclides in the test samples. Further treatment to remove key radionuclides would not be technically practical.
- The economic practicality assessment evaluated additional treatment and concluded that additional treatment would not have been economically practical.

## 4.1 Introduction

This section describes the key radionuclides and evaluations of technologies used to remove them from the test sample waste. This section also demonstrates the first criteria in DOE M 435.1-1, removal of these key radionuclides to the maximum extent technically and economically practical through the following:

Section 4.2 provides a summary of the key radionuclides in the test samples.

Section 4.3 describes the treatment methods that were considered and used, and the removal of key radionuclides to maximum extent technically and economically practical.

Section 4.4 summarizes the conclusions that the key radionuclides have been removed to meet the first criterion.

## 4.2 Key Radionuclides

This section begins with a brief introduction that describes the various factors considered, provides additional information on these factors, discusses their relevance to key radionuclide identification, and concludes with the identification of key radionuclides for this Test Sample WIR Evaluation.

### 4.2.1 Introduction

The key radionuclides in this Test Sample WIR Evaluation are based on consideration of the following information:

- Radionuclides known to be present in the test samples;
- Guidance in DOE Guide 435.1-1 on identification of key radionuclides;
- NRC requirements and radionuclide concentrations for classification of low-level radioactive waste for near-surface disposal, that appear in 10 CFR 61.55 and are mirrored in the Texas Administrative Code;
- Radionuclides important to meeting the performance objectives in 10 CFR Part 61, Subpart C and the Texas Administrative Code, based on the radionuclides of importance in the performance assessment for the WCS FWF
- The relationship between the waste acceptance criteria for the WCS FWF and the performance of the WCS FWF in meeting the performance objectives in the Texas Administrative Code, which are comparable to the NRC performance objectives in 10 CFR Part 61, Subpart C

Consideration of this information will ensure that those radionuclides in the test samples that could contribute significantly to radiological risks to workers, the public, and the environment are identified and taken into account.

### 4.2.2 DOE Guidance on Key Radionuclides

To identify which radionuclides in the test samples are "key radionuclides", DOE guidance is provided in Section II.B of DOE Guide 435.1-1, *Implementation Guide for Use with DOE M 435.1-1*. The applicable portion reads as follows:

> "... it is generally understood that [the term] key radionuclides applies to those radionuclides that are controlled by concentration limits in 10 CFR 61.55. Specifically these are: long-lived radionuclides, C-14, Ni-59, Nb-94, Tc-99, I-129, Pu-241, Cm-242, and alpha emitting transuranic nuclides with half-lives greater than five years and; short-lived radionuclides, H-3, Co-60, Ni-63, Sr-90, and Cs-137. In addition, key radionuclides are those that are important to satisfying the performance objectives of 10 CFR Part 61, Subpart C [for near-surface radioactive waste disposal facilities]."

This guidance considers both the waste classification requirements in 10 CFR 61.55[22] for radioactive waste destined for near-surface disposal and achieving the waste disposal site performance objectives.

[22] Title 30 of the Texas Administrative Code has similar requirements (Rule §336.362, Appendix E).

### 4.2.3 Requirements of 10 CFR 61.55 and Texas Administrative Code

The radionuclides listed in DOE Guide 435.1 appear in 10 CFR 61.55 in the form of two tables, which are reproduced here as follows.

**Table 4-1 10 CFR Part 61.55, Table 1 (Long-Lived Radionuclides)**

| **Radionuclides** | **Concentration (Ci/m$^3$)** |
|---|---|
| C–14 | 8 |
| C–14 in activated metal | 80 |
| Ni–59 in activated metal | 220 |
| Nb–94 in activated metal | 0.2 |
| Tc–99 | 3 |
| I–129 | 0.08 |
| Alpha Emitting Transuranic (TRU) nuclides with half-life greater than 5 years | 100$^{(1)}$ |
| Pu–241 | 3,500$^{(1)}$ |
| Cm–242 | 20,000$^{(1)}$ |

NOTE: (1) These values are in units of nanocuries per gram.

**Table 4-2 10 CFR Part 61.55, Table 2 (Short-Lived Radionuclides)**

| **Radionuclides** | **Concentration (Ci/m$^3$)** | | |
|---|---|---|---|
| | **Column 1 [Class A]** | **Column 2 [Class B]** | **Column 3 [Class C]** |
| Total of all nuclides with less than 5 year half-life | 700 | $^{(1)}$ | $^{(1)}$ |
| H-3 | 40 | $^{(1)}$ | $^{(1)}$ |
| Co-60 | 700 | $^{(1)}$ | $^{(1)}$ |
| Ni-63 | 3.5 | 70 | 700 |
| Ni-63 in activated metal | 35 | 700 | 7000 |
| Sr-90 | .04 | 150 | 7000 |
| Cs-137 | 1 | 44 | 4600 |

NOTE: (1) There are no limits established for these radionuclides in Class B or C wastes. Practical considerations such as the effects of external radiation and internal heat generation on transportation, handling, and disposal will limit the concentrations for these wastes. These wastes shall be Class B unless the concentrations of other nuclides in the table determine the waste to be Class C independent of these nuclides.

The concentrations given in these tables are used for waste classification purposes. Classification is determined by concentrations of long-lived radionuclides, by concentrations of short-lived radionuclides, or by both in those cases where the waste contains both types of radionuclides. The tables in the Texas Administrative Code mirror the 10 CFR 61.55 tables (Rule §336.362, Appendix E, Tables I and II).

The tank waste samples contain a mixture of both long-lived and short-lived radionuclides. .As discussed further in Section 6 of this Test Sample WIR Evaluation, the classification requirements of 10 CFR 61.55 for waste containing both long-lived and short-lived radionuclides are as follows:

(1) If the concentration of a nuclide listed in Table 1 does not exceed 0.1 times the value listed in Table 1, the class shall be that determined by the concentration of nuclides listed in Table 2.

(2) If the concentration of a nuclide listed in Table 1 exceeds 0.1 times the value listed in Table 1 but does not exceed the value in Table 1, the waste shall be Class C, provided the concentration of nuclides listed in Table 2 does not exceed the value shown in Column 3 of Table 2.

For mixtures of radionuclides, 10 CFR 61.55 specifies that the sum of fractions rule will be used in determining waste classification. This rule entails dividing each radionuclide‘s concentration by the appropriate limit, adding the resulting fractions, and comparing their sum to 1.0. A sum of fractions less than 1.0 indicates compliance of the radionuclide mixture with the relevant classification criteria.

### 4.2.4 Radionuclides Important to the Disposal Site Performance Assessment

DOE Guide 435.1-1 indicates that one consideration for determining key radionuclides is their importance in satisfying safety requirements comparable to the performance objectives at 10 CFR Part 61, Subpart C for the waste disposal facility. The Texas Administrative Code in Rules §§336.723-727 sets forth performance objectives for LLW disposal facilities, which mirror the NRC performance objectives in 10 CFR Part 61, Subpart C, as further discussed in Section 5.2 and Appendix C of this Test Sample WIR Evaluation. These performance objectives are discussed in further detail in Section 5.2.2 of this Test Sample WIR Evaluation.

Because meeting the waste acceptance criteria for a given disposal facility ensures that the facility performance objectives will be achieved, those radionuclides that are of particular importance in the disposal site performance analyses are considered in identifying key radionuclides.[23] The WCS performance assessment is discussed further in Section 5.2. For the WCS FWF, the most recent, updated performance assessment, titled *Radioactive Material License No. CN600616890/RN101702439 2015 Updated Performance Assessment for the WCS Disposal Facilities* (WCS 2015), at Table 3-2, shows that the following radionuclides are important to meeting the performance objectives: Kr-85, C-14, Tc-99, U-238, Rn-222, I-129, and Cs-137.These are the same radionuclides listed in Table 1 and 2 of the NRC regulations at 10 CFR 61.55, except for the addition of Kr-85 and U-238. Krypton-85 is not present in the test samples.

DOE also considers any license limits on specific radionuclides when identifying key radionuclides. The WCS LLW land disposal facility is licensed under Radioactive Material License No. 600616890, as amended, issued by the Texas Commission on Environmental Quality (TCEQ). The license contains total

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[23] Facility performance objectives must be met and following the criteria in the WCS FWF Generator Handbook ensures that compliance is achieved. The rationale for this conclusion for the WCS FWF may be briefly summarized as follows:

- Texas performance objectives for its LLW disposal facilities are comparable to those of 10 CFR 61, Subpart C;
- Disposal site performance in compliance with the performance objectives is determined by a performance assessment of the facility;
- This analysis is based on a projected total radionuclide inventory for the full, closed disposal site;
- This projected total inventory is based on the waste acceptance criteria, thus linking these criteria directly to the calculated disposal site performance;
- The treated and solidified test samples will meet the waste acceptance criteria, as set forth in the *WCS Federal Waste Facility (FWF) Generator Handbook* (WCS 2015); and
- Meeting the waste acceptance criteria will therefore ensure that the performance objectives will be achieved, because waste meeting these criteria would not increase the assumed waste inventory used in the performance assessment analyses.

These matters are addressed in more detail in Section 5.2. Appendix B shows that the State of Texas performance objectives in Texas Administrative Code, Title 30, Part 1, Chapter 336, Subchapter H, Rules §336.723-727 are comparable to the NRC performance objectives.

volume and curie limits for the FWF. However, the license, as amended by Amendment 26 (August 28, 2014) no longer contains limits for Tc-99, I-129 and C-14, or any other specific radionuclides, for disposal in the FWF.

### 4.2.5 Conclusions About Key Radionuclides in the Test Samples

DOE considers all radionuclides listed in Tables 1 and 2 of 10 CFR 61.55 (corresponding to Texas Rule §336.362, Appendix E, Tables I and II) to be key radionuclides for the purposes of this Test Sample WIR Evaluation, with the caveat that some are of lesser importance due to their low concentrations in the waste, their small dose conversion factors, or both. DOE also considers all radionuclides to be key radionuclides that, as shown by the WCS performance assessment, are important to meeting the performance objectives set forth in 10 CFR Part 61, Subpart C and Texas Administrative Code Rules §§336.723-727. Table 4-3 shows these radionuclides.

**Table 4-3. Key Radionuclides in the Test Samples**

| Radionuclide | 10 CFR 61.55 Long-Lived Radionuclides | 10 CFR 61.55 Short-Lived Radionuclides | Radionuclides Important to WCS PA |
|---|---|---|---|
| H-3 | | X | |
| C-14 | X | | |
| Co-60 | | X | |
| Ni-59 | X | | |
| Ni-63 | | X | |
| Sr-90 | | X | |
| Nb-94 | X | | |
| Tc-99 | X | | |
| I-129 | X | | |
| Cs-137 | | X | X |
| Th-229 | | | X |
| U-233 | | | X |
| U-234 | | | X |
| U-238 | | | X |
| Np-237(1) | X | | |
| Pu-238(1) | X | | |
| Pu-239(1) | X | | |
| Pu-240(1) | X | | |
| Pu-241 | X | | |
| Pu-242(1) | X | | |
| Am-241(1) | X | | |
| Am-243 | X | | |
| Cm-242 | X | | |
| Cm-243(1) | X | | |
| Cm-244(1) | X | | |

NOTE: (1) Alpha emitting transuranic radionuclides with half-life greater than five years (NRC 1982, Table 4.2).

## 4.3 Removal to the Maximum Extent Technically and Economically Practical

Removal to the maximum extent "technically and economically practical" is not removal to the extent "practicable" or theoretically "possible." Nor does the criterion connote removal which may be notionally capable of being done. Rather, the adverbs "technically" and "economically" modify and add important context to that which is contemplated by the criterion. Moreover, a "practical" approach as specified in the criterion is one that is "adapted to actual conditions" (Fowler 1930); "adapted or designed for actual use" (Random House 1997); "useful" (Random House 1997); selected "mindful of the results, usefulness, advantages or disadvantages, etc., of [the] action or procedure" (Random House 1997); fitted to "the needs of a particular situation in a helpful way" (Cambridge 2004); "effective or suitable" (Cambridge 2004). Therefore, the evaluation as to whether a particular key radionuclide has been or will be removed to the "maximum extent that is technically and economically practical" will vary from situation to situation, based not only on reasonably available technologies but also on the overall costs and benefits of deploying a technology with respect to a particular waste stream. The "maximum extent that is technically and economically practical" standard contemplates, among other things: consideration of expert judgment and opinion; environmental, health, timing, or other exigencies; the risks and benefits to public health, safety, and the environment arising from further radionuclide removal as compared with countervailing considerations that may ensue from not removing or delaying removal; life cycle costs; net social value; the cost (monetary as well as environmental and human health and safety costs) per curie removed; radiological removal efficiency; the point at which removal costs increase significantly in relationship to removal efficiency; the service life of equipment; the reasonable availability of proven technologies; the limitations of such technologies; the usefulness of such technologies; and the sensibleness of using such technologies. What may be removal to the maximum extent technically and economically practical in a particular situation or at one point in time may not be that which is technically and economically practical, feasible, or sensible in another situation or at a prior or later point in time. In this regard, it may not be technically and economically practical to undertake further removal of certain radionuclides because further removal is not sensible or useful in light of the overall benefit to human health and the environment.

### 4.3.1 Technical Practicality Assessment

Key radionuclides have been removed from the waste in the test samples through a series of steps. As a preliminary matter (or initial step), the test samples were retrieved from only the lower-activity supernate in the tanks, which is the liquid layer (not saltcake or sludge layers) in the tanks. The supernate contains primarily short-lived radionuclides such as Cs-137; those short-lived radionuclides emit radiation which, absent shielding or controls, may harm humans simply by proximity without inhalation or ingestion, but which decay in a relatively short time. (For example, the approximate half-life of Cs-137 is a little over 30 years.). The supernate contains relatively low amounts of long-lived radionuclides; [24] rather, as explained previously in this Test Sample WIR Evaluation, the longer-lived radionuclides tend to be entrained in the saltcake and sludge in the tanks, due to precipitation within the tanks. Having limited the test samples to only lower-activity supernate, ensures that the majority of longer-lived radionuclides are separated from, and not included in, the test samples.

The test samples were pretreated in the 222-S Laboratory (WRPS 2016) using the same processes planned for the pretreatment process at the LAWPS, currently being designed at the Hanford Site. Specifically, in the 222-S Laboratory, the test samples were:

- Decanted, to separate out solids in which insoluble, long-lived actinides tend to be entrained.

- Filtered, to remove any remaining insoluble solids. Following filtration, no visibly detectible solids were present and the majority of the radionuclides present in the resulting liquid were

[24] The long-lived, insoluble actinides are entrained primarily in the sludge, the bottom layer of the tank waste. Those long-lived radionuclides persist well into the future, and pose a risk to humans if inhaled or ingested.

those radionuclides that are partially or completely soluble, including Cs-137, Sr-90, Tc-99, I-129. The majority of the Sr-90 was removed by decanting and filtration.

- Passed through a series of two Spherical Resorcinol-Formaldehyde Resin (sRF) ion exchange columns, to remove Cs-137.

The sRF ion exchange pretreatment used in the 222-S test bed project is shown in Figure 2-3, and is described below, as well as in Section 2 of this Test Sample WIR Evaluation. As explained in more detail in Section 2, the system consists of two small columns containing the sRF ion exchange resin. In order to prevent Cs-137 from re-entering into the treated waste, the second column was used as a back-up treatment to identify the point of breakthrough of the lead (first) column (when the resin can no longer absorb additional Cs) in the test bed. It ensures that only low-activity waste is released for packaging and shipping. The use of 2 columns is also planned for the LAWPS and these columns were specifically sized to find the breakthrough point to assist the finalizing the LAWPS design. However, this column arrangement did not achieve breakthrough, which by itself was helpful because it provided valuable information on the Cs capture capabilities of sRF resin and showed that the capture of Cs on the sRF resin exceeded expectation.

The above approach – decanting, filtration, and sRF ion exchange -- is the same approach planned for use for pretreatment of LAW in the LAWPS. Consistent with guidance in DOE Guide 435.1-1, Chapter 2, the following discussion summarizes the process and basis for DOE's selection of the technology approach for the LAWPS. The technology approach for LAWPS was selected through a series of rigorous technology evaluations performed during the development of LAWPS. These potential technologies were identified at other DOE facilities and/or similar efforts conducted internationally (such as the Sellafield facility in the United Kingdom).

The pretreatment technologies were initially evaluated in the 1996 Technical Basis Summary report (WHC-SD-WM-TI-699). This evaluation narrowed the technology options to the choice in the second column of Table 4-4. In subsequent years, the technologies chosen were re-evaluated in 2002 and 2014 as shown in the right 2 columns in the same table.

The sRF resin provided the best safety basis due to (1) the ability to remove the Cs-137 with elution and radiolysis gases with fluidization and (2) the low risk of plugging due to the restoration steps periodically removing any potential solids accumulation (TOC-WP-14-1371). The 2014 review concluded, as in previous studies, that ion exchange using sRF is the best technology for removal of cesium for the tank waste with the LAWPS because:

(1) It will afford the lowest risk of unsuccessful project execution relative to other ion exchange options,

(2) It will have the lowest processing and disposal costs compared to other ion exchange options by a wide margin,

(3) It will have equal or better safety basis considerations compared to other ion exchange options.

(4) It ranked substantially higher in previous reviews than fractional crystallization and caustic side solvent extraction and there have been no improvements in other treatment technologies that would change the relative rankings.

Technologies that ranked the highest, considering a combination of criteria (including effectiveness at removing radionuclides, prior successful use at other facilities, and potential safety or environmental risks), were selected for the LAWPS. The basis for the selection of each of the preferred technologies is summarized in Table 4-4.

**Table 4-4 Low Activity Waste Separations Technologies Evaluated for WTP[a]**

| Treatment Function | 1996 Technology[a] | Candidates for Improved Technologies[b] | Selected Technology | |
|---|---|---|---|---|
| | | | 2002[b] | 2014[c] |
| Solids removal | Settling, decanting, and sludge washing with sodium hydroxide | • Ultrafiltration<br>• Deep bed filtration<br>• Centrifugation<br>• Pressure precoat filtration<br>• Sedimentation (tank farm or Pretreatment Facility) | Ultrafiltration | Ultrafiltration |
| Cesium removal | Single-stage ion exchange using Duolite CS-100, resorcinol formaldehyde, granular potassium cobalt hexacyanoferrate, crystalline silicotitanante, or Superlig® 644 | • Single use ion-exchanger<br>• Regenerable ion-exchanger<br>• Solvent extraction<br>• Ferrocyanide precipitation<br>• Crystallization<br>• Tetraphenyl borate precipitation | Regenerable ion-exchange using Superlig® 644 resin | Multi-stage regenerable ion-exchange using spherical resorcinol formaldehyde resin |
| Strontium removal | Some soluble Sr-90 precipitation during hydroxide adjustment process (Additional efforts to remove Sr not economically feasible) | • Isotopic Dilution<br>• Single-use ion-exchanger<br>• Regenerable ion-exchanger<br>• Activated carbon adsorption<br>• Titania adsorption | Isotopic dilution with strontium nitrate (for Envelope C[25] wastes only) | Isotopic dilution with strontium nitrate (for Envelope C wastes only) |
| Transuranic element removal | Treat liquid fraction by hydroxide adjustments | • Decomplexation/ adsorption<br>• Solvent extraction<br>• Ferric floc precipitation<br>• Activated carbon<br>• Adsorption | Decomplexation/ adsorption using sodium permanganate (for Envelope C wastes only) | Decomplexation/ adsorption using sodium hydroxide and sodium permanganate (for Envelope C wastes only |

[a]From the 1996 technical basis report (WHC-SD-WM-TI-699)
[b]From Carreon 2002.
[c]From the TC&WM EIS (DOE 2012).

When compared to the NRC concentration limits for Class C LLW (reproduced in Tables 4-1 and 4-2 of this Test Sample WIR Evaluation), the initial concentrations of the majority of key radionuclides were so low (prior to pretreatment in the 222-S Laboratory) that they already were a slight fraction of the NRC

[25] Envelope C wastes refer to "Complex Concentrate" wastes that contain high amounts of organic complexants that cause high soluble 90Sr concentrations. The samples selected for this test program are not categorized as Envelope C.

Class C concentration limits (Kosson 2008).[26] The heavier, nonsoluble radionuclides, such as the majority of the actinides, remained in the sludge layer at the bottom of the tanks and the supernate contained primarily soluble radionuclides. The decanting and filtering was sufficient to remove the long-term risk to the public from these tank wastes. However, soluble radionuclide with short half-lives, of which Cs-137 is an example, pose the majority of the risk to the workers because they can be exposed to radioactivity during handling of the waste. Once these wastes are decontaminated to a level sufficient to enable safe handling, the risk to the workers is very low. Therefore, the removal of Cs-137 (following decanting and filtration) was required to protect the workers outside of the hot cells that will be managing the waste throughout the solidification and disposal steps. There was little radioactivity remaining in the treated waste samples, compared to the waste in the tanks, as shown in Table 4-5. As explained more fully below, the majority of the Cs-137 was removed through treatment in the ion exchange column.

**Table 4-5 Concentration of Key Radionuclides Following Pretreatment of the Test Samples[27]**

| Isotope | Concentration in Tanks (Ci/L) | Sample Concentration after pretreatment (Ci/L) |
|---|---|---|
| H-3 | 1.36E-02 | 1.36E-03 |
| C-14 | 1.23E-03 | 5.76E-04 |
| Co-60 | 2.81E-02 | 9.52E-04 |
| Ni-59 | | 5.0x10-4 |
| Ni-63 | 7.29E-01 | 1.99E-02 |
| Sr-90 | 6.97E+02 | 7.40E-02 |
| Nb-94 | * | * |
| Tc-99 | 5.36E-02 | 4.55E-02 |
| I-129 | 2.36E-04 | 1.22E-04 |
| Cs-137 | 1.00E+02 | 1.73E-04 |
| Th-229 | 1.02E-04 | * |
| U-233 | 4.15E-02 | * |
| U-234 | 4.01E-03 | * |
| U-235 | 1.43E-04 | 1.41E-06 |
| Np-237 | 7.16E-04 | 5.41E-06 |
| Pu-238 | 7.63E-02 | 9.92E-05 |
| U-238 | 3.29E-03 | 8.71E-06 |
| Pu-239 | 1.46E+00 | 1.20E-03 |
| Am-241 | 2.87E+00 | 1.68E-05 |
| Pu-241 | 1.26E+00 | 8.21E-04 |

[26] The short-lived radionuclides that carry risk in these waste samples are those associated with Tc-99 and Cs-137. The majority of the Cs-137 was removed through pretreatment in the ion exchange column.

[27] Test Plan for the Preparation of Samples from Hanford Tanks 241-AN-101, 241-AN-106, 241-AP-105, 241-AP-106, 241-AP-107, and 241-AY-101. (WRPS 2016)

| Isotope | Concentration in Tanks (Ci/L) | Sample Concentration after pretreatment (Ci/L) |
|---|---|---|
| Cm-242 | 2.41E-03 | 2.15E-07 |
| Pu-242 | 1.89E-05 | 4.24E-06 |
| Am-243 | | * |
| Cm-243 | 3.43E-03 | 3.95E-07 |

* Below Detection Limits

Table 4-5 shows the concentrations of individual isotopes in the six tanks[28] based on the BBI, and the concentration of those isotopes after the four-step pretreatment process. Some of the long-lived radionuclides were removed through the decanting process, including Pu and U. Essentially, following decanting, most of the long-lived radionuclides were only present in trace amounts and therefore, particularly in this very small volume of waste in the tank samples, would not contribute to long-term dose of a member of the public.

Sr is also primarily in the solid phase in these tanks, although some was found as a precipitate during filtration.[29] For this test, when the samples were mixed prior to filtration, new Sr salts appeared in the liquid, which were removed during filtration.

The Cs-137 isotope was removed by the sRF ion exchange pretreatment. Cs-137 is soluble (remains in the liquid phase) and therefore was not removed by decanting and filtering. Pretreatment results demonstrate, in this small bench-scale test, that treatment, using the sRF ion exchange column in the 222-S Laboratory, removed approximately 99.9% of the Cs-137, the predominant radionuclide contributing to worker dose.

Given the removal efficiencies for the short-lived key radionuclides, and the rigorous process to select the removal technologies, further removal of short-lived radionuclides would not be technically practical (that is, sensible or useful). With respect to other radionuclides – including the long-lived radionuclides such as Tc-99, I-129 and C-14 – the removal efficiencies are lower. However, the initial concentrations of those radionuclides in the tank waste samples were in trace quantities which would not contribute significantly to risk. In addition, the license issued by TCEQ does not contain disposal limits for Tc-99, I-129 and C-14 in the WCS FWF.[30] The total curies in the treated waste samples to be disposed in the WCS FWF is less than 0.01% of the total curie limit for the WCS FWF, and in combination, would be insignificant contributors to dose.[31] Under these circumstances, it would not be practical (that is sensible

[28] The concentration of radionuclides in Table 4-5 includes the concentration of the sludge, salt cake, and supernate of the tanks included in this Test Sample WIR Evaluation based on a mass-balance calculation of the data from the BBI (WRPS 2016).

[29] This was also noted in the Savannah River Site Salt Waste Basis for Determination (DOE-WD-2005-01) which assumed a minimum decontamination factor of 12 during decanting; however, during testing, the decontamination factor was higher because the majority of the actinides and other radionuclides contributing to dose to remained in the sludge in the tanks.

[30] Although the license for the WCS FWF does not contain disposal limits for Tc-99, I-129, and C-14 (or any other radionuclide), and treated and solidified test sample waste must meet the criteria in the *WCS Federal Waste Facility (FWF) Generator Handbook* (WCS 2015)

[31] DOE generally considers that radionuclides do not make a significant contribution to dose at a disposal facility if the contribution to dose from the radionuclides, in combination, would not exceed 10% of the limits set forth in the performance objectives at 10 CFR Part 61, Subpart C, which correspond to Texas Administrative Code Rules §§336.723-727. This approach is consistent with the guidance and general approach in Volume 2 of NUREG-1757, *Consolidated NMSS Decommissioning Guidance*. [NRC 2006]

or useful), using a risk-based approach, to further treat the test samples to remove additional key radionuclides.

### 4.3.2 Economic Practicality Assessment

Economic practicality includes consideration of total lifecycle costs, the cost per curie removed, the relationship between costs and removal of the key radionuclides, and the point in this relationship at which removal costs increase significantly and thus become impractical (DOE Guide 435.1). In this regard, removal of key radionuclides to the "maximum extent . . . economically practical" includes consideration of net social benefit, expert judgment, and whether the benefits to health and safety outweigh the disadvantages, that is, whether further radionuclide removal would be useful and sensible in light of the overall benefit to human health and safety.

For the selection of the treatment process to be used for the LAWPS, the evaluation of the economic practicality of additional radionuclide removal from the tank waste focused on Cs removal for worker protection purposes (Cs has a short half-life and is a worker hazard, not a long-term disposal hazard as it would not impact the performance over the regulatory period of the disposal facility) and Tc-99 removal for groundwater protection (DOE 2013). In each case, the evaluation compared the potential benefits in improved worker and public health and safety (i.e., reduced worker and public risk from radiation exposure) with the expected impacts (Holton 2003). As described in Section 4.3.1 of this Test Sample WIR Evaluation, the intended target of LAWPS pretreatment is the low activity supernate from tanks with lower concentrations of radionuclides. It is, therefore, appropriate that the analysis presented in the Assessment of LAW Treatment and Disposal Scenarios for the River Protection Project (Holton 2003) evaluated the pretreatment of wastes that would require minimal processing and focused on removing solids and Cs-137. Additional pretreatment beyond that identified in this Test Sample WIR Evaluation and the River Protection Project Guidance for the Direct Feed LAW Business Case (DOE 2013), would result in increased cost with little decrease in risk, since the majority of risk would be in the solids, either remaining in the tank or removed through filtration.

### 4.3.3 Evaluation of Treatment for Cs Removal

For additional Cs removal, several of treatment technologies were evaluated: Selective Dissolution, Crystallization, Ion exchange, and Solvent extraction. The amount of cesium removed (i.e., decontamination factor) can vary significantly among these technologies.

**Selective Dissolution** allows for the removal of cesium from saltcake wastes. Because this Test Sample WIR Evaluation is only evaluating the Cs removal from supernate, this treatment is not discussed further.

**Crystallization** is a possible pretreatment technology to separate high-activity and low-activity waste for more efficient waste retrieval and processing. The process would dissolve solid tank waste in water and then, through filtration and evaporation, separate the waste into low-activity and high-activity waste streams. Highly radioactive isotopes such as cesium and technetium (i.e., the high activity waste) would be maintained in the liquid portion, which could be pumped out and transferred to the double-shell tanks for eventual vitrification in the Waste Treatment Plant (Bray 1993). The remaining low-activity waste, in the form of salt crystals and sludge, could be further dissolved and retrieved for processing to immobilize the waste. The estimated Cs DF for the washed salt crystals is 300.

**Ion exchange technology** relies on exchanging one charged chemical species (i.e., either a cation or an anion) from a liquid phase for another charged species contained in a solid phase. In the case of cesium, the Cs ion can be removed from alkaline waste streams by cation exchange, represented by the following general equation:

$$Cs^+(aq) + RM^+(s) \rightarrow M^+(aq) + R^-Cs^+(s)$$

where $M^+$ represents the exchanged cation and $R^-$ represents a solid material having negatively-charge (anionic) sites to supply electroneutrality for the exchange of the positively charged cations. A variety of polymeric organic resins and inorganic materials have been evaluated for removing Cs-137 from alkaline liquid wastes at the Hanford and Savannah River sites (Bray 1995; Brown 1996). During the initial design of the Hanford Waste Treatment Plant, the contractor chose Cs ion exchange using SuperLig™ 644 as the baseline technology for removing Cs-137 from the LAW stream (Kurath et al 2000). In later studies, sRF resin was investigated for the purpose of removing Cs-137 from Hanford LAW at the Hanford Waste Treatment Plant (Fiskum 2006). The sRF resin was effective at removing Cs from this highly alkaline waste with decontamination factors on the order of 100,000 having been achieved in testing.

**Solvent extraction** involves mixing two immiscible liquid phases, so that the desired component(s) is transferred from one phase to another, while undesired components are retained in the original phase. Typically, an organic-based extractant is mixed with an aqueous feed solution containing multiple components. The extractant phase is designed so that it has an affinity for the target component to be separated, allowing for transfer of that component to the organic phase. Physical separation of the organic phase from the aqueous phase results in a separation of the target component from the other components in the aqueous phase. A DF from 40,000 to 100,000 has been seen in testing. While Savannah River Site has a pilot-scale facility using this treatment and has constructed a full-sized facility (Salt Waste Processing Facility) currently undergoing commissioning, DOE was concerned that at the Hanford Site, the concentration of certain other chemicals (potassium) and the molarity of sodium in supernate could interfere with the effectiveness of using solvent extraction for Hanford tank wastes.

The cost of additional Cs removal does not provide a cost per unit volume benefit to the workers (DOE 2013). Because sRF resin has been used successfully with a greater than 99% removal efficiency for Cs-137 (Carreon 2002), DOE plans to use sRF resin for Cs removal at the LAWPS. Under these circumstances, it would not be economically practical (sensible or useful), using a risk-based approach, to further treat the test samples to remove additional Cs-137.

### 4.3.4 Evaluation of Treatment for Tc-99

Evaluations performed since 1997 have confirmed that it would be economically impractical to remove soluble Tc-99 from the waste (Bechtel 2002, DOE 2013). The total quantity of Tc-99 in the Hanford tanks is currently projected to be 25,500 Ci which represents less than 0.02% of the 190 million Ci total inventory of radioactive materials in the Hanford tanks (BBI). If Tc-99 removal is not performed in the WTP and the Tc-99 disposed in the onsite disposal facility, at this concentration, it would result in a final waste form containing a concentration of soluble Tc-99 of 0.2 $Ci/m^3$. This is far below the NRC 10 CFR Part 61 concentration limit of 3 $Ci/m^3$ for Class C LLW (Schepens 2003). At the low concentrations calculated, this radionuclide will have a negligible impact on disposal site performance. In addition, analysis has demonstrated that for the LAWPS, continued separations (to remove soluble Tc-99) would add additional cost with increased risk to both workers and the public (Holton 2003). Furthermore, with respect this Test Sample WIR Evaluation, the WCS license does not contain limits for Tc-99 for disposal in the WCS FWF. In addition, the total curies in the treated waste samples to be disposed in the WCS FWF is less than 0.01% of the total curie limit for the WCS FWF, and in combination, would be insignificant contributors to dose. As demonstrated in Section 6 of this Test Sample WIR Evaluation, the treated test samples are well below concentration limits for Class C LLW, including the Class C LLW concentration limits for Tc-99 (and all other key radionuclides). Based on the above considerations – including the increased costs in terms of both monetary expense and potential worker exposure -- additional treatment to further remove Tc-99 (or other radionuclides) would not be economically practical (sensible or useful), using a risk-based approach.

## 4.4 Summary and Conclusions

The technical practicality assessment shows that decanting, filtration and the sRF ion exchange separations processes are the appropriate for removing key radionuclides to the maximum extent technically practical. The economic practicality assessment (DOE 2013) has demonstrated that these treatments achieve the treatment levels in a manner that limits worker exposure while meeting the disposal requirements. In summary, the current treatment plans for the test samples will remove key radionuclides to the maximum extent that is technically and economically practical.

# 5. Criterion 2: The Waste Will Be Incorporated In A Solid Physical Form And Meet Safety Requirements Comparable To The Performance Objectives At 10 CFR Part 61, Subpart C

**Section Purpose**

The purpose of this section is to evaluate whether the treated test samples will be managed to meet safety requirements comparable to the performance objectives at 10 CFR Part 61, Subpart C for disposal of low-level radioactive waste.

**Section Contents**

This section addresses whether the treated test samples will meet safety requirements comparable to the performance objectives in 10 CFR Part 61, Subpart C for disposal of low-level radioactive waste and explains how the treated and solidified test samples will meet criteria for disposal as low-level radioactive waste.

**Key Points**

- The performance objectives in the Texas Administrative Code applicable to the WCS low-level waste disposal facility for Federal waste mirror the performance objectives in 10 CFR Part 61, Subpart C, and the facility must be operated to provide reasonable assurance that those performance objectives will be met.
- Disposal of the treated and solidified test samples at the WSC FWF will meet safety requirements comparable to the performance objectives at 10 CFR Part 61, Subpart C.

## 5.1 Introduction

Section 2 describes the reprocessing activity and the resulting tank wastes, and how the test samples were chosen for this test bed project. Section 2 also explains how the test samples were characterized for residual radioactivity prior to being treated to meet RCRA requirements and stabilized into the final waste form at PFNW. As noted previously, the test samples will be treated and solidified to meet RCRA and land disposal requirements, and prepared for transport at PFNW, prior to transport to the WCS FWF in Texas for disposal.

The second criterion of section II.B.2(a) of DOE Manual 435.1-1 applies to this evaluation:

> "[The waste] will be managed to meet safety requirements comparable to the performance objectives set out in 10 CFR Part 61, Subpart C, *Performance Objectives*."

This section addresses this criterion as follows:

Section 5.2 summarizes NRC performance objectives for disposal of LLW and compares these to the State of Texas requirements.

Section 5.3 discusses the waste acceptance criteria for the WCS FWF and how DOE assures that those criteria will be met.

## 5.2 Performance Objectives

DOE plans to dispose of the treated and solidified test samples at the WCS FWF,[32] which is required to comply with the Texas performance objectives set forth in the Texas Administrative Code Rules §§336.723-727. As explained in Appendices A and B,[33] the performance objectives in the State of Texas regulations mirror the NRC performance objectives at 10 CFR 61, Subpart C, i.e., they are essentially identical except for the use of different section numbers.

### 5.2.1 General Safety Requirement

The general requirement in NRC's performance objectives for licensed LLW disposal facilities at 10 CFR 61.40 sets forth the following requirement:

> "Land disposal facilities must be sited, designed, operated, closed, and controlled after closure so that reasonable assurance exists that exposures to humans are within the limits established in the performance objectives in Sections 61.41 through 61.44."

The general safety requirement of the State of Texas mirrors the NRC general safety requirement as shown in Appendix A.

### 5.2.2 Protection of the General Population from Releases of Radioactivity

The NRC performance objective at 10 CFR 61.41 provides:

> "Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants, or animals must not result in an annual dose exceeding an equivalent of 25 mrems to the whole body, 75 mrems to the thyroid, and 25 mrems to any other organ of any member of the public. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable."

The requirement of the State of Texas for protection of the general population mirrors the NRC requirement as shown in Appendix A.

**Assessment of WCS Federal Waste Disposal Facility Performance**

WCS included an initial performance assessment with its license application (WCS 2007). The performance assessment of the Federal Waste Disposal Facility considered a total inventory at closure of 57 million cubic feet of waste with 16.4 million curies of radioactivity.[34] It included the following estimated dose for the post-institutional control period: a maximum annual dose of 3.4 mrem per year to an adjacent resident, well under the limit of 25 mrem per year. In addition, a license condition requires that WCS prepare an updated performance assessment prior to accepting waste for disposal and annually thereafter to demonstrate that performance objectives will be met. Over the course of several years, WCS enhanced the PA. The underlying assumptions needed to estimate the impacts to human health were based

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[32] DOE Manual 435.1-1, section 1.2.F(4) requires approval for such offsite disposal at a non-DOE site, and notification to certain DOE offices and the Program Secretarial Officer of the basis for using any non-DOE radioactive waste disposal facility prior to the use of such facility.[33]For additional perspective, Appendices A and B also compare the NRC and Texas performance objectives to comparable DOE safety requirements, which would apply if the treated test samples were disposed of at a DOE facility.

[33]For additional perspective, Appendices A and B also compare the NRC and Texas performance objectives to comparable DOE safety requirements, which would apply if the treated test samples were disposed of at a DOE facility.

[34] Radioactive Material License No. R04100, Amended (WCS 2015)

on NUREG-4370, Update to Part 61 Impact Analysis Methodology, Methodology Report, Revision 1. The enhancements to the PA were intended to further demonstrate the suitability of the disposal facilities to isolate long-lived radionuclides from the environment. When WCS submitted its major amendment request seeking to remove the limits of radioactivity for I-129, C-14, and Tc-99, the more robust probabilistic PA was included to support the major amendment. The most recent performance assessment, titled *Radioactive Material License No. CN600616890/RN101702439 2015 Updated Performance Assessment for the WCS Disposal Facilities,* (WCS 2015) demonstrates that the Texas performance objectives will continue to be met.

### 5.2.3 Protection of Individuals

The NRC performance objective at 10 CFR 61.42 sets forth the following requirement:

> "Design, operation, and closure of the land disposal facility must ensure protection of any individual inadvertently intruding into the disposal site and occupying the site or contacting the waste at any time after active institutional controls over the disposal site are removed."

Pursuant to NRC guidance, NRC licensees for LLW disposal facilities should demonstrate that the annual dose to the inadvertent human intruder will not exceed 500 mrem per year after removal of institutional control.

The State of Texas requirement for protection of individuals from inadvertent intrusion is similar but is more stringent than the NRC requirement as shown in Appendix B.

**Assessment of WCS Federal Waste Disposal Facility Performance**

The performance assessment included with the WCS license amendment application (WCS 2015) provides the following estimated doses to inadvertent intruders. The most conservative model run for the oil field worker yielded 2.1E-6 mrem/yr, and the onsite resident's peak dose is 2.1E+00 mrem with a performance objective of 25 mrem/yr for the FWF. These estimated doses are well below the NRC 500 mrem intruder dose measure and the Texas 25mrem/yr dose limit to a member of the public.[35]

### 5.2.4 Protection of Individuals During Operations

The DOE requirements in DOE Manual 435.1-1, Section I.E(13), for protection of the individual during operations read as follows:

"Radioactive waste management facilities, operations, and activities shall meet the requirements of 10 CFR Part 835, Occupational Radiation Protection, and DOE Order 458.1, Radiation Protection of the Public and the Environment."

As discussed in Appendix B, NRC in 10 CFR 61.43 provides similar, comparable requirements:

"Operations at the land disposal facility must be conducted in compliance with the standards for radiation protection set out in Part 20 of this chapter, except for releases of radioactivity in effluents from the land disposal facility, which shall be governed by Section 61.41 of this part. Every reasonable effort shall be made to maintain radiation exposures as low as is reasonably achievable."

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[35] These estimates were for the Commercial Waste Facility. The estimated maximum annual dose for the FWF Canister Disposal Unit where the treated test samples would be disposed of was 1.8 mrem per year for the intruder driller and 0.79 mrem per year for the intruder resident (WCS 2007, Volume 31, Appendix 8.0-6, Table 8.0-6.13-2)

The State of Texas requirements mirrors the NRC requirements, as discussed in Appendix B.

**Comparability of DOE, NRC, and State of Texas Requirements**

DOE‘s requirements and dose limits for protection of individuals during operations in 10 CFR Part 835 and DOE Order 458.1, cross referenced in Section I.E(13) of DOE Manual 435.1-1, are comparable to the relevant NRC standards for radiation protection in 10 CFR Part 20, as cross referenced in the NRC performance objective at 10 CFR 61.43. For example, both DOE and NRC limit occupational dose to a total effective dose equivalent of 5 rem per year and doses to the public from operations to 0.1 rem per year, as further discussed in Appendix A. As explained in Appendix B, the State of Texas requirements and dose limits for protection of individuals during operations mirror the NRC requirements and dose limits.

DOE‘s regulatory and contract requirements for DOE facilities and activities ensure compliance with DOE‘s regulations at 10 CFR Part 835 and relevant DOE Orders that establish dose limits for the public and the workers during operations. Appendix B provides additional details concerning the DOE requirements for protecting individuals during operations.

In addition, DOE‘s regulation at 10 CFR 835.101(c) requires that each radiation protection program include formal plans and measures for applying the ALARA (as low as is reasonably achievable) approach to occupational exposures.

**Protection of Individuals During Operations at the Hanford Site**

The DOE requirements apply to the workers at the Hanford tank farms under the ORP Tank Operation Contractor, WRPS, who are involved with preparing the treatability volumes of tank waste for shipment offsite, as well as to the public at the site.

DOE sites, including the Hanford Site, maintain radiation protection programs based on the requirements of 10 CFR 835. These programs are consistent with DOE directives (including DOE Order 458.1, other Orders, policies, guides, and manuals), and supplemental technical standards.

The WRPS radiological protection program is described in HNF-MP-5184, Washington River Protection Solutions LLC Radiation Protection Program. Additional information on the program can be found in the Radiological Control Manual (HNF-5183) and the WRPS ALARA practices are outlined in TFC-PNL-48, ALARA Program Plan.as well as in Chapter 1, Part 1, Section 7 of the Radiological Control Manual.

The samples used in the test bed study were handled in the 222-S Laboratory Hot Cells to protect the workers from the anticipated dose rates from these samples. The dose rates for samples are generally not measured until they are removed from the hot cells in accordance with the site ALARA principles. Workers involved with handling of the test samples will receive doses below the WRPS administrative control level of 500 mrem per year, which is ten percent of the annual DOE occupational dose limit of 5000 mrem per year in 10 CFR 835, Subpart C. The radiation doses to workers to be involved with preparation of the treated test samples for shipment to PFNW will be minimized by compliance with the WRPS radiological control program and the associated ALARA processes.

Compliance with the radiological control program requirements and the ALARA processes will provide reasonable expectation that ORP worker doses will be well below the 500 mrem per year limit, especially considering the low radiation levels of the test samples and the short duration of the work to ship the waste. Furthermore, the work associated with preparing the waste package for shipment to PFNW is similar in nature to other ORP waste management work for which worker doses have been maintained ALARA and well below the 500 mrem annual limit.

Compliance with the ORP radiological control program requirements and the associated ALARA processes also ensure that potential exposures to the public from onsite work related to preparing the treated test samples for shipment are below the applicable limit. The waste separations treatment were performed within a radiologically controlled area within the Hanford Site security fence. Liquid LLW will be transported offsite for additional treatment and solidification in preparation for disposal. Past Hanford experience with similar waste management work indicates that potential doses to the public will be very low. In 2013, for example, a year in which similar waste management work was performed by the Hanford Site, the estimated dose to a maximally exposed offsite individual from airborne radioactivity emissions was 0.25 mrem (DOE/RL-2014-14 Radionuclide Air Emissions Report for the Hanford Site, Calendar Year 2013.) The airborne pathway is the only pathway of interest for potential exposure to a member of the public from onsite work to prepare the test samples for shipment. Such factors provide reasonable expectation that doses to the public from preparing the waste package for shipment to PFNW will be far below the applicable limit.

**Protection of Individuals During Operations at the WCS Facility**

Individuals would be protected during operations. As noted above, the applicable State of Texas dose standards mirror those of NRC. WCS is required to comply with the requirements of Texas Administrative Code, Title 30, Part 1, Chapter 336, Subchapter D, Standards for Protection Against Radiation, which provide for a comprehensive program to protect individuals and the public during waste disposal site operations.

### 5.2.5 Stability of the Disposal Site After Closure

The WCS license application (WCS 2007) – in Volume 2, Section 6, Closure – describes features of the planned closure system for that facility to meet the State requirements for stability of the disposal site after closure. These features include a depth of disposal significantly greater than five meters (16.4 feet) for all waste.

## 5.3 The Treated and Solidified Test Samples Meet the Disposal Site Waste Acceptance Criteria

To help establish the relationship between the waste acceptance criteria and performance assessment of the waste disposal site, this subsection provides a summary of the disposal site waste acceptance criteria and addresses meeting the WCS waste acceptance criteria.

### 5.3.1 Meeting WCS Waste Acceptance Criteria

The WCS waste acceptance criteria document, FWF Federal Generator Handbook (WCS 2015), addresses matters such as operations and regulatory parameters, pre-shipment requirements, documentation, and transportation and provides various forms including a waste profile sheet. The WCS Waste Acceptance Plan (WCS 2014) provides additional information related to the waste acceptance process, including waste form requirements and a description of the generator and waste approval processes.

The WCS license (TCEQ 2016) contains additional requirements related to waste disposal, including total waste volume limitations and total activity limitations for certain radionuclides. Table 5-1 shows representative requirements compared to the related parameters for the treated and solidified test samples.

**Table 5-1 Key WCS FWF License Requirements**

| **Requirement (Section)** (1) | **License Limit** (1) | **Test Samples** | **Test Samples % of License Limit** |
|---|---|---|---|
| Total waste volume, $ft^3$ (§7.B) | 8,100,000 | ~1 | ~1E-5 |
| Total activity, curies (§7.B) | 5,500,000 | <0.1 | <2E-6 |

NOTES: (1) From the WCS license (TCEQ 2016) with the associated section numbers and limits. The §7.B limits are for Class A containerized, Class B, and Class C LLW, collectively.

Table 5-1 shows the volume of the test sample waste package is a small fraction of the WCS FWF capacity limit, and that the total activity is a small fraction of the WCS FWF limit. PFNW will follow all requirements necessary characterization and documentation for demonstrating that these small volumes of treated and solidified test samples will meet the waste acceptance requirements for the WCS FWF prior to shipment[36].

[36] Because the WCS facility is licensed to accept Class A, B, and C LLW, DOE expects that the treated and solidified test sample waste package would be approved for disposal.

# 6. Criterion 3: The Waste Does Not Exceed Class C LLW Concentration Limits And Will Be Managed In Accordance With DOE Requirements As LLW

**Section Purpose**

The purpose of this section is to demonstrate that the test sample waste package will be in a solid physical form, will not exceed Class C concentration limits, and will be managed as low-level radioactive waste.

**Section Contents**

This section provides information showing that the grouted test sample waste package will be in a solid physical form, will not exceed the concentration limits for Class C low-level waste in 10 CFR 61.55, and will be managed and disposed of as low-level waste.

**Key Points**

- The grouted test sample waste package will be in a solid physical form.
- The radioactivity in the grouted, test sample waste package will not exceed Class C concentration limits.
- The test sample waste package will be managed and disposed of at an offsite low-level radioactive waste disposal facility in accordance with applicable requirements for low-level waste.

The third and final criterion of DOE Manual 435.1-1, Section II.B(2)(a) to be demonstrated is that the waste will be in a solid physical form and will not exceed Class C concentrations limits.

Radiological characterization of the treated test samples before packaging was described in Section 2.3. The treated waste will be put into final solid physical form during additional treatment at PFNW and prepared for disposal.

No additional credit is assigned for removal of actinides or Sr-90 during the filtration step, even though some insoluble Sr was removed. The filtration step was expected to remove residual suspended solids containing traces of these isotopes, and data is being gathered to provide additional information for LAWPS. Further, the concentrations shown in Table 4-5 reflect the liquid pretreated samples, with no credit taken for the ~50-100% volume increase that will occur when the waste is immobilized.

Estimated average concentrations for the grouted test sample waste associated with this test bed project were calculated for radionuclides identified in 10 CFR 61.55, Tables 1 and 2 (see Tables 4-1 and 4-2). These concentrations are compared to 10 CFR 61.55 Class C concentration limits in Table 6-2 below. Concentrations in Table 6-1 and 6-2 are shown in curies per cubic meter (Ci/m3) in the grouted sample waste (with no credit taken for the grout, as explained above) unless otherwise noted.

Because the test samples contain a mixture of radionuclides, the total concentration is determined by the sum of the fractions rule, as specified in 10 CFR 61.55(a)(7) (§336.362(a)(7) of the Texas Administrative Code parallels the NRC's regulations).

Estimated average concentrations for the treated test samples, prior to solidifying, were calculated for radionuclides identified in 10 CFR 61.55 concentration limits in Table 6-1 and 6-2 below. Concentrations in these tables are shown in curies per cubic meter (Ci/m3) in the treated test samples, unless otherwise noted.

**Table 6-1 Treated Test Samples Comparison to 10 CFR Part 61.55, Table 1**

| Radionuclides (Long-lived) | 10 CFR 61.55 Limit (Ci/m$^3$) | Estimated Average Concentration after Treatment (Ci/m$^3$) | Fraction of 10 CFR 61.55 Limit |
|---|---|---|---|
| C–14 | 8 | 5.76E-04 | 0.000072 |
| C–14 in activated metal | 80 | (*1*) | (*1*) |
| Ni–59 in activated metal | 220 | (*1*) | (*1*) |
| Nb–94 in activated metal | 0.2 | (*1*) | (*1*) |
| Tc–99 | 3 | 4.55E-02 | 0.015 |
| I–129 | 0.08 | 1.22E-04 | 0.0015 |
| Alpha Emitting Transuranic (TRU) nuclides with half-life greater than 5 years | 100 | 2.54E-04 (2) | 0.00003 |
| Pu–241 | 3,500 | 8.21E-04(2) | 0.0000002 |
| Cm–242 | 20,000 | 2.15E-07 | 0.000000001 |
| | | TOTAL | 0.016602201 |

(1) Not present in the treated test samples
(2) Units are in nanocuries per gram

**Table 6-2 Treated Test Samples Comparison to 10 CFR Part 61.55, Table 2**

| Radionuclides (Short-lived) | 10 CFR 61.55 Column 3, Class C Limit (Ci/m$^3$) | Estimated Average Concentration (Ci/m$^3$) | Fraction of 10 CFR 61.55 Column 3 Class C Limit |
|---|---|---|---|
| Total of all nuclides with less than 5 year half life | (*1*) | (*1*) | (*1*) |
| H-3 | (*1*) | (*1*) | (*1*) |
| Co-60 | (*1*) | (*1*) | (*1*) |
| Ni-63 | 700 | 1.99E-02 | 0.00003 |
| Ni-63 in activated metal | 7000 | (*2*) | (*2*) |
| Sr-90 | 7000 | 7.40E-02 | 0.00001 |
| Cs-137 | 4600 | 1.73E-04 | 0.00000004 |
| | | TOTAL | 0.00004004 |
| | | **SUM OF FRACTIONS (TABLE 6-1 PLUS TABLE 6-2)** | **0.016642241** |

(1) There are no limits established for these radionuclides in Class B or C wastes. Practical considerations such as the effects of external radiation and internal heat generation on transportation, handling, and disposal will limit the concentrations for these wastes. These wastes shall be Class B unless the concentrations of other nuclides in the table determine the waste to be Class C independent of these nuclides. The treated test samples will be lower than the concentration limits for Class C.
(2) Not present in the treated test samples.

In accordance with 10 CFR 61.55, the determination of the class of the waste is made by one of four different methods utilizing Tables 6-1 and 6-2. The relevant NRC regulations are reproduced below:

1) If the waste contains only the long-lived radionuclides listed in Table 6.1 above (10 CFR 61.55 Table 1), then classification is determined by 10 CFR 61.55 (a)(3):

**10 CFR 61.55 (a)(3)** – "Classification determined by long-lived radionuclides. If radioactive waste contains only radionuclides listed in Table 1, classification shall be determined as follows: (i) If the concentration does not exceed 0.1 times the value in Table 1, the waste is Class A. (ii) If the concentration exceeds 0.1 times the value in Table 1 but does not exceed the value in Table 1, the waste is Class C. (iii) If the concentration exceeds the value in Table 1, the waste is not generally acceptable for near-surface disposal. (iv) For wastes containing mixtures of radionuclides listed in Table 1, the total concentration shall be determined by the sum of fractions rule described in paragraph (a)(7) of this section".

2) If the waste contains only the short-lived radionuclides contained in Table 6.2 above (10 CFR 61.55 Table 2), then classification is determined by 10 CFR 61.55 (a)(4):

**10 CFR 61.55 (a)(4)** – "Classification determined by short-lived radionuclides. If radioactive waste does not contain any of the radionuclides listed in Table 1, classification shall be determined based on the concentrations shown in Table 2. However, as specified in paragraph (a)(6) of this section, if radioactive waste does not contain any nuclides listed in either Table 1 or 2, it is Class A. (i) If the concentration does not exceed the value in Column 1, the waste is Class A. (ii) If the concentration exceeds the value in Column 1, but does not exceed the value in Column 2, the waste is Class B. (iii) If the concentration exceeds the value in Column 2, but does not exceed the value in Column 3, the waste is Class C. (iv) If the concentration exceeds the value in Column 3, the waste is not generally acceptable for near-surface disposal. (v) For wastes containing mixtures of the nuclides listed in Table 2, the total concentration shall be determined by the sum of fractions rule described in paragraph (a)(7) of this section".

3) If the waste contains a mixture of short-lived and long-lived radionuclides, some of which are listed in Table 6.1 above (10 CFR 61.55 Table 1), and some of which are listed in Table 6.2 above (10 CFR 61.55 Table 2), classification is determined by 10 CFR 61.55 (a)(5):

**10 CFR 61.55 (a)(5)** – "Classification determined by both long- and short-lived radionuclides. If radioactive waste contains a mixture of radionuclides, some of which are listed in Table 1, and some of which are listed in Table 2, classification shall be determined as follows: (i) If the concentration of a nuclide listed in Table 1 does not exceed 0.1 times the value listed in Table 1, the class shall be that determined by the concentration of nuclides listed in Table 2. (ii) If the concentration of a nuclide listed in Table 1 exceeds 0.1 times the value listed in Table 1 but does not exceed the value in Table 1, the waste shall be Class C, provided the concentration of nuclides listed in Table 2 does not exceed the value shown in Column 3 of Table 2".

4) If the waste does not contain any of the radionuclides listed in either of the tables then classification is determined by 10 CFR 61.55 (a)(6):

**10 CFR 61.55 (a)(6)** – "Classification of wastes with radionuclides other than those listed in Tables 1 and 2. If radioactive waste does not contain any nuclides listed in either Table 1 or 2, it is Class A".

The low-activity treated and solidified test samples to be disposed of at WCS FWF will contain a mixture of short-lived and long-lived radionuclides from Table 6-1 (10 CFR 61.55 Table 1) and 6-2 (10 CFR 61.55 Table 2). Therefore, the waste concentration limits will be determined in accordance with 10 CFR

61.55(a)(5) and 10 CFR 61.55(a)(7). As provided in 10 CFR 61.55(a)(5), the radionuclide limits shown in Table 4-1 (10 CFR 61.55 Table 1) and radionuclides limits show in Column 3 of Table 4-2 (10 CFR 61.55 Table 2) are applicable.

Applying the sum of fractions rule, the sum of the fractions is 0.016642241, well below 1. The treated test samples will meet the concentration limits established in 10 CFR 61.55 for Class C LLW.

DOE Order 435.1, Radioactive Waste Management, provides that requirements in the Order that duplicate or conflict with requirements of an applicable Agreement State do not apply to facilities and activities licensed by the Agreement State. Therefore, the provisions in Chapter IV of DOE Manual 435.1-1 concerning matters such as monitoring, waste acceptance criteria, performance assessments, composite analysis, disposal facility operations, disposal authorizations, institutional control, and disposal facility closure do not apply to the WCS facility; instead, these matters are governed by the State of Texas requirements and license conditions.

Accordingly, as demonstrated above, disposal of the test sample waste package at the WCS FWF would meet the third criterion of DOE Manual 435.1-1, Section II.B.2(a).[37]

[37] This Test Sample WIR Evaluation was prepared by DOE, WRPS, and SRNL staff and followed the practices required by the Hanford Analytical Services Quality Assurance Requirements Documents (DOE/RL-96-68). All analytical work performed by 222-S Laboratory for the experiment described within this test plan adhered to the document WHL-MP-1011, Quality Assurance Project Plan for 222-S Laboratory. Analyses performed by WRPS were performed according to the requirements of ATS-MP-1032, 222-S Laboratory Quality Assurance Project Plan.

# 7. Conclusion

This Test Sample WIR Evaluation demonstrates that the treated test samples will meet the criteria in Section II.B(2)(a) of DOE Manual 435.1-1. Therefore, this Test Sample WIR Evaluation would support a WIR Determination, issued by the by the Associate Principal Deputy Assistant Secretary for Regulatory and Policy Affairs, Office of Environmental Management, that this waste is incidental to reprocessing, is not HLW, and may be managed and disposed of as LLW.

# 8. References

**Federal Statutes**

Low-Level Radioactive Waste Policy Act of 1985.

Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005, Public Law 108-375, 118 Stat. 1811. 108th United States Congress, October 28, 2004.

**Code of Federal Regulations and Federal Register Notices**

10 CFR Part 20, Standards for Protection Against Radiation.

10 CFR Part 61.55, Waste Classification.

10 CFR Part 61, Subpart C, Licensing Requirements for Land Disposal of Radioactive Waste, Performance Objectives.

10 CFR 835, Occupational Radiation Protection.

40 CFR 61, National Emission Standards for Hazardous Air Pollutants.

**DOE Orders, Policies, Manuals, and Standards**

DOE Order 435.1, Radioactive Waste Management, Change 1. U.S. Department of Energy, Washington, D.C.

DOE Order 458.1 Admin. Change 3, Radiation Protection of the Public and the Environment, U.S. Department of Energy, Washington, D.C.

DOE Policy 441.1, Department of Energy Radiological Health and Safety Policy. U.S. Department of Energy, Washington, D.C.

DOE Manual 435.1-1, Radioactive Waste Management Manual, Change 2. U.S. Department of Energy, Washington, D.C.

DOE Guide 435.1-1, Implementation Guide For Use With DOE M 435.1-1. U.S. Department of Energy, Washington, D.C.

**State Regulations**

Texas Administrative Code, Title 30, Part 1, Chapter 336, Radioactive Substance Rules https://texreg.sos.state.tx.us/public/readtac$ext.ViewTAC?tac_view=4&ti=30&pt=1&ch=336

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WHL-MP-1011, 1995, Quality Assurance Project Plan for 222-S Laboratory, Richland, Washington.

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# APPENDIX A

## Comparability of DOE, NRC and Texas Requirements for LLW Disposal

**Appendix Purpose**

The purpose of this appendix is to show that Department of Energy, Nuclear Regulatory Commission, and State of Texas requirements for disposal of low-level waste are comparable.

**Appendix Content**

This appendix identifies applicable Department of Energy performance objectives and the similar Nuclear Regulatory Commission and State of Texas performance objectives and discusses their comparability.

**Key Points**

- Requirements for low-level waste disposal are embodied in sets of performance objectives for the waste disposal facility.
- The Department of Energy performance objectives are described in DOE Manual 435.1-1, Radioactive Waste Management.
- The Nuclear Regulatory Commission performance objectives are described in Subpart C, Performance Objectives, of 10 CFR Part 61, Licensing Requirements for Land Disposal of Radioactive Waste.
- The performance objectives in the Texas Administrative Code that apply to the WCS low-level waste disposal facility – which are included in the Title 30, Part 1, Chapter 336, Subchapter H, Rules §336.723-727 – mirror the Nuclear Regulatory Commission performance objectives.
- Department of Energy, Nuclear Regulatory Commission, and State of Texas performance objectives for low-level waste disposal are comparable.

### 1.0 Introduction

This appendix identifies performance objectives for disposal of LLW by the DOE, the NRC, and the State of Texas, then compares these performance objectives. As noted previously, the performance objectives in the State of Texas regulations mirror the NRC performance objectives at 10 CFR 61, Part C, i.e., they are essentially identical except for the use of different section numbers.

Information in this appendix is based in part on previous detailed comparison studies of DOE and NRC performance objectives for LLW disposal (Cole 1995 and Wilhite 2001).

### 2.0 Applicable Performance Objectives

DOE Manual 435.1-1, Radioactive Waste Management, describes DOE requirements for disposal of LLW. The comparable NRC requirements appear in Subpart C of 10 CFR Part 61, which lists one general requirement and four performance objectives, which are set forth below.

Section 61.40, General Requirement

“Land disposal facilities must be sited, designed, operated, closed, and controlled after closure so that reasonable assurance exists that exposures to humans are within the limits established in the performance objectives in Sections 61.41 through 61.44.”

Section 61.41, Protection of the General Population from Releases of Radioactivity

“Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants, or animals must not result in an annual dose exceeding an equivalent of 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ of any member of the public. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.”

Section 61.42, Protection of Individuals from Inadvertent Intrusion

“Design, operation, and closure of the land disposal facility must ensure protection of any individual inadvertently intruding into the disposal site and occupying the site or contacting the waste at any time after active institutional controls over the disposal site are removed.”

Section 61.43, Protection of Individuals During Operations

“Operations at the land disposal facility must be conducted in compliance with the standards for radiation protection set out in Part 20 of this chapter, except for releases of radioactivity in effluents from the land disposal facility, which shall be governed by Section 61.41 of this part. Every reasonable effort shall be made to maintain radiation exposures as low as is reasonably achievable.”

Section 61.44, Stability of the Disposal Site After Closure

“The disposal facility must be sited, designed, used, operated, and closed to achieve long-term stability of the disposal site and to eliminate to the extent practicable the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required.”

The State of Texas requirements for LLW disposal at Texas Administrative Code, Title 30, Part 1, Chapter 336, Subchapter H, Rules §336.723-777 are based on the NRC requirements at Subpart C of 10 CFR Part 61 and are similar except for the minor wording differences identified below.

## 3.0 Comparability of the General Requirements

### 3.1 DOE

The general requirement in DOE Manual 435.1-1, Section IV.P(1), is expressed as follows:

“Low-level waste disposal facilities shall be sited, designed, operated, maintained, and closed so that a reasonable expectation exists that the following performance objectives will be met for waste disposed of after September 26, 1988.”

### 3.2 NRC

The NRC regulations in 10 CFR 61.40 provide in relevant part:

"Land disposal facilities must be sited, designed, operated, closed, and controlled after closure so that reasonable assurance exists that exposures to humans are within the limits established in the performance objectives in Sections 61.41 through 61.44."

### 3.3 State of Texas

The State of Texas regulations (Rule §336.723) mirror the NRC regulations in 10 CFR 61.40.

### 3.4 Discussion

The statement of NRC requirements in 10 CFR 61.40 is nearly identical to that of the DOE general requirement. The DOE requirement adds the concept of maintenance, which is implied in the NRC requirement. The DOE requirement does not mention control after closure, but this concept is embodied in the DOE requirements for closure, specifically DOE Manual 435.1, Section IV.Q (2)(c), which requires DOE control until it can be shown that release of the disposal site for unrestricted use will not compromise DOE requirements for radiological protection of the public.

The DOE general requirement for LLW disposal, the NRC general requirement of 10 CFR 61.40, and the State of Texas general requirement are therefore comparable.

## 4.0 Comparability Regarding Protection of the General Population from Releases of Radioactivity

### 4.1 DOE

DOE requirements of DOE Manual 435.1-1, Section IV.P(1), read as follows:

"(a) Dose to representative members of the public shall not exceed 25 mrem in a year total effective dose equivalent from all exposure pathways, excluding the dose from radon and its progeny in air.

(b) Dose to representative members of the public via the air pathway shall not exceed 10 mrem in a year total effective dose equivalent, excluding the dose from radon and its progeny.

(c) Release of radon shall be less than an average flux of 20 pCi/m2/s at the surface of the disposal facility. Alternatively, a limit of 0.5 pCi/L of air may be applied at the boundary of the facility."

### 4.2 NRC

NRC regulations in 10 CFR 61.41 are expressed as follows:

"Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants, or animals must not result in an annual dose exceeding an equivalent of 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ of any member of the public. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable."

### 4.3 State of Texas

The State of Texas regulations (Rule §336.724) mirror the NRC regulations in 10 CFR 61.41 with two minor wording differences. The Texas rule uses the phrase "annual dose above background" instead of "annual dose". In the second sentence, the Texas rule uses the phrase "Effort shall be made" instead of "Reasonable effort should be made".

### 4.4 Discussion

DOE uses more current radiation protection methodology, consistent with that used in NRC's radiation protection standards in NRC's 10 CFR 20, Standards for Protection Against Radiation. Because NRC has not revised 10 CFR 61.41 to reflect the more current methodology in 10 CFR 20, DOE's requirements and those in 10 CFR 20 differ slightly from those in 10 CFR 61.41. However, the resulting allowable doses are comparable, as NRC has acknowledged (NRC 2005). NRC has indicated that it expects DOE to use the newer methodology in 10 CFR 20 and DOE Manual 435.1-1. Both NRC and DOE use a performance assessment to assess whether the dose limit will be met.

The DOE requirements go beyond this NRC performance objective by specifying an assessment of the impacts of LLW disposal on water resources (i.e., DOE Manual 435.1, Section IV.P (2)(g)). The NRC requirement includes maintaining releases to the environment ALARA. Although this requirement is not included in the DOE performance objective, it is included in the performance assessment requirements (i.e., DOE Manual 435.1-1, Section IV.P (2)(f)).

Because the State of Texas regulations are essentially the same as the NRC regulations, the conclusions about the comparability of the DOE and NRC requirements also apply to the comparability of the State of Texas requirements.

## 5.0 Comparability Regarding Protection of Individuals from Inadvertent Intrusion

### 5.1 DOE

DOE requirements of DOE Manual 435.1-1, Section IV.P(2)(h), for protection of individuals from inadvertent intrusion read as follows:

"For purposes of establishing limits on the concentration of radionuclides that may be disposed of near-surface, the performance assessment shall include an assessment of impacts calculated for a hypothetical person assumed to inadvertently intrude for a temporary period into the low-level waste disposal facility. For intruder analyses, institutional controls shall be assumed to be effective in deterring intrusion for at least 100 years following closure. The intruder analyses shall use performance measures for chronic and acute exposure scenarios, respectively, of 100 mrem (1 mSv) in a year and 500 mrem (5 mSv) total effective dose equivalent excluding radon in air."

### 5.2 NRC

NRC requirements of 10 CFR 61.42 are expressed as follows:

"Design, operation, and closure of the land disposal facility must ensure protection of any individual inadvertently intruding into the disposal site and occupying the site or contacting the waste at any time after active institutional controls over the disposal site are removed."

### 5.3 State of Texas

The State of Texas regulations (Rule §336.725) mirror the NRC regulations in 10 CFR 61.42.

### 5.4 Discussion

The DOE LLW disposal requirement that the performance assessment include an assessment of the impacts on a person inadvertently intruding into the disposal facility is more stringent than the NRC requirement.  The NRC waste classification system is based on intruder calculations using a 500 mrem per year dose limit (NRC 1982).  The DOE requirement uses a 100 mrem per year limit for chronic exposures and a 500 mrem limit for acute exposures.

Because the State of Texas regulations mirror the NRC regulations, the conclusions about the comparability of the DOE and NRC requirements also apply to the comparability of the State of Texas requirements.

## 6.0 Comparability Regarding Protection of Individuals During Operations

### 6.1 DOE

The DOE requirements in DOE Manual 435.1-1, Section I.E(13), for protection of individual during operations read as follows:

"Radioactive waste management facilities, operations, and activities shall meet the requirements of 10 CFR Part 835, Occupational Radiation Protection, and DOE Order 458.1, Radiation Protection of the Public and the Environment."

### 6.2 NRC

The NRC requirements of 10 CFR 61.43 are expressed as follows:

"Operations at the land disposal facility must be conducted in compliance with the standards for radiation protection set out in Part 20 of this chapter, except for releases of radioactivity in effluents from the land disposal facility, which shall be governed by Section 61.41 of this part.  Every reasonable effort shall be made to maintain radiation exposures as low as is reasonably achievable."

### 6.3 State of Texas

The State of Texas regulations (Rule §336.726) mirror the NRC regulations in 10 CFR 61.43.

### 6.4 Discussion

The ALARA concept is an integral part of DOE radiation and environmental protection programs, as expressed in DOE Policy 441.1, Department of Energy Radiological Health and Safety Policy.  DOE requirements for occupational radiological protection are addressed in 10 CFR 835, and similar requirements for radiological protection of the public and the environment are addressed in DOE Order 458.1.  The NRC 10 CFR 61.43 requirement references 10 CFR 20, Standards for Protection Against Radiation, which contains similar radiological protection standards for workers and the public.

Appendix B provides additional information on the comparability of DOE and NRC radiation dose standards that apply to protection of individuals during operations.  The State of Texas radiation dose standards mirror the NRC dose standards as explained in Appendix B.

## 7.0 Comparability Regarding Stability of the Disposal Site After Closure

### 7.1 DOE

The DOE requirements of DOE Manual 435.1-1, Sections IV.Q(1)(a) and (b) and IV.Q(2)(c), for stability of the disposal site after closure are expressed as follows:

"Disposal Site Stability (DOE Manual 435.1, Section IV.Q(1)(a) and (b)). A preliminary closure plan shall be developed and submitted to Headquarters for review with the performance assessment and composite analysis. The closure plan shall be updated following issuance of the disposal authorization statement to incorporate conditions specified in the disposal authorization statement. Closure plans shall:

(a) Be updated as required during the operational life of the facility.

(b) Include a description of how the disposal facility will be closed to achieve long-term stability and minimize the need for active maintenance following closure and to ensure compliance with the requirements of DOE Order 458.1, Radiation Protection of the Public and the Environment."

"Disposal Facility Closure (DOE Manual 435.1, Section IV.Q(2)(c)). Institutional control measures shall be integrated into land use and stewardship plans and programs, and shall continue until the facility can be released pursuant to DOE Order 458.1, Radiation Protection of the Public and the Environment."

### 7.2 NRC

The NRC requirements of 10 CFR 61.44 state that:

"The disposal facility must be sited, designed, used, operated, and closed to achieve long-term stability of the disposal site and to eliminate to the extent practicable the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required."

### 7.3 State of Texas

The State of Texas regulations (Rule §336.727) mirror as the NRC regulations in 10 CFR 61.43.

### 7.4 Discussion

The DOE LLW disposal requirements address long-term stability of the site by requiring a description of how closure will achieve stability in the closure plan, and by a description of how closure will minimize the need for active maintenance following closure (DOE Manual 435.1, Section IV.Q (1)(b)). Additionally, one of the performance assessment requirements (DOE Manual 435.1, Section IV.P (2)(c)) states: "Performance assessments shall address reasonably foreseeable natural processes that might disrupt barriers against release and transport of radioactive materials." As explained above, the Texas regulations mirror the NRC regulations.

## 8.0 References

### Code of Federal Regulations

10 CFR 20, Standards for Protection Against Radiation.

10 CFR 61, Subpart C, Licensing Requirements for Land Disposal of Radioactive Waste, Performance Objectives.

10 CFR 835, Occupational Radiation Protection.

**DOE Orders, Policies, and Manuals**

DOE Order 458.1 Admin. Chg. 3, Radiation Protection of the Public and the Environment, Change 2. U.S. Department of Energy, Washington, D.C.

DOE Manual 435.1-1, Radioactive Waste Management Manual, Change 2. U. S. Department of Energy, Washington, D.C.

**State Regulations**

Texas Administrative Code, Title 30, Part 1, Chapter 336, Radioactive Substance Rules https://texreg.sos.state.tx.us/public/readtac$ext.ViewTAC?tac_view=4&ti=30&pt=1&ch=336

**Other References**

Cole, L., D. Kudera, and W. Newberry, 1995, Comparison of Selected DOE and Non-DOE Requirements, Standards, and Practices for Low-Level Radioactive Waste Disposal, DOE/LLW-225, Revision 0. Idaho National Engineering Laboratory, Lockheed Idaho Technologies Company, Idaho Fall, Idaho.

NRC 1982, Final Environmental Impact Statement on 10 CFR Part 61 Licensing Requirements for Land Disposal of Radioactive Waste, Summary and Main Report, NUREG-0945, Volume 1. U.S. Nuclear Regulatory Commission, Washington, D.C.

NRC 2005, U.S. Nuclear Regulatory Commission Technical Evaluation Report for the U.S. Department of Energy Savannah River Site Draft Section 3116 Waste Determination for Salt Waste Disposal. U.S. Nuclear Regulatory Commission, Washington, D.C.

Wilhite, E, 2001, Comparison of LLW Disposal Performance Objectives, 10 CFR 61 and DOE 435.1 (WSRC-RP-2001-00341) Westinghouse Savannah River Company, Aiken, South Carolina.

# APPENDIX B

## Comparability of DOE, NRC, and Texas Dose Standards

**Appendix Purpose**

The purpose of this appendix is to compare Department of Energy, Nuclear Regulatory Commission, and State of Texas radiation dose standards that apply to individual workers and to members of the public during operations.

**Appendix Content**

This appendix identifies applicable Department of Energy dose standards and the similar Nuclear Regulatory Commission and State of Texas dose standards and discusses their comparability.

**Key Points**

- The Department of Energy radiation dose standards appear in 10 CFR 835, Occupational Radiation Protection, and in DOE Orders.
- The Nuclear Regulatory Commission radiation dose standards appear in 10 CFR 20, Standards for Protection Against Radiation.
- Department of Energy and Nuclear Regulatory Commission radiation dose standards are comparable.
- The State of Texas dose standards that apply to the WCS low-level waste disposal facility – which are included in the Texas Administrative Code, Title 30, Part 1, Chapter 336, Subchapter D – mirrors the Nuclear Regulatory Commission dose standards.

### 1.0 Introduction

The purpose of this appendix is to compare the DOE, NRC, and State of Texas dose standards that apply to protection of the public and the workers from radiation during operations associated with preparing the test sample waste for shipment to PFNW and handling of the treated and solidified waste when it is received at the WCS LLW disposal facility in Texas for disposal.

Section 5.2.4 of the body of this Test Sample WIR Evaluation briefly addressed protection of individuals during these operations at the ORP and the WCS LLW disposal facility. Appendix C also addressed this matter. This appendix provides a more detailed treatment of the dose standards used.

Requirements in NRC's regulations at 10 CFR 61.43 state:

"[O]perations at the land disposal facility must be conducted in compliance with the standards for radiation protection set out in part 20 of this chapter [10 CFR], except for releases of radioactivity in effluents from the land disposal facility, which shall be governed by §61.41 of this part. Every reasonable effort shall be made to maintain radiation exposures as low as is reasonably achievable."

This requirement references 10 CFR 20, Standards for Protection Against Radiation, which contains radiological protection standards for workers and the public. The DOE requirements for occupational radiological protection are provided in 10 CFR 835, Occupational Radiation Protection, and those for radiological protection of the public and the environment are provided in DOE Order 458.1, Radiation Protection of the Public and the Environment. The State of Texas radiation protection standards appear in the Texas Administrative Code, Title 30, Part 1, Chapter 336, Subchapter D.

The NRC standards for radiation protection in 10 CFR 20 that are considered in detail in this Test Sample WIR Evaluation are the dose limits for the public and the workers during disposal operations set forth in 10 CFR 20.1101(d), 20.1201(a)(1)(i), 20.120 1(a)(1)(ii), 20.120 1(a)(2)(i), 20.120 1(a)(2)(ii), 20.1201(e), 20.1208(a), 20. 1301(a)(1), 20.1301(a)(2), and 20.1301(b).51. These NRC dose limits correspond to the DOE dose limits in 10 CFR 835 and relevant DOE orders that establish DOE regulatory and contractual requirements for DOE facilities and activities. As discussed in Section 5.2.4 of this Test Sample WIR Evaluation, operations related to disposal of the test sample waste will meet these dose limits and doses will be maintained ALARA. As explained below, the State of Texas radiation protection standards mirror the NRC radiation protection standards.

## 2.0 Air Emissions Limit for Individual Member of the Public

### 2.1 DOE

DOE limits doses from air emissions to the public to 10 mrem/y in DOE Order 458.1. The DOE is also subject to and complies with the U.S. Environmental Protection Agency requirement in 40 CFR 61.92, which has the same limit.

### 2.2 NRC

The NRC regulation in 10 CFR 20.1101(d) provides in relevant part:

[A] constraint on air emissions of radioactive material to the environment, excluding radon-222 and its daughters, shall be established ... such that the individual member of the public likely to receive the highest dose will not be expected to receive a total effective dose equivalent in excess of 10 mrem (0.1 mSv)/y from these emissions.

The standards for radiation protection in 10 CFR 20 (as cross-referenced in the performance objective in 10 CFR 61.43), which are relevant to this Test Sample WIR Evaluation, are the dose limits for radiation protection of the public and the workers during disposal operations, and not those which address general licensing, administrative, programmatic, or enforcement matters administered by NRC for NRC licensees. Accordingly, this Test Sample WIR Evaluation addresses in detail the radiation dose limits for the public and the workers during disposal operations that are contained in the provisions of 10 CFR 20 referenced above. Although 10 CFR 20.1206(e) contains limits for planned special exposures for adult workers, there will not be any such planned special exposures for work related to the treatment of the test samples at issue in this Test Sample WIR Evaluation. Therefore, this limit is not discussed further in this Test Sample WIR Evaluation. Likewise, 10 CFR 20.1207 specifies occupational dose limits for minors. However, there will not be minors working at ORP, PFNW, or WCS who would receive an occupational dose. Therefore, this limit is not discussed further in this Test Sample WIR Evaluation.

40 CFR 61.92 provides as follows: ―Emissions of radionuclides to the ambient air from DOE facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/y. It is assumed that the individual is an adult living at the site perimeter that is exposed to the maximum yearly radioactive atmospheric release and maximum radiation

concentration in food for 365 days per year. For the airborne pathway, the dose is developed by the input of atmospheric release data, vegetation consumption data, milk consumption data, and beef consumption data.‖

### 2.3 State of Texas

The State of Texas regulation in the Texas Administrative Code, Title 30, Part 1, Rule §336.304 mirrors the NRC regulation.

### 2.4 Discussion

The DOE, NRC, and State of Texas requirements are comparable.

## 3.0 Total Effective Dose Equivalent Limit for Adult Workers

### 3.1 DOE

DOE‘s regulation in 10 CFR 835.202(a)(1) requires that the occupational dose per year for general employees shall not exceed a total effective dose equivalent of 5 rems.

### 3.2 NRC

The NRC regulation in 10 CFR 20.1201(a), concerning occupational dose limits for adults, provides in relevant part:

"(a) [C]ontrol the occupational dose to individual adults, except for planned special exposures...to the following dose limits.

(1) An annual limit, which is the more limiting of –

(i) The total effective dose equivalent being equal to 5 rems (0.05 Sv)."

### 3.3 State of Texas

The State of Texas regulation in the Texas Administrative Code, Title 30, Part 1, Rule §336.305 mirrors the NRC regulation.

### 3.4 Discussion

The DOE, NRC, and State of Texas requirements are comparable.

## 4.0 Any Individual Organ or Tissue Dose Limit for Adult Workers

### 4.1 DOE

The DOE regulation in 10 CFR 835.202(a)(2) provides in relevant part:

". . . the occupational dose received by general employees shall be controlled such that the following limits are not exceeded in a year:

(2) The sum of the deep dose equivalent for external exposures and the committed dose equivalent to any organ or tissue other than the lens of the eye of 50 rems (0.5 sievert)"

The DOE's regulations at 10 CFR 835.202(a)(1) and (a)(2) require that the occupational dose per year for general employees shall not exceed both a total effective dose equivalent of 5 rems and the sum of the deep-dose equivalent for external exposures and the committed dose equivalent to any other organ or tissue other than the lens of the eye of 50 rems. The NRC's regulation specifies that either of these two limits shall be met by NRC licensees, whichever is more limiting. Thus, DOE imposes stricter, separate requirements. The provisions of DOE's requirements at 10 CFR 835.202(a)(1) and (a)(2), which correlate to NRC requirements at 10 CFR 20.1201(a)(1) and (a)(2), are discussed in separate subsections in this Test Sample WIR Evaluation.

### 4.2 NRC

The NRC regulation in 10 CFR 20.1201(a), concerning occupational dose limits for adults, provides in relevant part:

"(a) [C]ontrol the occupational dose to individual adults, except for planned special exposures...to the following dose limits.

(1) An annual limit, which is the more limiting of –...

(ii) The sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 rems (0.5 Sv)."

### 4.3 State of Texas

The State of Texas regulation in the Texas Administrative Code, Title 30, Part 1, Rule §336.305 mirrors the NRC regulation.

### 4.4 Discussion

The DOE, NRC, and State of Texas requirements are comparable.

## 5.0 Annual Dose Limit to the Lens of the Eye for Adult Workers

### 5.1 DOE

The DOE regulation in 10 CFR 835.202(a)(3) provides in relevant part:

". . . the occupational dose received by general employees shall be controlled such that the following limits are not exceeded in a year:

(3) A lens of the eye dose equivalent of 15 rems (0.15 sievert)"

### 5.2 NRC

The NRC regulation in 10 CFR 20.1201(a), concerning occupational dose limits for adults, provides in relevant part:

(a) [C]ontrol the occupational dose to individual adults, except for planned special exposure the following dose limits. ...

(2) The annual limits to the lens of the eye, to the skin of the whole body or to the skin of the extremities, which are:

(i) A lens dose equivalent of 15 rems (0.15 Sv).

### 5.3 State of Texas

The State of Texas regulation in the Texas Administrative Code, Title 30, Part 1, Rule §336.305 mirrors the NRC regulation.

### 5.4 Discussion

The DOE, NRC and State of Texas requirements are comparable.

## 6.0 Annual Dose Limit to the Skin of the Whole Body and to the Skin of the Extremities for Adult Workers

### 6.1 DOE

The DOE regulation in 10 CFR 835.202(a)(4) provides in relevant part:

“. . . the occupational dose received by general employees shall be controlled such that the following limits are not exceeded in a year:

(4) A shallow dose equivalent of 50 rems (0.5 sievert) to the skin or any extremity.”

### 6.2 NRC

The NRC regulation in 10 CFR 20.1201(a), concerning occupational dose limits for adults, provides in relevant part:

(a) [C]ontrol the occupational dose to individual adults, except for planned special exposures...to the following dose limits. ...

(2) The annual limits to the lens of the eye, the skin of the whole body, or to the skin of the extremities, which are: ...

(ii) A shallow-dose equivalent of 50 rem (0.5 Sv) to the skin of the whole body or to the skin of any extremity.

### 6.3 State of Texas

The State of Texas regulation in the Texas Administrative Code, Title 30, Part 1, Rule §336.305 mirrors the NRC regulation.

### 6.4 Discussion

The DOE, NRC, and State of Texas requirements are comparable.

## 7.0 Limit on Soluble Uranium Intake

### 7.1 DOE

Requirements in DOE Order 440.1A for soluble uranium intake are the more restrictive of the concentrations in the American Conference of Governmental Industrial Hygienists threshold limit values

(0.2 mg/m3, which is the same as noted in 10 CFR 20, Appendix B) or the Occupational Safety and Health Administration permissible exposure limit (0.05 mg/m3). The permissible exposure limit for soluble uranium, which equates to a soluble uranium intake of 2.4 mg/week, is the more restrictive of the two.

### 7.2 NRC

The NRC regulation in 10 CFR 20.1201(e), concerning occupational dose limits for adults, provides in relevant part: "in addition to the annual dose limits, ... limit the soluble uranium intake by an individual to 10 milligrams in a week in consideration of chemical toxicity."

### 7.3 State of Texas

The State of Texas regulation in the Texas Administrative Code, Title 30, Part 1, Rule §336.305 mirrors the NRC regulation.

### 7.4 Discussion

The DOE requirements are more restrictive.

## 8.0 Dose Equivalent to an Embryo/Fetus

### 8.1 DOE

The DOE regulation in 10 CFR 835.206(a) provides in relevant part:

"The dose equivalent limit for the embryo/fetus from the period of conception to birth, as a result of occupational exposure of a declared pregnant worker, is 0.5 rem (0.005 sievert)."

After declaration of pregnancy, DOE provides the option of a mutually agreeable assignment of work tasks, without loss of pay or promotional opportunity, such that further occupational radiation exposure during the remainder of the gestation period is unlikely. In addition, personnel dosimetry[38] is provided and used to monitor exposure carefully.

### 8.2 NRC

The NRC regulation in 10 CFR 20.1208(a), concerning the dose equivalent to an embryo/fetus, provides in relevant part:

"ensure that the dose equivalent to the embryo/fetus during the entire pregnancy, due to the occupational exposure of a declared pregnant woman, does not exceed 0.5 rem (5 mSv)."

### 8.3 State of Texas

The State of Texas regulation in the Texas Administrative Code, Title 30, Part 1, Rule §336.312 mirrors the NRC regulation.

[38] The term dosimetry or personnel dosimetry refers to a device carried or worn by an individual working near radiation for measuring the amount of radiation to which he or she is exposed.

### 8.4 Discussion

The DOE, NRC, and State of Texas requirements are comparable.

## 9.0 Dose Limits for Individual Members of the Public (Total Annual Dose)

### 9.1 DOE

Provisions in DOE Order 458.1 limit public doses to 0.1 rem per year.

### 9.2 NRC

The NRC regulation in 10 CFR 20.1301(a), concerning dose limits for individual members of the public, provides in relevant part:

(a) "[C]onduct operations so that –

(1) The total effective dose equivalent to individual members of the public ...does not exceed 0.1 rem (1 mSv) in a year, exclusive of the dose contributions from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive material and released..., from voluntary participation in medical research programs, and from the ...disposal of radioactive material into sanitary sewerage."

### 9.3 State of Texas

The State of Texas regulation in the Texas Administrative Code, Title 30, Part 1, Rule §336.313 mirrors the NRC regulation.

### 9.4 Discussion

The DOE, NRC, and State of Texas requirements are comparable.

## 10.0 Dose Limits for Individual Members of the Public (Dose Rate in Unrestricted Areas)

### 10.1 DOE

DOE's regulation in 10 CFR 835.602 establishes the expectation that the total effective dose equivalent in controlled areas will be less than 0.1 rem per year. In accordance with 10 CFR 835.602, radioactive material areas have been established for accumulations of radioactive material within controlled areas that could result in a radiation dose of 100 mrem per year or greater. Averaged over a work year, this yields a constant average dose rate of 0.00005 rem per hour. In addition, training and dosimetry are required for individual members of the public for entry into controlled areas, as well as signs at each access point to a controlled area.

### 10.2 NRC

The NRC regulation in 10 CFR 20.1301(a), concerning dose limits for individual members of the public, provides in relevant part:

(a) "[C]onduct operations so that –

(1) The total effective dose equivalent to individual members of the public from the licensed operation does not exceed 0.1 rem (1 mSv) in a year, exclusive of the dose contributions from background radiation, from any administration the individual has received, from exposure to individuals administered radioactive material and released under § 35.75, from voluntary participation in medical research programs, and from the licensee‘s disposal of radioactive material into sanitary sewerage in accordance with § 20.2003, and

(2) The dose in any unrestricted area from external sources, exclusive of the dose contributions from patients administered radioactive material and released in accordance with § 35.75, does not exceed 0.002 rem (0.02 millisievert) in any one hour.

(b) If the licensee permits members of the public to have access to controlled areas, the limits for members of the public continue to apply to those individuals."

### 10.3 State of Texas

The State of Texas regulation in the Texas Administrative Code, Title 30, Part 1, Rule §336.313 mirrors the NRC regulation.

### 10.4 Discussion

The DOE, NRC and State of Texas requirements are comparable.

## 11.0 Dose Limits for Individual Members of the Public With Access to Controlled Areas

### 11.1 DOE

The DOE regulation in 10 CFR 835.208 provides:

"The total effective dose equivalent limit for members of the public exposed to radiation and/or radioactive material during access to a controlled area is 0.1 rem (0.001 sievert) in a year."

DOE requires training for individual members of the public before entry into controlled areas. In addition, to ensure no member of the public exceeds radiation exposure limits, use of dosimetry is required if a member of the public is expected to enter a controlled area and receive a dose that may exceed 0.05 rem in a year

### 11.2 NRC

The NRC regulation in 10 CFR 20.1301(b), concerning dose limits for individual members of the public, provides in relevant part:

"if ... members of the public [are permitted] to have access to controlled areas, the limits for members of the public [0.1 rem (1 mSv)] continue to apply to those individuals."

### 11.3 State of Texas

The State of Texas regulation in the Texas Administrative Code, Title 30, Part 1, Rule §336.313 mirrors the NRC regulation.

### 11.4 Discussion

The DOE, NRC, and State of Texas requirements in this area are comparable.

## 12.0 As Low As Reasonably Achievable

### 12.1 DOE

The DOE regulation in 10 CFR 835.2 defines ALARA as “the approach to radiation protection to manage and control exposures (both individual and collective) to the work force and to the general public to as low as is reasonable, taking into account social, technical, economic, practical, and public policy considerations.” The DOE regulation in 10 CFR 835.2 also specifies: “ALARA is not a dose limit but a process which has the objective of attaining doses as far below the applicable limits as is reasonably achievable.”

### 12.2 NRC

The NRC regulation in 10 CFR 20.1003 defines ALARA in relevant part: “ALARA . . . means making every reasonable effort to maintain exposures to radiation as far below the dose limits . . . as is practical consistent with the purpose for which the . . . activity is undertaken.”

### 12.3 State of Texas

The State of Texas in the Texas Administrative Code, Rule §336.304(b) provides as follows:

“(b) The licensee shall use, to the extent practicable, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable (ALARA).”

### 12.4 Discussion

The DOE, NRC, and State of Texas definitions of ALARA are comparable.

## 12.0 References

### Code of Federal Regulations

10 CFR 20, Standards for Protection Against Radiation.

10 CFR 835, Occupational Radiation Protection.

40 CFR 61, National Emission Standards for Hazardous Air Pollutants.

### DOE Orders

DOE Order 440.1A, Worker Protection Management for DOE Federal and Contractor Employees. U.S. Department of Energy, Washington, D.C.

DOE Order 458.1 Admin.Chg. 3, Radiation Protection of the Public and the Environment. U.S. Department of Energy, Washington, D.C.

### State Regulations

Texas Administrative Code, Title 30, Part 1, Chapter 336, Radioactive Substance Rules
(http://www.wcstexas.com/facilities/licenses-permits/)

# APPENDIX C

## Consideration of the Criteria in Section 3116 of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005

**Appendix Purpose**

The purpose of this appendix is to discuss the criteria in Section 3116 of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 with respect to this Test Sample WIR Evaluation.

**Appendix Content**

This appendix describes the subject criteria in relation to the Department's plans for disposal of the test sample waste.

**Key Points**

- Section 3116 of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 does not apply to the test sample waste.
- However, disposal of the test sample waste at the WCS facility as low-level radioactive waste would be consistent with the criteria of Section 3116 of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005.

### 1.0 Introduction

Sections 4 through 6 of this Test Sample WIR Evaluation demonstrate that the test sample waste meets the criteria of DOE Manual 435.1-1 for determining that the waste is incidental to reprocessing and is not HLW, and will be managed and disposed of as LLW under DOE's regulatory authority as applicable pursuant to the Atomic Energy Act of 1954, as amended.  Section 3116 of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 contains similar criteria, and provides that the Secretary of Energy, in consultation with NRC, may determine that waste resulting from reprocessing of spent nuclear fuel at DOE facilities in South Carolina and Idaho, that is to be disposed of within those states, is not HLW where the criteria in section 3116(a)(1)-(3) are met.

Subsection (b) of Section 3116 addresses monitoring by NRC.  Subsection (c) addresses inapplicability to certain materials (i.e., materials transported from the covered State). Subsection (d) identifies the covered States (South Carolina and Idaho.) Subsection (e) addresses certain matters concerning construction of section 3116, and provides that the section does not establish any precedent in any State other than South Carolina and Idaho.  Subsection (f) provides for judicial review of determinations made pursuant to section 3116 and of any failure by NRC to carry out its monitoring responsibilities.

Although Section 3116 of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 does not apply to the test sample waste, the following discussion addresses the relevant criteria in 3116(a)(1)-(3) for perspective and information, and, shows that disposal of the test sample waste as LLW at the WCS facility would be consistent with relevant criteria in Section 3116(a)(1)-(3) of the National Defense Authorization Act for Fiscal Year 2005.

### 2.0 Consideration of Whether the Test Sample Waste Requires Permanent Isolation in a Deep Geologic Repository

The first criterion or clause in Section 3116(a), as set forth in Section 3116(a)(1), provides that the waste "does not require permanent isolation in a deep geologic repository for spent fuel or high-level radioactive waste". DOE Manual 435.1-1 does not contain an identical consideration, but similarly provides in relevant part in Chapter II.B.(2)(a) that the waste "will be managed as low-level waste" and meet the criteria in Section II.B.(2)(a).

With respect to the first criterion or clause, as provided in Section 3116(a)(1), the DOE has explained:

"Clause (1), noted above, is a broader criterion for the Secretary, in consultation with the NRC, to consider whether, notwithstanding that waste from reprocessing meets the other two criteria, there are other considerations that, in the Secretary's judgment, require its disposal in a deep geologic repository. Generally, such considerations would be an unusual case because waste that meets the third criterion would be waste that will be disposed of in a manner that meets the 10 CFR 61, Subpart C performance objectives and either falls within one of the classes set out in 10 CFR 61.55 that the NRC has specified are considered "generally acceptable for near-surface disposal" or for which the Secretary has consulted with NRC concerning DOE's disposal plans. As the NRC explained in In the Matter of Louisiana Energy Services, L.P. (National Enrichment Services) (NRC 2005), the 10 CFR Part 61, Subpart C performance objectives in turn "set forth the ultimate standards and radiation limits for (1) protection of the general population from releases of radioactivity; (2) protection of individuals from inadvertent intrusion; (3) protection of individuals during operations; and (4) stability of the disposal site after closure." It follows that if disposal of a waste stream in a facility that is not a deep geologic repository will meet these objectives.

It is possible that in rare circumstances a waste stream that meets the third criterion might have some other unique radiological characteristic or may raise unique policy considerations that warrant its disposal in a deep geologic repository. Clause (1) is an acknowledgement by Congress of that possibility. For example, the waste stream could contain material that, while not presenting a health and safety danger if disposed of at near- or intermediate-surface, nevertheless presents non-proliferation risks that the Secretary concludes cannot be adequately guarded against absent deep geologic disposal. Clause (1) gives the Secretary, in consultation with NRC, the authority to consider such factors in determining whether waste that meets the other two criteria needs disposal in a deep geologic repository in light of such considerations."

That is not the case here. As demonstrated in Section 4 of this Test Sample WIR Evaluation, key radionuclides have been removed from the test sample waste to the maximum extent technically and economically practical. Moreover, the test sample waste will be in a solid physical form and will not exceed the concentration limits for Class C low-level waste in 10 CFR 61.55, as described in Section 6. As explained in Section 5, management and disposal of the test sample waste as LLW at the WCS facility also would meet safety requirements comparable to the NRC performance objectives in 10 CFR 61, Subpart C, so as to provide for the protection of human health and safety and the environment. As such, the disposal of the test sample waste as LLW does not present a danger to human health and safety, such that disposal in a deep geologic repository would be warranted. Furthermore, the test samples do not present unique radiological characteristics, or raise non-proliferation risks or other unique policy considerations, which, while not manifesting a danger to human health, nevertheless would command deep geologic disposal. Accordingly, the planned disposal of the test sample waste as LLW at the WCS facility would be consistent with the first criterion of Section 3116(a).

**3.0 Consideration of Removal of Highly Radioactive Radionuclides**

The second criterion of Section 3116(a) specifies that the waste "has had highly radioactive radionuclides removed to the maximum extent practical." DOE Manual 435.1-1, Chapter II.B.(2)(a)1, contains a similar provision, which specifies that such wastes "[h]ave been processed, or will be processed, to remove key radionuclides to the maximum extent that is technically and economically practical."

Section 4, Table 4-3, of this Test Sample WIR Evaluation identifies key radionuclides for the test sample waste. As can be seen in this table, all radionuclides in Tables 1 and 2 of 10 CFR 61.55 were considered. Furthermore, Section 4 of this Test Sample WIR Evaluation describes how key radionuclides will be removed to the maximum extent technically and economically practical, thus satisfying the DOE criterion and evincing consistency with the second criterion of 3116(a).

## 4.0 Consideration of Radionuclide Concentration Limits and Waste Disposal Performance Objectives

The third criterion in section 3116(a)(3) concerns whether the waste meets the concentration limits for Class C LLW in 10 CFR 61.55 and whether the waste will be disposed of in accordance with the performance objectives at 10 CFR Part 61, Subpart C. The criteria in DOE Manual 435.1-1, Chapter II (B)(2)(a)2 and (a)3 similarly provide that waste "[w]ill be managed to meet safety requirements comparable to the performance objectives set out in 10 CFR Part 61, Subpart C" and "will be incorporated in a solid physical form at a concentration that does not exceed the applicable concentration limits for Class C low-level waste as set out in 10 CFR 61.55", respectively.

Section 6 of this Test Sample WIR Evaluation demonstrates that the treated and solidified test sample waste will not exceed the Class C concentration limits in 10 CFR 61.55 (which are mirrored in the Texas Administrative Code, Rule §336.362, Appendix E). In addition, the test sample waste will be packaged in a shipping container and in a solid physical form as discussed in Section 6. Section 4 of this draft evaluation further shows that management and disposal of the waste will meet safety requirements comparable to NRC performance objectives in 10 CFR Part 61, Subpart C. Given these considerations, management and disposal of the treatability volumes of tank waste as planned meets the above-referenced DOE criteria and would be consistent with the third criterion of Section 3116(a).

## 6.0 References


### Federal Statutes

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**Other References**

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