Technical Evaluation for Non-High-Level Radioactive Waste (Non-HLW) Determination under the HLW Interpretation:

Commercial Disposal of Defense Waste Processing Facility Recycle Wastewater from the Savannah River Site

U.S. Department of Energy
Office of Environmental Management

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Table of Contents

Executive Summary

This report evaluates whether a small quantity (up to 8 gallons) of Defense Waste Processing Facility (DWPF) recycle wastewater from Tank 22 at the Savanah River Site H Tank Farm meets the Department of Energy's (DOE) high-level radioactive waste (HLW) interpretation for classification as non-HLW.

In August 2020, DOE completed an environmental assessment and finding of no significant impact under the National Environmental Policy Act (NEPA), which analyzed the potential impacts of the Proposed Action and concluded that it does not constitute a major federal action significantly affecting the quality of the human environment.

This report provides background information on the HLW interpretation, the NEPA analysis, DWPF recycle wastewater, and the Waste Control Specialists, LLC (WCS) Federal Waste Facility; and demonstrates that the stabilized DWPF recycle wastewater meets the HLW interpretation. This information includes sampling results, waste profile data, quality assurance protocol, and other relevant information. This technical evaluation supports a waste determination that the up to 8 gallons of stabilized DWPF recycle wastewater from Tank 22 at the Savanah River Site H-Area Tank Farm, which will be stabilized into grout prior to disposal, meets the DOE's HLW interpretation for disposal as non-HLW. The waste is Class B low-level radioactive waste and hence may be disposed at WCS as low-level radioactive waste in accordance with the facility's waste acceptance criteria, license conditions, environmental permits, and all other applicable requirements. Supporting technical documents are available at: https://www.energy.gov/em/program-scope/high-level-radioactive-waste-hlw-interpretation.

Acronyms

AEA	Atomic Energy Act of 1954, as amended
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
DWPF	Defense Waste Processing Facility
EA	environmental assessment
ETF	Effluent Treatment Facility
FONSI	finding of no significant impact
FR	Federal Register
FWF	WCS Federal Waste Facility
HLW	high-level radioactive waste
LLW	low-level radioactive waste
NEPA	National Environmental Policy Act
NRC	Nuclear Regulatory Commission
NWPA	Nuclear Waste Policy Act of 1982, as amended
PA	performance assessment
QA	quality assurance
RCRA	Resource Conservation and Recovery Act
RCT	Recycle Collection Tank
SOF	sum of fractions
SRNL	Savannah River National Laboratory
SRNS	Savannah River Nuclear Solutions
SRR	Savannah River Remediation
SRS	Savannah River Site
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
WAC	waste acceptance criteria
WCS	Waste Control Specialists, LLC

1. Introduction

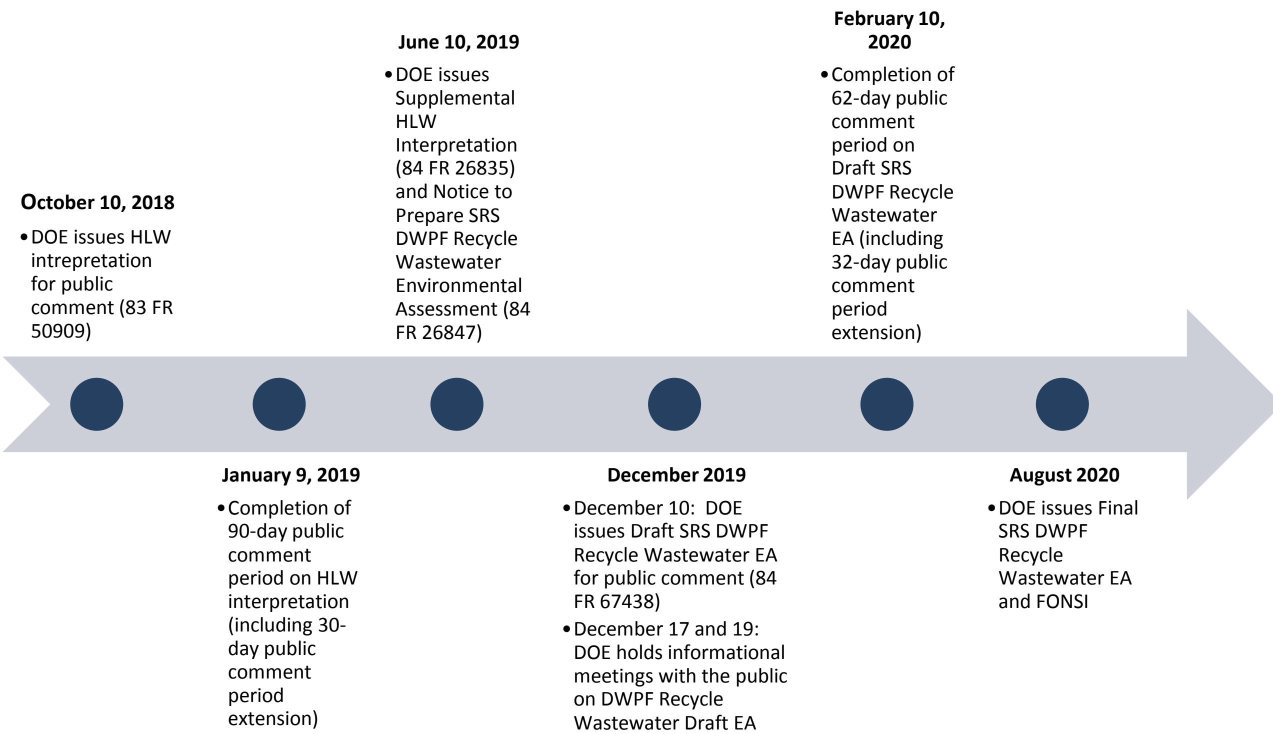
The purpose of this report is to demonstrate that a waste stream at the Savannah River Site (SRS) that is currently managed as high-level radioactive waste (HLW) meets the Department of Energy's (DOE) HLW interpretation, and therefore is non-HLW. This report assesses up to 8 gallons of Defense Waste Processing Facility (DWPF) recycle wastewater from the SRS for treatment and disposal as non-HLW at the Waste Control Specialists, LLC (WCS) Federal Waste Facility (FWF) in Andrews County, Texas. The HLW interpretation provides that "some reprocessing wastes may be classified as non-HLW and may be disposed of in accordance with their radiological characteristics."

DWPF recycle wastewater—a byproduct of reprocessing waste—is a combination of several dilute waste streams consisting primarily of condensates from the vitrification of tank waste at the SRS DWPF. Demonstration of disposal as a stabilized (grouted) waste form of up to 8 gallons of DWPF recycle wastewater at the WCS FWF will inform planning activities on treatment and disposal options for completion of the SRS liquid waste program.

In August 2020, DOE completed a National Environmental Policy Act (NEPA) analysis of its Proposed Action, which is the disposal of up to 10,000 gallons of stabilized (grouted) DWPF recycle wastewater from the SRS H-Area Tank Farm at a commercial low-level radioactive waste (LLW) disposal facility located outside of South Carolina and licensed by either the U.S. Nuclear Regulatory Commission (NRC) or an Agreement State under 10 Code of Federal Regulations (CFR) Part 61. The NEPA analysis determined that the Proposed Action was not a major federal action and would not have a significant impact on the quality of the human environment. DOE initially plans to proceed with stabilization and disposal of up to 8 gallons at the WCS FWF. This would inform subsequent actions to dispose of the remaining balance of the 10,000 gallons of DWPF recycle wastewater. A timeline of key events for the HLW interpretation and the SRS DWPF recycle wastewater NEPA evaluation is presented in **Figure 1**.

DWPF recycle wastewater is currently transferred from DWPF to Tank 22 (1.3 million gallon capacity) at the H Tank Farm for further processing. This technical evaluation applies to a small quantity (up to 8 gallons) of DWPF recycle wastewater stored in Tank 22 and proposed to be retrieved for treatment (stabilization) and disposal of the solid waste form as LLW at the WCS FWF. Treatment and disposal of the DWPF recycle wastewater would be in accordance with all applicable licenses and permits. The WCS FWF is licensed by the Texas Commission on Environmental Quality (TCEQ) for the disposal of Class A, B, and C LLW. Based on representative sampling and analyses, as discussed in **Section 3** of this report, the up to 8 gallons of DWPF recycle wastewater would be classified as Class B LLW under the NRC waste classification tables in 10 CFR Section 61.55 and Texas Administrative Code (TAC) waste classification tables in 30 TAC §336.362 Appendix E. The TAC waste classification tables mirror the NRC waste classification tables except that TAC adds an additional radionuclide (radium-226) to the waste classification table for long-lived radionuclides.

Figure 1. Timeline of Key Events



2. Background

This section provides background information supporting the classification of up to 8 gallons of DWPF recycle wastewater as non-HLW waste and disposal in an authorized near-surface facility. It presents an overview of DOE's HLW interpretation (**Section 2.1**) and NEPA Analysis (**Section 2.2**); and provides a description of DWPF wastewater (**Section 2.3**); WCS FWF (**Section 2.4**); and stabilization of the DWPF recycle wastewater (**Section 2.5**).

2.1 Overview of HLW Interpretation

On October 10, 2018, DOE published a notice in the *Federal Register* (83 FR 50909) requesting public comment on its interpretation of the definition of the statutory term, "high-level radioactive waste," as set forth in the Atomic Energy Act of 1954, as amended (AEA, 42 U.S.C. 2011 et seq.) and the Nuclear Waste Policy Act of 1982 as amended (NWPA, 42 U.S.C. 10101 et seq.). In that notice, DOE explained the history and basis for its interpretation of classifying reprocessing waste based on its radiological contents and not on the origin of the reprocessing waste.

Subsequently, on June 10, 2019, DOE published a Supplemental Notice in the *Federal Register* (84 FR 26835) that provided additional explanation of DOE's interpretation as informed by public review and comment and further consideration by DOE. In the Supplemental Notice, DOE explained its interpretation of the term HLW, as defined in the AEA and the NWPA. As discussed in the Supplemental Notice, DOE has the long-standing authority and responsibility under the AEA to ensure that all radioactive waste from the United States' defense program—including reprocessing waste—is managed and disposed of in a safe manner. The AEA and NWPA define HLW as:

> (A) the highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and
>
> (B) other highly radioactive material that the Commission, consistent with existing law, determines by rule requires permanent isolation. [42 U.S.C. 10101(12); *see* 42 U.S.C. 2014(dd)]

This definition of HLW makes clear that not all radioactive wastes from spent nuclear fuel reprocessing are HLW. DOE has the legal authority to interpret the term HLW in these statutes to determine that certain of its reprocessing wastes are non-HLW based on their radiological characteristics. Accordingly, DOE interprets those statutes to provide that reprocessing wastes are properly classified as non-HLW where the radiological characteristics of the waste, in combination with appropriate disposal facility requirements for safe disposal, demonstrate that disposal of such waste is fully protective of human health and the environment. Under DOE's interpretation, a reprocessing waste may be determined to be non-HLW if the waste meets either of the following two criteria:

> "(I) does not exceed concentration limits for Class C low-level radioactive waste as set out in section 61.55 of title 10, Code of Federal Regulations, and meets the performance objectives of a disposal facility; or
>
> (II) does not require disposal in a deep geologic repository and meets the performance objectives of a disposal facility as demonstrated through a performance assessment conducted in accordance with applicable requirements." [84 FR 26836]

Reprocessing waste meeting either of the above criteria is non-HLW, and—pursuant to appropriate processes (e.g., DOE approval)—may be classified and disposed in accordance with its radiological characteristics in an authorized facility provided all applicable requirements of the disposal facility are met.

As stated in the Supplemental Notice, the HLW interpretation "does not change or revise any current policies, legal requirements, or agreements with respect to HLW. Decisions about whether and how this interpretation of HLW will apply to existing wastes and whether such wastes may be managed as non-HLW will be the subject of subsequent actions." The Supplemental Notice further states that: "Each reprocessing waste stream has unique radiological characteristics and, accordingly, the interpretation will be implemented in subsequent actions on a site-specific basis, following consideration of: Evaluation and characterization of specific reprocessing waste streams in conjunction with the waste acceptance criteria and requirements of a specific waste disposal facility; input from affected stakeholders (e.g., federal, state, local and tribal officials; and members of the public); and compliance with applicable federal and state laws, regulations, and agreements."

In the Supplemental Notice and in separate concurrent Notice, *Draft Environmental Assessment for the Commercial Disposal of Defense Waste Processing Facility Recycle Wastewater from the Savannah River Site* (84 FR 26847, June 10, 2019), DOE announced that, as a first step in determining whether and how to implement this HLW interpretation specific to a particular waste stream, DOE was initiating a public process under NEPA to analyze the potential impacts associated with disposing up to 10,000 gallons of stabilized (grouted) DWPF recycle wastewater from the SRS H-Area Tank Farm at a commercial LLW disposal facility located outside of South Carolina and licensed by either the NRC or an Agreement State under 10 CFR Part 61. As discussed in **Section 2.2**, DOE has issued a final Environmental Assessment (EA) and a Finding of No Significant Impact (FONSI) for the Proposed Action.

2.2 NEPA

NEPA requires federal agencies to consider potential environmental impacts before making a decision regarding a proposed major federal action. It also provides a mechanism for public review and input and the consideration of reasonable alternative actions for major federal actions. As summarized below, DOE has completed the appropriate NEPA analysis for potential disposal of up to 10,000 gallons of DWPF recycle wastewater from SRS at a licensed commercial disposal facility, in accordance with Council on Environmental Quality and DOE NEPA implementing regulations at 40 CFR Parts 1500 through 1508 and 10 CFR Part 1021, respectively.

In August 2020, DOE issued the *Final Environmental Assessment for the Commercial Disposal of Defense Waste Processing Facility Recycle Wastewater from the Savannah River Site* (Final EA) and FONSI. DOE prepared the Final EA to evaluate potential impacts of the Proposed Action, which is the disposal of up to 10,000 gallons of stabilized (grouted) DWPF recycle wastewater from the SRS H-Area Tank Farm at a commercial LLW disposal facility located outside of South Carolina and licensed by either the NRC or an Agreement State[1] under 10 CFR Part 61.

Under the Proposed Action, up to 10,000 gallons of DWPF recycle wastewater would be characterized, stabilized, and disposed of at a commercial LLW disposal facility, if the performance objectives and waste acceptance criteria (WAC) of the selected disposal facility are met. The Final EA was informed by a 62-day public comment period (December 10, 2019, through February 10, 2020) on the Draft EA, issued on December 10, 2019 (84 FR 67438). Nineteen comment documents were received during the public comment period. Commenters included federal and state regulatory agencies, environmental groups, advisory groups, and citizens. DOE considered all comments received in preparing the Final EA. In addition, during the public comment period, DOE held an informational meeting in Augusta, Georgia on December 17, 2019, and an informational internet webinar on December 19, 2019, to provide the public and stakeholders with an overview of the Draft EA and HLW interpretation.[2]

Based on the analyses in the Final EA, DOE determined the Proposed Action would have no significant impacts on human health and the environment, does not constitute a major federal action within the context of NEPA, and thus does not require preparation of an environmental impact statement. In the FONSI, DOE announced its intention to implement the Proposed Action, which is the disposal of up to 10,000 gallons of stabilized (grouted) DWPF recycle wastewater from the SRS H-Area Tank Farm at a commercial LLW disposal facility located outside of South Carolina and licensed by either the NRC or an Agreement State under 10 CFR Part 61.

In 2020, DOE intends to ship up to 8 gallons of liquid DWPF recycle wastewater to the WCS site near Andrews, Texas for treatment and disposal as LLW in accordance with the facility's WAC, license conditions, environmental permits, and all other applicable requirements. The initial phase, which consists of the retrieval, transport, stabilization, and disposal of up to 8 gallons of liquid DWPF recycle wastewater, will help inform plans for the treatment and commercial disposal of the remaining balance of up to 10,000 gallons of DWPF recycle wastewater. Accordingly, the non-HLW determination is limited to the initial up to 8 gallons to be retrieved from Tank 22. Subsequent actions for the remaining balance (not to exceed 10,000 gallons) would consider the results of the initial up to 8-gallon phase and SRS liquid waste mission needs. Any retrieval of the remaining balance may not occur for several years following the initial phase and would require a separate non-HLW determination.

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[1] Congress authorized the NRC to enter into Agreements with states that allow the states to assume, and the NRC to discontinue, regulatory authority over source, byproduct, and small quantities of special nuclear material. The states, known as Agreement States, can then regulate byproduct, source, and small quantities of special nuclear materials that are covered in the Agreement, using its own legislation, regulations, or other legally binding provisions. (Section 274b of the Atomic Energy Act of 1954, as amended).

[2] Presentations given by DOE at the informational meetings are available online at: https://www.energy.gov/em/program-scope/high-level-radioactive-waste-hlw-interpretation

2.3 Description of DWPF Recycle Wastewater

This section provides a general description of DWPF recycle wastewater, including how it is generated and currently managed.

2.3.1 DWPF Operations

Over the years, a primary SRS mission has been the production of special radioactive isotopes to support national defense programs, including reprocessing of spent nuclear fuel and target materials. SRS generated large quantities of liquid radioactive waste as a result of reprocessing activities associated with its nuclear materials production mission. This liquid radioactive waste is currently managed as HLW. The waste was placed into underground storage tanks at SRS and consists primarily of three physical forms: sludge, saltcake, and liquid supernatant.[3] The high-activity waste streams (e.g., sludges) in the underground tanks or from salt processing facilities are being transferred on-site to the DWPF for vitrification in borosilicate glass to immobilize the radioactive constituents. In this process, a sand-like borosilicate glass (called "frit") is mixed with the waste and sent to the DWPF melter. In the melter, electricity is used to heat the waste/frit mixture to nearly 2,100 degrees Fahrenheit until molten. The resulting vitrified waste form is poured as molten glass into production canisters where it cools into a solid glass-waste and is securely stored at SRS until DOE establishes a final disposition path.

2.3.2 DWPF Recycle Wastewater

Under normal operations, DWPF produces a dilute secondary aqueous radioactive waste stream known as DWPF recycle wastewater. This recycle wastewater resulting from DWPF vitrification operations is ultimately collected on a batch basis in the DWPF Recycle Collection Tank (RCT), located inside the DWPF building, and subsequently transferred on a batch basis to Tank 22 (1.3 million gallon capacity) located at the SRS H-Area Tank Farm (**Figure 2**). There are several DWPF processes that generate secondary aqueous radioactive waste as contributors to DWPF recycle wastewater. Contributors to this waste stream include:

- Major Contributors: There are two major contributors (in terms of volume) to the DWPF recycle wastewater stream. The first major contributor is condensate from processing the tank sludge and salt waste prior to vitrification. Vapors from the processing operations are cooled, condensed, and eventually transferred to the RCT. The second major contributor is condensate from the melter off-gas system. Off-gases from the melter are treated in an off-gas system composed of quenchers, steam atomized scrubbers,

[3] Sludge components of radioactive liquid waste consist of the insoluble solids that have settled to the bottom of the waste storage tanks. Radionuclides present in the sludge include fission products (such as strontium-90) and long-lived actinides. Supernatant is the liquid portion of the waste stored with the sludge and saltcake. The combination of supernatant and saltcake is referred to as salt waste.

condensers, and filters, all of which remove radioactive particulate matter and volatile components before exhausting gases under an approved air permit. Condensate from the off-gas system is also collected and eventually transferred to the RCT.

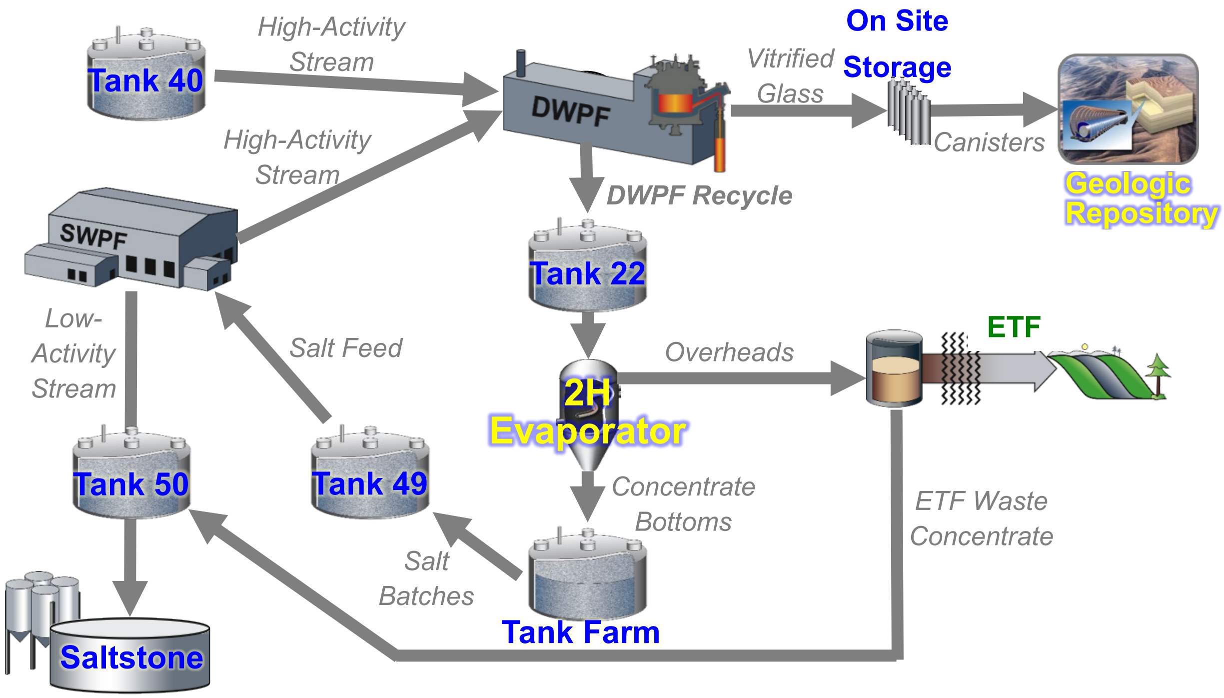
- Minor Contributors: There are four minor contributors, which include sample flushes, sump flushes, decontamination solutions, and high-efficiency mist eliminator dissolution solution. These aqueous streams are also collected in the RCT. Decontamination solutions are acidic solutions used to reduce radiation rates on equipment prior to work in a maintenance cell and rinse water, which can be pumped from a sump if necessary. Any collected solutions are neutralized to a pH greater than 7 and then sampled to confirm pH. The sampler is flushed prior to transfer of the liquids to the RCT.

While a small percentage of DWPF recycle wastewater has beneficial reuse in saltcake dissolution or sludge washing prior to vitrification, the majority is transferred to the 2H Evaporator system, which separates the concentrates (evaporator bottoms) from the condensates (overheads), reducing the volume necessary for tank farm storage. The concentrates are stored in the tank farm for future salt waste processing and the condensates are routed to the Effluent Treatment Facility (ETF) for further processing prior to release to a permitted outfall. **Figure 2** illustrates the relationship between DWPF recycle wastewater and the other facilities and processes.

The DWPF recycle wastewater contains short-lived and long-lived radionuclides. The primary short-lived radionuclide is cesium-137 (half-life of approximately 30 years). Key long-lived radionuclides include americium-241 (half-life of approximately 432 years); plutonium-238 (half-life of approximately 88 years); plutonium-239 (half-life of approximately 24,100 years); and technetium-99 (half-life of approximately 211,000 years).[4] A comprehensive listing of radionuclides currently contained in the DWPF Recycle Wastewater is presented in **Appendix B**. Regarding chemical properties, the liquid DWPF recycle wastewater exhibits the Resource Conservation and Recovery Act (RCRA) hazardous waste characteristic of corrosivity (D002 waste code) because its pH is greater than or equal to 12.5. When treated, the waste would be neutralized to remove its corrosivity. The DWPF recycle wastewater also exhibits the RCRA hazardous waste characteristic for toxicity due to mercury (D009) and selenium (D010). Stabilization is an acceptable treatment method for waste exhibiting the RCRA toxicity characteristic (40 CFR 268.48).

[4] Radioactive half-life refers to the interval of time required for one-half of the atomic nuclei of a radioactive isotope to decay (i.e., for it to change spontaneously into other nuclear species by emitting particles and energy), or, equivalently, the time interval required for the number of disintegrations per second of a radioactive material to decrease by one-half.

Figure 2. Current Process Flow for DWPF Recycle Wastewater



2.4 WCS FWF

DOE plans to dispose of up to 10,000 gallons of stabilized DWPF recycle wastewater at the WCS FWF in Andrews County, Texas (this technical evaluation is limited to up to 8 gallons). The WCS FWF is licensed by TCEQ under its Agreement State authority for the disposal of Class A, B, and C LLW that meets specified WAC. The facility is also permitted to receive mixed LLW. Disposal of the stabilized waste at the WCS FWF would be conducted in accordance with the facility's operating license (TCEQ License #R04100) and permits.

The WCS FWF was designed, permitted, and constructed for disposal of Class A, B, and C LLW and mixed LLW. The FWF was constructed for the sole purpose of disposing waste that is the responsibility of the federal government as defined by the Low-Level Radioactive Waste Policy Act, as amended (42 U.S.C. 2021b et seq.). All hazardous and radioactive waste at the FWF is disposed in a robust liner and cover system, featuring a seven-foot-thick liner system, which includes a one-foot-thick layer of reinforced concrete and a RCRA compliant geosynthetic layer. In addition, all of the waste is buried within the highly impermeable red-bed clay formation that extends hundreds of feet beneath the deepest layer of waste.[5]

[5] *See* http://www.wcstexas.com/facilities/federal-waste/.

The *WCS FWF Generator Handbook* provides guidance and specific criteria for waste acceptance at the FWF in compliance with WCS licenses, permits, and procedures. The general waste acceptance process that DOE will follow is described below and shown in **Figure 3**. Steps 1-4 of that process will be completed before the DWPF recycle wastewater is shipped from SRS and the incoming shipments will be verified by WCS once the shipments are received at WCS as shown in Step 5. As shown under the waste profile approval process (Step 2), WCS would review the waste profile for accuracy before shipment of the DWPF recycle wastewater is shipped from SRS.

Figure 3. Overview of WCS FWF Waste Acceptance Process

- **Generator certification (Step 1)** – All generators must be certified by WCS to be in accordance with its Quality Assurance (QA) Generator Certification Program prior to sending waste to WCS for disposal. Elements of the certification include the waste classification/characterization program (e.g., sampling and analytical procedures), waste packaging and shipping, personnel training program, and other requirements as described in the *WCS FWF Generator Handbook.* As part of the certification process, WCS conducts an on-site audit of the generator classification, characterization, and other program elements. DOE's management and operations contractor, Savannah River Nuclear Solutions, has been certified by WCS to ship acceptable waste to WCS FWF for treatment and/or disposal (**Appendix A**).

- **Waste profile approval (Step 2)** – A waste profile must be completed by the generator and approved by WCS for each authorized waste stream or appropriate combination of authorized waste streams that a generator intends to ship for disposal at the FWF. The completed waste profile and supporting documentation must allow WCS to demonstrate that the waste is compliant with regulatory requirements, along with license and permit conditions applicable to the WCS FWF. Analytical data and/or documentation of process knowledge are submitted with the waste profile. The data must be accompanied by an identification of the analytical method used for each parameter or constituent reported, and by QA/quality control results. The generator must demonstrate reasonable assurance that the waste is correctly classified as Class A, Class B, or Class C LLW in accordance with the waste classification tables in 30 TAC §336.362.[6] DOE's liquid waste contractor, Savannah River Remediation (SRR), has completed a waste characterization

[6] The TAC waste classification tables are the same as the NRC's waste classification tables in 10 CFR Section 61.55, Tables 1 and 2, except that TCEQ has added radium-226 to the list of long-lived radionuclides to be included in waste classification.

document (**Appendix B**) and a waste profile (**Appendix C)** for the up to 8 gallons of DWPF recycle wastewater. SRR will submit the waste profile for the up to 8 gallons of recycle wastewater to WCS for approval prior to any shipment. As stated in WCS's *Application for License to Authorize Near Surface Land Disposal of Low-Level Radioactive Waste*, Appendix 5.2-1: Waste Acceptance Plan (Revision 9): "The final authorized WCS profile reviewer will review the documentation to verify the Waste Profile Form conformance and compliance with the Waste Acceptance Plan, the LLW license, and applicable regulations. This review will focus on ensuring the Waste Profile Form, supporting documentation, and disposal plans are complete and compatible, and there are no discrepancies within the different WCS department approvals. Any issues identified by the final reviewer must be resolved before the profile is approved. The WCS Radiation Safety Officer may conduct and complete the compliance verification review. If the waste or information associated with the profile does not comply with, cannot be brought into compliance with, or cannot be substantiated as being in compliance with the Waste Acceptance Plan, the LLW license and/or applicable regulations (including but not limited to the waste classification, waste characterization, or chelating agent evaluation) the profile will not be approved, and the customer will be notified. Once the final reviews are complete and the waste is found to be in compliance, the waste stream is considered approved and the customer will be notified."[7]

- **Waste shipment request, approval, and verification (Steps 3, 4, and 5) –** Each shipment of waste to WCS must be pre-approved. Once a generator has completed generator certification and has an approved profile from WCS, then the generator can request to make a shipment to WCS. WCS will review the associated shipping documentation. Once WCS is satisfied with the shipping documentation and has approved the delivery of the shipment, WCS will provide the generator with a Waste Shipment Request form. This form will contain the scheduled date and time for delivery of the shipment. WCS approval of the Waste Shipment Request form is WCS's indication to the generator that it is authorized to ship the waste for disposal at the FWF. Waste verification will be performed by WCS on incoming shipments. The method and frequency will depend on the type of waste. DOE's contractor would satisfactorily complete this process with WCS before any of the up to 8 gallons of DWPF recycle wastewater is sent to WCS for treatment and disposal.

2.5 Stabilization of DWPF Recycle Wastewater

The DWPF recycle wastewater will be stabilized (grouted) at WCS to meet the WCS FWF WAC. Refer to **Section 2.4** for details on the waste acceptance process that would be applied to the DWPF recycle wastewater. The stabilization process will also treat the wastewater to meet

[7] http://www.wcstexas.com/wp-content/uploads/2016/01/Waste-Acceptance-Plan.pdf

RCRA requirements. Grout is a proven safe and effective technology that continues to be used by DOE and other national and international parties to stabilize radioactive wastes, including certain tank wastes, for disposal.[8] Use of stabilization agents for this purpose is consistent with the NRC's Concentration Averaging and Encapsulation Branch Technical Position, Revision 1 (https://www.nrc.gov/docs/ML1225/ML12254B065.pdf), which allows mixing of nonradioactive constituents with radioactive waste (e.g., solidification, encapsulation, or additives used in thermal processing), provided the mixing has a purpose other than reducing the waste classification, such as waste stabilization or process control. Furthermore, the addition of stabilization agents to the waste is often necessary to meet the NRC requirements in 10 CFR Section 61.56, "Waste Characteristics" and TCEQ requirements in TAC §336.362, Appendix E, "Classification and Characteristics of Low-Level Radioactive Waste" (e.g., to ensure stability of the waste form).

3. Technical Information for Disposal as Non-HLW

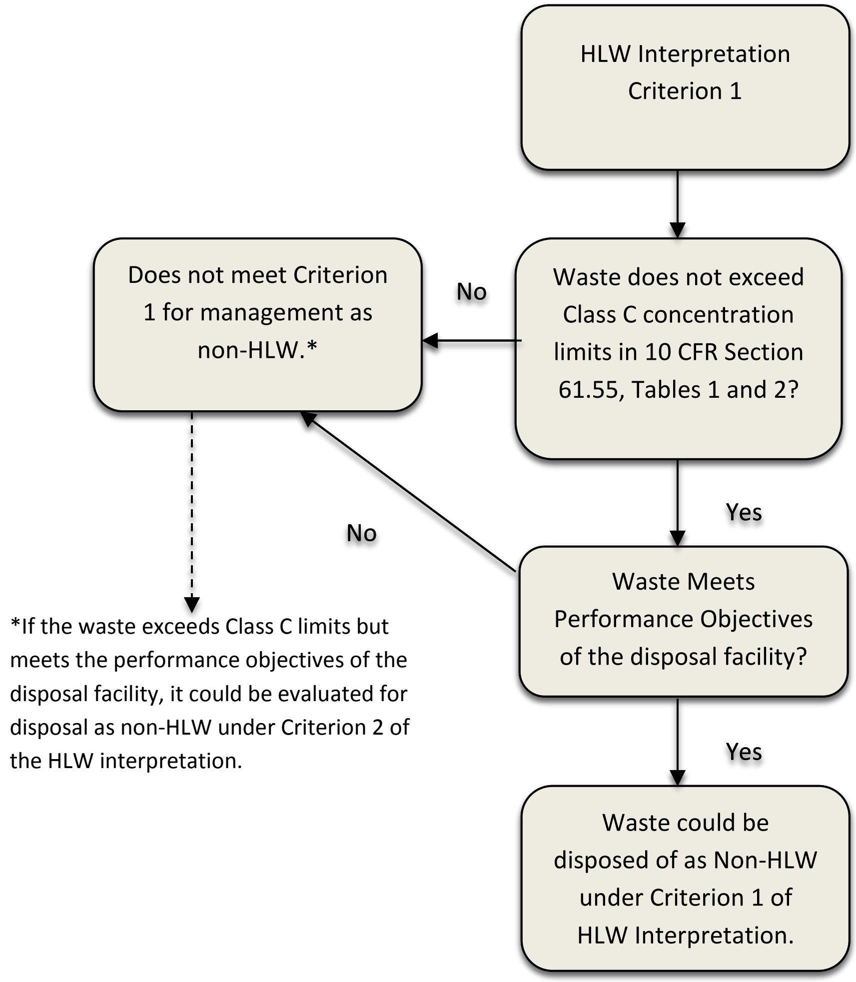
As discussed in **Section 2.1**, DOE's HLW interpretation provides that a reprocessing waste can be determined to be non-HLW if it meets either of the two criteria. For the up to 8 gallons of DWPF recycle wastewater, this technical information will demonstrate that the waste meets Criterion 1 of the HLW interpretation:

> Criterion 1: does not exceed concentration limits for Class C low-level radioactive waste as set out in section 61.55 of title 10, Code of Federal Regulations, and meets the performance objectives of a disposal facility. [84 FR 26836]

The two requirements contained in Criterion 1 are discussed individually below (**Sections 3.1** and **3.2**), followed by a discussion of the QA process used to characterize the waste (**Section 3.3**). **Figure 4** illustrates the decision process for Criterion 1.

[8] For example, the International Atomic Energy Agency report titled "The Behaviours of Cementitious Materials in Long Term Storage and Disposal of Radioactive Waste – Results of a Coordinated Research Project" (IAEA-TECDOC-1701) September 2013, states: "Cements are a suitable material for the immobilization of a variety of waste constituents due to their favourable chemical and physical properties." [pg. 39]. SRS has used saltstone (a form of grout) to solidify over 17 million gallons of liquid radioactive waste since 1991 (SRS 2019).

Figure 4. Criterion 1 of HLW Interpretation



3.1 The Waste does not Exceed Concentration Limits for Class C LLW as Set Out in Section 61.55 of Title 10, Code of Federal Regulations.

In the commercial disposal industry, LLW is segmented into waste categories of Class A, Class B, Class C, and greater than-Class C (GTCC), pursuant to NRC waste classification requirements at 10 CFR 61.55. These classifications are based on potential LLW hazards and disposal and waste form requirements. The four classes of LLW are based on the concentration of specific radionuclides. Class A waste contains the least radioactivity, most of which comes from relatively short-lived radionuclides (half-lives less than 100 years), which decay to background levels within a few decades. Class B waste is also relatively short-lived, but contains larger concentrations of short-lived radionuclides than Class A. Class C waste can contain larger concentrations of both short-lived and long-lived (half-lives equal to or greater than 100 years), while GTCC LLW is even larger. Three classes, A, B, and C, are considered suitable for shallow land burial, while the fourth class, GTCC LLW, requires different and, in general, more stringent disposal methods. These waste classifications apply to LLW that is disposed of at commercial facilities, and not DOE disposal facilities. However, these classifications are relevant when DOE sends its waste to a commercial facility for disposal.

The NRC waste classification system in 10 CFR 61.55 consists of two radionuclide tables (**Appendix D**): Table 1 includes a list of some principally long-lived key radionuclides. Table 2 consists of some shorter-lived key radionuclides (half-lives less than 100 years). The NRC waste classification tables are included in this report as **Table 1** and **Table 2**. Waste classification can be derived directly from the appropriate table if the waste stream contains only one key radionuclide. However, for waste streams that contain both long-lived and short-lived radionuclides, as is the case for DWPF recycle wastewater, the classification requirements of 10 CFR 61.55(a)(5) indicate:

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 Section 61.55 further specifies that the sum of fractions (SOF) 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 SOF less than 1.0 indicates compliance of the radionuclide mixture with the relevant classification criteria. Not all radionuclides in a waste stream are considered key radionuclides. Only those from the NRC tables are used for SOF calculations. In addition, DOE would also consider radium-226 in the waste classification determination as required by 30 TAC §336.362 Appendix E, Table I.[9]

[9] The NRC waste classification tables in 10 CFR Section 61.55 are the same as the TAC waste classification tables in 30 TAC §336.362 Appendix E, except that TAC includes an additional radionuclide (radium-226) that must be considered in the waste classification determination.

Table 1. NRC Waste Classification Table 1 for Long-Lived Radionuclides

(Note: This NRC waste classification table is the same as the
30 TAC §336.362 Appendix E, Table I, except that TAC includes radium-226)

Radionuclide	Concentration curies per cubic meter[2]
Carbon-14	8
Carbon-14 in activated metal	80
Nickel-59 in activated metal	220
Niobium-94 in activated metal	0.2
Technetium-99	3
Iodine-129	0.08
Alpha-emitting transuranic nuclides with half-life greater than 5 years	[1]100
Plutonium-241	[1]3,500
Curium-242	[1]20,000

Notes:

[1]Units are nanocuries per gram.

[2]If concentration is < 0.1 Table value, waste is Class A. If concentration is > 0.1 but less than or equal to Table value, waste is Class C. If concentration is > Table value, waste is greater than class C. For wastes containing mixtures of radionuclides listed in Table 1, the total concentration shall be determined by the SOF rule.

Table 2. NRC Waste Classification Table 2 for Short-Lived Radionuclides

(Note: This NRC waste classification table is the same as 30 TAC §336.362 Appendix E, Table II)

Radionuclide	Concentration, curies per cubic meter		
	Column 1	Column 2	Column 3
Total of all nuclides with less than 5 year half-life	700	([1])	([1])
Tritium	40	([1])	([1])
Cobalt-60	700	([1])	([1])
Nickel-63	3.5	70	700
Nickel-63 in activated metal	35	700	7000
Strontium-90	0.04	150	7000
Cesium-137	1	44	4600

Notes:

[1]There are no limits established for these radionuclides in Class B or C waste.

[2]If concentration does not exceed column 1, waste is Class A. If concentration is > column 1 and < column 2, waste is Class B. If concentration is > column 2 and < column 3, waste is Class C. If > column 3, waste is not acceptable for near-surface disposal. For wastes containing mixtures of radionuclides listed in Table 2, the total concentration shall be determined by the SOF rule.

SRR collected representative samples of the DWPF recycle wastewater in Tank 22 in December 2018, November 2019, and February 2020.[10] These samples were analyzed by the Savannah River National Laboratory (SRNL) to determine concentrations of radionuclides present in the DWPF recycle wastewater. SRR summarized the results of these waste characterization activities in a report titled "Concentration of Tank 22 Defense Waste Processing Facility Recycle Wastewater for Use in Phase 1 Off-site Disposition Activities," SRR-CWDA-2020-00025, Rev. 0, March 2020. The report is included as **Appendix B**.

Based on results of the sample analyses and other waste characterization activities, SRR prepared a waste profile report titled "Characterization of Tank 22 DWPF Recycle Wastewater," Calculation Number Q-CLC-H-0061, March 12, 2020. This report (**Appendix C**) documented the radiological and chemical characterization of the DWPF recycle wastewater to support off-site disposition of up to 8 gallons of wastewater. As stated in the SRR report, "Savannah River National Lab analytical results and process knowledge were used in this evaluation for the characterization." The SRR report provides the detailed calculations used to determine the NRC waste classification for up to 8 gallons of DWPF recycle wastewater, including the SOF as required by 10 CFR 61.55.[11] The SRR report concluded that the up to 8 gallons of DWPF recycle wastewater would be Class B LLW, as shown in **Table 3**. TAC requires that radium-226 also be considered in the LLW classification; however, radium-226 is not present in DWPF recycle wastewater at any significant concentration. The final solidified waste form following stabilization would have lower radionuclide concentrations because of the stabilization process.

As confirmed by sampling and analysis results, the up to 8 gallons of DWPF recycle wastewater meets the WCS WAC and, therefore, does not require removal of radionuclides (see **Tables 3** and **4** below).

Detailed Explanation of 10 CFR 61.55 Radionuclide Concentration Limits:

The DWPF wastewater contains a mixture of radionuclides, some of which are listed in NRC 10 CFR 61.55 Table 1 (Long-Lived Radionuclides), and some of which are listed in Table 2 (Short-Lived Radionuclides). Hence, in accordance with NRC 10 CFR 61.55(a)(5), the following two-step process applies:

[10] As presented in SRR-CWDA-2020-00025, the December 2018 sample analysis included an initial report for a smaller subset of key radionuclides and a second report that included a comprehensive set of key radionuclides. The additional sampling in November 2019 and February 2020 focused on cesium-137, which is a principal radionuclide constituent in DWPF recycle wastewater.

[11] The SRR report "Characterization of Tank 22 DWPF Recycle Wastewater," Calculation Number Q-CLC-H-0061, March 12, 2020, includes the mass of the 3-liter package for the up to 8 gallons of DWPF recycle wastewater in determining radionuclide concentrations for purposes of waste classification. In addition, the concentrations in the SRR report considered additional sampling and analysis events for implementation purposes. Therefore, the concentration values vary from the waste classification discussion presented in the Final EA (Appendix A of the Final EA); however, both documents conclude that the waste would be classified as Class B LLW.

"(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.

(7) The sum of the fractions rule for mixtures of radionuclides. For determining classification for waste that contains a mixture of radionuclides, it is necessary to determine the sum of fractions by dividing each nuclide's concentration by the appropriate limit and adding the resulting values. The appropriate limits must all be taken from the same column of the same table. The sum of the fractions for the column must be less than 1.0 if the waste class is to be determined by that column."

Application for DWPF Wastewater—Long-Lived Radionuclide Limits:

(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.*

This step applies to the blue highlighted fractional result for each radionuclide in the table below (**Table 3**).

In order for the concentration of a radionuclide to exceed 0.1, the Nuclide Fraction (column 4) would need to exceed 0.1. This number is the DWPF wastewater concentration (column 2) divided by the NRC classification limit (column 3). As indicated in the table, the values are far below 0.1. Because 0.1 is not exceeded for any radionuclide or the SOF of all Table 1 radionuclides, the classification of the DWPF wastewater shall be determined by the concentration of nuclides listed in the NRC Table for Short-Lived Radionuclides (**Table 4** below).

Table 3. NRC Limits for Long-Lived Radionuclides 10 CFR 61.55(a)(5)(i)[12]

Radionuclide (Column 1)	DWPF Recycle Wastewater Concentration (Column 2)	NRC Classification Limit (Column 3)	Nuclide Fraction (Column 4)
Carbon-14	0.000052 Ci/m3	8 Ci/m3	0.0000065
Technetium-99	0.00219 Ci/m3	3 Ci/m3	0.00073
Iodine-129	0.0000218 Ci/m3	0.08 Ci/m3	0.0002725
Alpha-emitting transuranic nuclides with half-life greater than 5 years: Total of Neptunium-237, Plutonium-238, Plutonium-239, Plutonium-240, and Plutonium-242	0.08063 nCi/g	100 nCi/g	0.0008063
Plutonium-241	NA	3,500 nCi/g	0.0
Curium-242	NA	20,000 nCi/g	0.0
Sum of Fractions for Long-Lived Radionuclides			0.0018

Application for DWPF Wastewater—Sum of Fractions Rule for Mixtures of Radionuclides

> *(7) The sum of the fractions rule for mixtures of radionuclides. For determining classification for waste that contains a mixture of radionuclides, it is necessary to determine the sum of fractions by dividing each nuclide's concentration by the appropriate limit and adding the resulting values. The appropriate limits must all be taken from the same column of the same table. The sum of the fractions for the column must be less than 1.0 if the waste class is to be determined by that column.*

Waste containing a mixture of radionuclides must be classified by applying the SOF rule. The SOF is determined by calculating the fractions for each radionuclide present (the radionuclide concentration divided by the NRC Classification concentration limit) in the waste stream, then adding them together, resulting in the SOF. SOF is calculated, first, by using the Class A concentrations; if needed, the SOF is calculated using the Class B concentrations and, if needed, the SOF is calculated using the Class C concentrations.

[12] The wastewater concentrations were obtained from the SRR report titled "Characterization of Tank 22 DWPF Recycle Wastewater," Q-CLC-H-00601, Revision 0, March 2020 (see Appendix C, Table A3-1, NRC Classification). The SRR report compares the measured concentrations to one-tenth of the NRC Limit, whereas Table 3 compares the concentrations directly to the NRC Limit. Both tables show that the individual radionuclide fractions, as well as the sum of fractions, are less than one-tenth of the NRC limits for long-lived radionuclides, and the waste classification is, therefore, determined by the limits for short-lived radionuclides (i.e., Table 4 below).

This SOF process applies to the green highlighted fractional result for each DWPF recycle wastewater radionuclide in Table 4 below. For the DWPF recycle wastewater (short-lived radionuclides), the SOF using the Class A concentrations equals 24.43. The NRC requirement is that, if this SOF is less than 1, the waste class is Class A. Because it is not less than 1, the SOF using Class B concentrations is then calculated; that SOF is 0.55005. The NRC requirement is that, if this SOF is less than 1, the waste class is Class B. According to NRC requirements, there is no need to calculate the Class C SOF because, based on the Class B SOF calculation, the waste has already been determined to be Class B.

Table 4. NRC Limits for Short-Lived Radionuclides 10 CFR 61.55(a)(5)(i)

Concentration and limit values in Ci/m3

Radionuclide	**DWPF Recycle Wastewater Concentration[1]**	**Class A Limit**	**Class A SOF**	**Class B Limit**	**Class B SOF**	**Class C Limit**	**Class C SOF**
Total of all nuclides with less than 5 year half-life: Barium-137m	22.9	700	0.0327	Unlimited	NA	Unlimited	
Tritium	0.0757	40	0.00189	Unlimited	NA	Unlimited	
Cobalt-60	NA	700	0.0	Unlimited	NA	Unlimited	
Nickel-63	NA	3.5	0.0	70	0.0	700	
Strontium-90	0.00791	0.04	0.19775	150	0.0000527	7000	
Cesium-137	24.2	1	24.2	44	0.55	4600	
Sum of Fractions for Short-Lived Radionuclides			**24.43**		**0.55005**		NA

[1]Values obtained from SRR report titled "Characterization of Tank 22 DWPF Recycle Wastewater," Q-CLC-H-00601, Revision 0, March 2020 (see Appendix C, Table A3-1, NRC Classification).

Criterion 1, part 1-10 CFR 61.55: Based on the sampling analysis, the stabilized DWPF recycle wastewater would not exceed Class C limits in 10 CFR 61.55, and therefore meet the first part of Criterion 1: "*does not exceed concentration limits for Class C low-level radioactive waste as set out in section 61.55 of title 10, Code of Federal Regulations*."

3.2 Compliance with Performance Objectives of a Disposal Facility

Performance objectives are the radiological standards set by the NRC or DOE to ensure protection of the health and safety of individuals and the environment during operation, and after permanent closure of the disposal facility. Commercial licensees/permittees have the responsibility for health and safety of the public, workers, and the environment by demonstrating that the disposal facility complies with specified dose limits and performance objectives. Commercial LLW disposal facilities are located in, and licensed by, Agreement States. Agreement States have incorporated LLW disposal performance requirements from 10 CFR Part 61 into their corresponding regulations and as conditions for their licenses. NRC performance objectives in 10 CFR Part 61, Subpart C, apply.

The relevant performance objectives for the WCS FWF are specified in 30 Texas Administrative Code (TAC) §336.723 and require protection of the general population, protection of individuals from inadvertent intrusion, and the protection of workers and the general population during facility operations; and the stability of the disposal site after closure[13]:

- "Concentrations of radioactive material which may be released to the general environment in groundwater, surface water, air, soil, plants, or animals shall not result in an annual dose above background exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, or 25 millirems to any other organ of any member of the public. Effort shall be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable (TAC §336.724);
- Design, operation, and closure of the land disposal facility shall 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 (TAC §336.725);
- Operations at the land disposal facility shall be conducted in compliance with the standards for radiation protection set out in Subchapter D of this chapter (relating to Standards for Protection Against Radiation), except for releases of radioactivity in effluents from the land disposal facility, which shall be governed by §336.724 of this title (relating to Protection of the General Population from Releases of Radioactivity). Effort shall be made to maintain radiation exposures as low as is reasonably achievable (TAC §336.726); and
- The disposal facility shall 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 (TAC §336.727)."

The technical means to demonstrate compliance with performance objectives are through a modeling and analytical tool commonly referred to as a performance assessment (PA). A PA is an internationally accepted risk informed approach to evaluating whether a waste disposal facility protects human health and the environment. Through advanced risk management methodologies, PAs quantitatively evaluate disposal facilities' ability to prevent the release of

[13] The performance objectives in the TAC applicable to the WCS FWF mirror the performance objectives in 10 CFR 61, Subpart C.

radioactivity and the resulting potential radiological exposure. The following factors are considered when conducting PAs:

- How the disposal facility and the surrounding area function to prevent radionuclides from posing a threat to the selected receptor groups.
- Performance of facility equipment to ensure that waste is disposed of safely and with minimal radionuclide release and limited influx of water. This equipment includes storage casks and other engineered barrier systems.
- Movement of radionuclides through the engineered barrier system and geosphere (underground portions of disposal facilities with little to no human contact).
- Potential for radiological exposure to humans.

The most recent PA for the WCS LLW facility, which included the FWF, was approved by TCEQ in 2019 and continues to demonstrate compliance with all applicable TAC performance objectives.[14] The up to 8 gallons of DWPF recycle wastewater would constitute a negligible inventory contribution to the PA WCS modeled and therefore would not negatively impact WCS FWF's continued compliance with the performance objectives[15]. Because the stabilized waste is generically considered as part of the assessed inventory of LLW planned to be disposed of in the FWF, as long as the up to 8 gallons of stabilized DWPF recycle wastewater meets the WCS FWF WAC requirements, it will not affect any of the facility's performance objectives, including those performance objectives that provide for protection of the general population from releases of radioactivity, of individuals from inadvertent intrusion, and of individuals during facility operations.

The WAC contains the technical and administrative requirements a waste must meet to be accepted at a disposal facility (e.g., waste characterization, waste form acceptability, and QA), and are established to ensure the disposal facility, in total, meets its safety-based performance objectives.[16] **Appendix E** provides a crosswalk showing that the up to 8 gallons of stabilized DWPF recycle wastewater would meet the WCS WAC. For example:

- The stabilized WCS recycle wastewater would not exceed Class C limits (*see* section 3.1);

[14] The latest version of the WCS PA is not available online but may be requested from TCEQ.
[15] In development of the disposal regulations for LLW, the NRC recognized that there might be a situation in which a waste stream could be created that was not contemplated as part of the original technical basis for 10 CFR Part 61, which is found in the draft and final EISs for the rule. The radionuclides provided in the 10 CFR Section 61.55 waste classification tables were based on a best estimate (in 1980) of projected inventories of radioactive waste that would be disposed of in a commercial LLW disposal facility. The DWPF waste stream, and its radionuclide content and concentrations, is sufficiently comparable to projected inventories of radioactive waste that would be disposed of in a commercial LLW disposal facility and therefore does not warrant an additional site-specific PA to ensure performance objectives are met.
[16] Each disposal facility has its own WAC, which is dictated in part by the physical characteristics of a site. The WAC for the WCS facility is available at: http://www.wcstexas.com/documents-and-forms/.

- The up to 8 gallons of DWPF recycle wastewater would constitute an extremely small percentage of the volumetric and radioactively limits for the WCS FWF; and
- The DWPF recycle wastewater would be stabilized thus meeting the WAC requirement that all waste forms be solids. WCS would place the stabilized DWPF recycle waste containers in a Modular Concrete Canister to meet stability requirements for facility closure, and the top of the all disposed LLW containers would be a minimum of five (5) meters below the top surface of the disposal facility cover or would be disposed of with intruder barriers designed to protect against an inadvertent intrusion for at least 500 years.

Criterion 1, part 2-Performance Objectives: In consideration of the license limitations (e.g. volume and curie limits), available PA results, and WAC, disposal of the stabilized DWPF recycle wastewater at WCS FWF meets the second part of Criterion 1: "*meets the performance objectives of the disposal facility.*"

Conclusion: Because the waste does not exceed Class C limits (Section 3.1) and disposal of the waste at WCS FWF meets the facility's performance objectives (Section 3.2), stabilized DWPF recycle wastewater meets DOE's HLW Interpretation, Criterion 1, for disposal as non-HLW at the WCS FWF.

3.3 Quality Assurance for Waste Characterization

Representative samples of DWPF recycle wastewater were collected from Tank 22 to ensure proper characterization and compliance with the waste acceptance requirements for the WCS FWF. The samples were collected and analyzed in accordance with SRS QA program, which complies with DOE Order 414.1D, *Quality Assurance*; American Society of Mechanical Engineers Nuclear Quality Assurance; and 10 CFR 830, Nuclear Safety Management.

4. Coordination with Regulatory Agencies and Stakeholders

The WCF FWF is licensed by the TCEQ under its Agreement State authority with NRC. The TCEQ provides oversight of the facility through every phase of LLW management and disposal to ensure compliance with the license conditions for protection of human health and the environment. DOE has coordinated with the TCEQ on the Department's plans to dispose of up to 8 gallons of DWPF recycle at the WCS FWF, including addressing TCEQ's comments on the Draft EA. In addition, DOE has held informational briefings and a webinar with stakeholders on the Draft EA and the HLW interpretation, as well as informal discussions with NRC and TCEQ staff and management. DOE anticipates on having an informational webinar(s) with stakeholders on the Final EA.

5. Conclusion

Based on this technical information, DOE has determined that the up to 8 gallons of DWPF recycle wastewater in Tank 22 would meet DOE's HLW interpretation under Criterion 1 and be non-HLW. Hence, this LLW could be disposed of at the WCS FWF consistent with the WCS FWF's operating license (TCEQ License #R04100), WCS FWF WAC, TCEQ regulations, and all other applicable requirements.

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Appendix A. Generator Certification

WASTE CONTROL SPECIALISTS	FORM	Effective Date: 02/07/2019	FO-QA-005
	Generator Certification Approval Letter	Revision 0	Page 1 of 1

Generator Certification Approval Letter

April 15, 2020

Betsy Westover
Solid Waste Engineering
Savannah River Nuclear Solutions, LLC
Building 704-60E
Aiken, SC 29808

RE: US DOE SAVANNAH RIVER NUCLEAR SOLUTIONS, LLC - SCSRNSSRS

Generator Certification Valid April 15, 2020 through April 30, 2021

Dear Betsy,

On April 15, 2020, Waste Control Specialists LLC (WCS) completed a review and found US DOE Savannah River Nuclear Solutions, LLC to have an acceptable waste management program and is authorized to ship waste materials to the Waste Control Specialists LLC Federal Waste Disposal Facility (FWF).

Be reminded, any change to the US DOE Savannah River Nuclear Solutions, LLC waste management program which reduces administrative control requires notification to Waste Control Specialists LLC. This Certification is valid until the last day of the month, 12 months from the date of issue.

The generator certification identification number is required on all documentation or correspondence with Waste Control Specialists LLC regarding waste disposal.

Waste Control Specialists LLC is pleased to have the opportunity to provide you with the quality waste management services that you need. If you have any questions or need further assistance, please feel free to contact me at (432) 525-8722 or at (432) 425-3517.

Sincerely,
WASTE CONTROL SPECIALISTS LLC

Jeff Shouse
Director of Quality Assurance

Appendix B. DWPF Recycle Wastewater Concentrations Report

SRR-CWDA-2020-00025
Revision 0

Concentrations of Tank 22 Defense Waste Processing Facility Recycle Wastewater for Use in Phase 1 Off-site Disposition Activities

March 2020

Prepared by: Savannah River Remediation LLC
Waste Disposal Authority
Aiken, SC 29808

Prepared for U.S. Department of Energy Under Contract No. DE-AC09-09SR22505

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3/4/2020
Date

1.0 INTRODUCTION

Savannah River Remediation (SRR) was requested by the Department of Energy Savannah River Operations Office (DOE-SR) to support Defense Waste Processing Facility (DWPF) recycle wastewater off-site disposition Phase 1 proof-of-principle activities. [WDPD-20-05] Phase 1 involves the shipment of up to ten 3-liter samples to off-site permitted and licensed treatment and disposal facilities in FY2020. These activities are the first phase of the ongoing DOE efforts to demonstrate the treatment and disposal of up to 10,000 gallons of DWPF recycle wastewater at a disposal facility outside of South Carolina as detailed in a draft Environmental Assessment (EA) which was issued by DOE for public comment. [DOE/EA-2115] In order to execute the Phase 1 shipments, several activities are necessary including comparison to receiving facility Waste Acceptance Criteria (WAC) and shipment paperwork as well as evaluations to support operational activities including dose rate, shielding and sample container gas generation rate calculations. This report has been prepared to provide a single reference for the concentrations of constituents present within the material in Tank 22 that will be the subject of Phase 1 shipments. A similar report will be necessary in the future to support any future activities related to the remaining 10,000 gallons as the concentrations in Tank 22 may fluctuate.

2.0 DISCUSSION

The primary mission of Tank 22 in the H Tank Farm at the Savannah River Site is to receive and store recycle wastewater from DWPF and transfer the material to the 2H Evaporator System for volume reduction. While individual batches sent from DWPF to Tank 22 may vary in concentration, the aggregate concentrations in Tank 22 have been, and are expected to remain, relatively constant for most constituents. Figure 1 presents data for two key chemical components of Tank 22 waste, NO_2^- and NO_3^-, and how their concentrations have varied over the last approximately five and a half years as informed by routine samples taken from the tank. The data marks on the curves represent individual sampling and analysis events and demonstrate the relative stability of the material chemistry in Tank 22.

This report draws upon four key references to recommend constituent concentrations in the material currently in Tank 22. On December 11, 2018, a large process sample was taken from Tank 22 for material characterization. The material was sent to the Savannah River National Laboratory for analysis. The chemical constituent concentrations as well as a few radionuclide concentrations were reported in SRNL-L3100-2019-00024 and a larger suite of radionuclide constituent concentrations were reported in SRNL-STI-2019-00604. These are the first two key concentration references. The red vertical line on Figure 1 represents the sampling event as documented in the two reports.

Following the December 2018 sampling event, Tank 22 was in full operations mode both receiving DWPF recycle wastewater transfers and transferring feed material to the 2H Evaporator System for volume reduction and disposition through existing Liquid Waste processes. In the summer of 2019, DWPF briefly halted operations in support of system tie-ins for the Salt Waste Processing Facility (SWPF) and has only operated sporadically in FY2020, greatly reducing overall generation of recycle wastewater. The 2H Evaporator System continued operations and thus the total volume in Tank 22 was greatly diminished. Figure 2 reflects the volume of material in Tank 22 from December 2018 through February 2020. In order to ensure that this report reflects the best available information about the current contents of Tank 22, data is utilized from two routine process samples taken in November 2019 and February 2020 at the lower Tank 22 volume level. The concentration from these two sample events are documented in LW-AD-PROJ-191112-2 and LW-AD-PROJ-200203-5. These analyses were also performed by SRNL and represent the final two key concentration references. The red arrows on Figure 2 represent the timing of all three sample events that inform this report.

Figure 1: Historical Tank 22 NO_2^- and NO_3^- Sample Concentrations

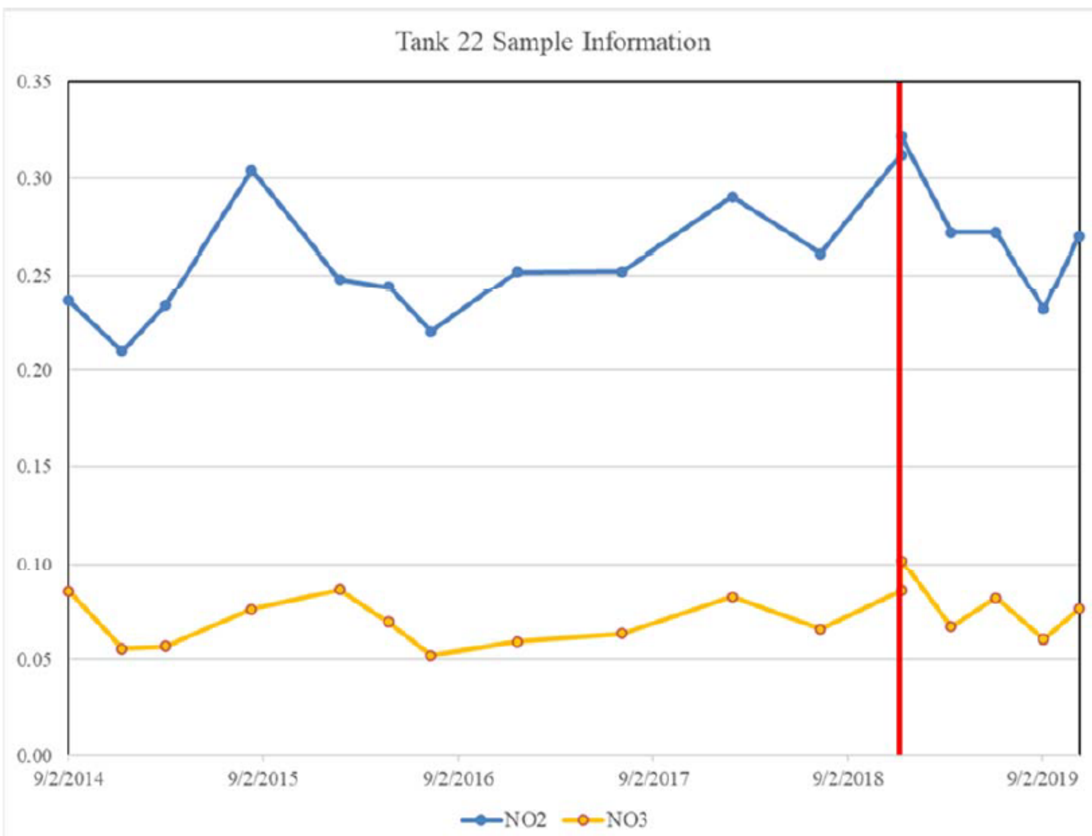
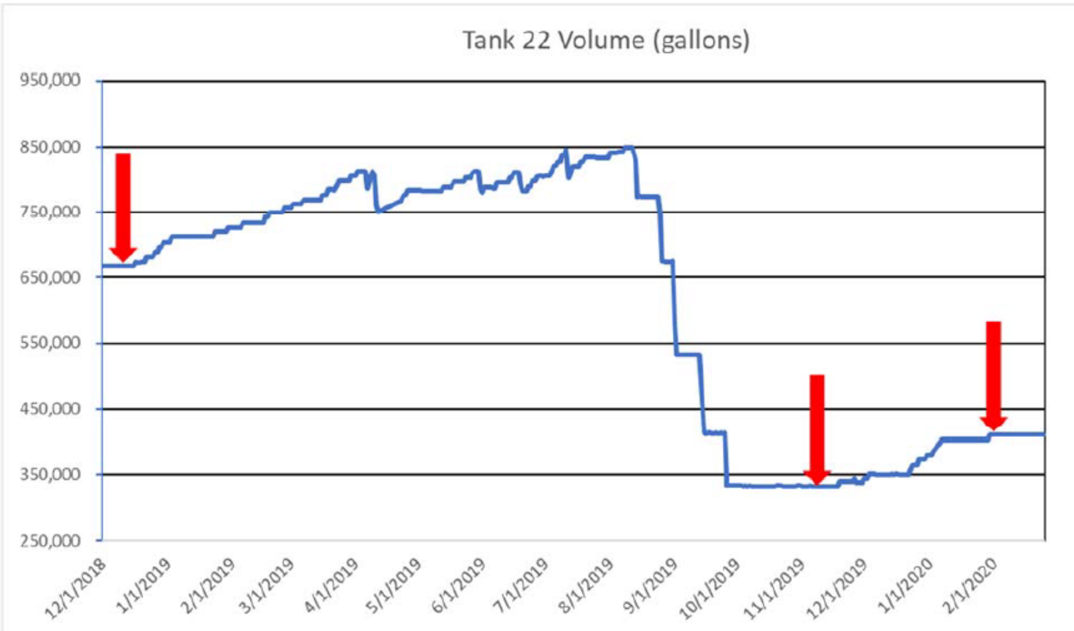


Figure 2: Recent Tank 22 Volume and Sampling Events



The available information from the four key references are presented in Tables 1 and 2 with Table 1 presenting the radionuclide concentrations and Table 2 presenting non-radiological concentrations. The columns in the table reflect data from SRNL-L3100-2019-00024 (Report 1), SRNL-STI-2019-00604 (Report 2), LW-AD-PROJ-191112-2 (Report 3) and LW-AD-PROJ-200203-5 (Report 4). While Reports 3 and 4 have a limited set of analytes, the reported data supports the expectation that the concentrations of constituents are stable. The one exception to this is Cs-137. Cs-137 is the principle constituent in concentrated strip effluent solution stabilized at DWPF. Based on the recent operations at DWPF, it was expected that the overall Cs-137 in recycle wastewater would increase. The sampling results reflect this expectation for Cs-137 while other constituent concentrations are stable. In addition, the density of the recycle wastewater is utilized in some calculations for waste classification and shipping and therefore Table 2 also includes sample analysis results for this property.

Based on inspection of the data from the four key references, Tables 1 and 2 include a final column of recommended concentrations for utilization in the Phase 1 activities. The recommendations reflect Reports 1 and 2 concentrations for all constituents except Cs-137 and density which reflect the most recent (and highest) concentrations from Report 4.

Table 1: Tank 22 Radionuclide Concentrations

	Report 1	Report 2	Report 3	Report 4	**Recommended**
Analyte	**Concentration (dpm/ml)**	**Concentration (dpm/ml)**	**Concentration (dpm/ml)**	**Concentration (dpm/ml)**	**Concentration (dpm/ml)**
C-14		1.61E+02			**1.61E+02**
Cl-36		<1.20E+02			**1.20E+02**
Ni-59		<6.72E+01			**6.72E+01**
Ni-63		<7.67E+01			**7.67E+01**
Co-60		≤4.20E-01			**4.20E-01**
Sr-90		2.45E+04			**2.45E+04**
Y-90		2.45E+04			**2.45E+04**
Nb-94		<1.62E+00			**1.62E+00**
Tc-99	5.64E+03	6.77E+03			**6.77E+03**
Ru-106		<7.02E+00			**7.02E+00**
Sb-125		8.94E+00			**8.94E+00**
Sb-126		1.42E+01			**1.42E+01**
Sn-126		1.42E+01			**1.42E+01**
I-129		<2.43E+00			**2.43E+00**
Cs-134		<5.38E+03	<2.37E+06		**5.38E+03**
Cs-137	3.07E+07	2.90E+07	6.15E+07	7.49E+07	**7.49E+07**
Ba-137m		2.74E+07			**2.74E+07**
Ce-144		<9.37E+00			**9.37E+00**
Eu-152		<1.42E+00			**1.42E+00**
Eu-154		<8.99E-01			**8.99E-01**
Eu-155		<1.94E+01			**1.94E+01**
Ra-226		<8.45E+00			**8.45E+00**
Th-232	<4.09E-02	*			**4.09E-02**
U-233	<2.40E+02	*			**2.40E+02**
U-234	<1.55E+02	*			**1.55E+02**
U-235	1.66E-01	*			**1.66E-01**
U-236	<1.61E+00	*			**1.61E+00**
Np-237	<1.75E+01	*			**1.75E+01**
U-238	3.72E+00	*			**3.72E+00**
Np-239		<4.94E+00			**4.94E+00**
Pu-238		<1.21E+02			**1.21E+02**
Pu-239		<1.54E+03			**1.54E+03**
Pu-240		<5.66E+03			**5.66E+03**
Pu-241		<1.72E+02			**1.72E+02**
Pu-242		<9.49E+01			**9.49E+01**
Pu-244		<4.41E-01			**4.41E-01**
Am-241		≤1.43E+01			**1.43E+01**
Am-242m		<1.08E-01			**1.08E-01**
Am-243		≤3.10E+00			**3.10E+00**
Cm-242		<1.98E+00			**1.98E+00**
Cm-243		<9.04E+00			**9.04E+00**
Cm-244		1.34E+02			**1.34E+02**
Cm-245		<7.39E+00			**7.39E+00**
Cm-247		<9.12E+00			**9.12E+00**
Cm-248		<1.21E+01			**1.21E+01**
Cf-249		<9.80E+00			**9.80E+00**
Cf-251		<8.76E+00			**8.76E+00**

* - These values are included in Report 2 but were part of the characterization efforts of Report 1.

Table 2: Tank 22 Non-Radiological Concentrations

Analyte	Report 1 Concentration (M)	Report 2 Concentration (M)	Report 3 Concentration (M)	Report 4 Concentration (M)	**Recommended Concentration (M)**
Ag	<2.70E-06				**2.70E-06**
Al	2.15E-03				**2.15E-03**
B	<2.97E-03				**2.97E-03**
Ba	<4.89E-07				**4.89E-07**
Be	<1.49E-06				**1.49E-06**
Ca	1.22E-05				**1.22E-05**
Cd	<7.97E-07				**7.97E-07**
Ce	<1.95E-05				**1.95E-05**
Co	<4.18E-06				**4.18E-06**
Cr	<4.74E-06				**4.74E-06**
Cu	<8.45E-06				**8.45E-06**
Fe	3.56E-05				**3.56E-05**
Gd	<3.13E-06				**3.13E-06**
K	<6.68E-04				**6.68E-04**
La	<1.77E-06				**1.77E-06**
Li	4.26E-03				**4.26E-03**
Mg	2.41E-06				**2.41E-06**
Mn	1.22E-06				**1.22E-06**
Mo	<2.14E-05				**2.14E-05**
Na	7.13E-01				**7.13E-01**
Ni	<6.48E-06				**6.48E-06**
P	<3.45E-04				**3.45E-04**
Pb	<6.03E-05				**6.03E-05**
S	<5.28E-03				**5.28E-03**
Sb	<2.28E-05				**2.28E-05**
Si	5.74E-03				**5.74E-03**
Sn	<5.69E-05				**5.69E-05**
Sr	<2.22E-05				**2.22E-05**
Th	<8.68E-06				**8.68E-06**
Ti	<9.35E-07				**9.35E-07**
U	<3.19E-05				**3.19E-05**
V	<1.76E-06				**1.76E-06**
Zn	<1.37E-05				**1.37E-05**
Zr	<9.82E-07				**9.82E-07**
Fluoride	<1.09E-02		<5.26E-03	<5.50E-03	**1.09E-02**
Formate	<4.62E-03				**4.62E-03**
Chloride	<5.85E-03		<2.82E-03	<2.85E-03	**5.85E-03**
Nitrite	3.12E-01		2.70E-01	2.82E-01	**3.12E-01**
Nitrate	8.53E-02		7.60E-02	7.99E-02	**8.53E-02**
Phosphate	<2.19E-03				**2.19E-03**
Sulfate	3.18E-03		1.65E-03	2.32E-03	**3.18E-03**
Oxalate	<2.36E-03				**2.36E-03**
Bromide	<2.60E-03				**2.60E-03**
Free OH-	<0.207		9.25E-02	1.32E-01	**2.07E-01**
Carbonate	9.49E-02				**9.49E-02**
Aluminate	2.15E-03				**2.15E-03**
MethylHg	1.03E-04				**1.03E-04**
Total Hg	5.67E-04				**5.67E-04**
	grams/cc	grams/cc	grams/cc	grams/cc	**grams/cc**
Density		1.008	1.029	1.029	**1.029**

3.0 CONCLUSION

Tables 1 and 2 include recommended concentrations for utilization in the Phase 1 implementation activities. As noted earlier, these recommendations are only applicable to the Phase 1 activities due to current stability of the contents of Tank 22. Any future activities for the remainder of the 10,000 gallons of DWPF recycle wastewater disposition will require a re-evaluation of the constituent concentrations.

4.0 REFERENCES

DOE/EA-2115, *Draft Environmental Assessment for the Commercial Disposal of Defense Waste Processing Facility Recycle Wastewater from the Savannah River Site*, December 2019.

LW-AD-PROJ-191112-2, *Sample Results Report*, January 7, 2020.

LW-AD-PROJ-200203-5, *Sample Results Report*, February 20, 2020.

SRNL-L3100-2019-00024, Oji, L. & J. Pareizs, *Tank 22 Composite Core Sludge Sample Characterization Results – Radionuclides, Elementals and Anions*, Revision 0, June 28, 2019.

SRNL-STI-2019-00604, Oji, L. & D. Diprete, *Tank 22 Supernate Sample Characterization for Select Radionuclides*, Revision 0, October 2019.

WDPD-20-05, C. Smith to G. Westbury, *Defense Waste Processing Facility (DWPF) Recycle Offsite Disposition – Phase 1 – Proof of Principle*, January 27, 2020.

Appendix C. Waste Profile for DWPF Recycle Wastewater

OSR 45-24 (Rev. 12-18-2019)

Page 1 of 20

Calculation Cover Sheet

Proc. Ref. E7, 2.31

Project/Task N/A	Calculation Number Q-CLC-H-00601	Project/Task Number N/A
Title Characterization of Tank 22 DWPF Recycle Wastewater		
Functional Classification General Service (GS)	Discipline Environmental	
Calculation Type ◉ Type 1 ○ Type 2	Type 1 Calculation Status ○ Preliminary ◉ Confirmed	
Computer Program Number ☐ N/A MS Excel	Version/Release Number 365	

Purpose and Objective

The purpose of this calculation is to document the radiological and chemical characterization of the Tank 22 Defense Waste Processing Facility (DWPF) recycle wastewater to support the off-site disposition Phase 1 proof-of-principle activities [Ref. 8.7].

The objective is to provide this information to Solid Waste Management (SWM) for disposition as Mixed Waste (MW).

DC/RO

Date N/A

Summary of Conclusion

This calculation radiologically and chemically characterizes a 3L volume of Tank 22 DWPF recycle wastewater. This waste is non-TRU, non-fissile, and NRC Class B waste. The waste is hazardous for Corrosivity [D002], Mercury [D009], and Selenium [D010].

Waste Weight - 27.43 lbs (12,453 g)
Activity (Ci) - 1.97E-01
Radionuclide Distribution - Table 6.2-1

Revisions	
Rev. No.	Revision Description
0	Initial Issue
Add Row	

Sign Off				
Rev. No.	Originator (Print / Sign & Date)	Verification/Checking Method	Verification/Checker (Print/Sign/Date)	Manager (Print/ Sign/Date)
0	C.D. Walters CD Walters 3-12-2020	☐ Design Check (GS/PS only) ☒ Document Review ☐ Qualification Testing ☐ Alternate Calculation ☐ Operational Testing	R.J. Petras [signature] 3/12/20	J.S. Kirk [signature] for J.S. Kirk 3/12/20

Calculation Cover Sheet (Continued)

Proc. Ref. E7, 2.31

Calculation Number Q-CLC-H-00601		Rev. No. 0
Additional Reviewer (Print) M. Ngachin	Signature M Ngachin	Date 3/12/20
Additional Reviewer (Print) K. R. Liner (ECA)	Signature K Liner	Date 3/12/20
Design Authority (Print) N/A	Signature	Date
Release to Outside Agency (Print) N/A	Signature	Date
Security Classification of the Calculation Unclassified		

Temporary Delegation of Authority

In accordance with SRS 1B Management Requirements and Procedures Manual, Procedure 3.10 Limits of Authority Procedure, temporary delegation of authority is hereby granted as indicated.

Delegating Manager: **KIRK, J. SCOTT**

Department: **WRL100 - S&H VPP/BBS/HPI PROGRAMS**

I hereby grant my authority to **SKIFF, DANIEL P.** for the period of **Mar 10, 2020** to **Mar 13, 2020**. For signature authority, a copy of this delegation will be attached to all documents signed on my behalf.

TABLE OF CONTENTS

1.0 INTRODUCTION

The purpose of this calculation is to document the radiological and chemical (hazardous and non-hazardous) characterization of the Tank 22 Defense Waste Processing Facility (DWPF) recycle wastewater to support the off-site disposition Phase 1 proof-of-principle activities [Ref. 8.7].

Characterization is performed in accordance with SRS Manual 1S Chapter 3 [Ref. 8.1] to meet the requirements of Chapter 6 [I. 3.7 and Ref. 8.3]. Savannah River National Lab (SRNL) analytical results and process knowledge were used in this evaluation for the characterization.

For the purposes of this calculation, the Tank 22 DWPF recycle wastewater and the 304/304L stainless steel waste container are considered the waste and therefore reflected in the waste weight.

The objective is to provide this information to Solid Waste Management (SWM) for disposition as Mixed Waste (MW).

2.0 OPEN ITEMS

There are no Open Items.

3.0 INPUTS

3.1. The Tank 22 radionuclide concentrations for all but tritium (H-3) and the non-radiological concentrations are provided in SRR-CWDA-2020-00025 [Ref. 8.7].

3.2. The H-3 concentration in Tank 22 is 0.0004 Ci/gal [Ref. 8.9].

3.3. Specific Activity values for each radionuclide are shown in Table 3.0-1 per 1S, Chapter 5 [Ref. 8.2].

3.4. The Pu-239 PEC weighting factors are downloaded from Waste Inventory Tracking System (WITS) (LLW PEC239) [Ref. 8.6] as provided in Table 3.0-1.

3.5. The U-235 FGE equivalence factors from 1S, Chapter 5 [Ref. 8.2] are in Table 3.0-1.

3.6. The regulatory limit for the maximum concentration of contaminants for the toxicity characteristic is listed in Table 1 of Reference 8.4.

3.7. Mixed Waste requirements are provided in 1S Chapter 6 [Ref. 8.3].

3.8. The calculated pH (<13.3) of the Tank 22 DWPF recycle wastewater is provided in SRNL-L3100-2019-00024 [Ref. 8.8].

3.9. The volume of the Tank 22 DWPF recycle wastewater is 3L [Ref. 8.7] per package.

3.10. The 3L waste container fabrication details are provided in M-R4-G-00001 [Ref. 8.11].

3.11. The procedure for calculating the Nuclear Regulatory Commission (NRC) Classification content is outlined in 10 CFR 61.55 [Ref. 8.5].

3.12. Table 1 of 40 CFR 268.48 lists the non-wastewater treatment standard limit for Underlying Hazardous Constituents (UHCs). [Ref. 8.10].

3.13. The Arsenic and Selenium concentrations in Tank 22 are 43.2 mg/L and 465.3 mg/L per Waste Characterization System (WCS), respectively [Ref. 8.9].

3.14. The waste weight is the Tank 22 DWPF recycle wastewater weight (6.8 lbs) plus the 3L waste container weight (20.63 lbs) (Total Waste Weight = 27.43 lbs (12,453 g)) [Ref. 8.12].

3.15. The density of 304/304L stainless steel is 7.9 g/cm^3. (Attachment 5)

Table 3.0-1 Specific Activity, Pu-239 PEC Weighting Factors, and U-235 FGE Equivalence Factor

Radionuclide	Specific Activity, SpA_i, Ci/g	Pu-239 PEC Weighting Factors, W_i	U-235 FGE Equivalence Factor, D_i
Ba-137m		1.30E-04	
C-14		4.00E-05	
Cs-137		6.27E-04	
H-3		8.97E-07	
I-129		1.30E-04	
Np-237		9.63E-01	
Pu-238		9.02E-01	
Pu-239	6.21E-02	1.00E+00	1.6
Pu-240		1.02E+00	
Pu-242		1.02E+00	
Sr-90		2.55E-03	
Tc-99		1.47E-05	
U-233		2.55E-01	
U-234		2.55E-01	
U-235	2.16E-06	2.34E-01	1

4.0 ASSUMPTIONS

4.1. The waste process will not concentrate the I-129 isotopic content.

Justification: There is no mechanism (i.e., process filter, resin) to concentrate the I-129 isotope in the Tank 22 waste generation process.

5.0 ANALYTICAL METHODS AND COMPUTATIONS

The 3L waste container is fabricated from type 304/304L stainless steel shown in M-R4-G-00001 (I. 3.10) and is not RCRA hazardous. Therefore, the hazardous characterization will determine if RCRA regulations apply to the Tank 22 DWPF recycle wastewater and if there are any UHCs. The radiological characterization will determine the radionuclides represented in the Tank 22 DWPF recycle wastewater.

5.1 Resource Conservation and Recovery Act (RCRA) Waste Characterization and Underlying Hazardous Constituents (UHCs)

5.1.1 Ignitability Characteristic (40 CFR Subpart C, Section 261.21; Hazardous Waste Code D001) [Ref. 8.4]

- The Tank 22 DWPF recycle wastewater is an aqueous liquid with no flash point.
- The Tank 22 DWPF recycle wastewater is:
    - not capable of spontaneous chemical changes
    - not capable of causing a fire through friction
    - not compressed gases
    - not an oxidizer
- Therefore, the Tank 22 DWPF recycle wastewater does not meet the RCRA requirements for ignitable materials.

5.1.2 Corrosivity Characteristic (40 CFR Subpart C, Section 261.22; Hazardous Waste Code D002) [Ref. 8.4]

- A calculated pH of <13.3 was reported in Ref. 8.8 (I. 3.8).
- The Tank 22 DWPF recycle wastewater is aqueous with a pH greater than or equal to 12.5.

- Therefore, the Tank 22 DWPF recycle wastewater meets the RCRA requirements for corrosive materials.

5.1.3 Reactivity Characteristic (40 CFR Subpart C, Section 261.23; Hazardous Waste Code D003) [Ref. 8.4]

- Tank 22 DWPF recycle wastewater:
  - is not unstable
  - does not react violently with water
  - does not form explosive mixtures with water
  - does not generate toxic gasses when mixed with water
  - is not a cyanide or sulfide bearing waste
  - cannot detonate
  - is not explosive.
- Therefore, Tank 22 DWPF recycle wastewater does not meet the RCRA requirements for RCRA-reactive materials.

5.1.4 Toxicity Characteristic (40 CFR Subpart C, Section 261.24; Hazardous Waste Code D004-D043) [Ref. 8.4]

RCRA regulations require that a waste generator determine if a waste is hazardous due to toxicity for any of the forty constituents by analyzing an extract of the waste obtained by the Toxicity Characteristic Leaching Procedure (TCLP). The forty constituents are a combination of twenty-six solvents and organic substances, six pesticides, and eight metals.

5.1.4.1 Organics, Pesticides, and Insecticides (Hazardous Waste Codes D012-D043) [Ref. 8.4]

- Tank 22 DWPF recycle wastewater:
  - does not contain the thirty-two toxicity characteristic solvents
  - contains trace levels of organic substances as organics are highly regulated by the Tank Farm WAC (Waste Acceptance Criteria) [Ref. 8.13]
  - does not contain pesticides

Therefore, Tank 22 DWPF recycle wastewater does not meet the RCRA requirements for organics, pesticides, and insecticides.

5.1.4.2 Metallic Impurities (Hazardous Waste Codes D004-D011) [Ref. 8.4]

The Tank 22 DWPF recycle wastewater contains all eight RCRA TCLP metals (I. 3.1 and 3.13). Samples were obtained from Tank 22 and sent to SRNL for analysis with results provided in Ref. 8.7. The analytical result (total concentration) from Ref. 8.7 was reported in mol/L and converted to TCLP concentration (mg/L) using equation 1 below. Arsenic and Selenium concentration values from Waste Characterization System (WCS) (I. 3.13) were used as the TCLP concentration (mg/L).

$$TCLP_{RCRA,i} = \frac{(C_{RCRA,i,L} \times M \times 1E{+}03 \times V_L)}{V_L + (20 \times W_C \times 0.454)} \qquad \text{Equation (1)}$$

Where

$TCLP_{RCRA,i}$	=	RCRA TCLP metal concentration for each constituent in the liquid, i, mg/L (I. 3.1 or 3.13)
M	=	Molar Mass, g/mol
$C_{RCRA,i}$	=	Concentration of constituent of the liquid waste, M (mol/L) (I. 3.1)
$1E{+}03$	=	Unit conversion (g to mg)
V_L	=	Volume of the liquid waste, L (I. 3.9)
W_C	=	Weight of the waste container, lbs (I. 3.14)
0.454	=	Conversion factor from lbs to kg

The RCRA TCLP constituent is compared to the threshold concentration of the relevant RCRA metal from Reference 8.4 (I. 3.6). If the RCRA TCLP constituent concentration value is higher than the RCRA limit, the material is considered hazardous for the toxicity characteristic. The results are provided in Attachment 4.

5.1.4.3 Waste Stream (Profile) Determinations and Concentrations

For documenting the contents of the waste streams on the Waste Characterization Form (WCF, OSR 29-47) and Characterization Process Report (CPR, OSR 29-92), the RCRA codes, UHCs (Section 5.1.5), and associated concentrations are included. The final RCRA data is summarized in Attachment 4. In addition, the total halogens are calculated using the equation below.

$$Total\ Wt\ \%_{Hal} = \sum \frac{C_{Hal} \times M \times V}{W_w} \times 100 \qquad \text{Equation (2)}$$

Where

$Total\ Wt\%_{Hal}$	=	Total weight percent halogens, wt%
W_w	=	Total Waste Weight, g (I. 3.14)
C_{Hal}	=	Concentration of halogens (Fluoride, Chloride, and Bromide), M (mol/L) (I. 3.1)
M	=	Molar Mass, g/mol
V	=	Waste Volume, L (I. 3.9)

The total weight% halogens is provided in Attachment 4.

5.1.5 Underlying Hazardous Constituents (UHCs) Determinations

Table 1 of 40 CFR, 268.48 [Ref. 8.10] list the non-wastewater concentrations. If the Tank 22 DWPF recycle wastewater is RCRA hazardous, UHC's will be evaluated by comparing the RCRA TCLP metal concentration to the UHC threshold presented in Table 1 of 40 CFR, 268.48 [I. 3.12 and Ref. 8.10]. If the RCRA TCLP constituent concentration value is higher than the UHC limit, the Tank 22 DWPF recycle wastewater is considered to contain that UHC. This comparison is provided in Attachment 4.

5.2 Radiological Characterization

5.2.1 Activity Calculations

The activity for the Tank 22 DWPF recycle wastewater package is determined using sample analysis from SRNL (I. 3.1). Sample data was reported in dpm/mL and converted to a common set of units (µCi/mL) using the following unit conversion.

$$\frac{\mu Ci}{mL} = \frac{dpm}{mL} \times \frac{1\ \mu Ci}{2.22E+06\ dpm} \qquad \text{Equation (3)}$$

The H-3 concentration (Ci/gal) in Tank 22 was provided by WCS (I. 3.2) and converted to activity (Ci) by multiplying by the volume (gal).

To convert the activity concentration (µCi/mL) to activity (Ci) the following equations were used.

$$A_i = A_{i,v}\left(\frac{1\ E-06 Ci}{1\ \mu Ci}\right) \times V \qquad \text{Equation (4)}$$

Where,

A_i	=	Activity of radionuclide, i, Ci
$A_{i,v}$	=	Activity concentration of radionuclide, i, µCi/mL
V	=	Waste volume, mL (I. 3.9)

The Ci % is determined using the equation below.

$$\%A_i = \frac{A_i}{A_T} \qquad \text{Equation (5)}$$

Where

A_i	=	Activity for radionuclide, i, Ci
$\%A_i$	=	Percent activity for radionuclide, i, Ci%
A_T	=	Total Activity (Ci)

After the data was converted into a common set of units, the analytical result was revised based on the following methodology:

1. The PA radionuclides (except I-129) were reported as follows:
   a. For detected PA radionuclides, the result was reported.
   b. For non-detected PA radionuclides, the result was reported at $0.1 \times MDA$.
2. I-129 was reported by multiplying the Cs-137 value by 9.00E-07 as described in 1S, Chapter 3 [Ref. 8.1]. Process knowledge shows that I-129 is not concentrated by the waste process (A. 4.1).
3. For TRU/Fissile radionuclides:
   a. For detected TRU or Fissile radionuclides, the result was reported.
   b. For non-detect TRU and Fissile radionuclides:
      i. If the MDA is less than one order of magnitude above the MALLD, the activity is zero.
      ii. If the MDA is greater than one order of magnitude above the MALLD then $0.1 \times MDA$ is used for activity quantification.
      iii. TRU/Fissile Radionuclides known not to be present in Tank 22 DWPF recycle waste stream were removed from the distribution.
4. For Non-PA, Non-TRU, and Non-Fissile radionuclides:
   a. Per 1S Manual Chapter 3, radionuclides were reported if activity is greater than 1% of the total curie distribution and/or above LLW Package Thresholds [Ref. 8.1].

The results of these above equations and methodology are shown in Attachment 1.

5.2.2 Daughter Radionuclides

Per 1S, Chapter 3 [Ref. 8.1], daughter radionuclides that account for more than 1 Ci% and greater than the LLW Package Thresholds must be reported using the following activity ratios:

- Ba-137m = 0.946 * Cs-137 (Note, Ba-137m was measured in the analysis but the scaled value from the highest reported Cs-137 is used for characterization)
- Pa-234m = 1.00 * U-238
- Th-234 = 1.00 * U-238
- Pa-233 = 1.00 * Np-237
- Th-231 = 1.00 * U-235
- Y-90 = 1.00 * Sr-90

5.3 U-235 FGE, PEC, TRU, and NRC Calculations

5.3.1 U-235 FGE Calculation

U-235 Fissile Gram Equivalent (FGE) content is calculated for each package based on information provided in 1S Chapter 5 [Ref. 8.2] along with the bounding radionuclide activity calculated in Equation 4. The U-235 FGE radionuclides in the Tank 22 DWPF recycle wastewater are U-233, U-235, and Pu-239.

$$FGE = \sum \left(\frac{A_i}{SpA_i}\right) \times D_i$$ Equation (6)

Where

A_i	=	Activity for nuclide, i, Ci
SpA_i	=	Specific activity of nuclide, i, Ci/g (I. 3.3)
D_i	=	Equivalence factor for nuclide, i (I. 3.5)
FGE	=	Total U-235 FGE from all radionuclides, g

The U-235 FGE is compared to the 50g limit in 1S Chapter 6 [Ref. 8.3]. The results of the U-235 FGE calculation are provided in Attachment 2 for the final radionuclide distribution.

5.3.2 PEC Calculation

The Pu-239 Plutonium Equivalent Curies (PEC) content is calculated using weighting factors downloaded from the Waste Inventory Tracking system (WITS) and Equation 6.

$$PEC = \sum A_i \times W_i$$ Equation (7)

Where,

W_i	=	Weighting factor for nuclide, i (I. 3.4)
A_i	=	Activity of nuclide, i, Ci
PEC	=	Total Pu-239 PEC for all radionuclides

The PEC value is then compared to the maximum allowable value of 4 PEC per 1S Chapter 6 [Ref. 8.3] and is provided Attachment 2.

5.3.3 TRU Concentration Calculation

The nuclide activity concentrations are calculated with Equation 8. Waste is considered TRU if it contains more than 100 nCi (alpha-emitting transuranic isotopes with half-lives greater than 20 years) per gram of waste. The TRU nuclides present in the Tank 22 DWPF recycle wastewater are Np-237, Pu-238, Pu-239, Pu-240, and Pu-242.

$$AC_i = \frac{A_i}{W_W} \times 1E + 09$$ Equation (8)

Where,

AC_i	=	Activity concentration for radionuclide, i, nCi/g
W_w	=	Total Waste Weight, g (I. 3.14)
$1E+09$	=	Conversion factor from Ci to nCi

The TRU concentration is provided in Attachment 1, Table A1-2.

5.3.4 NRC Classification Calculation

The procedure for calculating the Nuclear Regulatory Commission (NRC) Classification content is outlined in 10 CFR 61.55 [I. 3.11 and Ref. 8.5]. Specifically, waste containing both long-lived and short-lived nuclides, such as the bounding activity for this waste, utilizes limits in both Table 1 (long-lived) and Table 2 (short-lived), along with the sum-of-fractions (SOF) methodology. The procedure for determining if waste is Class A, B, C, or Greater than Class C (GTCC) is outlined in Figure 5.3.4-1. For those radionuclides based on an activity concentration (Ci/m^3 or Ci/g), those radionuclides' activity (Ci) were either divided by their waste volume (m^3) (I. 3.9) or mass (g) (I. 3.14) for their respected package. The waste volume for the waste container is calculated by multiplying its weight by the density of 304/304L stainless steel (I. 3.15). The waste container volume is added to the 3L Tank 22 DWPF recycle wastewater volume. The SOF calculation is provided by the below equation.

$$SOF = \sum \frac{ACD_i}{L_i} \qquad \text{Equation (9)}$$

Where

ACD_i	=	Activity concentration of nuclide, i, nCi/g or Ci/m^3
L_i	=	Limit for nuclide, i, nCi/g or Ci/m^3 [Ref. 8.5]
SOF	=	Sum-of-Fractions based on all applicable nuclides

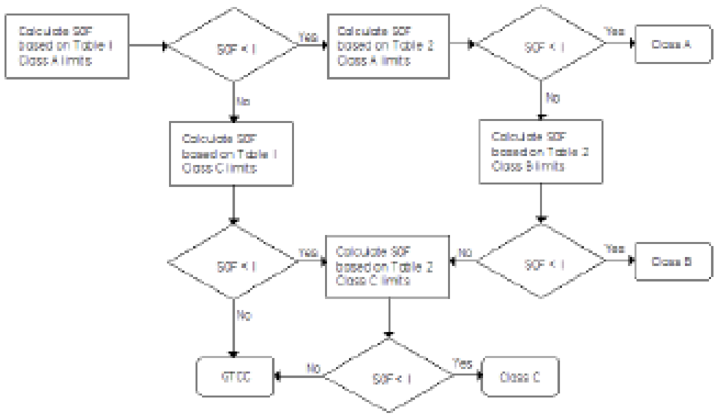


Figure 5.3.4-1: NRC Classification Procedure

The NRC classification for each package is provided in Attachment 3.

6.0 RESULTS

6.1 Resource Conservation and Recovery Act (RCRA) Waste Characterization

The RCRA results for are provided in Attachment 4. The Tank 22 DWPF recycle wastewater is hazardous for:

- Corrosivity [D002]
- Mercury [D009]
- Selenium [D010]

There are no UHC's in the Tank 22 DWPF recycle wastewater.

6.2 Activity Calculations

The activity calculations are provided in Attachment 1. The radiological distribution is provided in Table 6.2-1 for one package.

Table 6.2-1: Tank 22 DWPF Recycle Wastewater Radionuclide Distribution

Radionuclide Distribution		
Radionuclide	Activity (Ci)	Ci %
Ba-137m	9.58E-02	48.52%
C-14	2.18E-07	0.000110%
Cs-137	1.01E-01	51.29%
H-3	3.17E-04	0.161%
I-129	9.11E-08	0.0000462%
Np-237	2.36E-09	0.00000120%
Pu-238	1.64E-08	0.00000829%
Pu-239	2.08E-07	0.000105%
Pu-240	7.65E-07	0.000388%
Pu-242	1.28E-08	0.00000650%
Sr-90	3.31E-05	0.0168%
Tc-99	9.15E-06	0.00464%
U-233	3.24E-08	0.0000164%
U-234	2.09E-08	0.0000106%
U-235	2.24E-10	0.000000114%
Total	1.97E-01	100.00%

6.3 TRU Concentration

The TRU concentration for one package is provided in Attachment 1. The Tank 22 DWPF recycle waste is non-TRU waste.

6.4 U-235 FGE Calculation

The U-235 FGE for one package is provided Attachment 2. The U-235 FGE limit of 50g was not exceeded. Therefore, the waste is non-fissile.

6.5 Pu-239 PEC Calculation

The Pu-239 PEC for one waste package is provided Attachment 2. The PEC value of 4 was not exceeded.

6.6 NRC Classification

The NRC classification is Class B for one package and is provided Attachment 3.

7.0 CONCLUSION

The radiological distribution in Table 6.2-1 and RCRA results shown in Attachment 4 will be provided to SWM for disposition of these packages as MW.

8.0 REFERENCES

8.1 SRS Manual 1S, Chapter 3, "Waste Characterization Program", Rev. 4, September 28, 2017.

8.2 SRS Manual 1S, Chapter 5, "Low-level Waste", Rev. 1, November 13, 2014.

8.3 SRS Manual 1S, Chapter 6, "RCRA, TSCA, Mixed, and LLLW", Rev. 3, May 25, 2017.

8.4 South Carolina Hazardous Waste Management Regulations (SCHWMR), R.61-79.261.24.

8.5 10 CFR Part 61.55, "Waste Classification", December 2, 2015.

8.6 WITS Reports Download, "LLW PEC239", downloaded December 1, 2016.

8.7 K.H. Rosenberger, "Concentrations of Tank 22 Defense Waste Processing Facility Recycle Wastewater for Use in Phase 1 Off-site Disposition Activities", SRR-CWDA-2020-00025, Rev. 0, March 4, 2020.

8.8 C. Nash, "Tank 22 Composite Core Sludge Sample Characterizations Results – Radionuclides, Elementals, and Anions", SRNL-L3100-2019-00024, 6/28/2019.

8.9 WCS Online, "Tank 22H Tank Details, Supernate," Production v1.2019.0828.4.

8.10 40 CFR, Part 268.48, "Universal Treatment Standards".

8.11 M-R4-G-00001, "1, 2, and 3 Liter Sample Vials Assembly and Fabrication Details", Rev. 1, May 11, 2017.

8.12 M-CLC-H-02888 "1, 2, and 3 Liter Sample Vial Buoyancy Calculation", Rev. 2, October 20, 2016.

8.13 X-SD-G-00009, "Waste Acceptance Criteria for Liquid Waste Transfers to the Tank Farms (U)", Rev. 2, October 28, 2019.

ATTACHMENTS

1. Radiological Results
2. U-235 FGE, Pu-239 PEC
3. NRC Classification Calculations
4. RCRA Results
5. Stainless Steel Properties

Attachment 1: Radiological Results

Attachment 1, Page 1 of 3 "Best Available Copy"

Table A1-1: Radiologial Results

Tank 22 DWPF Recycle Wastewater Radionuclide Concentrations								
	Category	Result (dpm/mL)	Result MDA (dpm/mL)	MALLD (µCi/mL)	Calculated Result (µCi/mL), Equation 3	Revised Result (µCi/mL)	Compare to MALLD	Comments
C-14	PA	1.61E+02		1.00E-05	7.25E-05	7.25E-05	N/A Detected PA	
Cl-36			1.20E+02	NO MALLD	5.41E-05	0.00E+00	< MALLD	
Ni-59			6.72E+01	1.00E-04	3.03E-05	0.00E+00	< MALLD	
Ni-63			7.67E+01	1.00E-04	3.45E-05	0.00E+00	< MALLD	
Co-60			4.20E-01	1.00E-04	1.89E-07	0.00E+00	< MALLD	
Sr-90	PA	2.45E+04		1.00E-04	1.10E-02	1.10E-02	N/A Detected PA	
Y-90		2.45E+04		NO MALLD	1.10E-02	1.10E-02	N/A Detected	
Nb-94			1.62E+00	NO MALLD	7.30E-07	0.00E+00	< MALLD	
Tc-99	PA	6.77E+03		1.00E-06	3.05E-03	3.05E-03	N/A Detected PA	
Ru-106			7.02E+00	NO MALLD	3.16E-06	0.00E+00	< MALLD	
Sb-125		8.94E+00		NO MALLD	4.03E-06	4.03E-06	N/A Detected	
Sb-126		1.42E+01		NO MALLD	6.40E-06	6.40E-06	N/A Detected	
Sn-126		1.42E+01		NO MALLD	6.40E-06	6.40E-06	N/A Detected	
I-129	PA		2.43E+00	1.00E-06	1.09E-06	3.04E-05	N/A MDA- PA	Scale from Cs-137
Cs-134			5.38E+03	NO MALLD	2.42E-03	0.00E+00	< MALLD	
Cs-137		7.49E+07		1.00E-05	3.37E+01	3.37E+01	N/A Detected	
Ba-137m		2.74E+07		NO MALLD	1.23E+01	1.23E+01	N/A Detected	
Ce-144			9.37E+00	NO MALLD	4.22E-06	0.00E+00	< MALLD	
Eu-152			1.42E+00	NO MALLD	6.40E-07	0.00E+00	< MALLD	
Eu-154			8.99E-01	NO MALLD	4.05E-07	0.00E+00	< MALLD	
Eu-155			1.94E+01	NO MALLD	8.74E-06	0.00E+00	< MALLD	
Ra-226			8.45E+00	NO MALLD	3.81E-06	0.00E+00	< MALLD	
Th-232			4.09E-02	NO MALLD	1.84E-08	0.00E+00	< MALLD	
U-233	Fissile		2.40E+02	1.00E-06	1.08E-04	1.08E-05	> MALLD	0.1 X MDA
U-234	PA		1.55E+02	1.00E-06	6.98E-05	6.98E-06	N/A MDA- PA	0.1 X MDA
U-235	PA/Fissile	1.66E-01		1.00E-06	7.48E-08	7.48E-08	N/A Detected PA	
U-236			1.61E+00	1.00E-06	7.25E-07	0.00E+00	< MALLD	
Np-237	PA/TRU		1.75E+01	1.00E-06	7.88E-06	7.88E-07	N/A MDA- PA	0.1 X MDA
U-238		3.72E+00		1.00E-06	1.68E-06	1.68E-06	N/A Detected	
Np-239			4.94E+00	NO MALLD	2.23E-06	0.00E+00	< MALLD	
Pu-238	TRU		1.21E+02	1.00E-06	5.45E-05	5.45E-06	> MALLD	0.1 X MDA
Pu-239	TRU/Fissile		1.54E+03	1.00E-06	6.94E-04	6.94E-05	> MALLD	0.1 X MDA
Pu-240	TRU		5.66E+03	1.00E-06	2.55E-03	2.55E-04	> MALLD	0.1 X MDA
Pu-241	Fissile		1.72E+02	1.00E-05	7.75E-05	0.00E+00	Same OM as MALLD	
Pu-242	TRU		9.49E+01	1.00E-06	4.27E-05	4.27E-06	> MALLD	0.1 X MDA
Pu-244	TRU		4.41E-01	1.00E-06	1.99E-07	0.00E+00	< MALLD	
Am-241	TRU		1.43E+01	1.00E-05	6.44E-06	0.00E+00	< MALLD	
Am-242m	TRU/Fissile		1.08E-01	1.00E-06	4.86E-08	0.00E+00	< MALLD	
Am-243	TRU		3.10E+00	1.00E-06	1.40E-06	0.00E+00	Same OM as MALLD	
Cm-242			1.98E+00	1.00E-06	8.92E-07	0.00E+00	< MALLD	
Cm-243	TRU/Fissile		9.04E+00	1.00E-06	4.07E-06	0.00E+00	Same OM as MALLD	
Cm-244		1.34E+02		NO MALLD	6.04E-05	6.04E-05	N/A Detected	
Cm-245	TRU/Fissile		7.39E+00	1.00E-06	3.33E-06	0.00E+00	Same OM as MALLD	
Cm-247	TRU/Fissile		9.12E+00	1.00E-06	4.11E-06	0.00E+00	Same OM as MALLD	
Cm-248	TRU		1.21E+01	1.00E-06	5.45E-06	0.00E+00	Same OM as MALLD	
Cf-249	TRU/Fissile		9.80E+00	1.00E-06	4.41E-06	0.00E+00	Same OM as MALLD	
Cf-251	TRU/Fissile		8.76E+00	1.00E-06	3.95E-06	0.00E+00	Same OM as MALLD	
Total		1.02E+08	1.38E+04		4.61E+01	4.61E+01		

Radionuclide	Category	Ci/gal	Activity (Ci)
H-3	PA	0.0004	3.17E-04

Attachment 1, Page 2 of 3 "Best Available Copy"

Table A1-1: Radiological Results (continued)

	Radionuclide	Revised Result (µCi/mL)	Activity (Ci), Equation 4	Ci %, Equation 5	Ci/pkg	Revised Activity (Ci)	Comments
	H-3	N/A	3.17E-04	0.161%	N/A	3.17E-04	PA - keep, Note 1
	C-14	7.25E-05	2.18E-07	0.000110%	N/A	2.18E-07	PA - keep
	Sr-90	1.10E-02	3.31E-05	0.0168%	N/A	3.31E-05	PA - keep
	Tc-99	3.05E-03	9.15E-06	0.00464%	N/A	9.15E-06	PA - keep
	Sb-125	4.03E-06	1.21E-08	0.00000612%	9.20E-03	0.00E+00	<1% + below threshold
	Sb-126	6.40E-06	1.92E-08	0.00000972%	6.30E-05	0.00E+00	<1% + below threshold
	Sn-126	6.40E-06	1.92E-08	0.00000972%	2.00E-04	0.00E+00	<1% + below threshold
	I-129	3.04E-05	9.11E-08	0.0000462%	N/A	9.11E-08	PA - keep
	Cs-137	3.37E+01	1.01E-01	51.28%	3.30E-01	1.01E-01	> 1% - keep
	U-233	1.08E-05	3.24E-08	0.0000164%	2.60E-02	3.24E-08	Fissile - Keep
	U-234	6.98E-06	2.09E-08	0.0000106%	N/A	2.09E-08	PA - keep
	U-235	7.48E-08	2.24E-10	0.000000114%	N/A	2.24E-10	PA - keep
	Np-237	7.88E-07	2.36E-09	0.00000120%	N/A	2.36E-09	PA - keep
	U-238	1.68E-06	5.03E-09	0.00000255%	3.10E-02	0.00E+00	<1% + below threshold
	Pu-238	5.45E-06	1.64E-08	0.00000829%	1.10E-02	1.64E-08	TRU - Keep
	Pu-239	6.94E-05	2.08E-07	0.000105%	1.00E-02	2.08E-07	TRU/Fissile - Keep
	Pu-240	2.55E-04	7.65E-07	0.000388%	9.80E-03	7.65E-07	TRU - Keep
	Pu-242	4.27E-06	1.28E-08	0.00000650%	9.80E-03	1.28E-08	TRU - Keep
	Cm-244	6.04E-05	1.81E-07	0.0000918%	9.80E-03	0.00E+00	<1% + below threshold
Daughters	**Parent Isotope**						
Ba-137m	Cs-137	3.19E+01	9.58E-02	48.52%	1.00E+01	9.58E-02	> 1% - keep
Pa-233	Np-237	7.88E-07	2.36E-09	0.00000120%	1.00E+01	0.00E+00	<1% + below threshold
Pa-234m	U-238	1.68E-06	5.03E-09	0.00000255%	1.00E+01	0.00E+00	<1% + below threshold
Th-231	U-235	7.48E-08	2.24E-10	0.000000114%	1.00E+01	0.00E+00	<1% + below threshold
Th-234	U-238	1.68E-06	5.03E-09	0.00000255%	1.00E+01	0.00E+00	<1% + below threshold
Y-90	Sr-90	1.10E-02	3.31E-05	0.0168%	1.00E+01	0.00E+00	<1% + below threshold
Total		6.57E+01	1.97E-01	100.0%		1.97E-01	

Note 1 - H-3 was not directly measured. It has been added to the distribution at 0.0004 Ci/gal for Tank 22 supernate as provided in WCS.

Attachment 1, Page 3 of 3

Table A1-2: Radiologial Distribution and TRU Concentration

Radionuclide Distribution		
Radionuclide	Activity (Ci)	Ci %
Ba-137m	9.58E-02	48.52%
C-14	2.18E-07	0.000110%
Cs-137	1.01E-01	51.29%
H-3	3.17E-04	0.161%
I-129	9.11E-08	0.0000462%
Np-237	2.36E-09	0.00000120%
Pu-238	1.64E-08	0.00000829%
Pu-239	2.08E-07	0.000105%
Pu-240	7.65E-07	0.000388%
Pu-242	1.28E-08	0.00000650%
Sr-90	3.31E-05	0.0168%
Tc-99	9.15E-06	0.00464%
U-233	3.24E-08	0.0000164%
U-234	2.09E-08	0.0000106%
U-235	2.24E-10	0.000000114%
Total	1.97E-01	100.00%

TRU (nCi/g), Equation 8	8.07E-02

Attachment 2: U-235 FGE, Pu-239 PEC

Attachment 2, Page 1 of 1

Table A2-1: U-235 FGE and Pu-239 PEC

U-235 FGE, Equation 6	
Radionuclide	U-235 FGE
U-233	4.71E-06
U-235	1.04E-04
Pu-239	5.36E-06
Total	1.14E-04

Pu-239 PEC, Equation 7	
Radionuclide	Pu-239 PEC
Ba-137m	1.24E-05
C-14	8.70E-12
Cs-137	6.35E-05
H-3	2.84E-10
I-129	1.18E-11
Np-237	2.28E-09
Pu-238	1.47E-08
Pu-239	2.08E-07
Pu-240	7.80E-07
Pu-242	1.31E-08
Sr-90	8.44E-08
Tc-99	1.34E-10
U-233	8.27E-09
U-234	5.34E-09
U-235	5.25E-11
Total	7.70E-05

Attachment 3: NRC Classification

Attachment 3, Page 1 of 1

Table A3-1: NRC Classification

A	B	C	D	E	F	G	H	I	J	K	L
NRC Classification											
Radionuclide	**Activity, Ci**	**Activity Concentration, AC_i, nCi/g [=(B/12,453)X1E09]**	**Activity Density, AD_i, Ci/m³ [=B/0.00419]**	**Class A Limits L_i, (Table 1)**	**Units**	**Class A SOF (Table 1), Equation 9**	**Class A Limits, L_i, (Table 2)**	**Units**	**Class A SOF (Table 2), Equation 9**	**Class B Limits, L_i, (Table 2)**	**Class B SOF (Table 2), Equation 9**
Ba-137m	9.58E-02	7.69E+03	2.29E+01				700	Ci/m³	3.27E-02	Unlimited	
C-14	2.18E-07	1.75E-02	5.20E-05	0.8	Ci/m³	6.50E-05					
Cs-137	1.01E-01	8.13E+03	2.42E+01				1	Ci/m³	2.42E+01	44	5.50E-01
H-3	3.17E-04	2.55E+01	7.57E-02				40	Ci/m³	1.89E-03	Unlimited	
I-129	9.11E-08	7.32E-03	2.18E-05	0.008	Ci/m³	2.72E-03					
Np-237	2.36E-09	1.90E-04	5.65E-07	10	nCi/g	1.90E-05					
Pu-238	1.64E-08	1.31E-03	3.91E-06	10	nCi/g	1.31E-04					
Pu-239	2.08E-07	1.67E-02	4.97E-05	10	nCi/g	1.67E-03					
Pu-240	7.65E-07	6.14E-02	1.83E-04	10	nCi/g	6.14E-03					
Pu-242	1.28E-08	1.03E-03	3.06E-06	10	nCi/g	1.03E-04					
Sr-90	3.31E-05	2.66E+00	7.91E-03				0.04	Ci/m³	1.98E-01	150	5.27E-05
Tc-99	9.15E-06	7.35E-01	2.19E-03	0.3	Ci/m³	7.28E-03					
Total	**1.97E-01**					**1.81E-02**			**2.44E+01**		**5.50E-01**
						Calculate SOF based on Table 2 Class A Limits			Calculate SOF based on Table 2 Class B limits		Class B

Attachment 4: RCRA Results

Attachment 4, Page 1 of 1

Table A4-1: RCRA Results

Parameter	Result	Result MDA	Units	TCLP Concentration (mg/L), Equation 1	RCRA Limit (mg/L)	RCRA Hazardous?	UHC Limit (mg/L)	UHC?
Mercury [Hg]	5.67E-04		M	1.8	0.2	Yes	0.025	No
Arsenic [As]*	Not Analyzed	Not Analyzed	Not Analyzed	0.68	5	No	5	No
Barium [Ba]		4.89E-07	M	0.0011	100	No	21	No
Cadmium [Cd]		7.97E-07	M	0.0014	1	No	0.11	No
Chromium [Cr]		4.74E-06	M	0.0039	5	No	0.6	No
Lead [Pb]		6.03E-05	M	0.197	5	No	0.75	No
Selenium [Se]*	Not Analyzed	Not Analyzed	Not Analyzed	7.33	1	Yes	5.7	No
Silver [Ag]		2.70E-06	M	0.0046	5	No	0.14	No
Notes - *Concentration values (mg/L) for Arsenic and Selenium are provided in WCS. (I. 3.13)								

Other Parameters	Result MDA	Units	Weight Percent, Equation 2	
Fluoride	1.09E-02	M	0.020%	wt %
Chloride	5.85E-03	M	0.020%	wt %
Bromide	2.60E-03	M	0.020%	wt %
Total Halogens			0.060%	wt %

Other Parameters	Result	Units	Notes
Density	1.029	g/cc	I. 3. 1
pH	13.3	RCRA Corrosive	

Weight of Waste Container, W_c (lbs)	20.63
Weight of Liquid (lbs)	6.80
Waste Weight (lbs)	27.43
Waste Weight (g)	12453

Liquid Volume (ml)	3000
Liquid Volume (gal)	0.793
Liquid Volume (m^3)	0.003
Container Volume (m^3)	0.00119
Total Waste Volume (m^3)	0.00419

Attachment 5: 304/304L Stainless Steel Properties

Attachment 5, Page 1 of 1

Specification Sheet: Alloy 304/304L

(UNS S30400, S30403) W. Nr. 1.4301, 1.4307

Most Widely Used Austenitic Stainless Steel, a Versatile Corrosion Resistant Alloy for General Purpose Applications

Alloy 304/304L (UNS S30400/S30403) is the most widely utilized "18-8" chromium-nickel austenitic stainless steel. It is an economical and versatile corrosion resistant alloy suitable for a wide range of general purpose applications.

It is common practice for 304L to be dual certified as 304 and 304L. The low carbon chemistry of 304L combined with an addition of nitrogen enables 304L to meet the mechanical properties of 304.

Alloy 304/304L resists atmospheric corrosion, as well as, moderately oxidizing and reducing environments. The alloy has excellent resistance to intergranular corrosion in the as-welded condition. Alloy 304/304L has excellent strength and toughness at cryogenic temperatures.

Alloy 304/304L is non-magnetic in the annealed condition, but can become slightly magnetic as a result of cold working or welding. It can be easily welded and processed by standard shop fabrication practices.

Applications

- Chemical and Petrochemical Processing—pressure vessels, tanks, heat exchangers, piping systems, flanges, fittings, valves and pumps
- Food and Beverage Processing
- Medical
- Mining
- Petroleum Refining
- Pharmaceutical Processing
- Power Generation—nuclear
- Pulp and Paper

Standards

ASTM .... A 240
ASME .... SA 240
AMS 5511/5513
QQ-S 766

Chemical Analysis

Weight % (all values are maximum unless a range is otherwise indicated)

Element	304	304L
Chromium	18.0 min.–20.0 max.	18.0 min.–20.0 max.
Nickel	8.0 min.–10.5 max.	8.0 min.–12.0 max.
Carbon	0.08	0.030
Manganese	2.00	2.00
Phosphorus	0.045	0.045
Sulfur	0.030	0.030
Silicon	0.75	0.75
Nitrogen	0.10	0.10
Iron	Balance	Balance

Physical Properties

Density
0.285 lbs/in³
7.90 g/cm³

Specific Heat
0.12 BTU/lb-°F (32–212°F)
500 J/kg-°K (0–100°C)

Modulus of Elasticity
29.0 x 10^6 psi
200 GPa

Thermal Conductivity 212°F (100°C)
9.4 BTU/hr/ft²/ft/°F
16.3 W/m-°K

Melting Range
2550–2590°F
1398–1421°C

Electrical Resistivity
29.1 Microhm-in at 68°F
74 Microhm-cm at 20°C

Mean Coefficient of Thermal Expansion

Temperature Range °F	°C	in/in/°F	cm/cm °C
68–212	20–100	9.2 x 10^{-6}	16.6 x 10^{-6}
68–932	20–500	10.6 x 10^{-6}	18.2 x 10^{-6}
68–1600	20–870	11.0 x 10^{-6}	19.8 x 10^{-6}

Mechanical Properties

	Typical*	ASTM Type 304	ASTM Type 304L
0.2% Offset Yield Strength, ksi	42	30 min.	25 min.
Ultimate Tensile Strength, ksi	87	75 min.	70 min.
Elongation in 2 inches, %	58	40 min.	40 min.
Reduction in Area, %	70	—	—
Hardness, Rockwell B	82	92 max.	92 max.

*0.375 inch plate

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Appendix D. 10 CFR Section 61.55

§ 61.53 Environmental monitoring.

(a) At the time a license application is submitted, the applicant shall have conducted a preoperational monitoring program to provide basic environmental data on the disposal site characteristics. The applicant shall obtain information about the ecology, meteorology, climate, hydrology, geology, geochemistry, and seismology of the disposal site. For those characteristics that are subject to seasonal variation, data must cover at least a twelve month period.

(b) The licensee must have plans for taking corrective measures if migration of radionuclides would indicate that the performance objectives of subpart C may not be met.

(c) During the land disposal facility site construction and operation, the licensee shall maintain a monitoring program. Measurements and observations must be made and recorded to provide data to evaluate the potential health and environmental impacts during both the construction and the operation of the facility and to enable the evaluation of long-term effects and the need for mitigative measures. The monitoring system must be capable of providing early warning of releases of radionuclides from the disposal site before they leave the site boundary.

(d) After the disposal site is closed, the licensee responsible for post-operational surveillance of the disposal site shall maintain a monitoring system based on the operating history and the closure and stabilization of the disposal site. The monitoring system must be capable of providing early warning of releases of radionuclides from the disposal site before they leave the site boundary.

§ 61.54 Alternative requirements for design and operations.

The Commission may, upon request or on its own initiative, authorize provisions other than those set forth in §§ 61.51 through 61.53 for the segregation and disposal of waste and for the design and operation of a land disposal facility on a specific basis, if it finds reasonable assurance of compliance with the performance objectives of subpart C of this part.

§ 61.55 Waste classification.

(a) Classification of waste for near surface disposal. (1) *Considerations.* Determination of the classification of radioactive waste involves two considerations. First, consideration must be given to the concentration of long-lived radionuclides (and their shorter-lived precursors) whose potential hazard will persist long after such precautions as institutional controls, improved waste form, and deeper disposal have ceased to be effective. These precautions delay the time when long-lived radionuclides could cause exposures. In addition, the magnitude of the potential dose is limited by the concentration and availability of the radionuclide at the time of exposure. Second, consideration must be given to the concentration of shorter-lived radionuclides for which requirements on institutional controls, waste form, and disposal methods are effective.

(2) *Classes of waste.* (i) Class A waste is waste that is usually segregated from other waste classes at the disposal site. The physical form and characteristics of Class A waste must meet the minimum requirements set forth in § 61.56(a). If Class A waste also meets the stability requirements set forth in § 61.56(b), it is not necessary to segregate the waste for disposal.

(ii) Class B waste is waste that must meet more rigorous requirements on waste form to ensure stability after disposal. The physical form and characteristics of Class B waste must meet both the minimum and stability requirements set forth in § 61.56.

(iii) Class C waste is waste that not only must meet more rigorous requirements on waste form to ensure stability but also requires additional measures at the disposal facility to protect against inadvertent intrusion. The physical form and characteristics of Class C waste must meet both the minimum and stability requirements set forth in § 61.56.

(iv) Waste that is not generally acceptable for near-surface disposal is waste for which form and disposal methods must be different, and in general more stringent, than those specified for Class C waste. In the absence of specific requirements in this part, such waste must be disposed of in a geologic repository as defined in part 60 or 63 of this chapter unless proposals for disposal of such waste in a disposal site licensed pursuant to this part are approved by the Commission.

(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.

TABLE 1

Radionuclide	Concentration curies per cubic meter
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 nuclides with half-life greater than 5 years	[1] 100
Pu–241	[1] 3,500
Cm–242	[1] 20,000

[1] Units are nanocuries per gram.

(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.

TABLE 2

Radionuclide	Concentration, curies per cubic meter		
	Col. 1	Col. 2	Col. 3
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	0.04	150	7000
Cs–137	1	44	4600

[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 Table 2 determine the waste to be Class C independent of these nuclides.

(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.

(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.

(7) The sum of the fractions rule for mixtures of radionuclides. For determining classification for waste that contains a mixture of radionuclides, it is necessary to determine the sum of fractions by dividing each nuclide's concentration by the appropriate limit and adding the resulting values. The appropriate limits must all be taken from the same column of the same table. The sum of the fractions for the column must be less than 1.0 if the waste class is to be determined by that column. Example: A waste contains Sr-90 in a concentration of 50 Ci/m^3 and Cs-137 in a concentration of 22 Ci/m^3. Since the concentrations both exceed the values in Column 1, Table 2, they must be compared to Column 2 values. For Sr-90 fraction 50/150=0.33; for Cs-137 fraction, 22/44=0.5; the sum of the fractions=0.83. Since the sum is less than 1.0, the waste is Class B.

(8) *Determination of concentrations in wastes.* The concentration of a radionuclide may be determined by indirect methods such as use of scaling factors which relate the inferred concentration of one radionuclide to another that is measured, or radionuclide material accountability, if there is reasonable assurance that the indirect methods can be correlated with actual measurements. The concentration of a radionuclide may be averaged over the volume of the waste, or weight of the waste if the units are expressed as nanocuries per gram.

[47 FR 57463, Dec. 27, 1982, as amended at 54 FR 22583, May 25, 1989; 66 FR 55792, Nov. 2, 2001]

§ 61.56 Waste characteristics.

(a) The following requirements are minimum requirements for all classes of waste and are intended to facilitate handling at the disposal site and provide protection of health and safety of personnel at the disposal site.

(1) Waste must not be packaged for disposal in cardboard or fiberboard boxes.

(2) Liquid waste must be solidified or packaged in sufficient absorbent material to absorb twice the volume of the liquid.

(3) Solid waste containing liquid shall contain as little free standing and noncorrosive liquid as is reasonably achievable, but in no case shall the liquid exceed 1% of the volume.

(4) Waste must not be readily capable of detonation or of explosive decomposition or reaction at normal pressures and temperatures, or of explosive reaction with water.

(5) Waste must not contain, or be capable of generating, quantities of toxic gases, vapors, or fumes harmful to persons transporting, handling, or disposing of the waste. This does not apply to radioactive gaseous waste packaged in accordance with paragraph (a)(7) of this section.

(6) Waste must not be pyrophoric. Pyrophoric materials contained in waste shall be treated, prepared, and packaged to be nonflammable.

(7) Waste in a gaseous form must be packaged at a pressure that does not exceed 1.5 atmospheres at 20°C. Total activity must not exceed 100 curies per container.

(8) Waste containing hazardous, biological, pathogenic, or infectious material must be treated to reduce to the maximum extent practicable the potential hazard from the non-radiological materials.

(b) The requirements in this section are intended to provide stability of the waste. Stability is intended to ensure that the waste does not structurally degrade and affect overall stability of the site through slumping, collapse, or other failure of the disposal unit and thereby lead to water infiltration. Stability is also a factor in limiting exposure to an inadvertent intruder, since it provides a recognizable and nondispersible waste.

(1) Waste must have structural stability. A structurally stable waste form will generally maintain its physical dimensions and its form, under the expected disposal conditions such as weight of overburden and compaction equipment, the presence of moisture, and microbial activity, and internal factors such as radiation effects and chemical changes. Structural stability can be provided by the waste form itself, processing the waste to a stable form, or placing the waste in a disposal container or structure that provides stability after disposal.

(2) Notwithstanding the provisions in § 61.56(a) (2) and (3), liquid wastes, or

Appendix E. Compliance Crosswalk to WCS FWF WAC

WCF FWF Generator Handbook Requirement		DWPF Recycle Wastewater Compliance Statement		
		Meets WCS FWF Requirement?		
Requirement (Handbook Section)	Description	Yes	No	Supporting Statement
License Volume and Curie Limit (5.2.1)	Federal LLW volumes shall not exceed a total of 26,000,000 cubic feet of waste with a total decay corrected quantity of radioactivity not to exceed 5,600,000 curies and, of the total volume, 8,100,000 cubic feet can be containerized waste with a total quantity of radioactivity of containerized waste not to exceed 5,500,000 curies.	✓		Disposal of up to 8 gallons of stabilized DWPF recycle wastewater is within the license volume and curie limits.
Chelating Agents (5.2.2)	Limited to 8% by weight for each waste stream (e.g., profile).	✓		No chelating agents in stabilized DWPF recycle wastewater.
Free Liquids (5.2.3)	Must not exceed 1% of the volume in containerized waste.	✓		DWPF recycle wastewater will be grouted into a solid waste form containing no free liquids.
Void Space/Head Space (5.2.4)	Must be reduced to the extent practicable; LLW can have no more than 15% void space/headspace.	✓		Stabilized waste container packages will have less than 15% void space.
Void Filling/Solidification Agent (5.2.5)	Void filling/solidification agents are required to be non-biodegradable. Two examples are vermiculite and concrete.	✓		DWPF recycle wastewater will be stabilized in grout (a concrete formulation).
Waste Packaging (5.2.6)	Each package or container shall only contain one approved profiled waste stream; Packages should weigh 10,000 lbs. or less unless special arrangements have been made; Drums exceeding 1,000 lbs. must be palletized and banded unless alternate arrangements are made with WCS; All containers transported on public roads to WCS are required to meet the applicable requirements of the Texas Department of State Health Services (DSHS) and DOT regulations (49 CFR) Cardboard, fiberboard, and wood boxes are prohibited; Except for bulk waste in reusable containers and large components, waste packages must fit into a Modular Concrete Canister (MCC). WCS has two standard types of	✓		Waste container will only include stabilized DWPF recycle wastewater as an approved profiled waste stream. Waste will be packaged in steel containers and will not exceed 1,000 lbs. All transportation regulations will be met.

WCF FWF Generator Handbook Requirement		DWPF Recycle Wastewater Compliance Statement		
		Meets WCS FWF Requirement?		
Requirement (Handbook Section)	Description	Yes	No	Supporting Statement
	MCCs: Cylindrical: 6’ 8” D x 9’ 2” H (internal dimension); Rectangular: 9’ 6” L x 7’ 8” W x 9’ 2” H.			
Waste Class (5.2.7)	The FWF is authorized to receive containerized Class A, Class B, and Class C (as defined in 30 TAC §336.362) LLRW and LLMW, and bulk Class A LLRW and LLMW in reusable packages with a dose rates of <100 mrem/hr. at 30 centimeters.	✓		Solidified DWPF recycle wastewater does not exceed Class B limits. Dose rates for large packages may be >100 mrem/hr.
Waste Stability Requirements (5.2.9)	The MCC disposal structure provided by WCS will provide the stability required for radioactive waste in accordance with 10 CFR 10 CFR §61; therefore, the waste or the waste form as shipped to WCS is not required to meet stability requirements; All Class B, C, and HCD Class A waste will be placed in an MCC.	✓		WCS will place DWPF recycle waste containers in an MCC.
Prohibited Wastes Types (5.2.11)	Waste streams not specifically authorized by the license or with physical, chemical, and radiological characteristics not evaluated in the license application • Waste of international origin [THSC §401.207(0)] • Greater than Class C waste • Naturally-occurring radioactive material (NORM) waste including oil & gas NORM • Byproduct material waste [11.e(2)] • High-level radioactive waste • Uranium hexafluoride • Waste capable of generating toxic gases, vapors, or fumes (excluding radioactive gases) • Waste readily capable of detonation or of explosive decomposition or reaction at normal pressures and temperatures or of explosive reaction with water • Waste containing transuranic nuclides in concentrations greater than 100 nCi/g • Municipal solid waste	✓		Waste does not contain any prohibited waste types. DWPF recycle wastewater meeting the HLW interpretation for management as non-HLW would be declared non-HLW by DOE prior to shipment to WCS FWF.

WCF FWF Generator Handbook Requirement		DWPF Recycle Wastewater Compliance Statement		
		Meets WCS FWF Requirement?		
Requirement (Handbook Section)	Description	Yes	No	Supporting Statement
	• Liquid waste that is not stabilized or not solidified • Explosive materials • Pyrophoric material that has not been properly stabilized Putrescible waste • LLMW containing RCRA codes F020, F021, F022, F023, F026, and F027 (Dioxins and Furans) • Waste that is NOT considered Federal Waste.			