Department of Energy
Savannah River Operations Office
P.O. Box A
Aiken, South Carolina 29802

SEP 26 2019

Mr. Marty Lindler, Manager
Solid and Hazardous Waste Compliance
Bureau of Land and Waste Management
South Carolina Department of Health and Environmental Control
2600 Bull Street
Columbia, SC 29201

Dear Mr. Lindler:

SUBJECT: Dispute Resolution Agreement Supplemental Tank Closure Activity (STCA): Evaluation of the Technical Feasibility and Economic Efficiency of Savannah River Site Tank Closure Cesium Removal (TCCR) Unit 1 to Process Salt Waste from at Least One Additional Tank

REFERENCES: Dispute Resolution Agreement for Alleged Violations of Class 3 Industrial Solid Waste Landfill Permit Facility, Facility Permit ID# 025500-1603

In accordance with the provisions of the October 31, 2016 *Dispute Resolution Agreement for Alleged Violations of Class 3 Industrial Solid Waste Landfill Permit Facility, Facility ID #025500-1603*, enclosed is the STCA report titled "Evaluation of the Technical Feasibility and Economic Efficiency of Savannah River Site TCCR Unit 1 to Process Salt Waste From at least One Additional Tank" (SRR-CWDA-2019-00089). The Department of Energy (DOE) requests South Carolina Department of Health and Environmental Control review and response or approval.

DOE has completed this STCA as described in paragraph 18.c. of the Dispute Resolution Agreement and is providing this letter and the attached report as signed documentation of completion, executed by DOE's authorized representative consistent with paragraph 17.

If you have any questions, please contact me or have your staff contact Aaron White at (803) 208-7248 or Jeffrey Bentley at (803) 208-7513.

Sincerely,

James L. Folk, Jr.
Assistant Manager
Waste Disposition

WDPD-19-48

Enclosure:
Evaluation of the Technical Feasibility
and Economic Efficiency of Savannah
River Site Tank Closure Cesium Removal
(TCCR) Unit 1 to Process Salt Waste From
at Least One Additional Tank

cc:
Susan Fulmer, SCDHEC
Heather Cathcart, SCDHEC
Crystal Rippy, SCDHEC
Barry Mullinax, SCDHEC
Ken Taylor, SCDHEC
Van Keisler, SCDHEC

SRR-CWDA-2019-00089
Revision 0

Evaluation of the Technical Feasibility and Economic Efficiency of Savannah River Site Tank Closure Cesium Removal Unit 1 to Process Salt Waste From At Least One Additional Tank

September 25, 2019

Prepared by: Savannah River Remediation LLC
Aiken, SC 29808

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

APPROVALS

Prepared by:

Mark T. Keefer
TCCR Project Engineering Manager
Savannah River Remediation LLC

9/25/19
Date

Reviewed by:

Terri L. Fellinger
Flowsheet Development and Facility Integration
Savannah River Remediation LLC

9/25/19
Date

Larry B. Romanowski
Manager, Closure and Disposal Determinations
Savannah River Remediation LLC

9/25/19
Date

Approved by:

for MN Borders
Michael N. Borders
Project Director
Savannah River Remediation LLC

9/25/19
Date

EXECUTIVE SUMMARY

On October 31, 2017, the Department of Energy (DOE) and the South Carolina Department of Health and Environmental Control (SCDHEC) entered into the *Dispute Resolution Agreement for Alleged Violations of Class 3 Industrial Solid Waste Landfill Permit Facility, Facility ID #025500-1603, United States Department of Energy Savannah River Site* ("Agreement"). As part of this Agreement, the DOE agreed to perform certain Supplemental Tank Closure Activities including activities utilizing the "Tank Closure Cesium Removal" (TCCR) ion exchange technology. Paragraph (¶) 18 of the Agreement specifically outlines what the DOE has agreed to perform regarding TCCR Unit 1 and includes a milestone to complete an evaluation of the technical feasibility and economic efficiency of TCCR Unit 1 prior to the end of fiscal year 2019 (¶18.c) to support a decision to further utilize the system to process waste from at least one additional waste tank (¶18.d). The development and issuance of this report satisfies that milestone.

Based on the information available at this time, DOE has determined that it is technically feasible and economically efficient to process salt waste from at least one additional waste tank using TCCR Unit 1.

Tank 9 is a Type I waste tank that currently contains an estimated 550,000 gallons of saltcake waste. Efforts have been initiated to prepare Tank 9 to dissolve this saltcake waste and process the resulting dissolved salt solution through TCCR Unit 1. Dissolved salt solution from Tank 9 will be transferred to Tank 10 where it will be batched and sampled to determine processability through the TCCR ion exchange columns. The existing equipment and transfer lines currently in use for Tank 10 dissolved salt solution processing will continue to be used to feed TCCR Unit 1. Additional ion exchange media, columns and integral shield assemblies will be procured to support processing of Tank 9 dissolved salt solution through TCCR Unit 1.

Operation of TCCR Unit 1 was initiated on January 16, 2019 and two batches of dissolved salt solution from Tank 10 totaling 210,000 gallons have been processed. TCCR Unit 1 performed well: processing rates were sustained at five gallons per minute; pre-filters removed solids and recovered during backwash cleaning operations consistent with the design; and system pressures were within expected ranges. Two ion exchange columns were run in series (i.e., lead-lag configuration) during process operations. Individual components (e.g., valves, instruments) performed as expected. Ion exchange media performance (i.e., cesium loading) was lower than expected in relation to previous simulant and real waste test results conducted by Savannah River National Laboratory (SRNL) and other entities; however, the minimum design decontamination factor (DF) for cesium-137 (Cs-137) removal of 1,000 was achieved. Performance of the TCCR Unit 1 ventilation system, and the Programable Logic Controller and Human Machine Interface systems were acceptable. Overall, the TCCR Unit 1 operation has been demonstrated to be technically feasible for processing salt waste.

Furthermore, continued operation of the TCCR Unit 1 to treat the saltcake waste currently stored in Tank 9 is considered technically feasible specifically with respect to:

- The DF achieved for Cs-137;
- Worker and public safety;

- Compliance with applicable regulations; and
- Ability to result in beneficial (i.e., accelerated) liquid waste disposition.

Economically, crystalline silicotitanate (CST) ion exchange media has a substantially higher cost than regenerative resins or lower performance inorganic media. Although CST media performance during Tank 10 dissolved salt solution processing was lower than expected in relation to previous simulant and real waste test results, based on available information to date it is believed that adequate media performance can be achieved for processing Tank 9 saltcake waste. The costs associated with processing Tank 9 saltcake waste through TCCR Unit 1 are estimated to be commensurate with costs for processing similar waste streams through the Salt Waste Processing Facility.

Several initiatives to improve future TCCR Unit 1 operation to support Tank 9 dissolved salt solution processing are either ongoing or being evaluated and include:

- Procurement of an alternate filter media and increased filtration surface area to improve filtration capabilities;
- Laboratory testing by SRNL to understand current ion exchange media performance issues and enhance future ion exchange media performance;
- Utilization of CST with a smaller particle size to enhance adsorption;
- Adjustment to ion exchange column diameter to better allow processing of higher Cs-137 concentrations anticipated in Tank 9 dissolved salt solution;
- Enhancing the ability to more readily retrieve archived process data to simplify and improve the capability for detailed process evaluations;
- Improvement of the radiation detection capability for the decontaminated salt solution waste stream; and
- Piping modification to permit required column flushes to be returned to Tank 10, reducing the amount of Cs-137 sent to Tank 11 and increasing the overall system DF

In consideration of the experience and information available, it is concluded that it is technically feasible and economically efficient to process Tank 9 saltcake waste through TCCR Unit 1. This evaluation applies only to the processing of saltcake waste from Tank 9 through TCCR Unit 1 and does not apply to the feasibility determination of a second TCCR unit nor does it apply to the processing of additional salt waste beyond Tank 9.

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ACRONYMS

Cs-137	Cesium 137
CST	Crystalline Silicotitanate
DF	Decontamination Factor
DOE	Department of Energy
DSA	Documented Safety Analysis
DSS	Decontaminated Salt Solution
FFA	Federal Facility Agreement
FY	Fiscal Year
gpm	gallons per minute
HEPA	High Efficiency Particulate Air
HMI	Human-Machine Interface
PLC	Programmable Logic Controller
SAC	Specific Administrative Control
SCDHEC	South Carolina Department of Health and Environmental Control
SDF	Saltstone Disposal Facility
SPF	Saltstone Production Facility
SRNL	Savannah River National Laboratory
SSCs	Structures, Systems and Components
STCA	Supplemental Tank Closure Activity
TCCR	Tank Closure Cesium Removal

2. BACKGROUND

In 2015, the Department of Energy (DOE) directed Savannah River Remediation LLC, the Liquid Waste contractor, to pursue a supplemental waste treatment process to remove radioactive cesium-137 (Cs-137) from salt waste. The Tank Closure Cesium Removal (TCCR) system is the outcome of those pursuits and is a modular, at-tank treatment process utilizing ion exchange technology to target the removal of Cs-137. The approach for the initial operations of TCCR Unit 1 has been as a technology demonstration for processing dissolved salt solution from Tank 10 and dispositioning the resultant decontaminated salt solution stream. The loaded ("spent") ion exchange columns associated with this demonstration will be stored at an Interim Safe Storage (ISS) facility at the Savannah River Site until future disposition.

On October 31, 2017, the DOE and the South Carolina Department of Health and Environmental Control (SCDHEC) entered into the *Dispute Resolution Agreement for Alleged Violations of Class 3 Industrial Solid Waste Landfill Permit Facility, Facility ID #025500-1603, United States Department of Energy Savannah River Site* ("Agreement"). [1] As part of this Agreement, DOE agreed to perform certain Supplemental Tank Closure Activities (STCAs) including, among other things, activities utilizing the TCCR technology. Paragraph (¶) 18 of the Agreement specifically outlines what DOE has agreed to perform regarding TCCR Unit 1 and includes a milestone to complete an evaluation of the technical feasibility and economic efficiency of TCCR Unit 1 prior to the end of fiscal year (FY) 2019 (¶18.c) to support a decision to further utilize the system to process waste from at least one additional waste tank (¶18.d). The development and issuance of this report satisfies that milestone.

Operation of TCCR Unit 1 was initiated on January 16, 2019 and two batches of dissolved salt solution from Tank 10 totaling 210,000 gallons have been processed through the unit. The quantity of dissolved salt solution available for processing from Tank 10 has been significantly lower to date than originally planned due to the presence of an unexpected layer of difficult to dissolve saltcake containing burkeite within Tank 10. Water additions followed by several weeks of recirculation have resulted in a few inches of saltcake dissolved per batch. Preparation of a third batch had been initiated and was in progress when the Tank 10 transfer and recirculation pump failed during recirculation of the Tank 10 contents. Further operation of TCCR Unit 1 is suspended while activities are in progress to replace the Tank 10 pump.

Nonetheless, efforts have already been initiated to prepare Tank 9 to dissolve saltcake stored in the tank and process the resultant dissolved salt solution through TCCR Unit 1. The processing of the Tank 9 waste through TCCR Unit 1 would satisfy the commitment for processing the waste from at least one additional waste tank through this unit if "TCCR Unit 1 is found by DOE to be a technically feasible and economically efficient approach given other treatment operations available at SRS," consistent with paragraph 18.d of the Agreement.

Tank 9 has a similar waste history as Tank 10; following removal of sludge waste from both tanks in the 1960's, the tanks served as concentrate receipt tanks for the 242-H Evaporator System, forming over 500,000 gallons of saltcake in each tank. However, unlike Tank 10, Tank 9 has not

undergone any saltcake removal efforts and is currently storing approximately 550,000 gallons of saltcake waste. [2]

The current plan is for Tank 9 dissolved salt solution to be transferred to Tank 10 where it will be batched and sampled for processability. The existing equipment and transfer lines in Tank 10 will be utilized to provide feed to TCCR Unit 1. Note that additional removal of the remaining saltcake from Tank 10 is not necessary to begin processing dissolved salt solution from Tank 9. Additional ion exchange media, columns and integral shield assemblies will be purchased to support this effort. It is projected that Tank 9 will generate up to approximately 2.4 million gallons of dissolved salt solution and will require approximately 16 ion exchange columns to process all of this waste.

The discussions in the following sections of this document evaluate the technical feasibility and economic efficiency of TCCR Unit 1 to process Tank 9 saltcake waste. This evaluation applies only to the processing of saltcake waste from Tank 9 through TCCR Unit 1 and does not apply to the feasibility determination of a second TCCR unit nor does it apply to the processing of additional salt waste beyond Tank 9.

3. TCCR OPERATIONAL EVALUATION

Processing of the first batch ("Batch 1A") through TCCR Unit 1 was initiated on January 16, 2019, and approximately 152,000 gallons were processed. [3] TCCR Unit 1 performed well: processing rates were sustained at five gallons per minute (gpm), pre-filters removed solids and performed backwash cleaning operations consistent with the design, and system pressures were within expected ranges. Two columns ("A" and "B") were ran in series (i.e., lead-lag configuration) during operations. Individual components (e.g., valves, instruments) performed as expected. Several pauses in operation occurred during the batch to review parameters and ensure adequate operation, however, no system-initiated shutdowns occurred during the processing of Batch 1A. After each pause, the process was restarted without issue. Treatment of Batch 1A was completed on February 15, 2019.

The second batch ("Batch 2") consisted of approximately 58,000 gallons of dissolved salt solution and this waste was processed through TCCR Unit 1 from June 21, 2019 through June 29, 2019. [4] Two columns ("B" and "C") were ran in series while processing Batch 2. In an attempt to improve dissolution efficiency over that encountered during the first batch, smaller water additions were utilized resulting in a much smaller volume for Batch 2 when compared to Batch 1A. Processing of Batch 2 was delayed while attempting to flush the lead column back to Tank 10, repairing a leak on a check valve, and flushing the pre-filters with clean water. Again, TCCR Unit 1 performed well while processing Batch 2: processing rates were sustained at five gpm with short duration runs at eight and ten gpm to demonstrate the design throughput range, and system pressures remained within acceptable ranges. The pre-filters removed solids and backwash cleaning operations were performed but became challenging at the end of batch processing. For this reason, activities are in progress to improve filtration capabilities during future operations. Individual components (e.g., valves, instruments) continued to perform as expected. No system-initiated shutdowns occurred during the processing of Batch 2.

TCCR Unit 1 has processed a total of 210,000 gallons representing approximately 700 hours of operation. While this represents a relatively short period of process operation, there have been no observations or indications that the system is inadequate for future operations.

Ion exchange media performance (i.e., cesium loading) was lower than expected in relation to previous simulant and real waste test results conducted by Savannah River National Laboratory (SRNL) and other entities. The media currently utilized is the hydrogen form of crystalline silicotitanate (CST), R9120-B, manufactured by UOP Honeywell. Prior to operation, the media underwent a fines removal step and was caustic washed in-situ to exchange the hydrogen for sodium. Qualification testing for Batches 1A and 2 (representative of column media performance) resulted in measured Cs-137 equilibrium loading lower than the projected loadings based on other chemical constituents present in the dissolved salt solution competing for the same sorption sites on the ion exchange media. Additionally, process modeling indicated slower than anticipated reaction kinetics due to a larger manufactured particle size than previously studied. Activities are in progress to understand current media performance issues and enhance future media performance.

The TCCR Unit 1 ventilation system, programmable logic controller (PLC) and human-machine interface (HMI) performance were acceptable. The ventilation system maintained the process enclosure vacuum and airflow as designed, however the ability of the system to maintain enclosure temperature during cold ambient temperatures was marginal. Operations personnel were able to perform evolutions and monitor system operation as designed. However, the ability to retrieve archived data from the HMI for detailed process evaluation was found to be cumbersome and less than desired. Activities are underway to enhance the ability to more readily retrieve archived process data to simplify and improve the capability for detailed process evaluations. Overall, based on its operability TCCR Unit 1 is technically feasible to continue processing similar dissolved salt solutions.

3.1 Technical Feasibility

In addition to the overall operational attributes, the Agreement specifically requires technical feasibility to address, at a minimum, the following:

- The decontamination factor (DF) achieved for Cs-137;
- Worker and public safety;
- Compliance with applicable regulations; and
- Ability to result in beneficial (accelerated) liquid waste disposition.

Based on the above indicators TCCR Unit 1 was determined to be technically feasible to continue processing similar dissolved salt solutions. These areas are discussed in greater detail below.

3.1.1 Decontamination Factor Achieved for Cs-137

The DF is the measure of the efficiency of a component, process or operation to remove a species of interest (e.g., Cs-137) from a feed stream, source or system. Various methods or devices may be utilized to project, monitor and measure DF across multiple points throughout the process at various times. Several factors associated with the integration of the process within the existing Tank Farm facility, the sequence of various unit evolutions during operation, and the TCCR Unit 1 design itself affect the ability to precisely measure DF. These factors warrant additional discussion.

A projection of overall process operation and associated overall DF was performed utilizing the results of the qualification testing for each batch and the proposed operating parameters utilizing the VERSE-LC process modeling software. This modeling software has been used for many years by SRNL to model ion exchange process performance. The TCCR Unit 1 process equipment dimensions and characteristics, batch operating parameters and actual media loading values were inputs to the software to predict column media performance. The modeling software is capable of projecting instantaneous, as well as total ("bulk average") DF for a given volume of material processed. The results were used to monitor system performance during the processing of each batch.

TCCR Unit 1 is currently located in the H-Tank Farm to process dissolved salt solution fed from Tank 10 and transfer the resultant decontaminated salt solution (DSS) to Tank 11, prior

to subsequent transfer of this DSS to Tank 50 for eventual disposal in the Saltstone Disposal Facility (SDF). Sampling and analysis are performed on the feed stream in Tank 10 on a dissolved salt solution batch-by-batch basis so there is a good understanding of the Cs-137 concentration entering TCCR Unit 1. Similarly, samples are taken from Tank 11 and analyzed to better understand the constituents in the DSS. While sampling results from Tank 10 are representative of the Cs-137 concentration in the TCCR feed stream, comparing those results to Tank 11 Cs-137 concentration does not provide a direct indication of the total Cs-137 DF achieved by TCCR Unit 1.

During system startup operation, the Documented Safety Analysis (DSA) requires that lead column(s) be flushed prior to sending through a lag column in order to purge potentially higher concentrations of Cs-137 due to the desorption from the media at increased temperatures during stagnant periods. To return this flush material to Tank 10, the TCCR Unit 1 piping configuration requires that the flushes backflow through the pre-filters on the way to Tank 10, which has resulted in pluggage of the pre-filters with resin fines; therefore, operations to date have required periodical flushing of a potentially Cs-137-laden stream to Tank 11. Such flushing activities, while required, may have negatively affected the overall process DF. Additionally, Tank 11 contains a relatively small residual sludge heel that is likely leaching a small but unknown quantity of Cs-137 into the decontaminated waste stream processed through TCCR Unit 1. While the overall contents sampled from Tank 11 indicate that significant quantities of Cs-137 were removed by the TCCR process, comparison of the Tank 11 radionuclide concentration to that of the feed stream does not lend itself to an accurate measurement of DF across the process.

TCCR Unit 1 was designed and equipped with Geiger-Mueller radiation detectors located on the feed inlet and DSS transfer lines to measure the relative radiation rates associated with the respective streams. The difference between the two measurements is a good approximation of the instantaneous Cs-137 removal efficiency (i.e., DF) across the process. However, the detection capability of the DSS stream radiation detector is being influenced by: (1) the sensitivity range of the detector for the projected radionuclide concentration (i.e., the very low concentrations of Cs-137 in the stream); and (2) the background radiation in the vicinity of the detector. Because of these factors, the measured radiation value is likely higher than the true radiation value of the DSS stream. Additionally, the location of the detector downstream of the ion exchange column outlet does not have sufficient distance (for the design flowrates) to allow for Cs-137 and barium-137m (Ba-137m) to achieve secular equilibrium and would likely tend to bias the measured value higher resulting in a lower calculated DF value. Efforts are in progress to improve the radiation detection capability for the DSS stream to better quantify the associated ion exchange column's DF. Furthermore, the PLC/HMI system does not have the capability to track a total ("bulk average") DF for the total volume of material processed through the unit. Because of these factors, it is only possible to approximate the system DF with the installed radiation detectors. During processing of each batch, the difference between the feed radiation detector and the DSS detector in real time was consistently indicating a relative DF of approximately 4,000-5,000. This value is higher than the projections provided by the VERSE-LC process modeling software.

Despite the difficulty in obtaining an accurate value, it is estimated, based on the totality of information, that TCCR Unit 1 achieved the minimum design requirement DF of 1,000 (bulk average). Based on Tank 11 sampling and analysis, it was verified that TCCR Unit 1 produced a DSS stream that meets the waste acceptance criteria for disposal at the SDF.

Although the Cs-137 concentration of the Tank 9 saltcake waste is uncertain and is projected to be significantly higher than Tank 10, there is high confidence that a DF of at least 1,000 can be achieved when processing the dissolved salt solution from Tank 9, and that the associated DSS stream will meet the waste acceptance criteria for disposal in the SDF. A piping modification has been identified that will permit required column flushes to be returned to Tank 10, reducing this source of Cs-137 being sent to Tank 11 and further improving the overall system DF.

3.1.2 Worker and Public Safety

The design and operation of TCCR Unit 1 does not adversely affect the safety of the worker or the public. The design of the process is such that operation and monitoring of the system is performed remotely and does not require access inside the enclosure. The ion exchange columns and pre-filters are integrally shielded, reducing exposure to workers during periodic maintenance activities. While the process lines inside the enclosure are not shielded, they are sloped to free drain all liquid out of the enclosure to the feed and receipt tanks upon system shutdown. Flush connections provide the capability of flushing lines and components to remove residual material after draining. The ventilation system ensures any contamination which may have resulted from leaks or spills inside the enclosure is confined to the enclosure, and the airflow is filtered through a high efficiency particulate air (HEPA) filter prior to release to the environment. Prior to startup, the unit underwent stringent testing to ensure that the system and components functioned as designed.

Proposed operations of the system underwent a rigorous safety analysis review prior to startup. A team of subject matter experts representing multiple disciplines performed an in-depth hazards analysis. Development of the DSA to ensure safe TCCR operation involved review of each unit operation, development of accident scenarios, evaluation of potential consequences resulting from those accidents, and the application of controls to mitigate those consequences or eliminate the accident. [5] Structures, systems and components (SSCs) have been identified and evaluated to perform their necessary safety function. Development and implementation of a comprehensive Specific Administrative Control (SAC) program ensures that operation of the process does not result in loading of the ion exchange columns above established safety limits. DOE is pursuing the use of slightly smaller diameter ion exchange columns which would improve heat transfer out of the columns and potentially allow for increased loading of the columns. To ensure established safety limits are maintained, changes made to the column design will be evaluated as part of the DSA revision discussed below.

A revision to the DSA is required prior to processing Tank 9 dissolved salt solution through TCCR Unit 1. Given the similar waste history of the two tanks, the basic safety strategy developed for Tank 10 will apply to Tank 9. In addition, the DSA revision will address the differences in Cs-137 concentration and curie inventory between the two tanks, the increased

inventory of loaded ion exchange columns at ISS and the implementation of operability improvements to the unit. The DSA will be approved and implemented prior to processing the Tank 9 waste through TCCR Unit 1.

3.1.3 Compliance with Applicable Regulations

TCCR Unit 1 was designed and fabricated to applicable industry codes and standards. [6] Installation of the unit in the Tank Farm and associated support systems were designed and fabricated to applicable industry codes and standards and are compliant with the Federal Facility Agreement (FFA). [7] Robust quality assurance and quality control programs compliant with NQA-1 were integral to the design, fabrication and installation of the unit. Operation of the TCCR system is compliant with applicable DOE Orders. Operation of the TCCR system is authorized by SCDHEC under Industrial Wastewater permit 20150-IW. [8] As discussed in Section 3.1.1, TCCR Unit 1 achieved the minimum Cs-137 design requirement DF of 1,000 (bulk average), and therefore was compliant with Condition 2 of Permit 20150-IW.

The transfer line from Tank 9 to Tank 10 will be designed and fabricated to applicable industry codes and standards and compliant with the FFA. Replacement equipment and any modifications to the TCCR Unit 1 needed to process Tank 9 saltcake waste will also be designed and fabricated to applicable industry codes and standards. A revision to Industrial Wastewater Permit 20150-IW is not required, however SCDHEC will be provided appropriate documentation of any changes associated with TCCR Unit 1 and will be notified of readiness to process Tank 9 saltcake waste through the unit.

3.1.4 Ability to Result in Beneficial (Accelerated) Liquid Waste Disposition

Salt waste is the largest fraction of the waste inventory in the Liquid Waste System. The Salt Waste Processing Facility (SWPF) is nearing completion and is planned to process salt waste at an annual rate as high as nine million gallons per year. To achieve this, several waste tanks are needed to stage and qualify the salt waste prior to processing through SWPF. The recent and near-term priority within the Liquid Waste System has been to create the needed tank space to support effective SWPF operation.

TCCR Unit 1 was deployed to treat the saltcake waste from Tank 10. Tank 10 is one of the four original Type I waste tanks constructed and placed into service to receive waste from H-Canyon. The tank was not stress relieved during fabrication and has known leak sites typically at weld seams. The tank construction included only partial secondary containment (i.e., annulus pan) inside the structural concrete vault. Additionally, the entirety of Tank 10 is below the water table which poses a higher risk to the environment should a breach of the secondary containment occur. Tank 9 has the same history and poses the same potential short-term risk to the environment as Tank 10. These two tanks have no planned future use and will be grouted and operationally closed once they have been cleaned.

Early retrieval, treatment and disposition of the saltcake waste in Tank 9 through TCCR Unit 1 will reduce the environmental risk and potentially lead to accelerated closure of the waste tank. Early bulk waste removal from Tank 9 could also enable accelerated closure of Tanks

10 and 11. An advantage of using TCCR Unit 1 to process the bulk of the saltcake waste from Tank 9 is its independence from both SWPF and the Defense Waste Processing Facility operations. Should one of these facilities require a temporary suspension of operations for scheduled or unplanned maintenance activities, TCCR Unit 1 operations may not be impacted. Further, the transfer of the DSS produced by TCCR Unit 1 operations, that is collected and stored in Tank 11, to Tank 50 and ultimately on to the Saltstone Production Facility (SPF) can be scheduled and executed to optimize the management of Tank 50 and the operation of the SPF.

3.2 Economic Efficiency

The CST ion exchange media utilized by TCCR Unit 1 to process Tank 10 saltcake waste is an inorganic ion exchanger which has demonstrated high selectivity and affinity for cesium in highly alkaline (salt waste) streams. CST has a substantially higher cost than regenerative resins or lower performance inorganic media. As discussed previously, CST media performance was marginal in relation to previous simulant and real waste test results. Qualification testing for Batches 1A and 2 (representative of column media performance) resulted in measured Cs-137 equilibrium loading much lower than the projected loadings derived from previous test results. Sample analysis of the digested CST indicated that several cations (calcium, aluminum, iron, etc.) were sorbed to the CST and, potentially, were suppressing the affinity for ion exchange with cesium or blocking (by another mechanism) available sorption sites for cesium.

Additionally, VERSE-LC process modeling software indicated slower than anticipated reaction kinetics due to a larger manufactured particle size than previously studied. Slower kinetics result in ion exchange columns in a lead position having a decreased media bed utilization for a given volume of material processed and given velocity through the bed (flowrate).

As a result of directly coupling the saltcake dissolution tank to the ion exchange process (i.e., Tank 10 serving as the source of dissolved salt solution as well as the batch tank to feed TCCR Unit 1) and the difficulties in dissolving Tank 10 saltcake waste, overall batch volumes were less than optimal. Due to the DSA controls established to prevent overloading a column with Cs-137, a rigorous qualification of the batch is performed prior to processing the salt waste. An increased number of smaller batches increases qualification costs and extends production schedules.

The plan for TCCR Unit 1 processing of Tank 9 saltcake waste is that saltcake dissolution will first occur in Tank 9 and the associated dissolved salt solution will be transferred to Tank 10 for batch preparation and qualification. Tank 10 will serve as a dedicated batching and feed tank and utilize existing equipment to feed TCCR Unit 1.

A projected annual operating cost for SWPF is approximately $94 million at a nine million gallon per year processing rate. Based on that, the estimated cost of processing up to an estimated 2.4 million gallons of Tank 9 dissolved salt solution through SWPF is estimated to be approximately $25 million. The costs associated with processing Tank 9 saltcake waste through TCCR Unit 1 are commensurate with that of SWPF.

Testing is in progress with SRNL to understand current media performance issues and determine if the loading is being driven by the waste stream constituents or by the media product and preparation method. A smaller particle size is under evaluation to improve reaction kinetics in the ion exchange columns. A range of media types with different preparation methods are being tested with Tank 10 waste to evaluate loading characteristics and understand competing cation sorption mechanisms. Based on all the available information in aggregate, it is believed that adequate media performance can be achieved for processing Tank 9 saltcake waste.

4. CONCLUSIONS

Based on the information available at this time, it is concluded that it is technically feasible and economically efficient to process salt waste from at least one additional waste tank using TCCR Unit 1.

TCCR Unit 1 performed well mechanically during treatment operations of the first two batches: processing rates were sustained at five gpm, pre-filters removed solids and performed backwash cleaning operations consistent with the design, and system pressures were within expected ranges. Two columns were run in series (i.e., lead-lag configuration) during each batch. Individual components (e.g., valves, instruments) performed as expected. Ion exchange media performance (i.e., cesium loading) was less than expected in relation to previous simulant and real waste test results conducted by SRNL and other entities, however the process achieved the minimum design DF for Cs-137 removal of 1,000. Performance of the TCCR Unit 1 ventilation system, PLC and HMI were acceptable.

The saltcake waste in Tank 10 has been difficult to dissolve which has resulted in several months to prepare, qualify and process each batch. Preparation of a third batch had been initiated to dissolve Tank 10 saltcake and was in progress when the recirculation feed pump failed during recirculation operation. TCCR Unit 1 has processed 210,000 gallons representing approximately 700 hours of operation. While this may represent a relatively short period of process operation, there have been no observations or indications that the system is not adequate for future operations. TCCR Unit 1 operation is technically feasible to continue processing salt waste. Additional removal of the remaining saltcake waste from Tank 10 is not necessary to make the decision to process salt waste from Tank 9.

Furthermore, continued operation of the TCCR Unit 1 to treat the saltcake waste currently stored in Tank 9 is considered technically feasible with respect to:

- Decontamination factor achieved for Cs-137;
- Worker and public safety;
- Compliance with applicable regulations; and
- Ability to result in beneficial (accelerated) liquid waste disposition.

Economically, CST has a substantially higher cost than regenerative resins or lower performance inorganic media. CST media performance during Tank 10 processing was marginal in relation to previous simulant and real waste test results; however, based on all available information, it is believed that adequate media performance can be achieved processing Tank 9 saltcake waste. The costs associated with processing Tank 9 saltcake waste through TCCR Unit 1 are commensurate with that of SWPF.

Several initiatives to improve TCCR Unit 1 operation to support Tank 9 salt waste treatment are either ongoing or being evaluated and include:

- Procurement of an alternate filter media and increased filtration surface area to improve filtration capabilities;

- Laboratory testing by SRNL to understand current ion exchange media performance issues and enhance future ion exchange media performance;
- Utilization of CST with a smaller particle size to enhance adsorption;
- Adjustment to ion exchange column diameter to better allow processing of higher Cs-137 concentrations anticipated in Tank 9 dissolved salt solution;
- Enhancing the ability to more readily retrieve archived process data to simplify and improve the capability for detailed process evaluations;
- Improvement of the radiation detection capability of the effluent waste stream; and
- Piping modification to permit required column flushes to be returned to Tank 10 and reduce the amount of Cs-137 sent to Tank 11.

Efforts continue to prepare Tank 9 to dissolve saltcake waste stored in the tank and process the waste through TCCR Unit 1. In consideration of the experience and information available, it is concluded that it is technically feasible and economically efficient to process Tank 9 saltcake waste through TCCR Unit 1. This evaluation applies only to the processing of saltcake waste from Tank 9 through TCCR Unit 1 and does not apply to the feasibility determination of a second TCCR unit nor does it apply to the processing of additional salt waste beyond Tank 9.

5. REFERENCES

[1] *Dispute Resolution Agreement for Alleged Violations of Class 3 Industrial Solid Waste Landfill Permit Facility, Facility ID #025500-1603, United States Department of Energy Savannah River Site*, South Carolina Department of Health and Environmental Control, United States Department of Energy, Savannah River Site, Aiken, SC, October 31, 2016.

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