September 28, 2016

To: J. N. McKamy, Manager, US DOE Nuclear Criticality Safety Program (NCSP)

From: David Erickson, Chair, US DOE NCSP Criticality Safety Support Group (CSSG) dge

**Subject: CSSG Tasking 2016-03 Response**

In Tasking 2016-03 the CSSG was directed to provide a review of the status of WTP Contractor responses to Recommendations and OFIs from prior CSSG reviews (Tasking 2008-05 & Tasking 2009-04) as addressed by the current WTP criticality analysis, as well as review the Recommendations and OFIs from the 2013 Independent Review Team as they relate to the Heavy Plutonium Particulate waste stream.

The Tasking 2016-03 CSSG Review Team consisted of the following:

- Robert Wilson (Team Leader)
- David Erickson
- Michaele Brady-Raap
- William (David) Pointer (ORNL, Fluid Dynamics)

The draft report was provided to the entire CSSG for review, and to select Office of River Protection (ORP) personnel for factual accuracy review. The Review Team addressed all comments received as they deemed appropriate.

The Review Team is available to answer any questions, including those by ORP Staff, that may arise in working with the provided report.

The report from the review, which includes a copy of approved Tasking 2016-03, is included as an attachment to this transmittal.

cc: CSSG Members
A. S. Chambers (NA-511)
M. E. Dunn
L. Scott

Attachment: CSSG Tasking 2016-03 Response

# Review of Criticality Safety Issues at the Waste Treatment Plant

## CSSG Tasking 2016-03 Response
## 29 September 2016

**Executive Summary**

The Office of River Protection requested that the Criticality Safety Support Group (CSSG) assess the contractor's recent strategy for assuring Criticality Safety at the Waste Treatment Plant and Immobilization Plant (WTP) being constructed at Hanford. This effort was divided in to two parts 1) evaluation of the criticality safety of the co-precipitated plutonium, and 2) potential treatment of a heavy plutonium particulates (e.g. Pu oxide and Pu metal) in the WTP. Each of these potential criticality conditions are discussed separately.

**Co-precipitated Plutonium**

The plans for processing material from the Hanford Tank Farm containing co-precipitated Plutonium (Pu) were the most mature and the review team considers that an argument can be made that a criticality accident due to this material form is precluded. The CSSG Review Team recommends that the safety argument be further developed using industry standards (ANSI/ANS 8). Many recommendations to accomplish this are in the full report.

The status of resolution for all recommendations and opportunities for improvement (OFIs) from CSSG Taskings 2008-05 and 2009-06 were reviewed. While a number of them can now be considered as closed, the following recommendations and OFIs from CSSG Tasking 2008-05 are still considered as open.

Recommendations:

- *The CSER should identify required samples and location.*
- *Move key information from the CSER to AB documents and delete the CSER as a stand-alone AB document.*

*Opportunities for Improvement:*

- *WTP should use guidance from the ANS 8 standards on nuclear poisons.*
- *Update the validation documentation with currently available benchmark experiments*.
- *Temperature effects on cross-sections and reactivity feedback coefficients should be evaluated and impacts considered for systems considerably different than room temperature.*
- *Basis should be provided for the stated 30% "non-representativeness" and applicability of samples*. (Value revised from 5% to 30%)
- *NCS staff should review technical basis for control schemes at other similar DOE facilities.*

New Recommendations for co-precipitated plutonium based on the current CSSG Review Team review:

- *The WTP Contractor should address the applicability of ANS-8.14 on soluble neutron absorbers. (Revised from OFI, above)*
- *The basis needs to be provided for the stated 30% "non-representativeness" and applicability of the sample to other tanks*. *(Revised from OFI, above)*

- *There needs to be a process defined for tracking "open items" in the Hazards Analysis (HA) and how consistency will be maintained as both the HA and CSER are living documents.*
- *Recommend that the use of sensitivity/uncertainty techniques be used to support the appropriateness of the selected benchmarks, particularly in cases where no additional margin for the Area of Applicability (AoA) is utilized.*
- *The CSSG review team concluded that the validation report reviewed does not meet all the requirements of ANS-8.24 and should be revised.*
- *Recommend that additional effort is applied to ensure the assumptions are properly categorized, managed and controlled as applicable.*
- *Recommend the Criticality Safety Limits be restructured to support understanding of the safety margin and assist with response to potential abnormal events.*
- *Develop a CSER for the co-precipitated material that presents a better defined picture of the safety basis.*

**Heavy Plutonium Particulates**

The plans to process the Pu material not co-precipitated, the Heavy Plutonium Particulates (HPP), were presented to the CSSG Review Team in various technical documents and in a presentation. The CSSG Review Team sees the proposed plan as providing an adequate criticality safety strategy but it may require a complex control scheme and implementation. The CSSG Review Team considers the approach previously recommended by the 2013 Independent Review Team as providing a simpler and more reliable approach for ensuring criticality safety. This strategy was to develop tests to demonstrate that sufficient nuclear poison material would not separate from the HPP to maintain the 'form and distribution' argument in use at the tank farm and for the co-precipitated Pu. This approach would involve working with the Tank Farm contractor to obtain tank material to test. If this is not pursued, alternative strategies are discussed.

Open Recommendations for HPP based on the prior Recommendations from the IRT report.

- *Assure a Pu heel management system is available.*

New (or revised from prior) Recommendations for HPP based on the current CSSG Review Team review:

- *Proceed with the HPP distribution test to provide a technical basis for including some of the distributed nuclear poison in the criticality safety basis.*
- *Consider potential management of HPP criticality safety concerns via addition of caustic boron.*

**Conclusions**

While the most recent version of the documents reviewed are improvements over the previous versions, the CSSG Review Team noted that many of the previously identified recommendations and OFIs have not been addressed. Due to additional issues identified, several of the previous OFIs have now been elevated to recommendations. It appears there are a number of requirements from applicable ANS-8 standards that have not been met.

## CSSG Review

### **1.0** Background

The CSSG has supported the review of the Criticality Safety basis for the Waste Treatment Plant (WTP) being built at Hanford for a number of years. A technical assist visit in 2008 resulted in a number of Recommendations and Opportunities for Improvement (OFIs). During a 2009 CSSG technical review of the Criticality Safety basis of the Hanford Tank Farm operations, the Office of River Protection asked the team to comment on the implication on WTP regarding a recent revelation that some plutonium particles in the tank farms may not remain associated with nuclear poisons. The resultant report contained two additional Recommendations for the WTP contractor. A subsequent assessment of The WTP criticality safety posture by an Independent Review Team (IRT), initiated by Secretary Chu, was issued in 2013 and coincidently had three CSSG members on this team. Subsequently the WTP contractor issued a Plan for Resolution of Criticality Technical Issues in May 2014 (T2 Plan).

### 2.0 Task Statements

The Criticality Safety Support Group (CSSG) was requested by the Office of River Protection (ORP) perform two tasks as outlined in the Attachment to Tasking 2016-03 (see Appendix A). The current CSSG Review Team was tasked with the following actions, to address the two tasks, the results of which are presented in this report.

<u>Task #1 – Evaluate Preliminary WTP Co-Precipitated CSER</u> is split in to the following subtasks.

Task 1.a: Review the Recommendations and Opportunities for Improvements associated with the WTP from the 2008 and 2009 assessments to determine if these have been properly addressed. The focus is to be primarily on the processing of the co-precipitated plutonium that is currently in WTP scope.

Task 1.b: Review and comment on the *Preliminary Co-Precipitated Plutonium Criticality Safety Evaluation for the WTP Project* (24590-WTP-CSER-ENS-08-0001, Rev. 1) and associated technical support documents.

Task 1.a is addressed in Section 3, and Task 1.b is addressed in Section 4.

<u>Task #2 – Review Pretreatment Criticality Safety Evaluation Engineering Study in Support of T2</u> is split into the following subtasks.

Task 2.a: Review the status and progress on the Recommendations and Opportunities for Improvements from the IRT report.

Task 2.b: Review the *Pretreatment Criticality Safety Evaluation Engineering Study in support of T2* (24590-WTP-PTF-ES- 15-002, Rev. 2) and supporting documents and provide recommendations.

Task 2.a is addressed in Section 5, and Task 2.b is addressed in Section 6.

#### 2.1 References

The following is a list of documents reviewed in support of this CSSG Review Team review.

24590-HLW-RPT-NS-15-001, Rev. 0, *Criticality Hazards Assessment for the High Solids Vessels in the High-Level Waste Facility*.

24590-PTF-RPT-NS-15-001, Rev. 0, *Criticality Hazards Assessment Report for the High Solids Vessels in the Pretreatment Facility*.

24590-QL-HC9-WA49-00001-03-00056, PNNL-23468, WTP-RPT-234, Rev. 1, *Chemical Disposition of Plutonium in Hanford Site Tank Wastes*, May 2015.

24590-QL-HC9-WA49-00001-03-00055, PNNL-23717, WTP-RPT-235, Rev. 1, *Effects Influencing Plutonium-Absorber Interactions and Distributions in Routine and Upset Waste Treatment Plant Operations*, May 2015.

24590-WTP-CSER-ENS-08-0001, Rev. 1, *Preliminary Co-Precipitated Plutonium Criticality Safety Evaluation Report for the WTP Project*.

24590-WTP-ES-ENG-14-018, Rev. 0, *Engineering Study of Fluid Dynamics of PHM Mixed Vessels to Support Nuclear Criticality Evaluations*.

24590-WTP-PTF-ES-NS-15-002, Rev. 2, *Pretreatment Criticality Safety Evaluation Engineering Study in Support of T2*.

24590-WTP-RPT-ENG-14-059, Rev. 0, *Process Engineering Study to Support WTP Criticality Safety – WTP Process Analysis*.

24590-WTP-Z0C-W11T-00013, Rev. 2, *Pu Absorber Limits from MCNP Calculations*.

24590-WTP-Z0C-W11T-00018, Rev. 0, *Validation of MCNP5 for Hanford Waste Criticality Safety Calculations*.

24590-WTP-Z1C-W11T-00004, Rev. A, *Heavy Plutonium Particulate Mass Limits in a Vessel and Pipe*.

CCN-159363, *WTP Criticality Hazards Assessment*, October 2007.

CCN-280341, *Contract No. DE-AC27-01RV14136 – Transmittal of Criticality Safet Evaluation Study in Support of T2*, Rev. 2, April 2016.

PNNL-2371-WTP-RPT-235, Rev.0, *Effects Influencing Plutonium Absorber Interactions and Distributions in Routine and Upset Waste Treatment Plant Operations*, March 2015.

## 3.0 Results of CSSG Tasking Reviews (Task 1.a)

This section addresses the review of the contractor responses to the recommendations and identified OFI as provided in previous reviews by the CSSG.

### 3.1 CSSG Tasking 2008-05 Recommendations

1. *Process assumptions relied on should be identified in the control section of the CSER.*

   The process assumptions were not clearly associated with the control section in the revised CSER (24590-WTP-CSER-ENS-08-0001, Rev. 1). It does appear, however, that the assumptions are captured in Appendix A.2 of the referenced document.

   This recommendation is considered to be closed.

2. *The CSER should identify the need for clarity and robustness in the sampling program.*

   The Sampling Program (and the Waste Acceptance Criteria (WAC)) is identified as being important. The details are still lacking, but this is judged by the team as acceptable at this stage in the process design.

   This recommendation is considered to be closed.

3. *The CSER should identify required samples and location.*

The original CSER did not identify any controls after receipt of Tank Farm waste in the WTP. Sample locations were not discussed to ensure the process was proceeding within safe limits. The revised CSER identifies six sample points, most of them after receipt by WTP. However, only the HTF Batch Tank (sampling performed by the Tank Farm contractor) is identified as being required. The other sample locations were not considered further due to questions about the representativeness of the sample obtained.

However, as there are numerous process assumptions being made in the safety basis that may have the ability to negatively impact criticality safety, the CSSG believes that the use of samples from all identified locations should be considered for use to ensure, or support, and validate assumptions. Though there may be reduced confidence in the 'representativeness' of the samples (based on specific criticality safety concerns), the sample information should provide defense-in-depth information for criticality safety purposes to assure that the process is working as expected, and is within safe limits.

The recommendation to identify sample locations in support of criticality safety remains open.

4. *Move key information from the CSER to AB documents and delete the CSER as a stand-alone AB document.*

   This has not been accomplished at this time. It is understood that this will occur as 'final' facility/process specific CSERs are prepared, in contrast to the current universal WTP CSER.

   This recommendation remains open.

5. *Evaluate potential operational constraints due to uncertainties in the BBI data relating to combined uncertainties of fissile/absorber ratios*.

   This is now addressed in CSER Section 4.3.4.

   This recommendation is considered to be closed.

### 3.2 CSSG Tasking 2008-05 Opportunities for Improvements

1. *The HAZOP should be updated with some periodicity and rolled into the CSER.*

   Updated Hazard Assessments for the high level waste facility and the pretreatment facility have been performed and documented. This OFI has been addressed.

   This OFI is considered to be closed.

2. *CSER should address the NCS consequence of a seismic event*.

   Criticality Safety consequences of seismic events are addressed in Section 7.13.8.

   This OFI is considered to be closed.

3. *WTP should use guidance from the ANS 8 standards on nuclear poisons.*

   The reviewers were not able to identify where ANS-8.14 or 8.21 are referenced or addressed. The requirements related to nuclear absorbers from the applicable ANS-8 standards, including ANS-8.1, Section 4.2.4, clearly need to be addressed.

   Based on the definition of Soluble Neutron Absorber found in ANS-8.14 the CSSG considers that ANS-8.14 is applicable to WTP nuclear safety operations and for Standards compliance purposes the requirements of ANS-8.14 should be addressed.

This OFI remains open, and is recategorized as a Recommendation.

4. *Update the validation documentation with currently available benchmark experiments*.

   The latest provided validation report is from 2010 (24590-WTP-Z0C-W11T-00018, Rev. 0, *Validation of MCNP5 for Hanford Waste Criticality Safety Calculations*). While this version does include additional benchmarks from the prior revision, no effort was made by the current CSSG Review Team to discern if this adequately addressed the prior concern. Detailed comments addressing the validation report are presented in Section 4.2 of this report.

   This OFI remains open, and is recategorized as a Recommendation based on information presented in Section 4.2.

5. *Temperature effects on cross-sections and reactivity feedback coefficients should be evaluated and impacts considered for systems considerably different than room temperature.*

   The CSER did not address this recommendation. The WTP Contractor did provide a copy of a report developed for Savanah River Site processes (BNI letter CCN 193539); however no analysis was provided to indicate applicability to WTP processes.

   This OFI remains open.

6. *Basis should be provided for the stated 5% "non-representativeness" of samples*.

   The 5% sample "non-representativeness" has been revised to 30%. The 30% is asserted to be bounding. Though a basis is provided, it also indicates that it is based on data from only one tank (SY-102), and that more sampling is needed to ensure this is applicable to all waste tanks.

   There was no plan provided that more sampling is to be performed following waste feed receipt in the WTP, or how the additional data would be incorporated into controls identified in the CSER. Finally, it was not identified where, or if, the 30% uncertainty has been incorporated into the criticality safety limits. A recommendation on the structure of safety limits is also provided in Section 4.4.

   This OFI remains open, but is recategorized as a Recommendation to address the 30% value and the applicability of the sample to other tanks.

7. *NCS staff should review technical basis for control schemes at other similar DOE facilities.*

   Though evidence was provided that other facilities evaluations were reviewed, all that was concluded is that their control schemes were identified in those evaluations. There was no evidence of use, or consideration, of different control schemes in the CSER.

   This OFI remains open.

8. *Clarify the application of "double contingency" to facilities at which the accident is not considered credible*.

   Double Contingency is no longer the primary safety basis. Now the focus is 'demonstrating' incredibility for all facilities.

   This OFI considered to be closed.

9. *WTP should consider the development of a technical document that addresses the chemical and process issues relied upon on the CSER.*

   Several different chemistry documents have been provided that support resolution of this OFI.

   This OFI is considered closed.

### 3.3 CSSG Tasking 2009-06 Recommendations

1. *The fundamental issue of the possible separation of nuclear poisons from fissile material, raised by results of testing scale models of the WTP Pulse Jet Mixer, needs a resolution. The issue of heel removal from the mixing tank also needs resolution.*

   For the co-precipitated plutonium waste streams, the separations due to PJM operation is appropriately addressed in Section 7.1.7. Heel removal is appropriately addressed in several locations.

   This recommendation is considered closed for the co-precipitated waste. The recommendation remains open for the waste containing heavy plutonium particulate as discussed in Section 6 of this report.

2. *The Pulse Jet Mixer testing also raises issues on the mixing tank sampling uncertainty assumptions in the WTP preliminary CSER. Further data is needed to determine a reasonable sampling uncertainty*.

   Sampling within the WTP is no longer credited for criticality safety purposes. Credited sampling occurs at the Tank Farm. However, as discussed previously (Section 3.1 item 3), additional sampling should be considered to add confidence that the process is operating as expected and conditions remains within safe limits.

   While this recommendation is considered closed, the overall concern related to sampling from CSSG Tasking 2008-005, #3, remains open.

## 4.0 Review of Co-Precipitated Plutonium CSER (Task 1.b)

The review of the preliminary CSER for waste containing co-precipitated plutonium is addressed in this section. Reviews of supplemental documents including the referenced hazards analysis performed to support the CSER and the contractor validation report are included based on their importance to the CSER.

### 4.1 Review of Hazards Analysis - 24590-PTF-RPT-NS-15-001

A cursory review was made of the referenced Hazard Analysis (HA) report for the Pretreatment Facility. The HA is a clear improvement over documents provided in previous CSSG reviews. The approach appears to be systematic and thorough. The diversity of participants in the reviews is good and quite appropriate in a design/build project. The inclusion of waste chemistry experts in addition to process, engineering and nuclear safety staff is a significant benefit, particularly in light of the experience level of the project criticality safety staff.

Section 7 of the CSER does a good job of incorporating the upset conditions identified in the HA into the CSER. The discussion in the CSER and conclusion of the impact on criticality safety is not always consistent between the HA and the CSER. Many items were retained in the HA as “open items” and are indicated as “verified” assumptions in the CSER. This observation prompts the concern about the integration of the HA and the CSER.

A process has not been established for tracking “open items” in the HA and ensuring the maintenance of consistency between the HA and CSER as these documents are further developed.

The following are the few specific ‘issues’ between the HA and CSER identified during the review. (These issues should not be considered as all encompassing, these are just the ones noted during a quick review.)

- Per the HA, 24590-WTP-ICD-MG-01-019, *ICD 19 – Interface Control Document for Waste Feed* (referred to as ICD-19) has limits on Pu/Absorber, and 235U/Total U. These limits are lower than identified in the CSER.
- Node HLP1, Co-precipitated
  It Appears that the ICD-19 limits are credited for CS (and by the CSER), but ICD-19 is not considered a SB document, and relies on the CSER to set the limits. This appears to be circular logic.
- The HA states (in many locations): “The base assumption is that ICD-19 is met with a 90% confidence.” Not sure what this really means. It appears that 10% of the time one, or more, of IDC-19 parameters could be exceeded, but it does not quantify how much it could be exceeded by, and if that is ok or not.
- Some indicate ‘not a concern’ since not ‘part of authorization basis’ – that does not appear to be a valid basis.
- (Question B11) Inaccurate sample (not representative) not a problem due to 95% confidence process control point? But ICD-19 only 90% met? It is not clear how it all lines up.
- (Question F2) Credit of piping geometry – NO – but all piping is <4”. Why not credit?
- Node HLP1, Heavy Pu
  (Question B11) Over measuring of absorber – not applicable, but need to address 95% sampling?
- Node UFP1, Scenario 1
  (Q A11) Contains a confusing progression in the different columns --- Adverse change in concentration/’bad’ laboratory analysis > (Question needs improvement?) > Concentration measurable? (but not measured?)

The CSSG Review Team concluded that though there is much improvement with regards to the hazards analysis, more effort is required to ensure the final HA and CSER(s) are aligned. Therefore it is recommended that there be a process defined for tracking “open items” in the HA and how consistency will be maintained as both the HA and CSER are living documents.

## 4.2 Review of the 2010 Validation report used in CSER

An updated validation report (no copy or reference provided) was discussed by the WTP Contractor. However, as no newer version was provided to the CSSG Review Team, the following comments are based upon the review of document 24590-WTP-Z0C-W11T-00018 dated July 29, 2010.

- The WTP Contractor should describe the process for selection of the validation benchmarks. It does not appear that consideration was given to the use of sensitivity/uncertainty analysis techniques to support the use of specific benchmarks. It is noted that ANS-8.24 (industry validation standard) Section 8.1.4 specifies:

  *“The validation applicability shall be documented including the justification for any extrapolations or any wide interpolations beyond the bounds of the*

*benchmark applicability. Differences between the validation applicability and the system or process parameters shall be discussed and justified. Limitations of the validation (e.g., gaps in the data, correlated data points, missing or limited data) shall be described."*

- In the process for determining Area of Applicability (AOA) margins it appears that the assumption for absorbers, without any benchmarks, was to credit the cross-section data and assume an AoA margin of zero. The basis for this argument needs to be provided.
- The statistical analysis of the $k_{eff}$ results for the selected Pu benchmarks was shown not to be a normal distribution. The solution appears to be to reject a number of benchmarks. Did rejecting the high Pu cases meet the ANS-8.24 criteria for deleting outliers? After deleting the high Pu cases for the plutonium bias, were those cases used in the determination of any of the AoA (Table 9.1 respective margins)? Are any of the SS clad Pu benchmarks (presumably among those deleted from the calculation of the Pu bias) used in the final analysis for absorbers? Concern is that SS is a "fixed absorber" (ANS-8.21) and WTP waste more a "soluble absorber" (ANS-8.14). Neither of these standards are cited in the CSER or the validation.
- In Section 8.2.1, forty-two MOX experiment models are noted to involve MOX rods with SS cladding. The claim is that "*MOX experiment models featuring SS cladding are characterized predominantly by thermal neutron energy spectra. The neutron cross-sections of the primary constituents of SS, Fe, Cr, Ni, and Mn, have been exercised in the calculations for the MOX experiments and any bias introduced by these absorbers in thermal MOX systems is incorporated in the MOX bias-corrected $k_{eff}$ function*". The presence of these constituents in SS in the MOX critical experiments function as fixed-absorbers whereas in the WTP the neutron absorbers are more akin to soluble/distributed absorbers. It is recommended that the use of sensitivity/uncertainty techniques be used to support the appropriateness of these benchmarks, particularly in cases where no additional margin for the AoA is recommended.
- Table 7.2.1 indicates that a number of LEU benchmarks were deleted. Table 7.3.3 shows selected U-233 cases were deleted. Table 7.5.1 shows cases for LEU-Th were deleted. Table 7.6.2 indicates some MOX benchmarks were also treated as outliers. The only explanation is that the distributions with the smaller set of benchmarks were normally distributed. Was ANS-8.24 guidance used in this process?
- Pu/U+Pu ratios in waste compared to MOX benchmarks (0.2 -0.5, another tight group around 0.96) was done in Table 4.8. CSER calculations used the full range 0-1. There are no benchmark data cited between 0.5 and 0.96. This is a large gap. What is the basis for applicability in this range and is an AoA margin used to compensate for the data gap?
- Three parameters (H/X, AEG and EALF) are utilized for trending. Why were these chosen? AEG and EALF are not independent of one another.
- The validation report seems to promote a minimum MSM of 0.02 but defers to the CSER to make final determination. In the CSER the discussion of validation states a more conservative value of 0.03 is used (as discussed in Section 4.2.2). Section 4.2.2 says use 0.02 for U-235 and 0.03 for Pu and U-233 and references the validation document for the justification? This circular argument needs to be addressed.

The CSSG review team recommends that the use of sensitivity/uncertainty techniques be used to support the appropriateness of the selected benchmarks, particularly in cases where no additional margin for the AoA is utilized.

Based on the items identified above, the CSSG Review Team also concluded that the validation report reviewed does not meet all the requirements of ANS-8.24 and should be revised.

### 4.3 Review of Assumptions

Numerous sections of the CSER address various assumptions that are made in the development of the criticality control strategy for the co-precipitated waste. Appendix A.2 provides the basis for a brief summary discussion of assumptions identified in this CSER and an indication if these assumptions are verified. DOE STD 3007 would expect that these assumptions should be directly identified in the CSER with the discussion of limits and controls (Section 8) rather than in the Appendix. It is recommended that Table A.2.1 should be directly referenced in Section 8 and a final summary of key assumptions related to design features or process assumptions should also be provided in that section.

The current presentation of the 74 specific assumptions in Table A.2.1 is somewhat confusing and in some cases identifies inconsistencies within the CSER itself and/or the referenced HA. In order to clarify the information presented in Table A.2.1 and to promote consistency, it is suggested that a column be added to the table wherein key design features/process assumptions that were used to support the "statements/assumptions" can be explicitly identified. Items that are listed here as "verified" assumptions should not be identified in the HAs as "open items". The WTP Contractor should have a program to track and close open items from the HAs as well as any unverified assumptions in the CSER.

Many times there is no specific chapter/section or page cited in the reference column; this is a further OFI. In several cases, the reference is a document outside the control of the WTP Contractor's nuclear safety/criticality safety organization, i.e. the WTP Contract, the WTP/Hanford Tank Farm (HTF) Interface Control Document or the HTF CSER. No description is provided on how these documents are incorporated into the safety basis and how future changes to any of these are reviewed for impacts to criticality safety.

Some specific examples:

- Item 4. Pu dissolution without dissolution of absorbers limited to 13%. This statement infers that up to 13% of Pu can be preferentially dissolved from the absorbers. Under what conditions is this possible and are there other conditions which could result in a higher preferential dissolution? How is this accounted for in the development of the controls? Was this identified in the HA as an open item?
- Item 5. Na molarity seems to be the important parameter; is this based on a process assumption that highest molarity of NaOH is 19M? How does the SSL on the Pu and Na grams per kilogram limit for the liquid phase of the waste (SSL = 3.109 g/kg) from 24590-WTP-Z0C-W11T-00013, Rev 2. ensure compliance with the assumption on molarity? Additionally, the document states that compliance with the SSL is ensured by Contract requirements on Na molarity (DOE 2000, Part 1, Section C. Table TS-7.2, p. C-118). Will all contract changes be reviewed for their impact to criticality safety?
- Item 6. The statement is made that "separable organics do not pose an issue". Is this because the amount of organics is limited in the interface control document (ICD)? If

the ICD changed in the future, how would the impact to criticality safety be evaluated? How sensitive is this limit for criticality safety?

- Items 14/15. Is the oxidation state (Pu(IV)) important to these assumptions, were processes activities that could potentially change the oxidation state reviewed?
- Item 34. What are the “mechanical properties” referred to here? Should these be identified as “design features” important for criticality safety?
- Item 35. This statement appears to credit design features of tube wall, one statement says the thickness is sufficient to act as an absorber, another says too thin to be reflector. What is the assumed thickness, and the limiting thickness where these statements might not be true?
- Item 36. There is an assertion that in the evaporator, post acid cleaning and subsequent neutralization, Pu is more likely to precipitate than to plate out on the walls of the evaporator. Given that plating out and leaving buildup on the inside of the evaporator that could lead to higher concentrations of Pu, this appears to be a key assumption. Is the maximum molarity of NaOH important to this assertion, are there other process assumptions that are essential to this argument?
- Item 37. Is there any significance of the melter temperature that is important in this assumption? Have the cross-sections, particularly the absorber cross-sections been evaluated/validated at these temperatures?

Other Questions:

- Item 1. What leads to the assumption of sample non-representativeness of 30% based on data from a single tank as being accepted as bounding? Is representativeness an issue for co-precipitated waste? How is this 30% value incorporated into the proposed controls?
- Item 26. Is heel management important to criticality safety? If so, it would seem that the adoption of the standard high solid vessel design should be an important assumption since this standard vessel design greatly reduces the potential for heel formation and enhances heel management.
- Item 28. There are several occurrences of inconsistent statements within the “statements” column for numbered assumptions. For instance, item 28 includes the statement “selective leaching is limited” as well as “there is no evidence of selective leaching”.
- Item 33. The statement is made that “mechanical action separates Pu metals from absorbers”. Is this true for co-precipitated waste?
- Item 36. Please explain further the relevance of the surface area of OH particles being greater than the surface area of the tank walls and how this affects the possibility of resulting in deposits on evaporator walls.

Based on the above, the CSSG Review Team believes that additional effort is needed to ensure the assumptions are properly categorized, and managed/controlled as applicable.

### 4.4 Review of Criticality Safety Limits

The Criticality Safety Evaluation Report on Co-Precipitated Plutonium, dated February 25, 2016, provides four Criticality Safety limits (three with four CSER significant digits). These are usually called subcritical limits, or sometimes Critical Limits (CL) and just accommodate the calculational uncertainty but no credited safety margin. These do not accommodate the 30% uncertainty of the CSER's estimate of the tank farm's sampling and laboratory measurement used as the implementing process for compliance.

It is common at nuclear sites to provide, along with CLs, Safety Limits (SL), (which would account for other uncertainties such as sampling), Limiting Conditions for Operations (LCO), and then operations would develop operational limits convenient for them. Such a tiered system allows for a more measured response to upset conditions or when a limit is challenged. The one CL in the CSER is applied to the whole sequence of WTP processes. In developing a CSER one can start by defining what the normal conditions for the process are and the associated values of the applicable parameters. Then the conditions resulting from credible abnormal conditions are assessed. These can then be compared to the LCO, or even the SL, to assure an adequate safety margin.

Therefore the CSSG Review Team Recommends the Criticality Safety Limits be restructured to support understanding of the safety margin and assist with response to potential abnormal events.

### 4.5 Conclusions

The DOE/ORP cited four conditions of approval (COA) in their review of the preliminary CSER for processing co-precipitated waste in the WTP (see Appendix A). The CSSG agrees with these conditions for approval but are concerned that the lack of specificity may give the impression that a likewise general response is all that is required. We believe that there is considerable work to be done to address some of these items, particularly COA 1 and COA 2. Most of the items identified during the CSSG review are congruent with these two COAs and provide specificity as to what information needs to be provided to address the ambiguity in the margin of safety and concerns about the implementation of the proposed control set beyond WTP contract limits.

The concerns with the validation document line up closely with the need to articulate more clearly the margins of safety in COA 1. The lack of clarity of the design features and/or process assumptions credited in the analysis of normal and upset conditions as cited in the review of the CSER assumptions are well aligned with the general sense of COA 2.

It is recommended that ANS-8.14 be applied or at a minimum justification provided to exempt the analysis from ANS-8.14.

The use and maintenance of the hazard analysis process is imperative and this is challenged by the frequent criticality safety staff turnovers and the anticipated need for design changes.

There were minor editorial items including the use of undefined acronyms in the appendices.

Based on professional judgement and interpretation of available information, the CSSG Review Team considers that the safety basis for processing the co-precipitated Pu is adequate but the documents do not clearly present all necessary information to support this conclusion.

The CSSG Review Team finds it noteworthy that that the project plan is to produce multiple CSERs by facility/process area as the design matures to reduce the complexity of the CSER and to increase the clarity of the criticality safety defense. It seems prudent for the WTP Contractor to invest the effort in clearly articulating the normal process conditions, upset (credible abnormal) conditions and assumptions important to criticality safety in this early document. The result will be a well-annotated outline that will preserve the basis for safety and enhance the projects' ability to evaluate the impact of future changes on criticality safety.

The CSSG Review Team recommends that the WTP Contractor Develop a CSER for the co-precipitated material that presents a better defined picture of the safety basis.

## 5.0 Response to IRT Recommendations (Task 2.a)

The Independent Review Team focused on the discovery of the Heavy Plutonium Particulates in a number of the tanks and provided essentially five recommendations to BNI which are paraphrased below.

1. *Proceed with the settling test, described in the report, to provide basis for including some of the distributed nuclear poison in the criticality safety basis.*

   Although some settling related testing was referred to in the IRT report, this recommendation has not been fully addressed. As discussed later, the CSSG believes that additional settling testing is warranted.

   This recommendation remains open.

2. *Assure that an adequate sampling capability is available so that the WTP Waste Acceptance Criteria is met before waste is accepted at Pretreatment.*

   Sampling is key to the safety basis. This responsibility is now assigned to the Tank Farm contractor. The concept of a single operational contractor for the Tanks Farm and WTP, as a potential future possibility, should strengthen this assurance of the core measurement, but additional sampling for criticality safety purposes should be considered.

   This recommendation remains open.

3. *Assure a Pu heel management system is available.*

   This remains a work in progress, thus this recommendation remains open.

4. *Provide a comprehensive Chemical Study to understand possible upsets which could affect the safety basis.*

   This was accomplished.

   This recommendation is considered closed.

5. *Provide a comprehensive Hazard Assessment.*

   This was accomplished.

   This recommendation is considered closed.

## 6.0 Dealing with Heavy Plutonium Particulate (HPP) (Task 2.b)

Part 2.b of the tasking was to review and comment on the current plans to handle the HPP identified in Sixteen (16) of the tanks.

### 6.1 Background

In 2010 the criticality safety basis for Hanford tank farm facilities was challenged due to the discovery of Plutonium compounds not associated with nuclear poisons. This discovery showed that the Tank Farm safety argument needed revision. The change in basis would also affect the proposed criticality safety control measures being considered for the Waste Treatment Plant then in design/construction mode. In 2011 a report (RPP-RPT-50941) was issued by the PuO2 Review Team, which provided an estimate of the Pu laden particles in each of the Hanford tanks.

The report also included the Pu metal particles in the mass values. Although some 100 kg of Pu was thought present without being aligned with poisons, just 30 kg was determined to be troublesome due to assumptions on particle size. Since then the presence of other heavy particles has been postulated. The concern is that the HPP are especially heavy and will likely be somewhat separated from the bulk of the particles in the WTP by action of the Pulse Jet Mixers. The extent of the separation was considered difficult to estimate.

The CSSG Review Team considers the criticality safety risk due to the HPP collecting in a single vessel and without being accompanied by nuclear poison materials as very low but agrees that developing a technical basis for assessing and, if necessary, managing the risk is appropriate.

### 6.2 Current Control Proposal

The control philosophy presented to the CSSG team focused on the 16 tanks known to contain the HPP. The Pu content of the HPP in four of these tanks was listed as under 450 g in the report so the WTP contractor considers that these could be processed with no extra controls. The five tanks with listed mass between 450 g and 2700 g will be processed with the addition of sufficient nuclear poison boron (sodium pentaborate) to provide a safety basis feature in addition to a mass control protocol. The 2700 g limit was from a calculated geometry considered to be a worst case configuration due to actions of the Pulse Jet Mixer. The configuration is referred to in safety documents as resembling a fluted horn.

The calculation establishing the 2700 g limit relies on a model of the heavy plutonium particles as individual particles surrounded by poison/moderator. The applicability of the validation (appropriateness of selected benchmarks) and therefore the bias and uncertainty in this case are not yet established. The three tanks with Pu mass considered to exceed 2700 g do not yet have a proposed safety basis processing scheme nor has a specific control scheme to measure the mass of plutonium particulate independent of the co-precipitated plutonium been identified.

A primary assumption of the proposal is that the worst case geometry had been determined. This is discussed next.

### 6.3 Geometry

The consistent application of appropriate criteria in identification of the most limiting geometric configuration of HPP material in the Standard High Solid Vessel (SHSV) with respect to criticality is not sufficiently clear in the documentation of the Hazard Analysis, or the "Pretreatment Criticality Safety Evaluation Engineering Study in Support of T2" (24590-PTF-ES-NS-15-002, Rev 2) or the "Informal Engineering Study of Fluid Dynamics of PJM Mixed Vessels to Support Nuclear Criticality Evaluations" (24590-WTP-ES-ENG-14-018, Rev 0). While additional information provided by analysts in interviews provides greater confidence that appropriate geometric configurations have been considered, the documentation must be updated to clarify the geometries considered in those assessments.

#### 6.3.1 Operating Conditions

Particulate material in the vessel is subjected to a cycle of three distinct states during the operation of the Pulse Jet Mixers (PJM). The PJM is a 3-ft diameter tube (approximate overall volume of 794 gal) with a 4-inch diameter nozzle at the bottom. The PJM is driven by a compressed air charging system. During the suction phase (duration unknown to reviewers) the liquid and fine particulate mixture is drawn into the Pulse Jet Mixer (PJM) by gravity or vacuum. During the drive phase of the PJM (15-20% of the cycle), liquid and fine particulate mixture is pushed out of the PJM toward the floor of the vessel and any settled particulate material is swept across the floor of the vessel and lofted up into the vessel volume. During the vent phase (duration unknown to reviewers), the compressed air in the charge system is vented from the PJM and the system is reset for the next suction phase.

#### 6.3.2 Vent Phase Geometric Configuration

During the vent phase, fluid motion stops due to shear stress and material is free to settle into the bottom of the tank. While particulate may be concentrated at the center of the vessel at the start of the vent phase, the non-Newtonian fluid formed by the particulate mixed with liquid will flow out across the bottom of the vessel, forming a lens geometry in the bottom of the vessel. Analyses assume all material settles, although smaller particulates will remain in suspension. From the documentation, it is not clear that the fully settled lens configuration is the most conservative geometry from a criticality safety perspective, because the fully settled layer will be subject to less moderation than partially lofted material. In the review, analysts clarified that the fully settled lens layer was expanded into an optimally moderated layer for the criticality safety analysis. Documentation should be updated to fully describe the conditions considered in the criticality safety analysis in addition to the fully settled geometry.

#### 6.3.3 Suction Phase Geometric Configuration

During the suction phase, the non-Newtonian fluid-particulate mixture is drawn into the PJM in preparation for the next pulse. It is not clear that criticality in the PJM was considered in the reviewed documentation. In interviews, analysts clarified that optimally-moderated distributions of particulate material in the PJM geometry had been evaluated and criticality in the PJM had been shown to be incredible. Documentation should be updated to clarify the geometry considered in the suction phase case.

#### 6.3.4 Drive Phase Geometric Configurations

During the drive phase, five separate geometries were considered in the analysis. First, the concentration of lofted material in the center of the vessel was considered. The geometry of the PJMs limit the size and shape of the concentrated region. The largest possible sphere of optimally moderated material was evaluated and criticality in the central lofted region was found to be incredible. This evaluation is clearly discussed in the reviewed documentation.

A second drive phase configuration considered that particulate is swept into the knuckle of the vessel where the side wall is joined to the base. While material may collect in this region, it is acknowledged that reduced flows around the periphery of the vessel will result in less lofting of material and less opportunity for moderation. Documentation suggests that a ring or hollow disc configuration may have been considered in criticality safety analysis, but documentation does not adequately describe analysis geometries.

A third drive phase configuration considered that particulate may collect in so-called “batwings” along the “collision lines” between PJMs. Although potential flow theory based analyses may suggest the formation of such collision lines, the formation of a stable stagnation point between two adjacent turbulent jets is very unlikely. Furthermore, the drive phase of the PJMs will remove material from the lens at the bottom of the vessel, leaving only a subset of the material present in the vent phase lens case already considered. This scenario is adequately discussed in 24590-WTP-ES-ENG-14-018, Rev 0.

A fourth drive phase configuration considered the formation of a so-called fluted horn at the center of the vessel bottom. The fluted horn configuration is defined based on potential flow theory and extension of foundational theory of jet impingement flows. While reviewed documentation presents this lofted fluted horn geometry as the conservative limiting case, the conservatism of this configuration is not sufficiently clear. The most critical deficiency is the lack of clear validation of the applicability of the spread rate model for the jet impingement flow field to the curved surface of the lower vessel. In interviews, analysts clarified that criticality safety assessments actually considered an expansion of the fluted horn geometry to an optimally moderated condition which increases the volume of the fluted horn by a factor of approximately five. If this is the case, the substantial expansion of the considered geometry would certainly overwhelm the uncertainty associated with the spread rate. Documentation should be updated to clarify the geometry actually considered in the criticality safety assessment and its relationship to the geometry derived from potential flow theory.

The final drive phase configuration considered the formation of a foam layer at the top of the tank. Reviewed documentation discusses the evaluation of disk geometry capturing all particulate at the top of the tank but does not provide sufficient characterization of the foam or the distribution of particulate within it. In interviews, analysts confirmed that an optimally moderated condition was considered in this disk as well. Documentation should be updated to clarify the specific conditions considered in the foam.

### 6.4 Conclusions Regarding Current Approach

The CSSG Review Team agrees that the current proposed strategy for managing the HPP has a reasonable chance of succeeding. For several tanks, it will require a Pu mass control protocol as the material moves toward the receipt vessels which is anticipated to be a challenging endeavor. In addition, a method to assure adequate mixing of the added nuclear poison will be needed. Issues with the approach presented to the team will be discussed, followed by recommendations for other strategies. However these require further evaluation to determine their feasibility.

In the current HPP study, guidance from ANS-8.14 is not used. As in the co-precipitated CSER, the CSSG Review Team recommends that ANS-8.14 be applied or at a minimum justification provided to exempt the analysis from ANS-8.14. While the poison strategy could rely heavily on process knowledge to demonstrate that there would be no significant losses of poison throughout the PTF, the need for confirmation sampling should be considered. The overall mass control strategy will require confirmation of the mass of plutonium HPP in the HTF tanks and perhaps sampling throughout the PTF. Both of these bring the issue of representative sampling to the forefront. It is not clear that a reliable and practical method of implementing mass control would be possible.

The approach described attempts to use mass as a control. However the conditions that are proposed are based on highly conservative and unrealistic assumptions. Fundamentally, all of the HPP postulated to be in a waste tank at HTF must be transferred out of a million gallon tank and to PTF. The scenario on the PTF side assumes that once the material is received it is possible over multiple transfers to collect the entire mass in a single approximately 20K gallon capacity vessel (SHSV) designed to preclude heel formation over multiple transfers.

The engineering study focuses on the development and defense of the “fluted horn” and does not provide a discussion of the likelihood of the HPP settling out separately from most all other tank constituents, notably separating from the co-precipitated material. Based on discussions during the review it appears more likely that co-precipitated “particles” that are hydraulically equivalent to the HPP would settle with the HPP. Although it is possible that there could be finite regions (limited thickness) of HPP that would settle, the “layers” of HPP and other constituents of the waste would tend to lower the overall system neutron multiplication factor.

### 6.5 Other Control Proposals Considered By Team

The CSSG Review Team finds the most significant shortcoming of the engineering study is the lack of any substantial identification, development and evaluation of alternative control strategies. At this phase of design, multiple control options and methods for their implementation should be identified and evaluated. Alternative strategies include:

1) Demonstrating by testing that hydraulic equivalence will preclude all of the HPP from settling independent of the co-precipitated materials thereby removing the hazard.
2) Consider sending HPP tank wastes directly to the high level waste (HLW) facility where there are no PJMs to loft and create the potential for larger masses to loft/settle in unfavorable geometries.
3) Consider the impact to criticality safety in PTF if caustic boron poisons are added at the Hanford Tank Farm (HTF).
4) Consider making a case under ANS-8.10 to demonstrate that the identified Pretreatment facility criticality hazards are within the shielded part of the facility and an unlikely criticality accident would not result in a significant dose consequence to the co-located worker nor the public.

The Independent Review Team in its 2013 report noted that the assumption of complete separation of the non-co-precipitated Pu from nuclear poison material forms was unlikely but understood the issue of determining the extent of separation. The proposed technical solution was to test the actual degree of separation with a test. A testing protocol was included in the IRT report. The team had perceived that the worst case separation would be in the settling mode in the Pulse Jet Mixer and so suggested a settling test. The WTP Contractor received information that the worst case would more likely be in the lofting phase of mixing and did not pursue the IRT proposal. However, the testing protocol can be modified to include the shear forces of the lofting phase and the team sees advantage of performing both settling and lofting tests to provide a technical basis to include credit for nuclear poison material already available in the tank.

The weight of the particles in a mixing environment is but one of the factors governing separation. Hydraulic Equivalence will have a yet more significant effect and a test will presumably demonstrate this. Crediting even a fraction of the results of such tests would add substantially to the calculated safety margin, and could demonstrate that an inadvertent criticality was not credible.

The various CSERs supporting the Tank Farm form and distribution argument could likely be evaluated to determine the amount of other tank farm material necessary to support the WTP safety basis. That is, a continuation of the historic tank farm material criticality safety basis of form and distribution should be pursued.

The current strategy includes the addition of caustic boron chemicals to some of the tanks. There is some amount of boron which could be added to all of the 16 tanks with non-co-precipitated Pu which could eliminate the need for a mass balance protocol. We note that boron will be added at WTP to make borosilicate glass and should not significantly affect facility operations. The Engineering Study (24590-WTP-PTF-ES-NS-15-002, Rev. 2) notes that 3 g/l of Boron 10 would eliminate any need for other poisons for up to 12 kg of HPP. Some higher amount added to all 16 tanks could eliminate the need to keep track of the HPP mass even with no credit taken for the testing discussed above. An effective means of assuring mixing of the boron will be required. However, as mentioned previously, it may be possible to demonstrate a criticality is not credible and this would not be necessary.

One option that is mentioned in the Engineering Study but not completely described is the direct transfer of waste containing HPP directly to the HLW facility. The HLW facility has no PJMs to loft and create the potential for larger masses to loft/settle in unfavorable geometries. Vessels in the HLW facility use mechanical stirrers to mix the waste in preparation of producing glass logs for final disposal. These mechanical stirrers produce only flat pancake like geometries. Although some drifting/pile-up could occur at the outer radius under some conditions these off-normal geometries would not create concerns for criticality safety. Fundamentally, the simple geometries credible in HLW could make implementing a control strategy with poisons easier to implement using geometry (i.e. the thickness of the pancake(s)) rather than mass controls. An improvement to the engineering study would be to provide additional discussion on this option.

Given the prominence of adding caustic boron as a neutron poison in several of the potential control schemes including that recommended in the engineering study, it seems prudent to evaluate the advantages of adding poisons at HTF prior to receipt of waste at either PTF or HLW. Adding the poisons at the point of waste retrieval could benefit both HTF and WTP. The opportunities for promoting mixing during the transfer itself and the possibility of an intermediate collection vessel between HTF and WTP for testing and certification of the waste properties being in compliance with WTP requirements may significantly increase confidence in the WTP criticality safety strategy.

Another ANSI/ANS standard that could be implemented for WTP operations is ANSI/ANS-8.10, *Criteria for Nuclear Criticality Safety Controls in Operations with Shielding and Confinement*. ANS-8 standards only consider risk to personnel and if the disruption of mission and resulting costs of an accident are deemed acceptable, ANS-8.10 permits an increased risk of a criticality accident. Thus in cases where shielding/distance and confinement prevent excessive exposure to personnel; the analysis of the operation could be singly contingent rather than having to meet double contingency per ANSI/ANS-8.1. This approach may permit less restrictive controls to be implemented for the operation, but may result in a higher likelihood of criticality. The resulting controls may be few in number and/or of reduced complexity, which could be of great benefit to WTP. ANSI/ANS-8.10 has several requirements that must be met before the standard can be applied; WTP would have to perform a crosswalk to show how those requirements are met or, if not, what would have to be done to bring the facility into compliance. If people (worker, co-located worker and public) and the environment are protected by features inherent in the WTP design (shielding and confinement), the question becomes one of operational availability and the impact a criticality accident would have on meeting schedule requirements and glass specifications. Given that WTP is already processing highly radioactive materials, the additional radiation from a criticality accident may or may not be significant and potential damage to equipment must also be taken into consideration. But the main concern may be the generation of fission products such that glass produced by the melters would not be within specifications needed for disposal. In addition, if the product would be out of specification from the fission products, it is not clear how these unwanted elements would be removed from the process stream.

Since use of ANSI/ANS-8.10 is not fully compliant with the double contingency principle, then according to DOE O 420.1b (the version of the Order in the current WTP contract), Attachment 2, Chapter 3, Section 3.b(4), a deviation from the DCP requirement of the Order is required to be documented, justified, and approved by DOE.  Since only a deviation is required, this DOE approval is interpreted by the CSSG Review Team to be made by the local DOE.

The most realistic and implementable controls appear to be the demonstration of hydraulic equivalence and addition of caustic boron at HTF.  Concerns about the degree of heterogeneity in the wastes may make any control strategy relying heavily on measurements to be somewhat controversial.  The addition of caustic boron poisons at the point the waste is transferred from the tank of origin and confirmed prior to receipt at PTF would give the greatest potential to thoroughly mix the poison with the waste and to provide a measurement of concentration for the PTF safety basis.  In order to satisfy the requirements of ANS-8.14, additional testing may be required at key measurement points within the PTF.  This again could introduce the issue of sampling.  Using both approaches may be wise using one as the principle control (likely the addition of caustic boron) and the other (hydraulic equivalence) to be considered supporting a defense-in- depth argument.  The CSSG Review Team recommends both approaches be pursued in tandem.

Based on the above, the CSSG Review Team recommends that the WTP Contractor:

- Proceed with the HPP distribution test to provide a technical basis for including some of the distributed nuclear poison in the criticality safety basis.
- The WTP Contractor considers potential management of HPP criticality safety concerns via addition of caustic boron.

# Appendix A

## Approved Tasking 2016-03

**CSSG TASKING 2016-03**
Date Issued: June 1, 2016

**Task Title:** ***Review of Criticality Safety Issues at the Waste Treatment Plant***

**Background:**

The Criticality Safety Support Group (CSSG) has supported the Criticality Safety basis for the Waste Treatment Plant (WTP) being built at Hanford for a number of years. A Technical assist visit in 2008 resulted in a number of Recommendations and Opportunities for Improvement. During a 2009 CSSG technical review of the Criticality Safety basis of the Hanford Tank Farm operations, the Office of River Protection asked the team to comment on the implication on WTP regarding a recent revelation that some plutonium particles in the tank farms may not remain associated with nuclear poisons. The resultant report contained two additional Recommendations for the WTP contractor. A subsequent assessment of The WTP criticality safety posture by an Independent Review Team, initiated by Secretary Chu, was issued in 2013 and three CSSG members were on this team. Subsequently the WTP contractor issued a Plan for Resolution of Criticality Technical Issues in May 2014 (T2 Plan).

**Task Statement:**

The CSSG is tasked with reviewing the Recommendations and Opportunities for Improvements associated with WTP from the 2008 and 2009 assessments to determine if these have been properly addressed. This is Task 1 and is limited to the co-precipitated plutonium that is currently in WTP scope. Task 2 is to review progress on the T2 plan and subsequent documents dealing with addressing the identified technical issues related to potential heavy plutonium particulate which is outside of the current WTP scope but anticipated to be incorporated in the next couple of years. The CSSG is asked to review the preliminary analysis and provide perspective and guidance as to how to effectively incorporate this material into the WTP design. This heavy plutonium particulate was a significant concern of the Secretary of Energy's S-1 Team and identified in the Independent Review Team (IRT) assessment of WTP criticality safety. The Task 2 review should also address the consistency between the IRT report and the WTP study. A more detailed tasking description as provided by DOE/ORP including specific references is provided as an attachment. Both Tasks will be addressed in a single letter report.

**Resources:**

CSSG Task 2016-03 Team Members: (potential)

Robert Wilson (Team Leader)
David Erickson
Michaele Brady Raap
Fitz Trumble
William Pointer (ORNL, Fluid Dynamics)

Contractor CSSG members of the team will use their NCSP CSSG support funding as appropriate; DOE CSSG members of the team will utilize support from their site offices.

**Task Deliverables:**

1. CSSG Subgroup to hold task 'kickoff' telecom by June 30, 2016.
2. CSSG Subgroup to receive all necessary documentation prior to: June 15, 2016
3. Subgroup will meet at Richland: July 25-28, 2016
4. CSSG Subgroup to provide draft assessment to full CSSG for review: August 18, 2016
5. Full CSSG to provide review comments to Task Team Leader: September 1, 2016
6. CSSG team to issue final report to NCSP Manager: September 15, 2016

**Task Completion Date:** September 30, 2016

**Signed:** Jm McKamy

**Jerry N. McKamy, Manager US DOE NCSP**
**Office of the Chief of Defense Nuclear Safety, NA-511**

## ATTACHMENT

**CSSG Tasking Description for Review of WTP Criticality Safety Documents, 5/18/16**

**Task #1 – Evaluate Preliminary WTP Co-Precipitated CSER:**

Review and comment on the recently submitted Preliminary Co-Precipitated CSER for the WTP Project. Review the Bechtel National, Inc. (BNI) responses to the CSSG report of December 2008 and additional WTP issues from the December 2009 of the ORP Tank Farms Criticality Safety Program. Provide a determination if the CSSG comments are effectively resolved.

Documents for Review:

- 24590-WTP-CSER-ENS-08-0001, Rev. 1, *Preliminary Co-Precipitated Plutonium Criticality Safety Evaluation Report for the WTP Project.*
- 24590-WTP-Z0C-W11T-00013, Rev. 2, *Pu Absorber Limits from MCNP Calculations.*
- 24590-WTP-Z0C-W11T-00018, Rev. 0, *Validation of MCNP5 for Hanford Waste Criticality Safety Calculations.*
- 24590-PTF-RPT-NS-15-001, Rev. 0, *Criticality Hazards Assessment Report for the High Solids Vessels in the Pretreatment Facility.*
- 24590-HLW-RPT-NS-15-001, Rev. 0, *Criticality Hazards Assessment for the High Solids Vessels in the High-Level Waste Facility.*
- 24590-WTP-RPT-ENG-14-059, Rev. 0, *Process Engineering Study to Support WTP Criticality Safety – WTP Process Analysis.*
- 24590-QL-HC9-WA49-00001-03-00056, PNNL-23468, WTP-RPT-234, Rev. 1, *Chemical Disposition of Plutonium in Hanford Site Tank Wastes*, May 2015.
- 24590-QL-HC9-WA49-00001-03-00055, PNNL-23717, WTP-RPT-235, Rev. 1, *Effects Influencing Plutonium-Absorber Interactions and Distributions in Routine and Upset Waste Treatment Plant Operations*, May 2015.

Schedule: It is desired to complete this review by the CSSG with a final letter report provided to ORP (Joe Christensen) by September 30, 2016

**Task #2 – Pretreatment Criticality Safety Evaluation Engineering Study in Support of T2:**

Review and comment on the Criticality Safety Evaluation – Engineering Study (CSE-ES) for Hanford waste containing heavy plutonium particulate (HPP) consisting of plutonium oxide and plutonium metal fines. Provide CSSG perspective on the report recommendations of proposed HPP criticality controls and the supporting basis for the control strategy. The CSSG review is intended to be information only since this form of plutonium is not currently included in the WTP basis of design. CSSG review comments should provide input and consideration as the CSE-ES is more thoroughly evaluated into a future criticality safety evaluation report.

Documents for Review:

- 24590-WTP-PTF-ES-NS-15-002, Rev. 2, *Pretreatment Criticality Safety Evaluation Engineering Study in Support of T2.*
- 24590-WTP-ES-ENG-14-018, Rev. 0, *Engineering Study of Fluid Dynamics of PHM Mixed Vessels to Support Nuclear Criticality Evaluations.*
- 24590-WTP-Z1C-W11T-00004, Rev. A, *Heavy Plutonium Particulate Mass Limits in a Vessel and Pipe.*

Redundant documents from Task #1:

- 24590-PTF-RPT-NS-15-001, Rev. 0, *Criticality Hazards Assessment Report for the High Solids Vessels in the Pretreatment Facility.*
- 24590-HLW-RPT-NS-15-001, Rev. 0, *Criticality Hazards Assessment for the High Solids Vessels in the High-Level Waste Facility.*
- 24590-WTP-RPT-ENG-14-059, Rev. 0, *Process Engineering Study to Support WTP Criticality Safety – WTP Process Analysis.*
- 24590-QL-HC9-WA49-00001-03-00056, PNNL-23468, WTP-RPT-234, Rev. 1, *Chemical Disposition of Plutonium in Hanford Site Tank Wastes*, May 2015.
- 24590-QL-HC9-WA49-00001-03-00055, PNNL-23717, WTP-RPT-235, Rev. 1, *Effects Influencing Plutonium-Absorber Interactions and Distributions in Routine and Upset Waste Treatment Plant Operations*, May 2015.

Schedule: It is desired to complete this review by the CSSG with a final letter report provided to ORP (Joe Christensen) by September 30, 2016