U.S. Department of Energy
Office of River Protection
P.O. Box 450, MSIN H6-60
Richland, Washington 99352

FEB 03 2006

06-WED-009

Mr. J. P. Betts, Project Manager
Bechtel National, Inc.
2435 Stevens Center
Richland, Washington 99352

Dear Mr. Betts:

CONTRACT NO. DE-AC27-01RV14136 – TRANSMITTAL OF WASTE TREATMENT AND IMMOBILIZATION PLANT (WTP) OPERATIONS RESEARCH, TANK UTILIZATION, AND STEADY STATE FLOWSHEET ASSESSMENT DESIGN OVERSIGHT REPORT (D-05-DESIGN-021)

References:

1. BNI letter from J. P. Henschel to R. J. Schepens, ORP, "Hanford Tank Waste Treatment and Immobilization Plant Deliverable 2.5 Operations Assessment and Deliverable 2.6 WTP Tank Utilization Assessment," CCN: 106651, dated August 31, 2005.

2. BNI letter from J. P. Henschel to R. J. Schepens, ORP, "Deliverable 2.7 Hanford Tank Waste Treatment and Immobilization Plant Material Balance and Process Flowsheet Assessment," CCN: 106652, dated November 15, 2005.

References 1 and 2 provided the 2005 WTP Operations Research Assessment, 2005 WTP Tank Utilization Assessment, and 2005 WTP Material Balance and Process Flowsheet Assessment to the U.S. Department of Energy, Office of River Protection (ORP) for review and comment. ORP completed review of these three WTP process model assessments in December 2005 through January 2006. This letter transmits the WTP Operations Research, Tank Utilization, and Steady State Flowsheet Assessment Design Oversight Report which documents conclusions, recommendations, and open items from this review.

The primary objective of this design oversight was to evaluate the process models to demonstrate that the WTP design meets WTP Contract facility performance specifications. This oversight has determined the following:

1. The WTP Process Models have significantly advanced such that they can be used to more accurately predict WTP flowsheet and production performance and be used as diagnostic tools to assess design adequacy;

2. There is one Finding that the WTP Process Models are not being used to support the WTP Process design or to demonstrate waste treatment capacity;

FEB 03 2006

3. The results of the Operations Research Assessment do not support the minimum requirements for WTP facility availability as determined in the Basis of Design;

4. The results of the Tank Utilization Assessment do not demonstrate nameplate capacity for Low Activity Waste (LAW) and High Level Waste (HLW) treatment. The ultrafiltration system appears to be the limiting unit operation for waste treatment;

5. The steady state flowsheet assessment results do not demonstrate the nameplate capacity for LAW and HLW treatment. The steady state flowsheet assessment results revealed precipitation reactions that have not been accounted for in design calculations and the WTP Engineering Baseline Process Performance Software mass balance used for engineering design; and

6. Bechtel National, Inc. (BNI) acknowledged that the full capacity of the WTP is not known. The evidence presented in WTP Process Models indicates that the WTP Contract capacity requirements cannot be met with the current WTP design.

BNI is directed to perform the demonstration of WTP waste treatment capacity as required by the contract, Section C, Clause C.7(b). This demonstration should:

1. Demonstrate WTP treatment capability and confirm the design using the Operations Research, Tank Utilization, and Steady State Flowsheet models;

2. Select process model assumptions such that all models accurately represent the WTP design and can be used together to support conclusions regarding capacity and availability, and demonstrate performance against Contract Facility Specification requirements;

3. Assume waste feeds that cover the spectrum of waste planned for delivery to WTP over the mission of treating all Hanford tank waste;

4. Be performed on a priority basis to minimize potential impacts to ongoing WTP design and construction. The capacity demonstration including identification of potentially required design changes should be completed to support formalization of the project's Estimate at Completion due on May 31, 2006; and

5. Obtain ORP concurrence with key assumptions and methodology.

A Notice of Finding is attached to this letter (Attachment 1) for BNI action. The design oversight report (Attachment 2) identifies 16 Open Items in Section 5 for BNI action.

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BNI shall formally notify ORP of the plan and schedule for closure of the Finding and Open Items within 30 days of receipt of this letter. All Open Items resulting from this oversight shall be entered into the BNI Recommendation and Issues Report Tracking System.

Work to perform process modeling to demonstrate facility performance is within Contract scope. If you have any questions, please contact me, or your staff may call Bill Hamel, Director, WTP Engineering Division, (509) 373-1569.

Sincerely,

John R. Eschenberg, Project Manager
Waste Treatment and Immobilization Plant

WED:RAG

Attachments (2)

cc w/attachs:
J. P. Henschel, BNI
L. Lamm, BNI
S. Piccolo, WGI

Attachment 1
06-WED-009

Notice of Finding

WED:RAG
January 20, 2006

NOTICE OF FINDING

Contract DE-AC27-01RV14136, dated December 11, 2000, between the U.S. Department of Energy (DOE) and Bechtel National Inc. (BNI), defined the Waste Treatment and Immobilization Plant (WTP) facility functional specifications and design analysis requirements.

Section C.7 (b) specifies the WTP facility functional requirements and method to determine the facility availability. Section C.7 (b) states that: *"Waste treatment capacity for each major facility is defined as a product of the facility design capacity (facility nameplate design capacity) multiplied by the overall individual facility availability factor. The Contractor is to establish the facility design capacity through its engineering processes. The Contractor is to establish the facility availability factor from the Operational Research Assessments (emphasis added) as defined in Standard 2 (b) (1) Operational Research Assessments of the Waste Treatment and Immobilization Plant."*

Section C.7 (b) specifies the method to demonstrate the WTP facility waste treatment capacity. Section C.7 (b) states that: *"During the design process the WTP waste treatment capacity shall be demonstrated using process modeling.(emphasis added) The WTP waste treatment capacity will be verified through the plant testing performed during commissioning tests conducted in accordance with Standard 5, Commissioning."*

Standard 2 (b) specifies the use of models to support the design process. Standard 2 (b) states that: *"The Contractor shall develop and use analytical models to support the design of the process and facility system (emphasis added), support pre-operational planning assessments, and provide technical integration with Tank Farm Contractor waste feed staging and product acceptance activities. The Contractor will, at a minimum, use the following models:(emphasis added)*

> *"Operations Research Assessment of the Waste Treatment and Immobilization Plant:.." Standard 2 (b),(1)*
>
> *"Waste Treatment and Immobilization Plant Tank Utilization Assessment.." Standard 2 (b),(2)*
>
> *"Material Balance and Process Flowsheet:.." Standard 2 (b),(3)*

During the conduct of a design oversight on the WTP Operations Research, Tank Utilization, and Steady State Flowsheet Assessments conducted from December 13, 2005, through January 17, 2006, the DOE Office of River Protection (ORP) identified the following Finding:

Contrary to the above Contract requirements, BNI Engineering staff have not used the Process Models (Operations Research Assessment, Tank Utilization Assessment and Mass Balance and Process Flowsheet) to support the design of the WTP or demonstrate WTP waste treatment capacity. This was confirmed by BNI, in meetings with ORP, on December 13, 2005 and January 17, 2006. BNI Engineering staff identified that the Process Models are used for design assessment only and have no role in the design process. BNI Engineering staff also identified that BNI has not completed an assessment to determine the full capability of the WTP and therefore does not know the full design capability of the WTP.

The primary design tools used by BNI in process design are the WEBPPS Mass Balance (Mass and Energy Balance Calculation) and the Process System and Mechanical System Component Calculations.

- The Operations Research Model is used to confirm the average availabilities of the WTP facilities expressed as target values in the Basis of Design.

- The Tank Utilization Assessment (TUA) Model is used to complete tank utilization analysis, predict the results of Tank Farm feed blending scenarios and analyze mission duration/canister and container counts. The TUA model is not used to demonstrate the WTP capacity or support the design of the WTP.

- The Mass Balance and Process Flowsheet (Steady State Model) is used to provide permitting/emissions estimates, and chemistry predictions (thermodynamic equilibrium) for treatment of specific tank waste chemistries. The Steady State Model model is not used to demonstrate the WTP capacity or support the design of the WTP.

BNI shall provide, within 30 days of the date of the cover letter that transmitted this Notice, a reply to the Finding above. The reply shall include: (1) admission or denial of the Finding; (2) the reason for the Finding, if admitted, and if denied, the reasons why; (3) the corrective steps that have been taken and the results achieved: (4) the corrective steps that will be taken to avoid further Findings; and (5) the date when full compliance with the appropriate commitments in your Contract will be achieved. Where good cause is shown, considerations will be given to extending the requested response time.

Attachment 2
06-WED-009

WTP Operations Research, Tank Utilization, and Steady State Flowsheet Assessment Design Oversight Report

D-05-DESIGN-021

January 2006

WED:RAG
January 20, 2006

U.S. Department of Energy, Office of River Protection

WTP Operations Research, Tank Utilization, and Steady State Flowsheet Assessment Design Oversight Report

D-05-DESIGN-021

January 2006

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Director of WTP Engineering Division

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Executive Summary

The Office of River Protection (ORP) Waste Treatment and Immobilization Plant (WTP) Engineering Division (WED) performed a Design Oversight of the Bechtel National, Inc. (BNI) WTP Operations Research (OR), Tank Utilization (TUA), and Steady State Flowsheet Assessments.

The objective of this Design Oversight was to evaluate the WTP OR, TUA, and Steady State Flowsheet Assessments and confirm that the design meets WTP Contract Facility Performance specifications. Specific questions were evaluated with respect to WTP Contract compliance, demonstration of required facility availability and treatment capacity, identification of process flowsheet issues, identification of proposed solutions to process flowsheet issues, and implementation of solutions to process flowsheet issues.

The Oversight Team made the following Finding as a result of this Oversight.

> BNI has not used the Process Models in the design process to support the WTP design or demonstrate WTP waste treatment capacity as required by the WTP Contract Standard 2 (b) and Section C.7 (b) respectively.

The Oversight Team concludes the following based upon this Oversight:

1. BNI has continued the development of the OR, TUA and Steady State Flowsheet models for the WTP such that they can be used to more accurately predict the anticipated WTP flowsheet and production performance and be used as diagnostic tools to assess design adequacy. These models can be used to confirm the WTP design and support equipment design and process flowsheet decisions. These models can also be used as a basis to modify, and confirm, the primary design tools, the WEBPPS Engineering Mass Balance and the Process and Mechanical System Component Calculations to ensure that the WTP design is adequate.

2. BNI has developed the TUA and Steady State Flowsheet process models consistent with the scope of the technical analysis requirements defined in the WTP contract (e.g. vessel capacities, sampling requirements, process control, sludge processing etc.). The Operations Research model has not yet included all BOF systems such as the glass former facility. In addition, the OR Model was not used to the full extent of its programmed analytical capability and did not fully incorporate currently identified design changes resulting from BNI's evaluation of approaches to resolve the UFP design issues.

3. BNI has separately applied the OR, TUA and Steady State Flowsheet models to assess different aspects of the WTP design and project WTP performance. The three process models do not demonstrate or confirm plant design throughput capability. The configuration of the models is not consistent with respect to waste feeds, waste treatment requirements and the operating configuration. The model results were not integrated to provide a complete design confirmation and overall recommendations on WTP performance enhancements and

potential improvements.

4. BNI is effectively using the results of the OR Model in the design process to support decisions on equipment components (e.g. remote valve design features) and alternative operating concepts (e.g. use of the PIH crane) to assess WTP design adequacy.

5. BNI has developed and maintained a formally documented and comprehensive process, for maintaining configuration control of the process models.

6. BNI has not used the result of the TUA and Steady State Flowsheet models to confirm the WTP design as required by the "Design Process Plan and Description", Deliverable 3.1.

7. BNI has a formal and traceable process for resolution of design and process flowsheet issues identified in the process models. This is the Recommendation and Issues Tracking System (RITS) and/or the Project Risk Management Program (24590-WTP-GPP-PT-003). The issues identified in the process model deliverables have not been entered into either issue/risk management program.

8. The results of the OR Assessment overestimate the availability of the WTP facilities. As such, it has been determined by the Oversight Team that the OR Assessment results do not support the WTP Contract waste treatment requirements or target WTP facility availabilities specified in the Basis of Design. Major areas requiring development in the OR assessment are:

   - Use of nameplate design capacities for process and mechanical systems and clarification of inputs.
   - Use of a representative waste feed(s) and waste feed treatment process (e.g. washing, caustic leaching and oxidative leaching of the HLW waste sludge).
   - Completion of the OR Model to incorporate systems that impact overall facility availability (e.g. Glass Former Make-up Facility and facility structures such as shield doors and hatches)
   - Incorporation of human factors into MTTR estimates (e.g. discovery of the failure, inefficiencies in human effectiveness).
   - Incorporation of anticipated process upsets into plant availability.
   - Reporting of the confidence level of the facility availability results.
   - Reporting results such that the capacities of the major facilities are clearly presented.

9. BNI has developed an effective process for reconciliation and incorporation of R&T information into the process models (e.g. OR, TUA, Steady State Flowsheet). However based upon current plans, a two-year backlog for the incorporation of R&T information into the process models exists. This situation places the final design of the WTP at risk due to potential design changes which have not been identified.

10. The TUA Extended Model Run does not support the completion of the WTP processing mission consistent with the "2+2" melter proposal (CCN: 039390, TN-24590-02-00706). This is partially due to the assumptions on HLW glass loading and the design capacity of the

UFP System. The use of these assumptions also prevents an assessment of the treatment capacity of the WTP system. The ORP requested G2 Model Run (ORP Letter, 05-WED-032) should produce additional information that can be used to assess the design capability of the WTP.

The Oversight Team has made the following recommendations based upon the results of this Oversight. Additional Open Items are summarized in Section 5 for BNI action and completion.

1. BNI should use the process models in the WTP design process and use the process models to demonstrate WTP waste treatment capacity as required by the WTP Contract. BNI should provide a plan for completion of these activities.

2. The selection of process model assumptions should be strategically performed such that all models are accurately representing WTP design and can be used together to support conclusions regarding capacity, availability, and demonstrate performance against WTP Contract Facility Specification requirements.

3. The assumed waste feeds to be used in the process models should cover the spectrum of waste planned for delivery to WTP over the mission of treating waste contained in all Hanford tanks. The Hanford tank waste compositions have been bounded in the Contract in Specifications 7 and 8 in Envelopes A, B, C, and D.

4. Process modeling to demonstrate WTP treatment capacity and confirm the design should be performed on a priority basis to minimize potential impacts to ongoing WTP design and construction. Results should be used to facilitate changes to design and/or process flowsheets as necessary to achieve Contract Facility Specification requirements.

5. Obtain ORP concurrence with all key assumptions and methodology used in process modeling that is formally delivered to ORP to demonstrate WTP facility treatment capacity.

TABLE OF CONTENTS

1.0 Introduction

The U.S. Department of Energy, Office of River Protection (ORP) will design, construct, commission, and operate a Waste Treatment and Immobilization Plant (WTP) to treat and immobilize waste contained in 149 single-shell tanks and 28 double-shell tanks (DSTs) at Hanford. These tanks contain approximately 54 Mgal waste with 190 MCi of radioactivity. The WTP will receive waste in batches from the DSTs through transfer pipelines. This waste will be concentrated in an evaporator; strontium and transuranic will be precipitated from select waste streams; solids will be water washed, caustic leached, oxidative leached, and separated from the soluble fraction in an ultrafilter system; and cesium will be removed from the soluble fraction with an ion exchange system. The radionuclide enriched solids and cesium ion exchange eluant will be combined and immobilized in High Level Waste (HLW) glass. The Low-Activity Waste (LAW) supernatant will be further concentrated and immobilized in LAW glass or immobilized in an alternative waste form currently being studied.

The WTP Contract requires Bechtel National, Inc. (BNI) to develop and use analytical design models to support the design of the WTP process and facility system. Specific models specified in the Contract include:

- Operation Research (OR) to assure appropriate reliability, availability, maintainability, and inspectability.
- Tank Utilization (TUA) to: 1) assess utilization of process tank capacity, supporting equipment capability, and operational characteristics; 2) ensure that the tanks are appropriately sized to support process operations, sampling and analysis turnaround times, process control requirements, and waste form qualification needs.
- Material Balance and Process Flowsheet to conduct and document process and flowsheet material balance analyses for the treatment of Contract tank waste envelopes.

The WTP Contract Facility Specification requires the WTP treatment capacity to be demonstrated using process modeling during the design process. BNI's "Design Process Plan and Description" (24590-WTP-PL-ENG-01-004) stated that the design would be confirmed through the Steady State Flowsheet (ACM), Tank Utilization model (G2), and Operations Research model (Witness).

BNI documented their WTP OR, TUA, and Steady State Flowsheet Assessments in the following reports:

- 24590-WTP-RPT-PO-05-009, "2005 WTP Material Balance and Process Flowsheet Assessment," dated November 10, 2005.
- 24590-WTP-RPT-PO-05-008, Rev 0, "2005 WTP Tank Utilization Assessment," dated August 8, 2005.
- 24590-WTP-RPT-PO-05-001, Rev 0, "2005 WTP Operations Research Assessment," dated August 29, 2005.

This Design Oversight Report documents the ORP WTP Engineering Division (WED) evaluation of the BNI WTP OR, TUA, and Steady State Flowsheet Assessments. ORP's Design

Product Oversight Plan for is provided in Appendix E.

The results of this Oversight were reviewed with BNI staff on January 17, 2005.

No new safety issues were identified as a result of this Oversight.

2.0 Evaluation of WTP Operations Research, Tank Utilization, and Steady State Flowsheet Assessments

Sections 2.1 through 2.3 of this report summarize design oversight conclusions for each of the WTP OR, TUA, and Steady State Flowsheet Assessments. Section 2.4 provides an assessment of BNI use of process models in the WTP design process. Section 2.5 provides an assessment of the topics common to all three deliverables. Section 2.6 provides an assessment of the plant capability demonstrated by the process models. Section 2.7 provides recommendations for future WTP model work. Specific observations for each line-of-inquiry are documented in Appendix A, B, and C for the OR, TUA, and Steady State Flowsheet Assessments respectively. Questions posed by the Oversight Team of BNI, as part of this Oversight, are documented in Appendix D along with BNI responses.

2.1 Primary Conclusions from the Operations Research Assessment

The purpose of the OR Model Assessments was to independently determine if the target availabilities for the WTP facilities as specified in the WTP Basis of Design are achieved. These target availabilities for the Pretreatment, LAW Vitrification and HLW Vitrification facilities are 0.80, 0.70 and 0.70 respectively. The OR Model was used to estimate the treatment rate that is expected over a 12 year period. The availability is determined by comparison of the treatment rate projected with no RAM (reliability-availability-maintainability) failures to an estimate with RAM failures applied.

The OR Model is a stochastic calculation that uses statistical distributions for the principle variables used in the calculation; Mean Time Before Failure (MTBF) and Mean Time to Repair (MTTR). The negative exponential distribution is used to specify the range of values for the MTBF. The OR Model sets default values for this distribution. The Erlang Distribution is used for the MTTR. The K value for this distribution is set at 2 resulting in a log normal distribution. The output from the OR model run is a single value representing the treatment rate (e.g. cans of ILAW, cans of IHLW, units of Na and MTG equivalent for IHLW). In discussion with BNI it was indicated that the OR model run did not provide a treatment rate distribution. Thus, it is believed that the values reports are the mean values.

The OR Assessment Report (24590-WTP-RPT-PO-05-001) includes 8 scenarios that are specified with unique objectives. Three of the Scenarios are modeled to assess the availability of the Pretreatment, HLW Vitrifcation and LAW Vitrification facilities respectively. These results can be compared to the Baseline Scenario 4 (e.g. no RAM applied) to provide an indication of the facility availability and are presented below. (*Note: The OR Assessment compared Scenario 5 and Scenario 8 to estimate the Pretreatment availability which is not valid because the valve lifetime extension assumed for Scenario 8 has not been validated.*)

- Pretreatment Facility-Scenario 5, (24590-WTP-MRQ-PO-05-0025). When comparing Scenario 4 and Scenario 5, the LAW Pretreatment availability is estimated to be 90%, and the HLW availability is estimated to be 80%. However the LAW availability is based upon providing feed to the LAW Vitrification facility. Thus, the determination of the ability of the

Pretreatment facility to support 2950 units LAW (or 3400 units LAW) cannot be made. The HLW availability at 80% just meets the Basis of Design (24590-WTP-DB-ENG-01-001, Rev 1C) requirement.

- HLW Vitrification Facility-Scenario 6, 24590-WTP-MRQ-PO-05-0026. When comparing Scenario 4 and Scenario 6, the HLW Vitrification availability is estimated to be 83% which meets the Basis of Design requirement of 70%.

- LAW Vitrifcation Facility-Scenario 7, 24590-WTP-MRQ-PO-05-0027. When comparing Scenario 4 and Scenario 7, the LAW Vitrification availability is estimated to be 72% which meets the Basis of Design requirement of 70%.

Scenario 2 provides the best overall assessment of the WTP plant availability. The model assessment was completed with all WTP Plant and LAB RAM applied and assumes 15% rework of the analytical samples. 10 replication runs were completed based upon these assumptions. The results are summarized in Table 2.1 below and show that the integrated Pretreatment, LAW Vitrification and HLW Vitrification facility analysis results. Based upon this assessment the LAW system (which includes LAW Pretreatment and LAW Vitrification) has an average availability of 0.62 assuming the ILAW container holds 5.6 MTG and 0.69 assuming the ILAW container holds 6 MTG. The HLW system (which includes HLW Pretreatment and HLW Vitrification) has an average availability of 0.69.

Table 2.1 Summary of Production Quantities from Scenario 2, 24590-WTP-MRR-PO-05-009

Replication	ILAW, Total Containers	IHLW, Total Containers	ILAW, containers/day	IHLW, containers/day
1	14394	5851	3.42	1.39
2	13547	5461	3.22	1.30
3	13321	5495	3.16	1.30
4	14472	5875	3.43	1.39
5	13775	5706	3.27	1.35
6	13593	5747	3.23	1.36
7	14051	5736	3.33	1.36
8	14736	6189	3.50	1.47
9	13986	5839	3.32	1.39
10	14444	5880	3.43	1.40
Average	14032	5778	3.33	1.37
Plant Availability at Average Production			0.62 (0.69)	0.69
Average Production			18.6 MTG/d	500 Canisters/year

Notes:
The ILAW container is assumed to contain 5.6 MTG per the BARD resulting in an average availability of 0.62. If the ILAW container contains 6 MTG then the average availability is 0.69.

However, the OR Assessment is not complete in terms of the scope analyzed. Thus the estimates of availability are overstated. Table 2.2 summarizes some of areas of scope (factors) not addressed in the current OR Assessment and provides estimates based upon the Oversight Team judgment of the impact on availability. The factors include:

- The confidence level for reporting the availability of the WTP facilities. The OR Assessment results are presented as a mean value and in terms of statistical confidence represent a 50% confidence level. Meaning that there is a 50% chance the value will be above the value citied and a 50% chance the value will be below the value cited. The 10 results in Table 2.1 are normally distributed, and can be used to estimate the standard deviation and 90% confidence level (e.g. values 2 standard deviations below the mean).

- The availability of the Glass Former Facility is not considered in the OR Assessment. The procurement specification requires an availability of 90%. It is assumed the impact to overall system availability is 5% or 0.95.

- The waste treatment flowsheet in the OR Assessment does not incorporate caustic leaching and/or oxidative leaching into the sludge treatment flowsheet which will impact the through put of the Pretreatment facility due to the longer time to process the HLW. It is assumed the impact to production is 5% or 0.95.

- The MTTR estimates do not provide a time duration for discovery of the failure or needed setup to prepare for the repair (such as emptying a vessel prior to changing a valve). It is assumed the discovery time has a 1% or 0.99 impact on production capacity.

- The OR Assessment does not account for lost capacity due to process upsets, line pluggage or rework. It is assumed the process upsets has a 2% or 0.98 impact on production capacity.

When reviewed in isolation each of these omissions in the OR Assessment appear to have a small impact. However, when considered together, these omissions can have a significant impact on WTP availability. Considering these assumptions, the HLW system availability drops to 0.56 or 408 canisters/year, below the requirement in the WTP Contract and the Basis of Design. The LAW System Availability cannot be completely evaluated because the data reported in the OR Model runs is not complete.

Table 2.2 Potential Impact of LAW and HLW System Availability from Successive Addition of Availability Assumptions (Illustrative Case Only)

Assumptions	Value	LAW System Availability	HLW System Availability
Starting Value from Table A.1	NA	0.62	0.69
Reporting of Confidence Level at 95% based upon total "Plant" only.	2 standard deviations	0.58	0.64
Incorporation of Glass Former Facility Availability	0.95	0.55	0.61
Incorporation of Caustic Leach into Envelope A/D Flowsheet	0.95	0.52	0.58
Discovery Time associated with MTTR Estimates	0.99	0.52	0.57
Incorporations of process upsets and rework into	0.98	0.51	0.56

Table 2.2 Potential Impact of LAW and HLW System Availability from Successive Addition of Availability Assumptions (Illustrative Case Only)

Assumptions	Value	LAW System Availability	HLW System Availability
operations			
Average Production After Adjustments		NA	408 Canisters /year

Examples of other technical areas not included in the OR Assessments are:

- Repair of instrumentation to support process control and Important to Safety instrumentation operations,
- MTTR for combined piping and electrical jumper repair,
- Design changes resulting from vendor supplied equipment, and
- Changes to the design and operational performance of the equipment based upon reconciliation of the R&T data.

Results from the OR Assessments determined that the usage of the Pretreatment (PIH) crane and the lifetime for the hot cell valves were significant factors impacting the availability of the Pretreatment facility. BNI is currently investigating design and operational approaches to improve availability of the Pretreatment facility, these include:

- Assessment of the usage of the PIH crane to determine how best to maximize its usage. This assessment is starting with determination of the percentage time the crane is used for: self maintenance, replacement of critical equipment components, replacement of non critical components, waste/equipment size reduction and transportation of waste in the hot cell.
- In addition, a sensitivity case was completed (Scenario 8, 24590-WTP-MQR-PO-05-015) that modified the assumptions used for the MTBF for the hot cell valves based upon predicted dose rates. The MTBF for valves in low-radiation areas (<500 Rad/hr) was increased from 3.3 to 10 years and the MTBF for valves in high radiation areas (>500 Rad/hr) was extended from 3.3 to 5 years. The shorter life-time estimates are consistent with historical data collected at the Savannah River Site (WSRC-TR-93-262 Rev 1.0). The results of this sensitivity assessment showed an approximate 33% increase (1.37/1.83 IHLW canisters/day) in availability from the baseline results presented in Table 2.1. BNI is testing and evaluating prototypic valves to validate these proposed design life assumptions in a testing program that involves radiation exposure to 10^8 Rad followed by shake testing and valve operations testing. Following the completion of this testing, the baseline values for valve lifetime may be modified. Until testing is completed, validated and the data appropriately evaluated the modified valve lifetime estimated should not be used for design confirmation.

The mean-time-between-failure (MTBF) data for components used in the OR Assessment was obtained from numerous sources, including actual failure rate data for components obtained from review of failure events and sources that estimate failure rates (WSRC-TR-93-262). BNI has augmented the literature information for component MTBF data through structured expert opinion workshops. The component MTBF data provided in WSRC-TR-93-262, Rev. 1 is identified in three categories defined as:

- Category 1- Sources with actual failure data obtained from a detailed review of failure events (to ensure applicability to the failure mode being considered) and a detailed review of component populations and exposure duration's (or demands). Such data include the plant-specific component failure data collected for probabilistic risk assessments (PRAs) or reliability studies. The NUCLARR1 database has 19 Category 1 sources, all from nuclear power plants. For this project, the Savannah River Site (SRS) reactor data were added.

- Category 2- Sources with actual failure data but which have an added uncertainty in the data compared with Category 1 sources. This added uncertainty can result from a less comprehensive search for actual failures, a more approximate method for determining component populations or exposure duration's (or demands), or a less clear breakdown of failures into the failure modes of concern.

- Category 3- Sources that list only failure rate estimates. Six representative sources were used in this project.

For valves used in chemical processing service similar to the WTP, the MTBF data from WSRC-TR-93-262 are provided in Table 2.3. WSRC-TR-93-262, lists only category 3 source data and the recommended MTBF data is actually based on water service valves due to the more extensive data available (see WSRC-TR-93-262, Rev. 1, pages 204 – 211). Therefore, the MTBF duration possibly could be shorter for valves used in the PT facility due to chemical service and radiation exposure.

BNI has assumed in the OR Assessments "In determining the PT facility availability, a valve replacement strategy was applied and based on dose mapping, the MTBF of plug valve and actuator seals was extended to around 5 years for valves in the high radiation areas, and 10 years for valves in the low radiation areas in the hot cells" (24590-WTP-RPT-PO-05-001, page 8). This assumption is not consistent with the reference MTBF data for valves cited in WSRC-TR-93-262 and may bias high the PT facility availability.

> <u>*Open Item 1*</u>*: BNI has assumed the MTBF data for Pretreatment valves that may bias high the Pretreatment facility availability. BNI should review the OR assumed MTBF data for PT facility valves based on available industry data. BNI should apply an appropriate distribution reflective of the uncertainty in the valve MTBF data when conducting OR assessments.*

Table 2.3 Chemical Service Valves Mean Time Between Failure Data (1)

Chemical Process Valve	Mean Failure Rate (1/day)	Mean Failure Rate (year)
Manual Valve fails to open / close	3.00E-04	9.1
Check Valve fails to open / close	5.00E-05	54.8
Motor Operated Valve fails to open /	3.00E-03	0.9

Table 2.3 Chemical Service Valves Mean Time Between Failure Data [1]

Chemical Process Valve	Mean Failure Rate (1/day)	Mean Failure Rate (year)
close		
Air Operated Valve fails to open / close	1.00E-03	2.7
Solenoid Operated Valve fails to open / close	1.00E-03	2.7

[1] WSRC-TR-93-262, revision 1, page 21

The dose rate cut off of 500 Rad/hr for the low and high dose rates combined with the selection of valves for low and high dose rates used in the Scenario 8 MTBF assumptions is not readily traceable to selections made in the Scenario 8 model run. In addition other factors such as valve service duty (e.g. cycles of opening and closing), valve type, fluid type (e.g. low solids versus high solids) and vibration may impact the anticipated valve life. Assuming that the valve lifetime values are to be adjusted compared to the historical data collected at the Savannah River Site (WSRC-TR-93-262 Rev 1), then BNI should provide a comprehensive basis for modification of the MTBF values.

> *Open Item 2: BNI is proposing to modify the MTBF for the Pretreatment valves based upon testing and engineering assessments. BNI should provide a comprehensive and complete basis for the modification of MTBF for Pretreatment hot cell valves based upon dose rate, valve service duty, fluid type and operating environment compared to the historical data collected at the Savannah River Site (WSRC-TR-93-262 Rev 1).*

Based upon the results of the "Baseline Run" (Scenario 2, 24590-WTP-MRR-PO-05-009) the WTP facility complex does not support the availability requirements identified in the Basis of Design. However, it appears BNI is completing the appropriate analysis to identify design and operational changes to support establishment of a fully compliant WTP design. These actions include:

- Completion of the ORP Model and scenario analyses to include significant design and operational features not currently modeled or evaluated.
- Further examination of the PIH crane to determine how it is being used, and identification of potential operational features to improve utilization of the crane.
- Potential modification of the MTBF values for Pretreatment facility hot cell valves.

Because of the significant uncertainties associated with the ability of the WTP facilities to meet the Basis of Design availability requirements (and WTP contract waste treatment requirements), the ORP is requesting informal reviews of interim model runs.

> *Open Item 3: The OR Model requires further development and use to determine if the WTP design supports WTP Contract and Basis of Design requirements. BNI should complete additional analysis using a more completely developed OR Model and appropriate operational scenarios to determine if the WTP design supports the WTP Contract and Basis of Design requirements. These results should be presented to ORP for review as they are completed to ensure that the design solution is adequately progressing.*

The Results from the OR Model scenario runs are presented in Appendix A of each model report. These results are typically presented in a table that identified the replication number, total number of LAW and HLW containers and daily production of LAW and HLW. The results for LAW are only presented in terms of the LAW immobilized in WTP and do not include the entire volume of LAW treated. Thus it is not possible to determine if the total LAW treatment rate requirements are being met. BNI should revise the format of the OR Model output to provide a clear demonstration of the capability of the Pretreatment, LAW and HLW facilities, in terms of the amount of material processed and immobilized.

> *Open Item 4: The OR Model output does not allow an assessment of the capability of the Pretreatment facility. BNI should revise the OR Model output requirements to clearly show the Pretreatment, LAW Vitrification and HLW Vitrification facility production quantities and availabilities. Where applicable the treatment capacities should be expressed in terms used in the WTP Contract and Basis of Design.*

BNI has estimated the availability of each of the major WTP facilities: Pretreatment, LAW Vitrification and HLW Vitrification in the OR Assessments. Target values for the availability for each facility have been established by BNI in the Basis of Design. These facility specific OR Assessments are important to evaluate BNI's facility specific design. However, these assessments do not necessarily support the requirements for the treatment rates as specified in the WTP contract. This is clearly illustrated when comparing the results of Scenario 2, a "Plant" assessment with RAM applied to the individual results for the three major facilities (Scenario 5, 6 and 7). It is only the "Plant" assessments that are relevant in terms of validating that the WTP contract requirements are met. Because of this and the presentation in the OR Assessment it appears that the availability requirements established by BNI in the Basis of Design may not support the WTP Contract waste treatment rates.

> *Open Item 5: The Basis of Design facility specific availabilities may not support the WTP Contract waste treatment requirements for IHLW and ILAW. BNI should update the Basis of Design to ensure that the relationship between the target plant availabilities and the WTP Contract treatment requirements are clearly presented.*

The OR Assessment identifies an equipment list used as a basis for the OR assessments in Appendix B. However a spare parts inventory is not established or recommended. (*"The OR flowsheet reliability data have been used as a basis to establish an equipment list that will be used to develop a spare parts inventory."*) Section 2.10, page 13 of 24590-WTP-RPT-PO-05-001)

> *Open Item 6: A spare parts inventory for the WTP was not established based upon the OR Assessment results. A spare parts inventory should be included in the next formal submission of the OR Assessment Report to ORP.*

The OR Assessment has made no specific recommendations to improve the reliability or throughput of the WTP facilities. The OR Assessment concludes that the PIH crane is heavily utilized and indicates that further assessments are required. In addition the assessment results indicate that the lifetime of the remote valves in the Pretreatment facility will significantly impact the availability of this facility due to the large number of valves. Thus further evaluation of valve lifetime (e.g. MTBF) is planned.

2.2 Primary Conclusions from the Tank Utilization Assessment

The scope of the TUA Model was established to support the requirements of the WTP Contract. This involves a determination of the adequacy of the process vessel/equipment capacity considering: anticipated process operations, process sampling, process control and waste form qualification compliance strategies. The TUA has also been configured to assess the impact of specific tank waste compositions on the process flowsheet to estimate time dependent volumetric throughputs and quantities of ILAW and IHLW. All requirements associated with the technical scope of the TUA Model as defined by the WTP Contact were met. These requirements will need to be reassessed as WTP process flowsheet design matures and is finalized. This assessment does not include use of the model results to confirm the design as discussed below.

BNI has proposed recent equipment capacity design and process flowsheet changes to resolve design capacity issues associated with the Ultrafiltration Process (CCN: 106650). The process flowsheet changes including Al solubility correlation and feed forward of process streams have been incorporated into the TUA Model. However, the proposed design changes, most notably the UFP filter surface area size have not been incorporated into the TUA Model. Thus, a confirmatory run to assess the adequacy of the WTP design has not been completed.

The TUA modeled five cases consisting of:

- AP-101 / AY-102 commissioning feed,
- TPA milestone M-062-00A completion,
- TPA milestone M-062-00A completion with unlimited HLW melter feed storage,
- RPP Mission completion run with alkaline leaching, and
- RPP Mission completion run with alkaline leaching and sequential oxidative leaching.

All TUA cases assume 100% availability of WTP systems and components.

The Oversight Team evaluated the results of each TUA case to determine the waste stream production rates. Table 2.4 summarizes the waste stream production rates for each of the TUA cases. None of the TUA cases demonstrate the capability of the WTP to meet nameplate waste treatment capacities for HLW Vitrification (6 MT/day), LAW Vitrification (30 MT/day) and LAW Pretreatment (3,400 Na waste units per year).

The Tank Farm feed vector provided to BNI used water wash factors from the Tank Waste Information Network System (TWINS) database, which over estimated the solubility of transuranic elements (e.g. ^{241}Am and ^{239}Pu) compared to wash factors measured experimentally. For example, the TWINS database reports a ^{241}Am water wash factor of 0.028 for tank 241-AZ-101. The experimentally determined ^{241}Am water wash factor is 0 for tank 241-AZ-101 (PNWD-3206). The use of the TWINS transuranic water wash factors results in the Tank Utilization model predicting several batches of ILAW will exceed the 100ηCi/gram transuranic concentration limit, as shown in Figure 3-14 of 24590-WPT-RPT-PO-05-008, Rev. 0.

> *<u>Open Item 1 (CH2M Hill Hanford Inc.)</u>: The water wash factors in the TWINS predict higher transuranic element solubility when compared to experimentally measured wash factors. If uncorrected, several ILAW glass batches will be incorrectly predicted to exceed the 100ηCi/gram transuranic concentration limit. The Tank Farm Contractor should implement improvements to the water wash factors for transuranic elements or develop another method to estimate the solubility of transuranic elements in the waste.*

The mission runs (Case 4 and Case 5) for the TUA was completed to support an assessment of the benefits of oxidative leaching in reducing the number of HLW glass canisters produced. Oxidative leaching treatment of the HLW sludge is one strategy to reduce the HLW canister production requirement. These results showed that the IHLW canister production requirements without and with oxidative leaching is ~35,000 and ~23,000 canisters respectively. Based upon average HLW vitrification capacity of 480 canisters/year, this corresponds to 73 to 48 years of production operations. The December 2005 Tank Farm Contractor Development Run estimated canister production at 11,100 canisters corresponding to 23 years of operation.

The primary reasons for the TUA not showing that the HLW production can be completed in 17 years include:

- HLW glass waste loading assumptions, based upon the minimum requirements from the WTP contract, which project lower waste incorporation rates.
- Use of outdated wash and leach factors, primarily for sulfate, which leads to higher concentrations of sulfate in the washed sludge, thereby increasing waste loading.
- Uncompleted ultrafiltration system design improvements which slow the treatment rate of the Pretreatment facility.

Because of the use of these major assumptions, the capability of the WTP facilities to meet ORP's strategic goals cannot be evaluated. It is also possible that the WTP design has other issues which have not been identified. These issues will be evaluated in an ORP requested TUA assessment (05-WED-032) to be completed by BNI.

BNI has not finished development of the design approach for hydrogen mitigation. Therefore, the TUA model does not include elements of the hydrogen mitigation strategy. Conclusions about tank utilization and capacity can not be reached until the additional flush volume and frequencies are assessed in the TUA model.

Assuming the hydrogen mitigation strategy for pipes and ancillary vessels results in increases in flush volumes, the plant wash vessel (PWD-VSL-00044) would be used to collect additional flush volume before processing in the feed evaporator process (FEP) system. BNI has assessed the utilization of the plant wash vessel PWD-VSL-00044 during sequential alkaline and oxidative leaching run conditions for the mission duration (24590-WTP-MRR-PO-05-006, scenario 4.0.8a). The batch volume of waste solution in plant wash vessel PWD-VSL-00044 varies from minimum heel to a maximum of ~65,300-gallons (March 10, 2023), which is ~94% of the maximum batch volume (69,166-gallons) allowable in this vessel. The batch volume of waste solution in plant wash vessel PWD-VSL-00044 is frequently in excess of 80% of the maximum batch volume (Refer to Appendix B, Figure B.1).

The additional flush volumes generated from the hydrogen mitigation strategy must either not result in exceeding the maximum batch volume in PWD-VSL-00044 or more frequent transfers of waste solutions to the FEP system must occur.

> *Open Item 7: The TUA does not consider impacts from hydrogen mitigation control strategies. BNI should assess the impacts on tank utilization from increased flush volumes resulting from implementation of the hydrogen mitigation strategy for pipes and ancillary vessels as part of the establishment of the HPAV mitigation strategy.*

The TUA report does not provide material balances or process volume balances for key waste streams nor was this information located by the Oversight Team in the model run reports accompanying the TUA report. These are necessary to ensure that the results from the TUA are valid.

> *Open Item 8: The TUA does not include key material balance information. BNI should include in future TUA reports material balance information for key streams to demonstrate model closure. Material balance information should include sufficient information to demonstrate model closure for water and key components such as solids, sodium, ^{137}Cs, ^{90}Sr, transuranic elements, ^{129}I, ^{99}Tc, aluminum, chromium, iron, sulfate, and nitrate.*

Table 2.4 Summary of Design Capacities Demonstrated in WTP Tank Utilization Assessment

Case	Purpose	Results	Comments [1]
Case 1: AP-101 and AY-102/C-106 (no leaching)	Demonstrate tank utilization at 3,400 Na units of LAW and 6 MT/day IHLW for commissioning feed	IHLW Glass: 6 MT/day ILAW Glass: 30 MT/day Pretreated LAW: 2400 units of Na/year	**Case does not demonstrate PT facility meets required nameplate capacity of 3,400 units of Na/year.** The two UFP trains were operated independently with LAW/HLW blended feed or LAW only feed. The implications of this UFP operating mode were "… when lag storage was full, the ultrafiltration train discharging solids was idle until sufficient room was available to complete the solids transfer. When lag storage was full, the second ultrafiltration train processed AP-101 (LAW feed) without blending the LAW and HLW feeds. Because one ultrafiltration train was often idle and waiting to discharge solids, the HLW facility limited ultrafiltration and the PT sodium throughput" (24590-WPT-RPT-PO-05-008, page 14). However, the ACM model for the AP-101 / AY-102 feed assumed a different operating mode for the ultrafilter trains, "… where both ultrafilter trains are allowed to concentrate in parallel" (24590-WTP-RPT-PO-05-009, page 21). BNI did not fully assess the tank utilization or waste chemistry implications of operating the ultrafilters trains for the proposed operating scenario.
Case 2: TPA Phase 1 Milestone with HLW melter	Assess performance of the WTP through the end of the TPA Milestone M-062-	Average yearly production for years 1 thru 7 IHLW Glass: 4.8 MT/day	**Case does not demonstrate WTP facilities meet required nameplate capacities.**

Table 2.4 Summary of Design Capacities Demonstrated in WTP Tank Utilization Assessment

Case	Purpose	Results	Comments [1]
at 6 MTG/day	00A (2/28/2018)	ILAW Glass: 22.7 MT/day Pretreated LAW: 2400 units of Na/year	Average yearly production rates are based on data from Table 3.1 and Section 3.2.1 (page 42) of TUA. Assumes 5.58 MTG/ ILAW container and 3.13 MTG/ IHLW canister per BARD pages 3.2-34 and 4.2-29. Year 0 is hot commission and year 8 is terminated in February, therefore data from these years are not included in the average yearly production rates.
Case 3: TPA Phase 1 Milestone with HLW melter feed storage unlimited	Assess performance of the WTP through the end of the TPA Milestone M-062-00A (2/28/2018) assuming unlimited HLW melter feed stored: decouples HLW Pretreatment from HLW Vitrification	Average yearly production for years 1 thru 7 IHLW Glass: 4.9 MT/day ILAW Glass: 26.8 MT/day Pretreated LAW: 2,850 units of Na/year	**Case does not demonstrate WTP facilities meet required nameplate capacities.** Average yearly production rates are based on data from Table 4.1 and Section 4.3 (page 87) of TUA. Assumes 5.58 MTG/ ILAW container and 3.13 MTG/ IHLW canister per BARD pages 3.2-34 and 4.2-29. Year 0 is hot commission and year 8 is terminated in February, therefore data from these years are not included in the average yearly production rates.
Case 4: Mission Run with Alkaline Leaching; No Oxidative Leaching	Evaluate effect of alkaline leaching on the performance of the WTP while processing entire DOE supplied feed vector.	Average yearly production IHLW Glass: ~5.78 MT/day ILAW Glass: ~16.6 MT/day Pretreated LAW: No data provided	**Case does not demonstrate WTP facilities meet required nameplate capacities.** Average yearly production rates are based on data from Sections 5.1 and 5.2 (page 89 and 90) of TUA. ILAW: 16.6 MTD = (12%)(30MTD) + (88%)(14.8MTD) IHLW: 5.78 MTD = (12%)(4.18MTD) + (88%)(6MTD)
Case 5: Mission Run with Sequential Alkaline and	Evaluate effect of sequential alkaline and oxidative leaching on the performance of the WTP	Average yearly production IHLW Glass: ~5.6 MT/day ILAW Glass: ~23.5 MT/day Pretreated LAW: No data	**Case does not demonstrate WTP facilities meet required nameplate capacities.** Average yearly production rates are based on data

Table 2.4 Summary of Design Capacities Demonstrated in WTP Tank Utilization Assessment

Case	Purpose	Results	Comments [1]
Oxidative Leaching	while processing entire DOE supplied feed vector.	provided	from Sections 5.3 and 5.4 (page 99 and 100) of TUA. ILAW: 23.5 MTD = (11%)(30MTD) + (89%)(21.4MTD) IHLW: 5.6 MTD = (11%)(4.18MTD) + (89%)(5.8MTD)

Notes:
1. Caustic leaching only performed if it will reduce the quantity of HLW glass by 10% or more for a waste batch per section 1.4.2 of 24590-WTP-PO-05-008.
2. Sequential oxidative leaching only performed if it will reduce the quantity of HLW glass by 10% or more for a waste batch per section 1.4.4 of 24590-WTP-PO-05-008.

2.3 Primary Conclusions from the Steady State Flowsheet (Mass Balance) Assessment

The Steady State Flowsheet Assessment Model has been more completely developed and can predict anticipated production performance for the WTP. BNI has included the capability to predict precipitation reactions in the Steady State Flowsheet for three waste feed compositions. The model can be used to confirm the WTP design, support equipment design, and support process flowsheet decisions. The model can also be used as a basis to modify and confirm the primary design tools, the WEBPPS Engineering Mass Balance and the Process and Mechanical System Component Calculations to ensure that the WTP design is adequate. Further development of the Steady State Flowsheet to better represent analytes present in waste and assessment of additional waste feed compositions will substantively improve the understanding of WTP operations.

All three feeds analyzed in the Steady State Flowsheet assessment failed to achieve WTP Contract nameplate production capacities. It is not expected that all feeds to WTP can be processed at nameplate capacity; however, the rationale for why a feed cannot be processed at nameplate is important to understand WTP process capability and design adequacy. The rationale for not achieving the nameplate capacity included:

- Mismatches in the balance of LAW and HLW in feed processed.
- Sodium oxalate precipitation in the recycle of ultrafiltration process wash solutions reducing the size of HLW solids batches that could be process through the ultrafiltration system.

Precipitation reactions were identified in the following process locations:

- Sodium oxalate in the wash stream recycles to ultrafiltration.
- Sodium carbonate in the treated LAW solids.
- Solids in feed stream to cesium ion exchange.
- Solids formed in treated LAW from ion exchange.
- Solids formed in evaporator condensate.

These precipitation reactions have potential to reduce WTP facility processing capability, create safety issues that were not foreseen in accident analysis, and foul cesium ion-exchange resin columns. These reactions are currently not factored into the WEBPPS or calculations used to underpin WTP design.

The Tank Farm Contractor is working to include enhancements to the HTWOS model to develop balanced feed vectors and improve WTP operability and throughput. Additionally, Tank Farm Contractor blending studies are underway that should improve operability and throughput.

The WTP Flowsheet Basis, Assumptions, and Requirements (24590-WTP-RPT-PT-02-005) specifies reduced ion exchange processing rates for AZ-101 supernatant. Recent changes to the hydrogen generation rate source term will require AZ-101 solids to be blended. This blending will result in commingling or blending of the AZ-101 supernatant with other waste. BNI should define criteria for blending the AZ-101 supernatant to allow processing at higher rates.

CH2MHILL plans for managing the AZ-101 supernatant should consider these criteria.

> Open Item 9: *The BARD specified reduced ion exchange processing rates while treating AZ-101 and AZ-102 waste supernatants. BNI should incorporate composition based criteria for determination if a batch of tank waste will require a reduced ion exchange processing rate into the TUA and Steady State Mass Balance model.*

The caustic leaching process modeled in the flowsheet was not effective in removing solid aluminum from the HLW solids. Figure 3-1 of the Steady State Flowsheet shows that HLW solids delivered to WTP include 5.20 kg Al per hour. The Figure 3-1 also shows concentrated solids sent to HLW vitrification include 6.03 kg Al per hour. The overall solids pretreatment process is precipitating soluble aluminum into HLW solids resulting in increased production of IHLW. The process does not meet the Contract Specification 12 performance standard for caustic leaching.

The caustic leaching flowsheet included in the Steady State Flowsheet Assessment is not consistent with the flowsheet included in the TUA. Changes were made to the TUA flowsheet that predict and add increased levels of caustic to improve Al solubility. Similar changes, if implemented in the Steady State Flowsheet Assessment may improve caustic leaching performance. Little progress has been made over the past two years by BNI in developing and assessing an effective caustic leaching process with the Steady State Flowsheet. If uncorrected, the BNI flowsheet will result in unacceptable HLW solids pretreatment and unreasonably increase the quantity of HLW glass produced over the mission and extend mission duration.

> Open Item 10: *BNI's Steady State Flowsheet shows that the caustic leaching process is ineffective in removing aluminum from tank waste solids sent to HLW vitrification. If uncorrected the flowsheet will result in unacceptable flowsheet performance. BNI should implement improvements to the process flowsheet to effectively leach aluminum.*

The Steady State Flowsheet model does include prediction of some precipitation reactions, which is an improvement over previous versions of this model. However, the model does not track all solid compounds known to be present in the feeds analyzed. For example, the Tank Farm contractor has conducted mixing tests with tank AP-101 supernate and tank AY-102 solids with supernate (see letter 7S110-RWW-04-029, *241-AP-101 / 241-AY-102 Mixing Study Report*). These tests indicate dawsonite ($NaAlCO_3(OH)_2$) is present in the AY-102 solids and may dissolve when mixed with AP-101 supernate. Additional studies conducted by the Tank Farm Contractor with tank AY-102 solids have resulted in the identification of several solids phases, including dawsonite ($NaAlCO_3(OH)_2$) and cancrinite ($Na_6Ca_{1.5}Al_6Si_6O_{24}(CO_3)_{1.6}$) (see letter 7S110-DLH-03-007, *Caustic Demand Test Results, Tank 241-AY-102 Sludge*). Similar studies with AZ-102 solids have also tentatively identified the presence of dawsonite in this waste as well (see letter CH2M-0205411.1, *Caustic Demand Test Results, Tank 241-AZ-102 Sludge*).

Dawsonite and cancrinite solid phases are not tracked in the Steady State Flowsheet model, as indicated by their absence from Table 3-1 on page 35 and Table A-5 on page A-5 of the *WTP Material Balance and Process Flowsheet Assessment* report. Discussions with BNI personnel on December 14, 2005 confirmed the ACM Steady State Flowsheet model does not include these solid phases.

> <u>Open Item 11</u>: *The absence of mineral phases found in tank waste samples from the ACM Steady State Flowsheet model indicates the BNI assessment <u>may not</u> represent expected solids formation during waste processing in the WTP. It is recommended BNI continue to improve the ACM Steady State Flowsheet model by incorporating available Tank Farm contractor information on solids present in tank wastes.*

BNI has identified potential solutions to precipitation issues listed in Table C-3, Appendix C. BNI is still evaluating the identified precipitation issues to determine appropriate implementation of resolutions. BNI has identified precipitation issues and proposed solutions relating to the FEP and UFP systems, but has not implemented proposed solutions.

Precipitation of 5.8% solids in the LAW treated concentrate vessel (TCP-VSL-00001) was identified in the AP-101/AY-102 Steady State Flowsheet Assessment. BNI stated this result is inconsistent with observations in the Semi-Integrated Pilot Plant (SIPP). BNI stated further work is required to reconcile flowsheet data with SIPP results, assess mixing capability, and assess vessel design criteria including erosion allowances.

The Oversight Team identified the following additional precipitation issues:

- **Sodium oxalate management resolution will increase HLW glass mass** - BNI has proposed the following resolution to the recycle and precipitation of sodium oxalate during the processing of SY-102: "*The run results reported for SY-102 are for the baseline process as described in the BARD. No attempt has been made to optimize the caustic and oxidative leach processes. It is noted in the AZ-101 evaluation that a scoping run was made using the UFP rigorous model to determine the affect of reducing the wash volume after caustic leaching on sodium oxalate dissolution. By reducing the wash volume to less than 1 concentrate volume, essentially all the sodium oxalate could be prevented from dissolving.*"

  The SY-102 glass formulation is already at 88% of the total alkali limit (page 36, Table 3-2) and boric acid (a glass former not planned for use in the WTP) must be added during HLW Vitrification to avoid increasing the glass mass (top of page 33). Reducing the UFP wash volume to prevent sodium oxalate from dissolving will increase the mass of sodium in the UFP concentrated solids and would increase the mass of HLW glass produced from processing SY-102. BNI should assess sending the UFP wash solution forward to the CXP system to avoid sodium oxalate re-precipitation and addition to the UFP concentrated solids.

- **Solids blockage of Cs ion exchange column** - The waste solutions recycled to the ion exchange system (stream CXP09) are predicted to contain solids; 0.115 kg/hr for AZ-101 (page C-8), 0.128 kg/hr for AY-101/AP-101 (page C-20), and 0.14 kg/hr for SY-102 (page C-32). The UFP permeate from processing SY-102 is also predicted to contain 0.0482 kg/hr (18.8-ppm) solids (stream UFP33, page C-32). These solids will accumulate in the lead ion exchange column, cause blockage during LAW solution processing, and interruption of waste treatment processing. BNI should assess sending stream CXP09 forward to the TLP system to avoid solids blockage in the cesium ion exchange column.

- **Solids formation in treated LAW solution from Cs ion exchange column** – The ACM model predicts an increase in the mass flow rate (kg/hr) of solids in the pretreated LAW solution exiting the ion exchange columns (stream CXP08) relative to the CXP feed solution (stream CXP01) for AZ-101 and SY-102 wastes. This may be due to precipitation of solids in the cesium ion exchange column or an artifact of the ACM model architecture (e.g. column regeneration solutions blended with pretreated LAW solution post ion exchange column). Precipitation of solids in the cesium ion exchange columns would lead to blockage and interruption of waste treatment processing. BNI should investigate the cause for solids formation in stream CXP08).

- **Solids in Feed Evaporator condensate -** During processing of SY-102 waste, the ACM model predicts the solids content of stream RLD01 is 366-ppm (0.96 kg solids / hour ÷ 2.62E+03 kg total mass / hour). The main source of these solids is stream FEP12, condensate from the feed evaporator process system, which contains 2.51 kg of solids / hour. Process condensate from the feed evaporator should not contain solids. BNI should investigate the cause for solids formation in steam FEP12.

> *<u>Open Item 12</u>: The Steady State Flowsheet identified precipitation reactions that require further assessment and potentially flowsheet and design changes. BNI should assess sodium oxalate management, solids blockage of Cs ion exchange columns, solids from treated LAW from Cs ion exchange, solids in feed evaporator condensate, and solids in TCP-VSL-00001.*

The Steady State Flowsheet model feeds the leachate from the ultrafiltration process forward to the cesium ion exchange process. Feeding the leachate forward to the cesium ion exchange process could result in the feed composition changing during the loading cycle. Changing the feed composition during the loading cycle of the cesium ion exchange process will result in changing the equilibrium between competing cations (e.g. Na, K and Cs) with the resin and may displace cesium from the resin. The Steady State Flowsheet model does not assess the impacts from changing feed compositions during the ion exchange loading cycle. BNI should consider the use of the TUA model to predict the changes in the ion exchange feed composition during processing and then use a first principles cesium ion exchange model to predict impacts from changing the feed (WSRC-TR-2004-00100 and BNF-003-98-0220).

Table C-2, Appendix C identifies several opportunities to simplify the Pretreatment flowsheet to increase effectiveness and potentially mitigate issues with unwanted solids formation observed in the ACM Steady State Flowsheet model.

> *<u>Open Item 13</u>: The WTP flowsheet as configured may lead to the reduced capability of the Pretreatment facility. BNI should utilize the Steady State Flowsheet model and the TUA dynamic model to assess opportunities to simplify the Pretreatment flowsheet to increase effectiveness.*

2.4 Use of OR, TUA and Steady State Flowsheet Model Results in WTP Design Process

BNI has developed a concept for the Engineering Analysis Tools (OR Model, TUA Model and Stready State Flowsheet) that describes the purpose and role of each in the design process. This concept was presented in discussions between the Oversight Team and BNI, on December 13, 2005. The fundamental tools used in the design process are the WEBPPS (Mass and Energy Balance Calculation) and the Process System and Mechanical System Component Calculations. The BNI defined role for the process models in the design process is as follows:

- The OR Model is used to confirm the average capacities of the WTP facilities as expressed as target values in the Basis of Design,
- The TUA Model is used to complete tank utilization analysis, predict the results of Tank Farm feed blending scenarios and analyze mission duration/canister and container counts,
- The ACM Steady State Model is used to provide permitting/emissions estimates, chemistry predictions (thermodynamic equilibrium) and as a comparison tool to the WEBPPS model runs.

The WTP Contract requires that:

> *"The Contractor shall develop and use analytical models to support the design of the process and facility system (emphasis added), support pre-operational planning assessments, and provide technical integration with Tank Farm Contractor waste feed staging and product acceptance activities. The Contractor will, at a minimum, use the following models:..." Standard 2, (b).*
> *Waste treatment capacity for each major facility is defined as a product of the facility design capacity (facility nameplate design capacity) multiplied by the overall individual facility availability factor. The Contractor is to establish the facility design capacity through its engineering processes. The Contractor is to establish the facility availability factor from the Operational Research Assessments (emphasis added) as defined in Standard 2 (b) (1) Operational Research Assessments of the Waste Treatment and Immobilization Plant. Section C.7 (b)*
>
> *During the design process the WTP waste treatment capacity shall be demonstrated using process modeling.(emphasis added) The WTP waste treatment capacity will be verified through the plant testing performed during commissioning tests conducted in accordance with Standard 5, Commissioning. Section C.7 (b)*

The "Design Process Plan and Description" (24590-WTP-PL-ENG-01-004), requires that:

> *"Process operations confirms the design (emphasis added) through the ACM, the capacity model G2, and the operations research (OR) model Witness, which are reviewed by DOE." Section 3.3, page 14.*

FINDING: Contrary to the above Contract requirements, BNI Engineering staff have not used the Process Models (Operations Research Assessment, Tank Utilization Assessment and Mass Balance and Process Flowsheet) to support the design of the WTP or demonstrate WTP waste treatment capacity. This was confirmed by BNI, in meetings with ORP, on December 13, 2005 and January 17, 2006. BNI Engineering staff identified that the Process Models are used for design assessment only and have no role in the design process. BNI Engineering staff also identified that BNI has not completed an assessment to determine the full capability of the WTP and therefore does not know the full design capability of the WTP.

The primary design tools used by BNI in process design are the WEBPPS Mass Balance (Mass and Energy Balance Calculation) and the Process System and Mechanical System Component Calculations.

The Oversight Team found that:

- The results of the OR Assessment are used to validate the target availabilities established in the Basis of Design. There are some indications that the OR Assessment results are being used to critically assess the design of the WTP and are used in design decisions. Identification and resolution of issues associated with the integrity of the valves in the Pretreatment hot cell is one example on how the OR Assessments are used to assess or confirm the design. However because of the incompleteness of the OR Model and to some extent completion of the design, the OR model cannot be used to confirm the design.
- Early assessments using the TUA Model were completed to assess the adequacy of vessel sizing in the WTP design. These assessments were completed prior to the identification of design and process flowsheet issues identified in the ORP UFP Oversight. BNI has developed specific changes to the WTP design and process flowsheet to modify the design to support the design requirements (CCN: 106650). These issues have not been evaluated in the TUA Model to ensure design adequacy. ORP has provided further guidance for BNI to verify design adequacy (05-WED-032) using the TUA Model. This analysis has not been completed. Thus, the adequacy of the WTP design, and potential design and operational changes, identified by BNI has not been verified.
- The Steady State Flowsheet Model is not being used to validate the WEBPPS Mass Balance of support assessment of the WTP design. The Oversight Team found that there is no "bench mark" analysis which compares the results of the Steady State Flowsheet and WEBPPS Mass Balance using a "design basis" feed vector established by BNI for the WTP design. The WEBPPS has technical limitations and cannot be used to predict process chemistry. The Steady State Flowsheet is based upon chemical predictions. Because there is no benchmark comparison of the WEBPPS and Steady State Flowsheet it cannot be determined if the WEBPPS is a valid and useful design tool.

<u>Open Item 14</u>: BNI has not confirmed or demonstrated the WTP design with the process models as required by the WTP Contract. BNI should establish and implement a plan for the use of the process models to confirm the WTP design is consistent with the requirements of the WTP Contract and Design Process Plan and Description. The confirmation of the design using the process models should be completed prior to finalization of the process design particularity for the Pretreatment facility.

<u>Open Item 15</u>: BNI should complete a "benchmark run" using the WTP design basis feed vector as identified in the Basis of Design using the OR, TUA and Steady State Flowsheet process models to confirm adequacy of the proposed WTP process and equipment design as measured against the Basis of Design and WTP Contract.

During discussions with BNI staff on December 21, 2005 it was indicated that BNI is relying on the Project Risk Assessment program (24590-WTP-GPP-PT-003) to address a limited number of the issues identified from the model assessment results. The risk assessment process requires that *someone on the WTP project* identify these issues and ensure the issues are entered into the risk assessment. The issues are categorized as: BNI risks which could impact the WTP Estimate to Complete, and DOE risks as part of the Technical and Programmatic Risk Assessment (TPRA).

During discussions with BNI staff on January 17, 2006 it was indicated the design and process flowsheet issues identified in the process models would be dispositioned by either the: Recommendation and Issues Tracking System (RITS), Project Risk Management Program or prior to entry into one of these action/issues tracking systems. It was also noted that the issues identified in the process models deliverables have not been entered into either issue management program.

> *Open Item 16: BNI has a process for resolution of design and operational issues identified in the process models. However there is no evidence that this process is being used. BNI should identify the issue resolution tool (e.g. RITS or Project Risk Management Program) used to track the resolution of the design, operational and process chemistry issues identified in the OR, TUA and Steady State Models and periodically present the plans for, and results of, issues resolution in periodic informal meetings with the ORP.*

2.5 Evaluation Topics common to the WTP Process Design Models

Reconciliation of the Models with R&T Data

The 2005 Concept Deliverables Paper (24590-WTP-RPT-PO-04-025) commits to update the OR, TUA and Steady State Flowsheet models to be "in alignment with the scheduled Research and Technology (R&T) data reconciliation efforts and design alignment items as of November 8, 2004".

BNI has a process to reconcile R&T test report results with the WTP process models and associated basis documentation. This process is described in "Desk Instructions, Process Operations: Document and Data Review Tracking" (P&O-2003-DI-PO-001). A Review Tracking Coversheet is prepared for each test report documenting BNI's assessment of results and identifying required changes to models or associated basis documentation. Change requests are prepared when revisions to models or associated basis documentation is required.

Shown in Figure 2.1 is the current status of the data reconciliation effort. Based on discussions with BNI, over 150 reports are issued that have not been reviewed for reconciliation. Completion of the reconciliation process is projected to extend through 2007. BNI also stated this schedule may be extended as a result of FY 2006 project funding levels. The oversight team considers review of R&T test reports to reconcile the process models and design basis documentation as critical to assuring the WTP design has appropriate technical underpinning.

Completion of review and reconciliation of data in test reports is critical to support the project's objective to provide appropriate separation between design and construction to reduce project risk to more reasonable levels. Information learned from R&T reports has the potential to impact facility equipment design, waste routing, process flowsheet design, and operational performance.

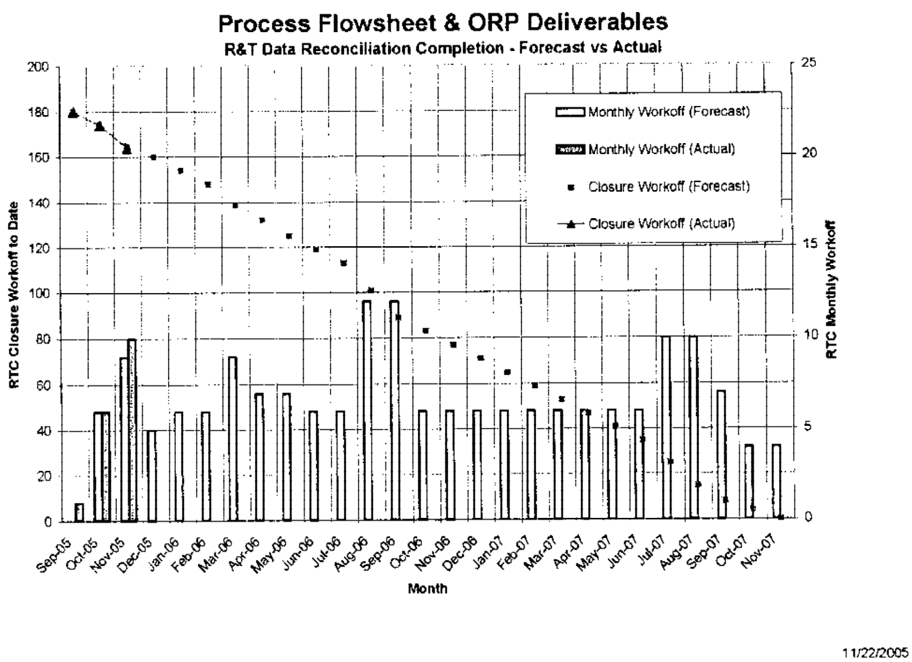


Figure 2.1 Current Status of Reconciliation of the R&T Reports for the WTP Process Models.

<u>Configuration Control of the Models</u>

BNI maintains configuration control of the models according to requirements in their procedure 24590-WTP-GPP-IT-008, Software Life Cycle Management and processes defined in 24590-WTP-GPP-PT-013, Lifecycle Control of Process Models.

The Oversight Team found configuration control of the OR, TUA and Steady State Flowsheet Models acceptable.

2.6 Overall Assessment of Design Capability to Meet Facility Performance Specifications

The results of the OR Assessment, TUA Assessment and Steady State Flowsheet either considered separately, or together do not support a determination that the WTP design will support the waste treatment requirements specified in the WTP Contract and Basis of Design. The overall causes for this are related to the sizing of the process equipment and inadequacies in the process chemistry in the WTP flowsheet. These issues cannot, and would not, have been identified using the design products (calculations and the WEBPPS) used by BNI engineering to develop the design.

The OR Assessment results showed that the WTP design marginally met WTP Contract treatment requirements and the Basis of Design required availabilities. When the OR Assessment results are adjusted to include other missing factors such as Glass Former Facility availability, caustic and oxidative leaching cycles, time to diagnose required repairs, process upsets, and rework, the availabilities are predicted to fall well below the Basis of Design specified requirements.

The TUA Assessment results showed that the WTP nameplate treatment capacity at 100 percent availability was not demonstrated for all cases assessed. BNI has not evaluated the TUA data to fully understand the causes for this condition. Part of this condition may be due to vessel removal from the process flowsheet that occurred during Pretreatment Reconfiguration studies in 2001 and the variable composition of the waste feed vector.

The BNI Steady State Flowsheet Assessment showed that the WTP nameplate treatment capacity at 100 percent availability was not achieved. Additionally, precipitation reactions were predicted, that if real, would substantively reduce the WTP treatment capacity. Reconciliation of these results with other WTP process models, the WEBPPS, and design calculations may reveal required process and design changes required for the WTP to efficiently treat Hanford tank waste represented by WTP Contract waste feed envelopes A, B, C, and D.

In discussion with BNI process engineering on January 17, 2006 it was noted than BNI has not completed an assessment to determine the full capability of the WTP.

2.7 Recommendations for Future WTP Model Work

As required by the WTP Contract, BNI should perform process modeling to demonstrate WTP treatment capacity and confirm the design using the OR, TUA, and Steady State Flowsheet models.

Selection of model assumptions should be strategically performed such that all models represent the WTP design, and are consistent with each other such that the results can be used together to reach conclusions regarding capacity, availability, and demonstrate performance against WTP Contract facility specification requirements.

Assumed feeds should cover the spectrum of waste planned for delivery to WTP over the Hanford tank waste treatment mission. The Hanford tank waste has been bounded in the WTP Contract in Specifications 7 and 8 by the Envelopes A, B, C, and D compositions. A "bench marking" run is needed to ensure that the primary design tools (WEBPPS and design calculations) are valid. ORP concurrence with all key assumptions and methodology should be obtained prior to starting the bench marking runs.

Modeling to demonstrate WTP treatment capacity and confirm the design should be performed on a priority basis to minimize potential impacts to ongoing WTP design and construction. The results should be used to identify changes to the operating mode, design and/or process flowsheets as necessary to achieve WTP Contract Facility Specification requirements.

3.0 Conclusions

The Oversight Team made the following Finding as a result of this Oversight.

> BNI has not used the Process Models in the design process to support the WTP design or demonstrate WTP waste treatment capacity as required by the WTP Contract Standard 2 (b) and Section C.7 (b) respectively.

The Design Oversight team has concluded the following:

1. BNI has continued the development of the OR, TUA and Steady State Flowsheet models for the WTP such that they can be used to more accurately predict the anticipated WTP flowsheet and production performance and be used as diagnostic tools to assess design adequacy. These models can be used to confirm the WTP design and support equipment design and process flowsheet decisions. These models can also be used as a basis to modify, and confirm, the primary design tools, the WEBPPS Engineering Mass Balance and the Process and Mechanical System Component Calculations to ensure that the WTP design is adequate.

2. BNI has developed the TUA and Steady State Flowsheet process models consistent with the scope of the technical analysis requirements defined in the WTP contract (e.g. vessel capacities, sampling requirements, process control, sludge processing etc.). The Operations Research model has not yet included all BOF systems such as the glass former facility. In addition, the OR Model was not used to the full extent of its programmed analytical capability and did not fully incorporate currently identified design changes resulting from BNI's evaluation of approaches to resolve the UFP design issues.

3. BNI has separately applied the OR, TUA and Steady State Flowsheet models to assess different aspects of the WTP design and project WTP performance. The three process models do not demonstrate or confirm plant design throughput capability. The configuration of the models is not consistent with respect to waste feeds, waste treatment requirements and the operating configuration. The model results were not integrated to provide a complete design confirmation and overall recommendations on WTP performance enhancements and potential improvements.

4. BNI is effectively using the results of the OR Model in the design process to support decisions on equipment components (e.g. remote valve design features) and alternative operating concepts (e.g. use of the PIH crane) to assess WTP design adequacy.

5. BNI has developed and maintained a formally documented and comprehensive process, for maintaining configuration control of the process models.

6. BNI has not used the result of the TUA and Steady State Flowsheet models to confirm the WTP design as required by the "Design Process Plan and Description", Deliverable 3.1.

7. BNI has a formal and traceable process for resolution of design and process flowsheet issues identified in the process models. This is the Recommendation and Issues Tracking System (RITS) and/or the Project Risk Management Program (24590-WTP-GPP-PT-003). The issues identified in the process model deliverables have not been entered into either issue/risk management program.

8. The results of the OR Assessment overestimate the availability of the WTP facilities. As such, it has been determined by the Oversight Team that the OR Assessment results do not support the WTP Contract waste treatment requirements or target WTP facility availabilities specified in the Basis of Design. Major areas requiring development in the OR assessment are:

   - Use of nameplate design capacities for process and mechanical systems and clarification of inputs.
   - Use of a representative waste feed(s) and waste feed treatment process (e.g. washing, caustic leaching and oxidative leaching of the HLW waste sludge).
   - Completion of the OR Model to incorporate systems that impact overall facility availability (e.g. Glass Former Make-up Facility and facility structures such as shield doors and hatches)
   - Incorporation of human factors into MTTR estimates (e.g. discovery of the failure, inefficiencies in human effectiveness).
   - Incorporation of anticipated process upsets into plant availability.
   - Reporting of the confidence level of the facility availability results.
   - Reporting results such that the capacities of the major facilities are clearly presented.

9. BNI has developed an effective process for reconciliation and incorporation of R&T information into the process models (e.g. OR, TUA, Steady State Flowsheet). However based upon current plans, a two-year backlog for the incorporation of R&T information into the process models exists. This situation places the final design of the WTP at risk due to potential design changes which have not been identified.

10. The TUA Extended Model Run does not support the completion of the WTP processing mission consistent with the "2+2" melter proposal (CCN: 039390, TN-24590-02-00706). This is partially due to the assumptions on HLW glass loading and the design capacity of the UFP System. The use of these assumptions also prevents an assessment of the treatment capacity of the WTP system. The ORP requested G2 Model Run (ORP Letter, 05-WED-032) should produce additional information that can be used to assess the design capability of the WTP.

Recommendations

The Oversight Team has made the following recommendations based upon the results of this Oversight. Additional Open Items are summarized in Section 5 for BNI action and completion.

1. BNI should perform process modeling to demonstrate WTP treatment capacity and confirm the design using the OR, TUA, and Steady State Flowsheet models as required by the WTP Contract.

2. The selection of process model assumptions should be strategically performed such that all models are accurately representing WTP design and can be used together to support conclusions regarding capacity, availability, and demonstrate performance against WTP Contract Facility Specification requirements.

3. The assumed waste feeds to be used in the process models should cover the spectrum of waste planned for delivery to WTP over the mission of treating waste contained in all Hanford tanks. The Hanford tank waste compositions have been bounded in the Contract in Specifications 7 and 8 in Envelopes A, B, C, and D.

4. Process modeling to demonstrate WTP treatment capacity and confirm the design should be performed on a priority basis to minimize potential impacts to ongoing WTP design and construction. Results should be used to facilitate changes to design and/or process flowsheets as necessary to achieve Contract Facility Specification requirements.

5. ORP concurrence with all key assumptions and methodology used in process modeling formally delivered to ORP to demonstrate WTP facility treatment capacity should be obtained.

4.0 Open Items from Design Oversight

The following Open Items have been identified by the Design Oversight team for BNI and CH2M Hill Hanford Inc. action.

Table 5.1 List of BNI Open Items

Open Item Number	Open Item
1	BNI has assumed the MTBF data for Pretreatment valves that may bias high the Pretreatment facility availability. BNI should review the OR assumed MTBF data for PT facility valves based on available industry data. BNI should apply an appropriate distribution reflective of the uncertainty in the valve MTBF data when conducting OR assessments.
2	BNI is proposing to modify the MTBF for the Pretreatment valves based upon testing and engineering assessments. BNI should provide a comprehensive and complete basis for the modification of MTBF for Pretreatment hot cell valves based upon dose rate, valve service duty, fluid type and operating environment compared to the historical data collected at the Savannah River Site (WSRC-TR-93-262 Rev 1).
3	The OR Model requires further development and use to determine if the WTP design supports WTP Contract and Basis of Design requirements. BNI should complete additional analysis using a more completely developed OR Model and appropriate operational scenarios to determine if the WTP design supports the WTP Contract and Basis of Design requirements. These results should be presented to ORP for review as they are completed to ensure that the design solution is adequately progressing.
4	The OR Model output does not allow an assessment of the capability of the Pretreatment facility. BNI should revise the OR Model output requirements to clearly show the Pretreatment, LAW Vitrification and HLW Vitrification facility production quantities and availabilities. Where applicable the treatment capacities should be expressed in terms used in the WTP Contract and Basis of Design.
5	The Basis of Design facility specific availabilities may not support the WTP Contract waste treatment requirements for IHLW and ILAW. BNI should update the Basis of Design to ensure that the relationship between the target plant availabilities and the WTP Contract treatment requirements are clearly presented.
6	A spare parts inventory for the WTP was not established based upon the OR Assessment results. A spare parts inventory should be included in the next formal submission of the OR Assessment Report to ORP.
7	The TUA does not consider impacts from hydrogen mitigation control strategies.

Table 5.1 List of BNI Open Items

Open Item Number	Open Item
	BNI should assess the impacts on tank utilization from increased flush volumes resulting from implementation of the hydrogen mitigation strategy for pipes and ancillary vessels as part of the establishment of the HPAV mitigation strategy.
8	The TUA does not include key material balance information. BNI should include in future TUA reports material balance information for key streams to demonstrate model closure. Material balance information should include sufficient information to demonstrate model closure for water and key components such as solids, sodium, ^{137}Cs, ^{90}Sr, transuranic elements, ^{129}I, ^{99}Tc, aluminum, chromium, iron, sulfate, and nitrate.
9	The BARD specified reduced ion exchange processing rates while treating AZ-101 and AZ-102 waste supernatants. BNI should incorporate composition based criteria for determination if a batch of tank waste will require a reduced ion exchange processing rate into the TUA and Steady State Mass Balance model.
10	BNI's Steady State Flowsheet shows that the caustic leaching process is ineffective in removing aluminum from tank waste solids sent to HLW vitrification. If uncorrected the flowsheet will result in unacceptable flowsheet performance. BNI should implement improvements to the process flowsheet to effectively leach aluminum.
11	The absence of mineral phases found in tank waste samples from the ACM Steady State Flowsheet model indicates the BNI assessment <u>may not</u> represent expected solids formation during waste processing in the WTP. It is recommended BNI continue to improve the ACM Steady State Flowsheet model by incorporating available Tank Farm contractor information on solids present in tank wastes.
12	The Steady State Flowsheet identified precipitation requirements that require further assessment and potentially flowsheet and design changes. BNI should assess sodium oxalate management, solids blockage of Cs ion exchange columns, solids from treated LAW from Cs ion exchange, solids in feed evaporator condensate, and solids in TCP-VSL-00001.
13	The WTP flowsheet as configured may lead to the reduced capability of the Pretreatment facility. BNI should utilize the Steady State Flowsheet model and the TUA dynamic model to assess opportunities to simplify the Pretreatment flowsheet to increase effectiveness.
14	BNI has not confirmed or demonstrated the WTP design with the process models as required by the WTP Contract. BNI should establish and implement a plan for the use of the process models to confirm the WTP design is consistent with the

Table 5.1 List of BNI Open Items

Open Item Number	Open Item
	requirements of the WTP Contract and Design Process Plan and Description. The confirmation of the design using the process models should be completed prior to finalization of the process design particularity for the Pretreatment facility.
15	BNI should complete a "benchmark run" using the WTP design basis feed vector as identified in the Basis of Design using the OR, TUA and Steady State Flowsheet process models to confirm adequacy of the proposed WTP process and equipment design as measured against the Basis of Design and WTP Contract.
16	BNI has a process for resolution of design and operational issues identified in the process models. However there is no evidence that this process is being used. BNI should identify the issue resolution tool (e.g. RITS or Project Risk Management Program) used to track the resolution of the design, operational and process chemistry issues identified in the OR, TUA and Steady State Models and periodically present the plans for, and results of, issues resolution in periodic informal meetings with the ORP.

Table 5.2 List of CH2M Hill Hanford Inc. Open Items

Open Item Number	Open Item
1	The water wash factors in the TWINS predict higher transuranic element solubility when compared to experimentally measured wash factors. If uncorrected, several ILAW glass batches will be incorrectly predicted to exceed the 100ηCi/gram transuranic concentration limit. The Tank Farm Contractor should implement improvements to the water wash factors for transuranic elements or develop another method to estimate the solubility of transuranic elements in the waste.

5.0 References

1. 24590-WTP-RPT-PO-05-001 Rev 0, "2005 WTP Operations Research Model", August 29, 2005, Bechtel National Inc, Richland, Washington.
2. 24590-HLW-RPT-PO-05-0001 Rev 0., "HLW Reliability, Availability, and Maintainability Data Development Report", Bechtel National Inc, Richland, Washington.
3. 24590-PTF-RPT-PO-05-0001 Rev 0, "PTF Reliability, Availability, and Maintainability Data Development Report", Bechtel National Inc, Richland, Washington.
4. 24590-LAW-RPT-PO-05-0001, "LAW Reliability, Availability and Maintainability Data Development Report", Bechtel National Inc, Richland, Washington.
5. 24590-WTP-MRR-PO-05-012, Rev 0, "Operations Research Flowsheet Pretreatment Availability Assessment Results", Bechtel National Inc, Richland, Washington.
6. 24590-WTP-MDD-PR-01-001 Rev 1 , "Operations Research (Witness) Model Design Document", Bechtel National Inc, Richland, Washington.
7. WSRC-TR-93-262 Rev 1.0, "Savannah River Site Generic Data Base Development", Westinghouse Savannah River Site.
8. CCN: 047010, "OEE Sheets for Analytical Laboratory", Bechtel National Inc, Richland, Washington
9. 24590-WTP-RPT-PR-01-006, Rev 12, "Risk Assessment Report", December 23, 2005, 16
10. WTP Contract No. DE-AC27-01RV14136.
11. 24590-WTP-RPT-PO-05-009, "2005 WTP Material Balance and Process Flowsheet Assessment," November 10, 2005, Bechtel National Inc, Richland, Washington.
12. 24590-WTP-RPT-PO-05-008, Rev 0, "2005 WTP Tank Utilization Assessment," August 8, 2005, Bechtel National Inc, Richland, Washington.
13. 24590-WTP-RPT-PO-05-001, Rev 0, "2005 WTP Operations Research Assessment," August 29, 2005, Bechtel National Inc, Richland, Washington.
14. BNI letter from R. F. Naventi, BNI to R. J. Schepens, ORP, "Rightsizing for Acceleration," CCN: 039390, dated August 23, 2002, Bechtel National Inc, Richland, Washington.
15. 24590-WTP-RPT-PT-02-005, Rev. 3, "Flowsheet Bases, Assumption, and Requirements," June 29, 2005, Bechtel National Inc, Richland, Washington.
16. P&O-2003-DI-PO-001, Desk Instructions, Process Operations: Document and Data Review Tracking, Bechtel National Inc, Richland, Washington.
17. 24590-WTP-RPT-PO-04-025, Rev. 2, 2005 Deliverables Concept Paper, dated May 26, 2005, Bechtel National Inc, Richland, Washington.
18. TN-24590-02-00706, "2+2 Melter Option" Trend, dated December 5, 2002, Bechtel National Inc, Richland, Washington.
19. 24590-WTP-GPP-PT-003, Rev 3., "Project Risk Management", Bechtel National Inc, Richland, Washington.

Appendix A
ORP Assessment of the Operations Research Assessment, Deliverable 2.5

Contract Compliance Questions

1. **Does the Operations Research assessment determine that the facility design incorporates appropriate design and operational features to meet plant capacity requirements and reduce construction and/or operations costs? Plant capacity requirements include:**
   a. Pretreatment
      i. Basis of Design (BOD) availability of 80%
      ii. HLW Pretreatment shall support vitrification of an average of 480 canisters of IHLW per year.
      iii. LAW Pretreatment shall process and average of 2,200 Na waste units per year. BNI shall notify DOE if the governing unit operation drops below 3400 total Na units per year or predicted availability drops below 2950 total Na units per year (~86% availability if governing unit is 3400 total Na units per year).
   b. HLW
      i. BOD availability of 70%
      ii. Produce an average of 480 canisters per year assuming 1.16 cubic meters of glass per canister
   c. LAW
      i. BOD availability of 70%
      ii. Produce glass with an average of 733 Na waste units per year.

Assessment

The purpose of the OR Model Runs was to independently determine if the target availabilities for the WTP facilities as specified in the WTP Basis of Design are achieved. These target availabilities for the Pretreatment, LAW Vitrification and HLW Vitrification facilities are 0.80, 0.70 and 0.70 respectively. The OR Model is used to estimate the treatment rate that is expected over a 12 year period. The availability is determined by comparison of the treatment rate projected with no RAM (reliability-availability-maintainability) failures to an estimate with RAM failures applied.

The OR Model is a stochastic calculation that uses statistical distributions for the principle variables used in the calculation; Mean Time Before Failure (MTBF) and Mean Time to Repair (MTTR). The negative exponential distribution is used to specify the range of values for the MTBF. The OR Model sets default values for this distribution. The Erlang Distribution is used for the MTTR. The K value for this distribution is set at 2 resulting in a log normal distribution. The output from the OR model run is a single value representing the treatment rate (e.g. cans of ILAW, cans of IHLW, units of Na and MTG equivalent for IHLW). In discussion with BNI it was indicated that the OR model run does not output a treatment rate distribution. Thus it is believed that the values reports are the mean values.

The OR Assessment Report (24590-WTP-RPT-PO-05-001) includes 8 scenarios that are specified with unique objectives. Three of the Scenarios are modeled to assess the availability of the Pretreatment, HLW Vitrifcation and LAW Vitrification facilities. These results can be compared to the baseline Scenario (e.g. no RAM applied) to provide an indication of the facility availability. (Note: The OR Assessment compared Scenario 5 and Scenario 8 to estimate the Pretreatment availability which is not valid because the valve lifetime extension assumed for Scenario 8 has not been validated.)

- Pretreatment Facility-Scenario 5, 24590-WTP-MRQ-PO-05-0025. When comparing Scenario 4 and Scenario 5, the LAW Pretreatment availability is estimated to be 90%, and the HLW availability is estimated to be 80%. However the LAW availability is based upon providing feed to the LAW Vitrification facility. Thus the determination of the ability of the Pretreatment facility to support 2950 Units LAW (or 3400 Units LAW) cannot be made. The HLW availability at 80% just meets the Basis of Design requirement.

- HLW Vitrification Facility-Scenario 6, 24590-WTP-MRQ-PO-05-0026. When comparing Scenario 4 and Scenario 6, the HLW Vitrification availability is estimated to be 83% which meets the Basis of Design requirement of 70%.

- LAW Vitrifcation Facility-Scenario 7, 24590-WTP-MRQ-PO-05-0027. When comparing Scenario 4 and Scenario 7, the LAW Vitrification availability is estimated to be 72% which meets the Basis of Design requirement of 70%.

Scenario 2 provides the best overall assessment of the WTP design capability. The model assessment was completed with all WTP Plant and LAB RAM applied and assumes 15% rework of the analytical samples. 10 replication runs were completed based upon these assumptions. The results are summarized below and show that the integrated Pretreatment, LAW Vitrification and HLW Vitrification facility analysis results. Based upon this assessment the LAW system has an average availability of 0.62 assuming the ILAW container holds 5.6 MTG and 0.69 assuming the ILAW container holds 6 MTG. The HLW system has an average availability of 0.69.

Table A.1 Summary of Production Quantities from Scenario 2, 24590-WTP-MRR-PO-05-009

Replication	ILAW, Total Containers	IHLW, Total Containers	ILAW, containers/day	IHLW, containers/day
1	14394	5851	3.42	1.39
2	13547	5461	3.22	1.30
3	13321	5495	3.16	1.30
4	14472	5875	3.43	1.39
5	13775	5706	3.27	1.35
6	13593	5747	3.23	1.36
7	14051	5736	3.33	1.36
8	14736	6189	3.50	1.47
9	13986	5839	3.32	1.39
10	14444	5880	3.43	1.40

Table A.1 Summary of Production Quantities from Scenario 2, 24590-WTP-MRR-PO-05-009

Replication	ILAW, Total Containers	IHLW, Total Containers	ILAW, containers/day	IHLW, containers/day
Average	14032	5778	3.33	1.37
Plant Availability at Average Production			0.62 (0.69)	0.69
Average Production			18.6 MTG/d	500 container/year

Notes:
The ILAW container is assumed to contain 5.6 MTG per the BARD resulting in an average availability of 0.62. If the ILAW container contains 6 MTG then the average availability is 0.69.

The OR model Assessment is not complete in terms of the scope analyzed. Thus the estimates of availability are overstated. Table A.2 summarizes some of areas of scope (factors) not addressed in the current OR Model and provides estimates based upon the Oversight Team judgment of the impact of availability. The factors include:

- The confidence level for reporting. The OR results are presented as a mean value and in terms of statistical confidence represent a 50% confidence level. Meaning that there is a 50% chance the value will be above the value citied and a 50% chance the value will be below the value cited. The 10 results in Table A.1 are normally distributed, and can be used to estimate the standard deviation and 90% confidence level (e.g. values 2 standard deviations below the mean).
- The availability of the Glass Former Facility is not considered in the OR Model. The procurement specification requires an availability of 90%. It is assumed the impact to overall system availability is 5% or 0.95.
- The waste treatment flowsheet in the OR Model does not incorporate caustic leaching and oxidative leaching which can impact the thru put of the Pretreatment facility. It is assumed the impact to production is 5% or 0.95.
- The MTTR estimates do not provide a time duration for discovery of the failure. It is assumed the discovery time has a 1% or 0.99 impact on production capacity.
- The OR Model does not account for lost capacity due to process upsets, line pluggage or rework. It is assumed than that the process upsets a 2% or 0.98 impact on production capacity.

When reviewed in isolation each of these omissions in the OR Model appear to have a small impact. However, when considered together, these omissions can have a significant impact on WTP availability. Considering these assumptions the HLW system availability drops to 0.56 or 408 canisters/year, below the requirement in the WTP Contract and the WTP Basis of Design (Reference). The LAW System Availability cannot be completely evaluated because the data reported in the OR Model runs is not complete.

Table A.2 Impact of LAW and HLW System Availability from Additional Assumptions

Assumptions	Value	LAW System Availability	HLW System Availability
Starting Value from Table A.1	NA	0.62	0.69
Reporting of Confidence Level at 95% based upon total "Plant" only.	2 standard deviations	0.58	0.64
Incorporation of Glass Former Facility Availability	0.95	0.55	0.61
Incorporation of Caustic Leach into Envelope A/D Flowsheet	0.95	0.52	0.58
Discovery Time associated with MTTR Estimates	0.99	0.52	0.57
Incorporations of process upsets and rework into operations	0.98	0.51	0.56
Average Production After Adjustments		NA	408 Canisters/year

Other technical areas not included in the OR Assessments include:

- Instrumentation to support process control and Important to Safety operations,
- MTTR for combined piping and electrical jumpers,
- Design changes resulting form vendor supplied equipment,
- R&T initiated changes to the design and operational performance of the equipment.

Results from the OR Model assessments determined that the usage of the PIH crane and the lifetime for the hot cell valves were significant factors impacting the availability of the Pretreatment facility. BNI is currently investigating design and operational approaches to improve availability of the Pretreatment facility, these include:

- Assessment of the usage of the PIH crane to determine how best to maximize its usage. This assessment is starting with determination of the percentage time the crane is used for: self maintenance, replacement of critical equipment components, replacement of non critical components, waste/equipment size reduction and transportation of waste in the hot cell.
- In addition, a sensitivity case was completed (Scenario 8, 24590-WTP-MQR-PO-05-015) that modified the assumptions used for the MTBF for the hot cell valves based upon predicted dose rates. The MTBF for valves in low-radiation areas (<500 Rad/hr) was increased from 3.3 to 10 years and the MTBF for valves in high radiation areas (>500 Rad/hr) was extended from 3.3 to 5 years. The shorter life-time estimates are consistent with historical data collected at the Savannah River Site (WSRC-TR-93-262 Rev 1.0). The results of this sensitivity assessment showed an approximate 33% increase (1.37/1.83) in availability from the baseline results presented in Table A.1. BNI is testing and evaluating valves to validate these proposed design life assumptions in a testing program that involves radiation exposure to 10^8 Rad followed by shake testing and valve operations testing. Following the completion of this testing, the baseline values for valve lifetime may be modified.

The mean-time-between-failure (MTBF) data for components used in the OR Model was obtained from numerous sources, including actual failure rate data for components obtained from review of failure events and sources that estimate failure rates (WSRC-TR-93-262, revision 1, 1998, *Savannah River Site Generic Data Base Development*, Westinghouse Savannah River Company, Aiken South Carolina). BNI has augmented the literature information for component MTBF data through structured expert opinion workshops. The component MTBF data provided in WSRC-TR-93-262, revision 1 is identified in three categories defined as:

- Category 1- Sources with actual failure data obtained from a detailed review of failure events (to ensure applicability to the failure mode being considered) and a detailed review of component populations and exposure duration's (or demands). Such data include the plant-specific component failure data collected for probabilistic risk assessments (PRAs) or reliability studies. The NUCLARR1 database has 19 Category 1 sources, all from nuclear power plants. For this project, the Savannah River Site (SRS) reactor data were added.

- Category 2- Sources with actual failure data but which have an added uncertainty in the data compared with Category 1 sources. This added uncertainty can result from a less comprehensive search for actual failures, a more approximate method for determining component populations or exposure duration's (or demands), or a less clear breakdown of failures into the failure modes of concern.

- Category 3- Sources that list only failure rate estimates. Six representative sources were used in this project.

For valves used in chemical processing service similar to the Waste Treatment and Immobilization Plant, the MTBF data from WSRC-TR-93-262, revision 1 are provided in Table A-1. WSRC-TR-93-262, revision 1 lists only category 3 source data and the recommended MTBF data is actually based on water service valves due to the more extensive data available (see WSRC-TR-93-262, revision 1, pages 204 – 211). Therefore, the MTBF duration possibly could be shorter for valves used in the PT facility due to chemical service and radiation exposure.

BNI has assumed in the OR Model "… In determining the PT facility availability, a valve replacement strategy was applied and based on dose mapping, the MTBF of plug valve and actuator seals was extended to around 5 years for valves in the high radiation areas, and 10 years for valves in the low radiation areas in the hot cells" (24590-WTP-RPT-PO-05-001, page 8). This assumption is not consistent with the reference MTBF data for valves cited in WSRC-TR-93-262 and may bias high the PT facility availability.

Table A-1 Chemical Service Valves Mean Time Between Failure Data [(1)]

Chemical Process Valve	Mean Failure Rate (1/day)	Mean Failure Rate (year)
Manual Valve fails to open / close	3.00E-04	9.1
Check Valve fails to open / close	5.00E-05	54.8
Motor Operated Valve fails to open /	3.00E-03	0.9

Table A-1 Chemical Service Valves Mean Time Between Failure Data [1]

Chemical Process Valve	Mean Failure Rate (1/day)	Mean Failure Rate (year)
close		
Air Operated Valve fails to open / close	1.00E-03	2.7
Solenoid Operated Valve fails to open / close	1.00E-03	2.7

[1] WSRC-TR-93-262, revision 1, page 21

The dose rate cut off of 500 Rad/hr for the low and high dose rates combined with the selection of valves for low and high does rates used in the Scenario 8 MTBF assumptions is not readily traceable to selections made in the Scenario 8 model rum. In addition other factors such as valve service duty (e.g. cycles of opening and closing), valve type, fluid type (e.g. low solids versus high solids) and vibration may impact the anticipated valve life. Assuming that the valve lifetime valves are to be adjusted compared to the historical data collected at the Savannah River Site (WSRC-TR-93-262 Rev 1.0), then BNI should provide a comprehensive basis for modification of the MTBF valves.

Based upon the results of the "Baseline Run" (Scenario 2, 24590-WTP-MRR-PO-05-009) the WTP facility complex does not support the availability requirements identified in the Basis of Design. However, it appears than BNI is completing the appropriate analysis to identify design and operational changes to support establishment of a fully compliant WTP design. These actions include:

- Completion of the ORP Model and scenario analyses to include significant design and operational features not currently modeled or evaluated.
- Further examination of the PIH crane to determine how it is being used, and identification of potential operational features to improve utilization of the crane.
- Potential modification of the MTBF values for Pretreatment facility hot cell valves.

Because of the significant uncertainties associated with the ability of the WTP facilities to meet the Basis of Design availability requirements (and WTP contract waste treatment requirements), the ORP is requesting informal reviews of interim model runs.

The Results from the OR Model scenario runs are presented in Appendix A of each model report. These results are typically presented in a table that identified the replication number, total number of LAW and HLW containers and daily production of LAW and HLW. The results for LAW are only presented in terms of the LAW immobilized in WTP and do not include the entire volume of LAW treated. Thus it is not possible to determine if the total LAW treatment rate requirement are being met. BNI should revise the format of the OR Model output to provide a clear demonstration of the capability of the Pretreatment, LAW and HLW facilities, in terms of the amount of material processed and immobilized.

BNI has estimated the availability of each of the major WTP facilities, Pretreatment, LAW Vitrification and HLW Vitrification in the OR Assessments. Target values for the availability for each facility have been established by BNI in the Basis of Design. While these facility specific OR Assessments are important to evaluate BNI's facility specific design, they do not necessarily meet the requirements for the treatment rates as specified in the WTP contract. This is clearly illustrated when comparing the results of Scenario 2, a "Plant" assessment with RAM applied to the individual results for the three major facilities (Scenario 5, 6 and 7). In terms of validating that the WTP contract requirements are met, only the "Plant" assessments are relevant. Because of this and the presentation in the OR Assessment it appears that the requirements established by BNI in the Basis of Design are in error.

2. Does the Operations Research assessment include sampling and analysis requirements including sample turnaround times?

Assessment

The OR Assessment includes sampling and analysis requirements including sample turnaround times. The executive summary of the OR Assessment states that the "sample points, sample frequencies, and analytical time available (ATA) for each sample point were updated from the Integrated Sampling and Analysis Requirement Document ("the ISARD," 24590-WTP-PL-PR-04-001)". Section 2.2 states that "The WTP OR flowsheet reads data from the Laboratory spreadsheet, which contains information from the ISARD (24590-WTP-PL-PR-04-001). The ISARD provides the Laboratory analytical times available (ATAs) required for all sample points in the PT, HLW, and LAW processes, and the detailed tasks and durations for each process sampling point."

The Oversight Team did not verify that the sample point information in the ISARD was properly entered into the Laboratory spreadsheet, nor did we verify the Witness model itself, nor did we verify traceability through the various model run requests and model reports.

3. Does the Operations Research assessment include tank capacities and times to conduct individual process steps in unit operations?

Assessment

The OR Assessment includes tank capacities and times to conduct individual process steps in the unit operations. The OR Assessment uses the Witness model which is described in the Model Design Document (24590-WTP-MDD-PR-01-001). Section 4 of the Model Design Document provides a brief description of each key unit operation and presents the tank capacities (generally in terms of a working batch size) and times (either in terms of the input and output flowrates or as a time for a discrete process step, as appropriate).

The OR Assessment was based upon the treatment of an Envelope A/D feed and used only filtration and sludge washing to treat the HLW solids. Caustic leaching and oxidative leaching of the HLW sludge will be completed as part of normal operations in the Pretreatment facility. These process steps were not modeled in the Pretreatment flowsheet, although the capability exists to complete this analysis using the current model. These additional process steps are anticipated to reduce the treatment rate (and correspondingly, the availability) of the Pretreatment facility due to extending the time to treat the tank waste.

4. Does the Operations Research assessment include time for mechanical handling steps?

Assessment

The OR Model includes the necessary times to complete the mechanical handling steps including travel times, batch process times and RAMI times (MTBF, MTTR, etc). Storage limitations in terms of volumes and physical space locations (in container racks) are also included in the model.

5. Does the Operations Research assessment include equipment reliability?

Assessment

The OR Model is based upon RAM data developed by the WTP project which considers the use of existing data bases (WSRC-TR-93-262) and expert reviews conducted by BNI. The RAM data is documented in a series of documents identified below:

- 24590-PTF-RPT-PO-05-0001, "PT Reliability, Availability and Maintainability Data Development Report".
- 24590-HLW-RPT-PO-05-0001, "HLW Reliability, Availability and Maintainability Data Development Report".
- 24590-LAW-RPT-PO-05-0001, "LAW Reliability, Availability and Maintainability Data Development Report".
- CCN: 047010, "OEE Sheets for Analytical Laboratory".

6. Does the Operations Research assessment include time estimates for maintenance and repair of facility and process systems?

Assessment

The OR Assessment is based upon RAM data that is presented is a series of reports (see response to question 5 above). A large portion of the RAM assessment is devoted to estimating the Mean Time to Repair (MTTR).

The MTBF and MTTR are presented as distributions in the OR Model. Via conversations with BNI on December 29, 2005, these distributions which are not documented in the model are the NEGEXP (negative exponent) distribution for MTBF and the ERLANG distribution with K=2 for MTTR.

The suitability of using these distributions needs to be examined. Sensitivity runs may be needed to understand the effects of these (and other assumptions) on availability and capacity.

7. Does the Operations Research assessment include estimated spare equipment inventory?

Assessment

The OR Assessment identifies an equipment list used as a basis for the OR assessments in Appendix B. However a spare parts inventory is not established or recommended. (*"The OR flowsheet reliability data have been used as a basis to establish an equipment list that will be used to develop a spare parts inventory."* Section 2.10, page 13 of 24590-WTP-RPT-PO-05-001)

8. Does the Operations Research assessment include recommendations to improve reliability and throughput of the production facilities?

Assessment

The OR Assessment has made no specific recommendations to improve the reliability or throughput of the WTP facilities. The OR Assessment concludes that the PIH crane is heavily utilized and indicates that further assessments are required. In addition the assessment results indicate that the lifetime of the remote valves in the Pretreatment facility will significantly impact the availability of this facility due to the large number of valves. Thus further evaluation of valve lifetime (e.g. MTBF) is planned.

9. Does the Operations Research assessment ensure appropriate reliability, availability, maintainability, and inspectability for the WTP balance of facilities?

Assessment

The OR Assessment results for Scenario 2 which are the best representation of the "WTP baseline" do not support the WTP contract waste treatment requirements as discussed in the question #1 response above. A number of unresolved issues still exist in the design and operational concepts to ensure than the WTP will meet WTP contract requirements. As such the appropriate reliability, availability, maintainability, and inspectability is still to be established.

10. Does the Operations Research assessment reflect the latest design and information from research and technology?

Assessment

Based upon the commitments in the **Error! Unknown document property name.**, the OR Model was to be updated to be "in alignment with the scheduled Research and Technology (R&T) data reconciliation efforts and design alignment items as of November 8, 2004".

BNI has a process to reconcile R&T test report results with the WTP process models and associated basis documentation. This process is described in "Desk Instructions, Process Operations: Document and Data Review Tracking" (P&O-2003-DI-PO-001). A Review

Tracking Coversheet is prepared for each test report documenting BNI's assessment of results and identifying required changes to models or associated basis documentation. Change requests are prepared when revisions to models or associated basis documentation is required.

Shown in Figure A.1 is the current status of the data reconciliation effort. Based on discussions with BNI, over 150 reports are issued that have not been reviewed for reconciliation. Completion of the reconciliation process is projected to extend through 2007. BNI also stated this schedule may be extended as a result of FY 2006 project funding levels. The oversight team considers review of R&T test reports to reconcile the process models and design basis documentation as

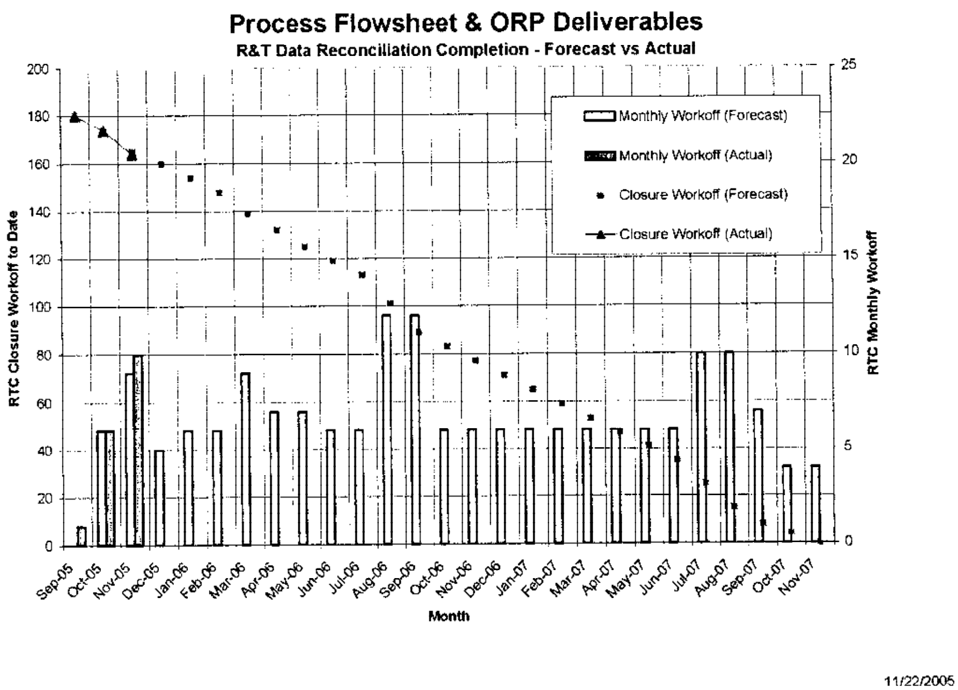


Figure A.1 Current Status of Reconciliation of the R&T Reports for the WTP Process Models.

critical to assuring the WTP design has appropriate technical underpinning. Completion of review and reconciliation of data in test reports is critical to support the project's objective to provide appropriate separation between design and construction to reduce project risk to more reasonable levels. Information learned from R&T reports has the potential to impact facility equipment design, waste routing, process flowsheet design, and operational performance.

11. Has BNI maintained configuration control to manage the models and analyses?

Assessment

BNI maintains configuration control of the models according to requirements in their procedure 24590-WTP-GPP-IT-008, Software Life Cycle Management and processes defined in 24590-WTP-GPP-PT-013, Lifecycle Control of Process Models.

24590-WTP-MRR-PO-05-012 stated the following, "The OR Flowsheet Version 4.0 was verified and validated and was documented in the *Operations Research (Witness) Model Version 4.0 Verification and Validation Report* (24590-WTP-VV-PO-05-002)."... "Run results were validated by the Process Operations flowsheet engineers." Similar statements are provided in each Model Run Request.

The Oversight Team found configuration control of the OR Assessment acceptable.

12. Has BNI established facility design capacity through its engineering processes?

Assessment

BNI has developed a concept for the Engineering Analysis Tools that describes the purpose and role of the OR Model, TUA Model and ACM Steady State Model in the design process. This concept was presented in discussions between the Oversight Team and BNI, on December 13, 2005. The fundamental tools used in the design process are the WEBPPS (Mass and Energy Balance Calculation) and the Process System and Mechanical System Component Calculations. The role of the process models in the design process is as follows:

- The OR Model is used to confirm the average capacities (availabilities) of the WTP facilities,
- The TUA model is used to complete tank utilization analysis, predict the results of Tank Farm feed blending scenarios and analyze mission duration/canister and container counts,
- The ACM Steady State Model is used to provide permitting/emissions estimates, chemistry predictions (thermodynamic equilibrium) and as a comparison tool to the WEBPPS model runs.

The WTP Contract requires that

> *"The Contractor shall develop and use analytical models to support the design of the process and facility system (emphasis added), support pre-operational planning assessments, and provide technical integration with Tank Farm Contractor waste feed staging and product acceptance activities. The Contractor will, at a minimum, use the following models:..." Standard 2, (b).*

The "Design Process Plan and Description" (24590-WTP-PL-ENG-01-004), requires that:

> *"Process operations confirms the design (emphasis added) through the ACM, the capacity model G2, and the operations research (OR) model Witness, which are reviewed by DOE." Section 3.3, page 14.*

The Oversight Team has found that the results of the OR Assessment are used to validate the target availabilities established in the Basis of Design. There are some indications that the OR Assessment results are being used to critically assess the design of the WTP and are used in design decisions. Identification and resolution of issues associated with the integrity of the valve in the Pretreatment hot cell is one example on how the OR Model is used to assess or confirm the design. However because of the incompleteness of the OR Model and to some extent completion of the design, the OR model cannot be used to confirm the design.

Other Technical Questions

1. **Does the Operations Research model support BNI's commitment in their two HLW melter and two LAW melter proposal (CCN: 039390) to process all Hanford tank waste in a seventeen year operational period? If not, why not?**

Assessment

The OR Assessment results as discussed in question #1 response above indicate that the WTP facilities do not have a sufficiently high availability compared to the Basis of Design requirements to support the completion of Hanford tank waste processing within a 17 year period.

2. **Does the Operations Research model identify the limiting unit operation or handling steps to achieve production goals?**

Assessment

The OR Model appears to be configured to generate the necessary output to address this question. However specific model runs have not been completed. BNI has begun in the last year to beginning to use the OR model as a design assessment tool to support design assessment and design. However only limited data is available at this time.

3. **Can LAW vitrification support ORP's stretch case goal of 45 metric tones glass per day? If not, what changes are required?**

Assessment

The 45 MTG/d refers to a design capacity. The ORP Stretch case as provided in ORP System Plan Rev 2 assumes that the design capacity of the LAW Vitrification facility is 45 MTG/d. ORP has conducted Oversight assessments to determine how to achieve this design capacity. However, the ORP System Plan also assumes that the availability of the LAW Vitrification facility is 0.75 (e.g. 34 MTG-d/45 MTG-d). The results from Scenario 2 indicate the LAW System availability is 0.62 and the LAW Vitrification facility assessment is 0.72. Both availability estimates fall short of ORP's assumption used in the System Plan.

4. Can HLW vitrification support ORP's stretch case goal of 6.0 metric tones glass per day? If not, what changes are required?

Assessment

The 6 MTG/d refers to a design capacity. The ORP Stretch case as provided in ORP System Plan Rev2 and the WTP contract require that the design capacity of the HLW Vitrification facility be 6 MTG/d. The ORP System Plan also assumes that the availability of the HLW Vitrification facility is 0.83 (e.g. 5 MTG-d/6 MTG-d). The results from Scenario 2 indicate the HLW System availability is 0.69 and the HLW Vitrification facility assessment is 0.83. The HLW system availability estimate falls short of ORP's assumption used in the System Plan.

5. What are the limiting operations or handling steps that prevent the Pretreatment facility from achieving a 3,400 unit Na/7.5 metric tonne HLW and 2950 unit Na/7.5 metric tonne HLW production rate?

Assessment

The OR Model is currently not configured to generate the necessary output to address this question. An Open Item was identified above to begin to provide this information to support these assessments.

References

1. 24590-WTP-RPT-PO-05-001 Rev 0, "2005 WTP Operations Research Model", August 29, 2005, Bechtel National Inc, Richland, Washington.
2. 24590-HLW-RPT-PO-05-0001 Rev 0., "HLW Reliability, Availability, and Maintainability Data Development Report", Bechtel National Inc, Richland, Washington.
3. 24590-PTF-RPT-PO-05-0001 Rev 0, "PTF Reliability, Availability, and Maintainability Data Development Report", Bechtel National Inc, Richland, Washington.
4. 24590-LAW-RPT-PO-05-0001, "LAW Reliability, Availability and Maintainability Data Development Report", Bechtel National Inc, Richland, Washington.
5. 24590-WTP-MRR-PO-05-012, Rev 0, "Operations Research Flowsheet Pretreatment Availability Assessment Results", Bechtel National Inc, Richland, Washington.
6. 24590-WTP-MDD-PR-01-001 Rev 1 , "Operations Research (Witness) Model Design Document", Bechtel National Inc, Richland, Washington.
7. WSRC-TR-93-262 Rev 1.0, "Savannah River Site Generic Data Base Development", Westinghouse Savannah River Site.
8. CCN: 047010, "OEE Sheets for Analytical Laboratory", Bechtel National Inc, Richland, Washington

APPENDIX B
WTP TANK UTILIZATION ASSESSMENT, DELIVERABLE 2.6

Contract Compliance Questions

1. Does the TUA assess utilization of process tank capacity and supporting equipment capability and operational characteristics, to ensure that the tanks are appropriately sized to support process operations, sampling and analysis turnaround times, process control requirements and waste form qualification needs?

Assessment

The scope of the TUA Model was established to support the requirements of the WTP Contract. This involves a determination of the adequacy of the process vessel/equipment capacity considering: anticipated process operations, process sampling, process control and waste form qualification compliance strategies. The TUA has also been configured to assess the impact of specific tank waste chemistries on the process flowsheet to estimate time dependent volumetric throughputs and quantities of ILAW and IHLW. All requirements associated with the technical scope of the TUA Model as defined by the WTP Contact have been met. These requirements will need to be reassessed as WTP process Flowsheet design matures and is finalized. This assessment does not include use of the model results to confirm the design as discussed below and in Question 1, Other Technical Questions.

BNI has proposed recent equipment capacity design and process flowsheet changes to resolve design capacity issues associated with the Ultrafiltration Process (CCN: 106650). The process flowsheet changes including Al solubility correlation and feed forward of process streams have been incorporated into the TUA Model. However, the proposed design changes, most notably the UFP filter surface area size has not been incorporated into the TUA Model. Thus a confirmatory run to assess the adequacy of the WTP design has not been completed.

2. Does the TUA reflect the latest design and information from research and technology (R&T)?

Based upon the commitments in the, Rev. 2, 2005 Deliverables Concept Paper (24590-WTP-RPT-PO-04-025), the TUA was to be updated to be "in alignment with the scheduled Research and Technology (R&T) data reconciliation efforts and design alignment items as of November 8, 2004".

BNI has a process to reconcile R&T test report results with the WTP process models and associated basis documentation. This process is described in "Desk Instructions, Process Operations: Document and Data Review Tracking" (P&O-2003-DI-PO-001). A Review Tracking Coversheet is prepared for each test report documenting BNI's assessment of results and identifying required changes to models or associated basis documentation. Change requests are prepared when revisions to models or associated basis documentation is required.

Assessment

Shown in Figure A.1 is the current status of the data reconciliation effort. Based on discussions with BNI, over 150 reports are issued that have not been reviewed for reconciliation. Completion of the reconciliation process is projected to extend through 2007. BNI also stated this schedule may be extended as a result of FY 2006 project funding levels. The oversight team considers review of R&T test reports to reconcile the process models and design basis documentation as critical to assuring the WTP design has appropriate technical underpinning. Completion of review and reconciliation of data in test reports is critical to support the project's objective to provide appropriate separation between design and construction to reduce project risk to more reasonable levels. Information learned from R&T reports has the potential to impact facility equipment design, waste routing, process flowsheet design, and operational performance.

3. **Has BNI demonstrated WTP waste treatment capacity using process modeling? Plant capacity requirements include:**
    a. Pretreatment
        i. Basis of Design (BOD) availability of 80%
        ii. HLW Pretreatment shall support vitrification of an average of 480 canisters of IHLW per year.
        iii. LAW Pretreatment shall process and average of 2,200 Na waste units per year. BNI shall notify DOE if the governing unit operation drops below 3400 total Na units per year or predicted availability drops below 2950 total Na units per year (~86% availability if governing unit is 3400 total Na units per year).
    b. HLW
        i. BOD availability of 70%
        ii. Produce an average of 480 canisters per year assuming 1.16 cubic meters of glass per canister
    c. LAW
        i. BOD availability of 70%
        ii. Produce glass with an average of 733 Na waste units per year.

The TUA modeled five cases consisting of (1) AP-101 / AY-102 commissioning feed, (2) TPA milestone M-062-00A completion, (3) TPA milestone M-062-00A completion with unlimited HLW melter feed storage, (4) mission completion run with alkaline leaching, and (5) mission completion run with alkaline leaching and sequential oxidative leaching. All TUA cases assume 100% availability of WTP systems and components. The review team evaluated the results of each TUA case to determine the waste stream production rates. Table B-1 summaries the waste stream production rates for each of the TUA cases. None of the TUA cases demonstrate the capability of the WTP to meet nameplate waste treatment capacities for HLW Vitrification (6 MT/day), LAW Vitrification (30 MT/day) and LAW Pretreatment (3,400 Na waste units per year).

Assessment: BNI has not demonstrated the capability of the WTP to meet nameplate waste treatment capacities.

The TUA runs contain the following assumptions:

- LAW vitrification facility SBS / WESP recycle is transferred to Supplemental LAW Treatment along with excess pretreated LAW
- Caustic leaching only performed if it will reduce the quantity of HLW glass by 10% or more for a waste batch
- Oxidative leaching only performed if it will reduce the quantity of HLW glass by 10% or more for a waste batch

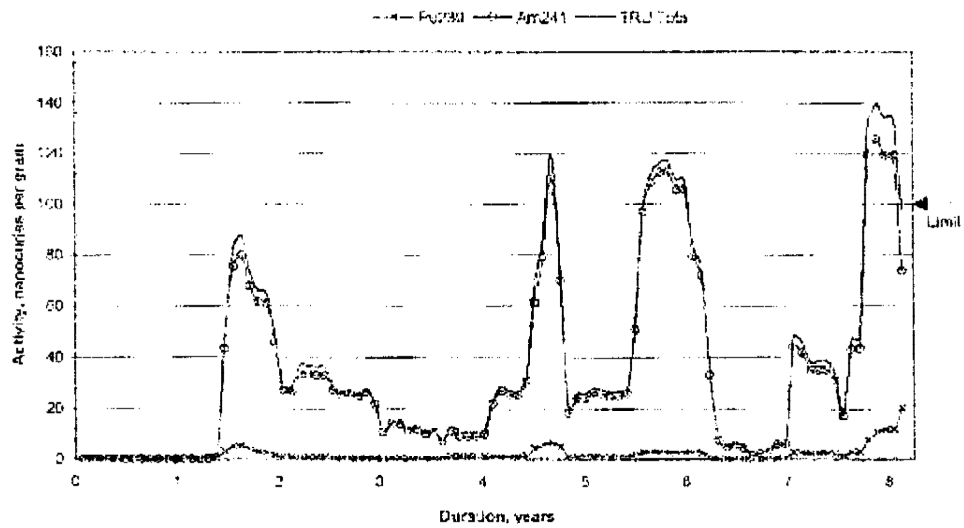
The first assumption results in a larger fraction of sulfate and technetium being transferred to the Supplemental LAW Treatment system and artificially increases the waste sodium loading in WTP ILAW glass. However, this assumption is inconsistent with section 1.2.2 of the Flowsheet Bases, Assumptions and Requirements Document (BARD), 24590-WTP-RPT-PT-02-005, revision 3, page 1.2-2, which states: "Condensables from the SBS and the WESP are collected in the liquid effluent system and recycled to the treated LAW evaporator in the PT facility". BNI's Tank Utilization model does not represent the operating conditions of the WTP, consistent with the BARD.

The second and third assumptions are arbitrary, and may lead to unwanted increase in IHLW glass production. The review team did not have sufficient information to quantify the impact to IHLW glass production from these two assumptions. Data presented in Table 5.3 of BNI's TUA indicates ~43% of the HLW melter feed batches (representing ~41% of the total glass produced) contain aluminum or chromium as limiting constituents following alkaline and sequential oxidative leaching. It is apparent that removing additional aluminum and/or chromium from the HLW sludge batches will reduce the quantity of IHLW glass produced.

The Tank Farm feed vector provided to BNI used water wash factors from the Tank Waste Information Network System (TWINS) database, which over estimate solubility of transuranic elements (e.g. ^{241}Am and ^{239}Pu) compared to wash factors measured experimentally. For example, the TWINS database reports a ^{241}Am water wash factor of 0.028 for tank 241-AZ-101. The experimentally determined ^{241}Am water wash factor is 0 for tank 241-AZ-101 (PNWD-3206).

The use of the TWINS transuranic water wash factors results in the Tank Utilization model predicting several batches of ILAW will exceed the 100ηCi/gram transuranic concentration limit, as shown in Figure 3-14, 24590-WPT-RPT-PO-05-008, revision 0.

Figure 3-14 TRU Radionuclides in the LAW Glass (TPA Phase 1 Milestone with HLW Melter at 6 MTD)



4. Has BNI established facility design capacity through its engineering processes?

BNI has developed a concept for the Engineering Analysis Tools that describes the purpose and role of the OR Model, TUA Model and ACM Steady State Model in the design process. This concept was presented in discussions between the Oversight Team and BNI, on December 13, 2005. The fundamental tools used in the design process are the WEBPPS (Mass and Energy Balance Calculation) and the Process System and Mechanical System Component Calculations. The role of the process models in the design process is as follows:

- The OR Model is used to confirm the average capacities of the WTP facilities,
- The TUA model is used to complete tank utilization analysis, predict the results of Tank Farm feed blending scenarios and analyze mission duration/canister and container counts,
- The ACM Steady State Model is used to provide permitting/emissions estimates, chemistry predictions (thermodynamic equilibrium) and as a comparison tool to the WEBPPS model runs.

The WTP Contract requires that

> *"The Contractor shall develop and use analytical models to support the design of the process and facility system (emphasis added), support pre-operational planning assessments, and provide technical integration with Tank Farm Contractor waste feed staging and product acceptance activities. The Contractor will, at a minimum, use the following models:..." Standard 2, (b).*

Waste treatment capacity for each major facility is defined as a product of the facility design capacity (facility nameplate design capacity) multiplied by the overall individual facility availability factor. The Contractor is to establish the facility design capacity through its engineering processes. The Contractor is to establish the facility availability factor from the Operational Research Assessments (emphasis added) as defined in Standard 2 (b) (1) Operational Research Assessments of the Waste Treatment and Immobilization Plant. Section C.7 (b)

During the design process the WTP waste treatment capacity shall be demonstrated using process modeling.(emphasis added) The WTP waste treatment capacity will be verified through the plant testing performed during commissioning tests conducted in accordance with Standard 5, Commissioning. Section C.7 (b)

The "Design Process Plan and Description" (24590-WTP-PL-ENG-01-004), requires that:

"Process operations confirms the design (emphasis added) through the ACM, the capacity model G2, and the operations research (OR) model Witness, which are reviewed by DOE." Section 3.3, page 14.

Assessment

Historical assessments using the TUA were completed to assess the adequacy of vessel sizing in the WTP design. These assessments were completed prior to the identification of design and process flowsheet issues identified in the ORP UFP Oversight. BNI has proposed specific changes to the WTP design and process flowsheet to modify the design to support the design requirements (CCN: 106650). These issues have not been evaluated in the TUA Model to ensure design adequacy. ORP has provided further guidance for BNI to verify design adequacy (05-WED-032) using the TUA Model. This analysis has not been completed. Thus, the adequacy of the WTP design, and potential design and operational changes, identified by BNI has not been verified.

5. Has BNI maintained configuration control to manage the models and analyses?

Assessment

BNI maintains configuration control of the models according to requirements in their procedure 24590-WTP-GPP-IT-008, Software Life Cycle Management and processes defined in 24590-WTP-GPP-PT-013, Lifecycle Control of Process Models.

The review team found configuration control of the TUA acceptable.

Other Technical Questions

1. Does the Tank Utilization Assessment model support BNI's commitment in their two HLW melter and two LAW melter proposal (CCN: 039390) to process all Hanford tank waste in a seventeen year operational period? If not, why not?

Assessment

The mission run in the TUA was completed to support an assessment of the benefits of oxidative leaching in reducing the number of HLW glass canisters produced. Oxidative leaching treatment of the HLW sludge is one strategy to reduce the HLW canister production requirement. These results showed that the IHLW canister production requirements without and with oxidative leaching is ~35,000 and ~23,000 canisters respectively. Based upon average HLW vitrification capacity of 480 canisters/year this corresponds to 73 to 48 years of production operations. Estimates by CHG for the December 2005 Development Run have estimated canister production at 11,100 canisters corresponding to 23 years of operation.

The primary reasons for the TUA not showing that the HLW production can be completed in 17 years include:

- HLW glass waste loading assumptions, based upon the WTP contract, which project lower waste incorporation rates
- Use of outdated wash and leach factors, primarily for sulfate, which leads to higher concentrations of sulfate in the washed sludge, thereby increasing waste loading
- Uncompleted ultrafiltration system design improvements which slow the treatment rate of the Pretreatment facility.

Because of the use of these major assumptions, the capability of the WTP facilities to meet ORP's strategic goals cannot be met. It is also possible that the WTP design has other issues which have not been identified. These issues will be evaluated in an ORP requested TUA assessment (05-WED-032) to be completed by BNI.

2. Can management of secondary waste support potential increases in flush volume due to hydrogen in pipes and ancillary vessel control strategies?

Assessment

BNI has not finished development of the design approach for hydrogen mitigating strategy. Therefore, the Tank Utilization model does not include elements of the hydrogen mitigation strategy. No conclusions about tank utilization and capacity can be reached until the additional flush volume and frequencies are assessed in the Tank Utilization model.

Assuming the hydrogen mitigation strategy for pipes and ancillary vessels results in increases in flush volumes, the plant wash vessel (PWD-VSL-00044) would be used to collect additional flush volume before processing in the feed evaporator process (FEP) system. BNI has assessed the utilization of the plant wash vessel PWD-VSL-00044 during sequential alkaline and oxidative leaching run conditions for the mission duration (24590-WTP-MRR-PO-05-006, scenario 4.0.8a). The batch volume of waste solution in plant wash vessel PWD-VSL-00044 varies from minimum heel to a maximum of ~65,300-gallons (March 10, 2023), which is ~94% of the maximum batch volume (69,166-gallons) allowable in this vessel. The batch volume of waste solution in plant wash vessel PWD-VSL-00044 is frequently in excess of 80% of the maximum batch volume, as shown in Figure B-2.

The additional flush volumes generated from the hydrogen mitigation strategy must either not result in exceeding the maximum batch volume in PWD-VSL-00044 or more frequent transfers of waste solutions to the FEP system must occur.

3. What opportunities exist to simplify the Pretreatment flowsheet to increase effectiveness of process operations?

Assessment

Table B-2 identifies several opportunities to simplify the Pretreatment flowsheet to increase effectiveness and potentially mitigate issues with unwanted solids formation observed in the ACM Steady State Flowsheet model.

Table B.2 Opportunities to Simplify Pretreatment Flowsheet

Stream	Current Disposition	Proposed Change	Benefit
Oxidative leachate solution from UFP-VSL-00062C	Routed to FEP system	Route to TLP system	Reduces IHLW glass produced by avoiding potential precipitation and recycle of chromium to UFP system
Cesium nitric acid eluate stream	Routed to CNP system for evaporation, recovery and re-use of nitric acid. CNP concentrate routed to HLP	Route directly to HLP	Eliminates CNP system
Cesium ion exchange caustic regeneration solution	First 1,300 gallons of caustic regeneration solution is routed to PWD-VSL-00015/16 and then to the FEP system. Second 1,200-gallons of caustic regeneration solution is recycled to CXP-VSL-00005 for use in displacing the LAW feed from the cesium ion	Route to TLP system	Simplifies chemistry and avoid potential solids precipitation issues.

Table B.2 Opportunities to Simplify Pretreatment Flowsheet

Stream	Current Disposition	Proposed Change	Benefit
	exchange column.		
Cesium ion exchange column elution with nitric acid	Column is eluted in the down-flow direction; same as LAW load direction	Elute column in up-flow direction	Reduces cross contamination of resin and head space in column; removes solids that may have collected / precipitated in column

4. Do material balances for key streams close?

Assessment

The TUA report does not provide material balances or process volume balances for key waste streams nor was this information located by the Oversight Team in the model run reports accompanying the TUA report. These are necessary to ensure that the results from the TUA are valid.

Table B-1 Summary of Design Capacities Demonstrated in WTP Tank Utilization Assessment

Scenarios	Purpose	Results	Comments [1]
AP-101 and AY-102/C-106 (no leaching)	Demonstrate tank utilization at 3,400 Na units of LAW and 6 MT/day IHLW for commission feed	IHLW Glass: 6 MT/day ILAW Glass: 30 MT/day Pretreated LAW: 2400 units of Na/year	**Scenario does not demonstrate PT facility meets required nameplate capacity of 3,400 units of Na/year.** The two UFP trains were operated independently with LAW/HLW blended feed or LAW only feed. The implications of this UFP operating mode were "… when lag storage was full, the ultrafiltration train discharging solids was idle until sufficient room was available to complete the solids transfer. When lag storage was full, the second ultrafiltration train processed AP-101 (LAW feed) without blending the LAW and HLW feeds. Because one ultrafiltration train was often idle and waiting to discharge solids, the HLW facility limited ultrafiltration and the PT sodium throughput" (24590-WPT-RPT-PO-05-008, page 14). However, the ACM model for the AP-101 / AY-102 feed assumed a different operating mode for the ultrafilter trains, "… where both ultrafilter trains are allowed to concentrate in parallel" (24590-WTP-RPT-PO-05-009, page 21). BNI did not fully assess the tank utilization or waste chemistry implications of operating the ultrafilters trains for these two proposed operating scenario.

Table B-1 Summary of Design Capacities Demonstrated in WTP Tank Utilization Assessment

Scenarios	Purpose	Results	Comments (1)
TPA Phase 1 Milestone with HLW melter at 6 MTG/day	Assess performance of the WTP through the end of the TPA Milestone M-062-00A (2/28/2018)	Average yearly production for years 1 thru 7 IHLW Glass: 4.8 MT/day ILAW Glass: 22.7 MT/day Pretreated LAW: 2400 units of Na/year	**Scenario does not demonstrate WTP facilities meet required nameplate capacities.** Average yearly production rates are based on data from Table 3.1 and Section 3.2.1 (page 42) of TUA. Assumes 5.58 MTG/ ILAW container and 3.13 MTG/ IHLW canister per BARD pages 3.2-34 and 4.2-29. Year 0 is hot commission and year 8 is terminated in February, therefore data from these years are not included in the average yearly production rates.
TPA Phase 1 Milestone with HLW melter feed storage unlimited	Assess performance of the WTP through the end of the TPA Milestone M-062-00A (2/28/2018) assuming unlimited HLW melter feed stored: decouples HLW Pretreatment from HLW Vitrification	Average yearly production for years 1 thru 7 IHLW Glass: 4.9 MT/day ILAW Glass: 26.8 MT/day Pretreated LAW: 2,850 units of Na/year	**Scenario does not demonstrate WTP facilities meet required nameplate capacities.** Average yearly production rates are based on data from Table 4.1 and Section 4.3 (page 87) of TUA. Assumes 5.58 MTG/ ILAW container and 3.13 MTG/ IHLW canister per BARD pages 3.2-34 and 4.2-29. Year 0 is hot commission and year 8 is terminated in February, therefore data from these years are not included in the average yearly production rates.
Mission Run with Alkaline	Evaluate effect of alkaline leaching[1] on the	Average yearly production IHLW Glass: ~5.78 MT/day	**Scenario does not demonstrate WTP facilities meet required nameplate**

[1] Caustic leaching only performed if it will reduce the quantity of HLW glass by 10% or more for a waste batch per section 1.4.2 of 24590-WTP-PO-05-008.

Table B-1 Summary of Design Capacities Demonstrated in WTP Tank Utilization Assessment

Scenarios	Purpose	Results	Comments (1)
Leaching; No Oxidative Leaching	performance of the WTP while processing entire DOE supplied feed vector.	ILAW Glass: ~16.6 MT/day Pretreated LAW: No data provided	**capacities.** Average yearly production rates are based on data from Sections 5.1 and 5.2 (page 89 and 90) of TUA. ILAW: 16.6 MTD = (12%)(30MTD) + (88%)(14.8MTD) IHLW: 5.78 MTD = (12%)(4.18MTD) + (88%)(6MTD)
Mission Run with Sequential Alkaline and Oxidative Leaching	Evaluate effect of sequential alkaline and oxidative leaching[2] on the performance of the WTP while processing entire DOE supplied feed vector.	Average yearly production IHLW Glass: ~5.6 MT/day ILAW Glass: ~23.5 MT/day Pretreated LAW: No data provided	**Scenario does not demonstrate WTP facilities meet required nameplate capacities.** Average yearly production rates are based on data from Sections 5.3 and 5.4 (page 99 and 100) of TUA. ILAW: 23.5 MTD = (11%)(30MTD) + (89%)(21.4MTD) IHLW: 5.6 MTD = (11%)(4.18MTD) + (89%)(5.8MTD)
Nameplate Capacity	Contract Requirement	IHLW Glass – 6 MT/day ILAW Glass – 30 MT/day Pretreated LAW – 3,400 units/year	None

(1) All Tank Utilization Assessment model runs assume WTP availability is 100%. Therefore availability is not considered when assessing design capacity.

[2] Sequential oxidative leaching only performed if it will reduce the quantity of HLW glass by 10% or more for a waste batch per section 1.4.4 of 24590-WTP-PO-05-008.

References

1. 24590-WTP-RPT-PO-04-025, Rev. 2, 2005 Deliverables Concept Paper, dated May 26, 2005.

2. September 13, 2004", Richland, Washington.

3. 24590-WTP-MRR-PO-05-006, June 10, 2005, *Dynamic (G2) Flowsheet 2005 TUA Extended Run with Sequential Oxidative Leaching Run Results, Scenario 4.0.8a*, Bechtel National Inc., Richland Washington.

4. 24590-WTP-PL-ENG-01-004, Rev 2.0, "Design Process Plan and Description", August 4, 2004, Bechtel National Inc., Richland Washington.

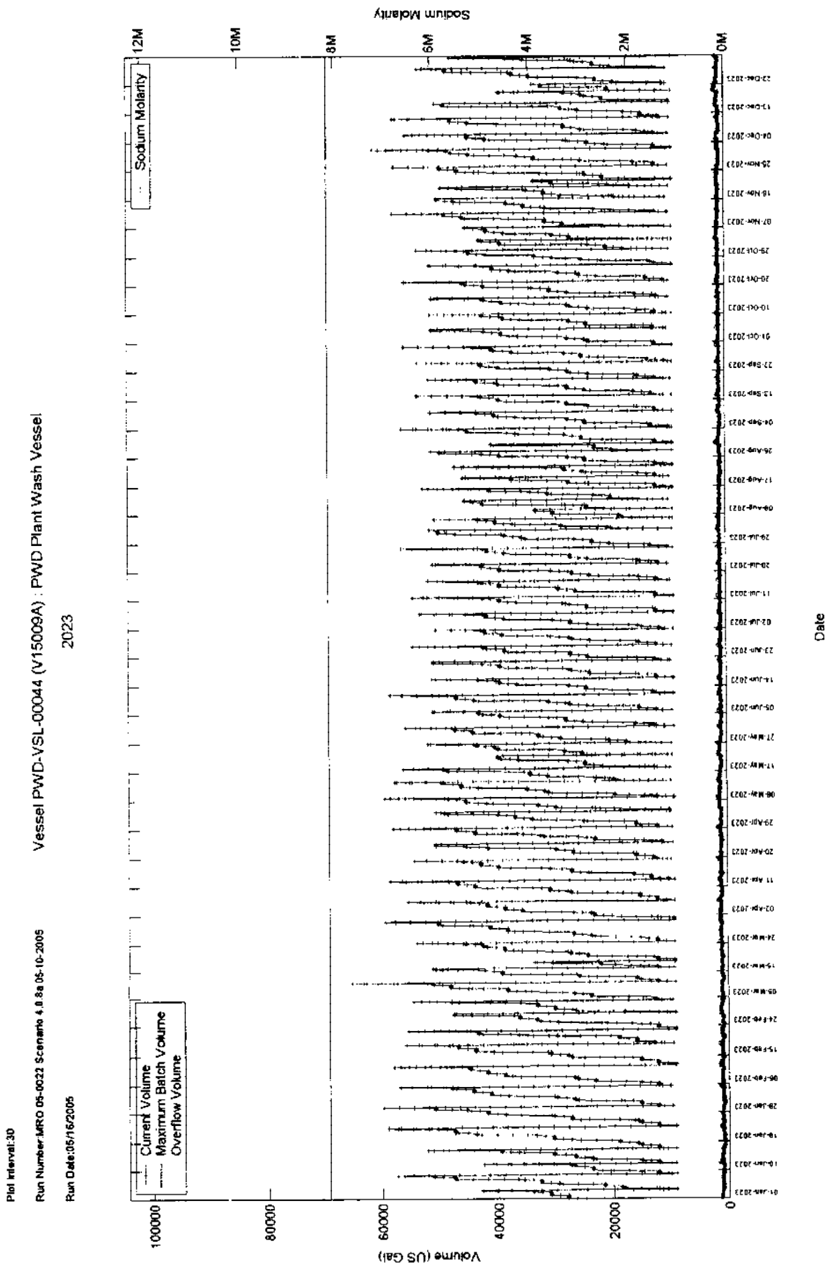
5. 05-WED-032, Letter ORP to BNI, *Ultrafiltration Process (UFP) System Capacity Improvement Study Results and Direction*, dated November 14, 2005, Office of River Protection, Richland, Washington.

6. CCN: 106650, Letter BNI to ORP, *Transmittal of Ultrafiltration Capacity Improvement Study Reports*, dated July 19, 2005, Bechtel National Inc., Richland Washington.

7. P&O-2003-DI-PO-001, *Desk Instructions, Process Operations: Document and Data Review Tracking*, Bechtel National Inc., Richland Washington.

8. PNWD-3206, 2003, *Filtration, Washing, and Caustic Leaching of Hanford Tank 241-AZ-101*, Pacific Northwest National Laboratory, Richland Washington.

Figure B-2 Plant Wash Vessel PWD-VSL-00044 Utilization for 2023



APPENDIX C
WTP STEADY STATE FLOWSHEET ASSESSMENT, DELIVERABLE 2.7

Contract Compliance Questions

1. Do the material balances estimate the quantity of ILAW, IHLW, and relevant secondary streams for the three feed tank compositions analyzed?

The 2005 WTP Material Balance and Process Flowsheet Assessment reported annual estimates of IHLW, ILAW, and Pretreated LAW. Data was included for all significant points in the WTP process. Modeled streams included applicable data for physical properties, gas composition, aqueous composition, and solid composition. Stream results were documented in:

- 24590-WTP-MRR-PO-05-018, Rev 0, Steady-State Flowsheet (AES) Version 4.0, AP-101 with AY-102/C-106 Blended Run for Deliverable 2.7.
- 24590-WTP-MRR-PO-05-007, Rev 1, Steady-State Flowsheet (AES) Version 4.0, SY-102 Oxidative Leaching Run for Deliverables 2.7 and 2.8.
- 24590-WTP-MRR-PO-05-019, Rev 0, Steady-State Flowsheet (AES) Version 4.0, AZ-101 Run for Deliverable 2.7.

Production of primary waste streams for the three model runs are summarized in the following table:

Table C-1 Primary Waste Stream Production Rates

Stream	AY-102/AP-101	SY-102	AZ-101	Nameplate Capacity
IHLW glass	5.9 MT/d	2.3 MT/d	2.5 MT/d	6 MT/d
ILAW glass	30 MT/d	30 MT/d	30 MT/d	30 MT/d
ILAW units/year	1320	1400	1490	
Pretreated LAW units/year	3210	2110	3680	3400

Assessment: The 2005 WTP Material Balance and Process Flowsheet Assessment provided the required estimates of primary and secondary streams.

2. Does the Steady State Flowsheet assessment provide annual estimates for ILAW, IHLW, and relevant secondary streams?

24590-WTP-MRR-PO-05-018, 24590-WTP-MRR-PO-05-007, and 24590-WTP-MRR-PO-05-019 provided estimates of primary and secondary streams in kilograms per hour. These can readily be converted to annual estimates.

Assessment: The 2005 WTP Material Balance and Process Flowsheet Assessment provided the required estimates of primary and secondary streams.

3. Is the Steady State Flowsheet consistent with the latest process verification testing, product qualification activities, and feed characterization information, as appropriate?

Waste feed composition used in the Steady State Flowsheet was based on reconciled Research and Development characterization data obtained from tank waste samples provided to the WTP project. The reconciliation process was documented in three memoranda (CCN: 087361 for AY-102, CCN: 087360 for AP-101, and CCN: 092312 for AZ-101.

The Steady State Flowsheet predicted precipitation reactions that were not observed in the Semi-Integrated Pilot Plant testing with the AY-102/AP-101 simulant. This is discussed further in Other Technical Questions 1 and 2 below.

BNI has a process to reconcile research and technology test report results with WTP models and associated basis documentation. This process is described in P&O-2003-DI-PO-001, Desk Instructions, Process Operations: Document and Data Review Tracking. A Review Tracking Coversheet is prepared for each test report documenting BNI's assessment of results and identifying required changes to models or associated basis documentation. Change requests are prepared when revisions to models or associated basis documentation is required.

BNI tracks progress in reconciling test reports. Figure A-1 presents the current status and projection for reconciling test reports with models and associated basis documentation. Based on discussions with BNI, over 150 reports are issued that have not been reviewed for reconciliation. Completion of the reconciliation process is projected to extend through 2007. BNI also stated this schedule may be extended as a result of FY 2006 project funding levels. The review team considers review of research and technology test reports to reconcile models and basis documentation critical to assuring the WTP design has appropriate technical underpinning. Completion of review and reconciliation of data in test reports is critical to support the project's objective to provide appropriate separation between design and construction to reduce project risk to more reasonable levels. Information learned from research and technology reports has the potential to impact facility equipment design, waste routing, process flowsheet design, and operational performance.

Comparison of Steady State Flowsheet results with product qualification activities was not performed in this design oversight.

<u>Assessment</u>:

BNI has a systematic process to verify that the Steady State Flowsheet is consistent with the latest process verification testing, product qualification activities, and feed characterization information. However, this verification is not complete or current putting WTP process design and associated facility equipment design at risk.

4. Has BNI demonstrated WTP waste treatment capacity using process modeling? Plant capacity requirements include:

  a. Pretreatment

    1. Basis of Design (BOD) availability of 80%

2. HLW Pretreatment shall support vitrification of an average of 480 canisters of IHLW per year.
3. LAW Pretreatment shall process and average of 2,200 Na waste units per year. BNI shall notify DOE if the governing unit operation drops below 3400 total Na units per year or predicted availability drops below 2950 total Na units per year (~86% availability if governing unit is 3400 total Na units per year).

b. HLW
    1. BOD availability of 70%
    2. Produce an average of 480 canisters per year assuming 1.16 cubic meters of glass per canister

c. LAW
    1. BOD availability of 70%
    2. Produce glass with an average of 733 Na waste units per year.

The Material Balance and Process Flowsheet Assessment assumed processing was performed 365 days per year and did not provide an assessment of availability.

The Steady State Flowsheet provides an indication of the production rate that could be achieved while processing the specific feed being analyzed with 100 percent availability. Accordingly, the oversight compared production rates achieved in the Steady State Flowsheet against facility nameplate production rates specified in the WTP Contract and Basis of Design. If the nameplate production rate was not achieved the oversight team evaluated potential rationale for the lower than nameplate performance.

Nameplate production rates assumed in this analysis were as follows:

Pretreatment
- 3400 LAW units per year
- 6 MT IHLW glass per day

HLW
- 6 MT glass per day

LAW
- 30 MT glass per day

All three feeds analyzed in the Steady State Flowsheet assessment failed to achieve Contract nameplate capacities. Treatment of AP-101/AY-102 was the only feed that approached the nameplate capacity for HLW of 6 MT glass per day.

To approach the HLW nameplate capacity for AP-101/AY-102, BNI modified the operating approach to run the UFP trains in parallel. 24590-WTP-MRR-PO-05-018, Rev 0 stated the following "1) for UFP - the cycle time >= ½ * (time to concentrate solids + time to treat solids)." BNI has not demonstrated that tank utilization while operating in this mode is feasible. ORP requested a G2 Model Run (ORP Letter, 05-WED-032) to evaluate potential enhancements to the WTP ultrafiltration process. Enhancements expected to be evaluated in this assessment include operating the UFP trains in parallel.

For AZ-101, Contract capacity for treatment and immobilization of HLW was not demonstrated. The assessment attributes the low IHLW production to low solids concentration in the feed coupled with the Cs ion exchange constraint of 7.5 gpm while processing Envelope B AZ-101 supernatant. The BARD states this limit was established to be consistent with laboratory testing.

AZ-101 solids are currently planned to be blended with C-102 solids to reduce the hydrogen generation rate associated with this material. This blending should allow delivery of slurry with higher solids content and facilitate IHLW production. Future model runs should place less emphasis on the AZ-101 feed because it will not be provided to WTP for treatment in its current state.

The BARD specifies reduced processing for Envelope B (AZ-101 and AZ-102) supernatant. AZ-102 supernatant will be blended with other lower sulfate supernatant and should not be constrained to 7.5 gpm while processing. AZ-101 supernatant will be commingled with other waste supernatant in the process of blending the AZ-101 solids. BNI should define criteria for blending the AZ-101 supernatant to allow processing at higher rates. CH2MHILL plans for managing the AZ-101 supernatant should consider these criteria.

The caustic leaching process modeled in the flowsheet was not effective in removing solid aluminum from the HLW solids. Figure 3-1 of the 2005 WTP material Balance and Process Flowsheet Assessment shows that HLW solids delivered to WTP include 5.20 kg Al per hour. The Figure also shows concentrated solids sent to HLW vitrification include 6.03 kg Al per hour. The overall solids pretreatment process is precipitating soluble aluminum into HLW solids resulting in increased production of IHLW. The process does not meet the Contract Specification 12 performance standard for caustic leaching.

The caustic leaching flowsheet included in the Steady State Flowsheet Assessment is not consistent with the flowsheet included in the TUA. Changes were made to the TUA flowsheet that predict and add increased levels of caustic to improve Al solubility. Similar changes, if implemented in the Steady State Flowsheet Assessment may improve caustic leaching performance. Little progress has been made over the past two years by BNI in developing and assessing an effective caustic leaching process with the Steady State Flowsheet. If uncorrected, the BNI flowsheet will result in unacceptable HLW solids pretreatment and unreasonably increase the quantity of HLW glass produced over the mission and extend mission duration.

The projected IHLW production rate of 2.5 MT IHLW per day would be lower if an effective caustic leaching process were implemented. Waste loading would increase in the IHLW resulting in less required glass production per quantity of HLW solids treated. The Tank Farm Contractor plans to blend the AZ-101 solids with C-102 solids. Future assessments should place less emphasis on the AZ-101 feed.

For SY-102, BNI has not demonstrated required nameplate performance for both HLW and LAW treatment. BNI attributed the reduced LAW capacity to lack of LAW feed associated with the HLW feed. BNI attributed the reduced HLW capacity to high HLW glass waste loading and sodium oxalate precipitation in the Plant Wash Drain system being recycled to the UFP process and occupying space required to treat HLW solids.

See Other Technical Questions 1 and 2 below for a details discussion of the sodium oxalate precipitation issue.

5. Has BNI maintained configuration control to manage the models and analyses?

BNI maintains configuration control of the models according to requirements in their procedure 24590-WTP-GPP-IT-008, Software Life Cycle Management and processes defined in 24590-WTP-GPP-PT-013, Lifecycle Control of Process Models.

24590-WTP-MRR-PO-05-018 stated the following, "The Steady-State Flowsheet (AES) Version 4.0 was verified and validated and was documented in the *Steady-State Flowsheet (AES) Version 4.0 Verification and Validation Report* (24590-WTP-VV-PO-05-003). This model run (24590-WTP-MRQ-PO-05-0035) was executed on the baseline AES Version 4.0 with scenario specific modifications as described in the Run Plan. The model inputs and results have been verified and validated in accordance with the requirement in the *Lifecycle Control of Process Models* (24590-WTP-GPP-PT-013) procedure."

Assessment: The review team found configuration control of the Steady State Flowsheet Assessment acceptable.

Other Technical Questions

1. Are precipitation reactions predicted and observed in the Steady State Flowsheet results? Do precipitation reactions present operations issues?

The ACM Steady State Flowsheet model does include prediction of some precipitation reactions, which is an improvement over previous versions of this model. However, the model does not track all solid compounds known to be present in the feeds analyzed. For example, the Tank Farm contractor has conducted mixing tests with tank AP-101 supernate and tank AY-102 solids with supernate (see letter 7S110-RWW-04-029, *241-AP-101 / 241-AY-102 Mixing Study Report*). These tests indicate dawsonite ($NaAlCO_3(OH)_2$) is present in the AY-102 solids and may dissolve when mixed with AP-101 supernate. Additional studies conducted by the Tank Farm Contractor with tank AY-102 solids have resulted in the identification of several solids phases, including dawsonite ($NaAlCO_3(OH)_2$) and cancrinite ($Na_6Ca_{1.5}Al_6Si_6O_{24}(CO_3)_{1.6}$) (see letter 7S110-DLH-03-007, *Caustic Demand Test Results, Tank 241-AY-102 Sludge*). Similar studies with AZ-102 solids have also tentatively identified the presence of dawsonite in this waste as well (see letter CH2M-0205411.1, *Caustic Demand Test Results, Tank 241-AZ-102 Sludge*).

Dawsonite and cancrinite solid phases are not tracked in the ACM Steady State Flowsheet model, as indicated by their absence from Table 3-1 on page 35 and Table A-5 on page A-5 of the *WTP Material Balance and Process Flowsheet Assessment* report. Discussions with BNI personnel on December 14, 2005 confirmed the ACM Steady State Flowsheet model does not include these solid phases.

The ACM Steady State Flowsheet model has not been updated to include the aluminum solubility correlation developed by BNI. BNI has incorporated an aluminum solubility correlation in the *2005 WTP Tank Utilization Assessment*. Therefore, insufficient sodium hydroxide is added in the ACM Steady State Flowsheet model to maintain aluminum in solution during alkaline leaching of HLW sludge. This leads to inaccurate prediction of precipitation issues, HLW glass composition / mass and LAW glass composition / mass.

Assessment: The Steady State Flowsheet has made significant advancements in its ability to predict precipitation reactions. Further work is required to better understand and predict WTP process flowsheet performance. This information is required to demonstrate treatment capacity and confirm facility design and performance.

2. Have solutions to precipitation issues been proposed and implemented?

BNI has identified potential solutions to precipitation issues listed in Table C-3. BNI is still evaluating the identified precipitation issues to determine appropriate implementation of resolutions. BNI has identified precipitation issues and proposed solutions relating to the FEP and UFP systems, but has not implemented proposed solutions.

Precipitation of 5.8% solids in the LAW treated concentrate vessel (TCP-VSL-00001) was identified in the AP-101/AY-102 Steady State Flowsheet Assessment. BNI stated this result is inconsistent with observations in the Semi-Integrated Pilot Plant (SIPP). BNI stated further work is required to reconcile flowsheet data with SIPP results, assess mixing capability, and assess vessel design criteria including erosion allowances.

The Oversight Team has identified the following additional precipitation issues as a result of this Oversight.

- **Sodium oxalate management resolution will increase HLW glass mass** - BNI has proposed the following resolution to the recycle and precipitation of sodium oxalate during the processing of SY-102: "*The run results reported for SY-102 are for the baseline process as described in the BARD. No attempt has been made to optimize the caustic and oxidative leach processes. It is noted in the AZ-101 evaluation that a scoping run was made using the UFP rigorous model to determine the affect of reducing the wash volume after caustic leaching on sodium oxalate dissolution. By reducing the wash volume to less than 1 concentrate volume, essentially all the sodium oxalate could be prevented from dissolving.*"

  The SY-102 glass formulation is already at 88% of the total alkali limit (page 36, Table 3-2) and boric acid (a glass former not planned for use in the WTP) must be added during HLW Vitrification to avoid increasing the glass mass (top of page 33). Reducing the UFP wash volume to prevent sodium oxalate from dissolving will increase the mass of sodium in the UFP concentrated solids and would increase the mass of HLW glass produced from processing SY-102. BNI should assess sending the UFP wash solution forward to the CXP system to avoid sodium oxalate re-precipitation and addition to the UFP concentrated solids.

- **Solids blockage of Cs ion exchange column** - The waste solutions recycled to the ion exchange system (stream CXP09) are predicted to contain solids; 0.115 kg/hr for AZ-101 (page C-8), 0.128 kg/hr for AY-101/AP-101 (page C-20), and 0.14 kg/hr for SY-102 (page C-32). The UFP permeate from processing SY-102 is also predicted to contain 0.0482 kg/hr (18.8-ppm) solids (stream UFP33, page C-32). These solids will accumulate in the lead ion exchange column, cause blockage during LAW solution processing, and interruption of waste treatment processing. BNI should assess sending stream CXP09 forward to the TLP system to avoid solids blockage in the cesium ion exchange column.

- **Solids formation in treated LAW solution from Cs ion exchange column** – The ACM model predicts an increase in the mass flow rate (kg/hr) of solids in the pretreated LAW solution exiting the ion exchange columns (stream CXP08) relative to the CXP feed solution (stream CXP01) for AZ-101 and SY-102 wastes. This may be due to precipitation of solids in the cesium ion exchange column or an artifact of the ACM model architecture (e.g. column regeneration solutions blended with pretreated LAW solution post ion exchange column). Precipitation of solids in the cesium ion exchange columns would lead to blockage and interruption of waste treatment processing. BNI should investigate the cause for solids formation in stream CXP08).

- **Solids in Feed Evaporator condensate** - During processing of SY-102 waste, the ACM model predicts the solids content of stream RLD01 is 366-ppm (0.96 kg solids / hour ÷ 2.62E+03 kg total mass / hour). The main source of these solids is stream FEP12, condensate from the feed evaporator process system, which contains 2.51 kg of solids / hour. Process condensate from the feed evaporator should not contain solids. BNI should investigate the cause for solids formation in steam FEP12.

Assessment: BNI has identified potential solutions to some of the precipitation issues observed in the Steady State Flowsheet. However, the review team found that several precipitation issues were overlooked by BNI. Further work is required to better understand precipitation issues and development of potential solutions. This information is required to demonstrate treatment capacity and confirm facility design and performance.

3. Do material balances for key streams close?

The material balances for key waste streams were manually verified to close.

Assessment: The review team found closure of the material balances for key waste streams to be acceptable.

4. What opportunities exist to improve the capability of the Pretreatment process flowsheet?

BNI has identified in the ACM Steady State Flowsheet model that solids form during recycle of several waste solutions (e.g. ultrafiltration system wash solution recycled to the waste feed evaporator system and ion exchange regeneration solution recycled to the ion exchange feed vessel). The formation of additional solids affects the throughput of the ultrafiltration system, could lead to blockage of the cesium ion exchange column, and increase the mass of HLW glass.

BNI should accelerate their ongoing effort to validate the accuracy of their thermodynamic model through reconciliation of completed Research and Testing reports. BNI should assess sending these waste solutions forward in the process and / or transfer problematic waste streams to Supplemental LAW Treatment to avoid these operational issues. See the Open Item under Other Technical Questions number 2.

The Steady State Flowsheet model feeds the leachate from the ultrafiltration process forward to the cesium ion exchange process. Feeding the leachate forward to the cesium ion exchange process could result in the feed composition changing during the loading cycle. Changing the feed composition during the loading cycle of the cesium ion exchange process will result in changing the equilibrium between competing cations (e.g. Na, K and Cs) with the resin and may result displacing cesium from the resin. The Steady State Flowsheet model does not assess the impacts from changing feed compositions during the ion exchange loading cycle. BNI should use the G2 model to predict the changes in the ion exchange feed composition during processing and then use a first principles cesium ion exchange model to predict impacts from changing the feed (WSRC-TR-2004-00100 and BNF-003-98-0220).

Assessment: BNI has continued to increase the level of technical maturity of the Steady State Flowsheet model. Validation of the model through reconciliation of completed Research and Testing reports still needs to be completed. The Steady State Flowsheet model provides a resource for assessing potential solutions to precipitation issues and demonstrating treatment capacity. The assessment team found BNI has not fully exercise the model for this purpose. This information is required to demonstrate treatment capacity and confirm facility design and performance.

Table C-2 identifies several opportunities to simplify the Pretreatment flowsheet to increase effectiveness and potentially mitigate issues with unwanted solids formation observed in the ACM Steady State Flowsheet model.

Table C.2 Opportunities to Simplify Pretreatment Flowsheet

Stream	Current Disposition	Proposed Change	Benefit
Oxidative leachate solution from UFP-VSL-00062C	Routed to FEP system	Route to TLP system	Reduces IHLW glass produced by avoiding potential precipitation and recycle of chromium to UFP system
Cesium nitric acid eluate stream	Routed to CNP system for evaporation, recovery and re-use of nitric acid. CNP concentrate routed to HLP	Route directly to HLP	Eliminates CNP system

Table C.2 Opportunities to Simplify Pretreatment Flowsheet

Stream	Current Disposition	Proposed Change	Benefit
Cesium ion exchange caustic regeneration solution	First 1,300 gallons of caustic regeneration solution is routed to PWD-VSL-00015/16 and then to the FEP system. Second 1,200-gallons of caustic regeneration solution is recycled to CXP-VSL-00005 for use in displacing the LAW feed from the cesium ion exchange column.	Route to TLP system	Simplifies chemistry and avoid potential solids precipitation issues.
Cesium ion exchange column elution with nitric acid	Column is eluted in the down-flow direction; same as LAW load direction	Elute column in up-flow direction	Reduces cross contamination of resin and head space in column; removes solids that may have collected / precipitated in column

Table C-3 2005 WTP Material Balance and Process Flowsheet Assessment; BNI Identified Solutions to Precipitation Issues

Page	Text
Page viii, 5th Par.	Envelope B/D (AZ-101) Summary "Changes to the washing process after caustic leaching, such as adding sufficient caustic to control aluminum precipitation, may improve waste loading."
Page ix, 2nd Par.	Envelope A/D (SY-102) Summary "For waste tanks containing oxalate, operational changes to the UFP washing cycle may significantly benefit IHLW production."
Page 15, (AZ-101) Section 3.1.3.1.2, 1st Par.	"Approximately 16 % of total aluminum received into the ultrafiltration process is from the FEP evaporator, which contains concentrated recycle streams. During mixing and cooling, gibbsite (Al(OH)3) precipitates. This precipitation is attributed to cooling. During this step, the total solid gibbsite increases by a factor of 3.6 above the amount in the original feed. Noticeable gibbsite precipitation is observed during initial cooling in UFP-

Table C-3 2005 WTP Material Balance and Process Flowsheet Assessment; BNI Identified Solutions to Precipitation Issues

Page	Text
Page 15, (AZ-101) Section 3.1.3.1.2, 2nd and 3rd Par.	VSL-00001A/B, where a factor of two times more gibbsite solids are sent to HLW Vitrification than are received in the WTP from the tank farms." "Increasing the sodium hydroxide concentration in the caustic leach step and/or increasing the sodium hydroxide concentration in the wash water and reducing the volume of wash water may reduce the amount of aluminum sent to the HLW Vitrification." "An additional analysis using only the UFP rigorous chemistry model was performed to examine the effects of reducing the volume of wash water used after leaching. The test involved reducing the wash water volume to about 25 % of original. The results show that reducing the wash volume prevented sodium oxalate solids from re-dissolving and less gibbsite precipitated in the washing step. Additional studies with the rigorous chemistry models around UFP can be performed to improve the process. Based on this single evaluation, it is likely that adjustments to the amount of sodium hydroxide and wash volume can be made that will improve the overall aluminum dissolution efficiency for caustic leaching."
Page 19, Section 3.1.4 *AZ-101 Conclusions*, 1st Par.	"No unexpected or unusual amounts of solids are precipitated in the plant. Additional improvements to the leach process would be necessary to maximize aluminum dissolution if this tank were to be campaigned through the facility."
Page 23, (AP-101/AY-102) Section 3.2.3.1.2	"Recycled solids (including sodium oxalate and sodium silicate octahydrate) account for 21.5 % of the total solids fed to the ultrafiltration blend vessels. Unlike the SY-102 flowsheet (Section 3.3.3.1.2.1), the recycled solids did not inhibit solids throughput enough to make ultrafiltration the limiting unit operation. It is noted that operational approaches to reduce the amount of recycles, such as reducing wash volume and increasing the pH of the wash, have not been included in this investigation."
Page 26, Section 3.2.4 *AP-101/AY-102 Conclusions*, 1st Par.	"In addition to the sodium silicate octahydrate and sodium oxalate solids formation in UFP, sodium carbonate solids form in the Treated LAW Evaporator (TLP); however, the solids concentration is low, so it is not expected to cause operational problems."
Page 28, (SY-102) Section	"The SY-102 HLW pretreated feed production is 58.3 kg

Table C-3 2005 WTP Material Balance and Process Flowsheet Assessment; BNI Identified Solutions to Precipitation Issues

Page	Text
3.3.3.1.1.1, 5th Par. And Page 29, 1st Par.	solids/hr, resulting in 2.3 MTG per day IHLW. The reason for this limited production rate is primarily the high oxalate concentration of the feed, combined with the benefits of increased waste loading resulting from oxidative leaching. HLW production is limited due to the small size of the batches transferred to HLP-VSL-00027A/B, resulting from the dissolution/precipitation of sodium oxalate. Sixty percent of solids in a concentrated solids batch are sodium oxalate. During treatment of the batch of solids, 86 % of the sodium oxalate dissolves. Much of the dissolved sodium oxalate is recycled to the next UFP batch as a solid by way of the FEP evaporator. Details of this phenomenon are discussed in the oxidative leaching section below. The SY-102 UFP process is performed based on two trains, such that one train is concentrating solids while the other train is treating solids. This is the baseline operating plan described in the UFP System Description (24590-PTF-3YD-UFP-00001). However, based on the results of this run, HLW production is limited by the UFP process. As discussed earlier in this section, the time to concentrate a batch of solids to 20 % solids is 62 hours and the time to treat the solids is 92 hours. This means that changing the filter operating approach to two trains operating in parallel could gain al 33 % improvement."
Page 30, (SY-102) Section 3.3.3.1.2.1, 1st Par.	"Recycled solids (including sodium oxalate) account for 52 % of the total solids fed to the ultrafiltration blend vessels. It is noted that operational approaches to reduce the amount of recycles, such as reducing wash volume, have not been included in this investigation."
Page 33, Section 3.3.4 *SY-102 Conclusions*, 2nd Par.	"The run results reported for SY-102 are for the baseline process as described in the BARD. No attempt has been made to optimize the caustic and oxidative leach processes. It is noted in the AZ-101 evaluation that a scoping run was made using the UFP rigorous model to determine the affect of reducing the wash volume after caustic leaching on sodium oxalate dissolution. By reducing the wash volume to less than 1 concentrate volume, essentially all the sodium oxalate could be prevented from dissolving."
Page 34, (SY-102) Section 3.4, 1st Par.	"For the SY102 run, the FEP solids concentration is greater than 8.9 wt% (10.2 wt% solids); however, the wt% solids constraint does not apply for the reasons which follow."

References

1. 7S110-DLH-03-007, *Caustic Demand Test Results, Tank 241-AY-102 Sludge*, Interoffice Memo dated October 17, 2003 from D. L. Herting to K. G. Carothers, CH2M Hill Hanford Group Inc. Richland Washington.

2. CH2M-0205411.1, *Caustic Demand Test Results, Tank 241-AZ-102 Sludge*, Interoffice Memo dated March 23, 2004 from D. L. Herting to K. G. Carothers, CH2M Hill Hanford Group Inc. Richland Washington.

3. 7S110-RWW-04-029, *241-AP-101 / 241-AY-102 Mixing Study Report*, Interoffice Memo dated October 14, 2004 from R. W. Warrant and G. A. Cooke to J. H. Rasmussen, CH2M Hill Hanford Group Inc. Richland Washington.

4. 24590-WTP-RPT-PO-05-009, revision 0, 2005, *2005 WTP Material Balance and Process Flowsheet Assessment*, J. Bernards and E. Lee, Bechtel National Inc., Richland Washington.

5. CCN: 087361, *Reconciliation of Tank AY-102/C-106 Waste Characterization Data*, memorandum dated July 20, 2004 from J. G. Reynolds to S. A. Sanders, Bechtel National Inc., Richland Washington.

6. CCN: 087360, *Reconciliation of Tank AP-101 Waste Characterization Data*, memorandum dated June 7, 2004 from J. G. Reynolds to S. A. Sanders, Bechtel National Inc., Richland Washington.

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8. P&O-2003-DI-PO-001, Desk Instructions, Process Operations: Document and Data Review Tracking

9. 24590-WTP-MRR-PO-05-018, Rev 0, Steady-State Flowsheet (AES) Version 4.0, AP-101 with AY-102/C-106 Blended Run for Deliverable 2.7.

10. 24590-WTP-MRR-PO-05-007, Rev 1, Steady-State Flowsheet (AES) Version 4.0, SY-102 Oxidative Leaching Run for Deliverables 2.7 and 2.8.

11. 24590-WTP-MRR-PO-05-019, Rev 0, Steady-State Flowsheet (AES) Version 4.0, AZ-101 Run for Deliverable 2.7.

12. BNF-003-98-0220, 2000, *Preliminary Ion Exchange Modeling for Removal of Cesium from Hanford Waste Using SuperLig® 644 Resin*, L. L. Hamm et al, Westinghouse Savannah River Company, Aiken South Carolina.

13. WSRC-TR-2004-00100, 2004, *Ion Exchange Modeling for Removal of Cesium from Hanford Waste Using Resorcinol-Formaldehyde Resin*, B. J. Hardy et al, Westinghouse Savannah River Company, Aiken South Carolina.

APPENDIX D

WTP OPERATIONS RESEARCH, TANK UTILIZATION, AND STEADY STATE FLOWSHEET ASSESSMENT QUESTIONS ASKED BY THE DESIGN OVERSIGHT TEAM

The following questions were presented to BNI during the design oversight and were discussed with BNI on December 13-15, 2005. BNI provided written responses on January 11, 2006.

Operations Research Assessment, Deliverable 2.5

Questions

1. ES, second para. page viii. The Executive Summary states that "*When RAM data was activated for these four integrated facilities, the WTP met the requirements specified in the WTP contract Statement of Work (DE-AC27-01RV14136) of producing 480 canisters per year of immobilized HLW and 733 Na waste units of immobilized LAW per year.*"

   A determination of the treatment capacity, as stated above, requires an understanding of the design capacity and availability as determined by the OR Model. What is the design capacity of each of the WTP facilities and where is this design capacity documented and verified? What role does the Dynamic Model have in determination of the design capacity? (LH)

   As stated in Section 1.0, the OR Model baseline design capacity is:
   PT - 80 MTD LAW glass production equivalent
   LAW - 30 MTD of ILAW
   HLW - 6 MTD of IHLW

   Design capacity is documented in Basis of Design and implementing design calculations. The dynamic model demonstrates plant performance under various feed conditions. The dynamic model does not determine design capacity.

2. Executive Summary, page viii. The availability of the PT, HLW and LAW facilities is stated as 83%, 82% and 72% respectively. Based upon this data the "availability" of the HLW system (HLW Pretreatment and HLW Vitrification) is 68% (83% x 82%) and the LAW system (LAW Pretreatment and HLW Vitrification) is 60% (83% x 72%). These system availabilities are further modified, although slightly, by the availability of the LAB and BOF.

   Considering the "composite" availability (e.g. "*When RAM data was activated for these four integrated facilities...*") is the following statement still correct "*the WTP met the requirements specified in the WTP contract Statement of Work (DE-AC27-01RV14136) of producing 480 canisters per year of immobilized HLW and 733 Na waste units of immobilized LAW per year.?*"

   Scenario 1 integrated all plant failures. The results for "composite" availability are found in Section 3.5 of the OR Assessment Report and confirm that the facility availabilities support the treatment capacities specified in the WTP Contract Statement of Work.

What are the availabilities of the LAB and BOF? (LH)

The LAB availability was not determined individually for this assessment. However, the impact of LAB failures is included in evaluations of other facilities. The BOF availability was evaluated by Relex, and was determined to be near 100% due to equipment redundancy built into the design as discussed in section 3.7 of the assessment report.

3. The OR model was used to simulate a 12 year operating period to determine availability. Was an availability determined for discrete time periods (e.g. annually) and averaged, or is the availability determined over the entire time period only. If the availability is determined over discrete time periods, what is the distribution of availabilities, including the median and mean availability? What is the confidence level associated with the estimate of availability? (LH)

   The availability was determined over the entire period of 12 years. Ten replications were performed and the average production from these runs was reported.

4. Section 1.1 Purpose. The stated purpose of the assessment is "*to confirm that the design and operating features of the facilities support the plant availability requirement*". Given this purpose, please explain the role of the Target Availability Critierion from the Basis of Design and OR Model result. Also please identify the "margin" allowed in the OR assessment to have an acceptable availability outcome. (e.g. the Target for PT is 80% and the OR Model predicted 83%, is the 3% difference [3/80 = 3.75%] considered acceptable based upon the uncertainty in the OR Model and the WTP design?). How small does the availability margin need to be before a design change is warranted? (LH)

   The Basis of Design (BOD) availability requirement versus the OR Model results:
   PT - 80% BOD. 83% with PT hot cell valve life extension, and 72% without.
   HLW - 70% BOD. 82% OR Model results.
   LAW - 70% BOD. 72% OR Model results.

   As a result of reduced availability for PT, further evaluations are underway to assess improvements and potential design changes.

5. Section 1.2. Why was the Relex software used for determination of the BOF availability? (LH)

   Relex was used because it is less complex, and more suitable for this type of analysis.

6. Section 1.2. What was the assumed availability for the glass former facility in the current OR assessment? How does that availability compare with the specification for the procurement of the glass former facility, or the actual vendor results if currently available? (LH)

The glass former facility was assumed 100% available in the OR Assessment. However, without vendor data and input, we realize that this is an uncertainty. We plan to incorporate the glass former facility vendor data in a future update.

7. Table 1-1. Does the 15% rework of analytical samples apply to all samples? Please explain how the samples are processed in the LAB, e.g., are they processed as first-in/first-out (FIFO), or based upon the need to maintain vitrification facility operations, or some other basis? (LH)

   The 15% rework of analytical samples applies to all samples. All samples--including sample rework--are processed based on FIFO and assigned priority. The hold point samples (e.g., PT2, HLW2, and LAW 1) are assigned the highest priority, and are worked first once these samples enter the Laboratory. The non-hold point samples are assigned the lowest priority, and are worked after the priority samples are processed.

8. Was LAW and HLW melter replacement considered in the determination of availability? What was the time duration assumed for the replacements of the LAW melter? What was the time duration assumed for the replacement of the HLW melter? (LH)

   Both LAW and HLW melter replacement are considered in the determination of availability. (Melter replacement does not occur when the system is at 100% availability.) The time duration for either Melter (LAW or HLW) is 6 months. This includes the removing of the spent melter, the installation of the new melter, and the 30 day heat up period. This figure was based on the experience of Lee Stegman, DWPF Melter Outage Manager, and the WTP Mechanical Flow Diagrams that contain a step-by-step process for replacing and installing melters.

9. Please explain the build-up of the MTTR duration. Is it assumed that once a component fails (except for redundant components) that its failure is instantly diagnosed and instantly the equipment component is repaired? (LH)

   Yes - a failure is instantly diagnosed- as the assumed remedy is to replace with no diagnoses prior to replacement. Diagnoses can occur after the fact to prevent future repairs.
   No - an equipment component is not instantly repaired. An appropriate MTTR is applied.

10. Did the PT operations cases consider caustic leaching of the HLW sludge? (LH)

    All PT cases did not consider caustic leaching of the HLW sludge. However, it is not expected to affect availability. The valve failure associated with caustic leaching is already included in the OR Model. Including caustic leaching could affect overall throughput due to the additional time required, but not availability. Availability is defined as (Throughput with failures/Throughput without failures)

11. Did the HLW Vitrification facility and LAW Vitrification facility OR assessments include solid waste size reduction, solid waste packaging and handling? (LH)

Neither HLW nor LAW Vitrification included solid waste size reduction, solid waste packaging and handling into the OR assessment. Both HLW and LAW Vitrification solid waste size reduction are not expected to impact availability of the plant because the size reduction function is independent of the vitrification process equipment.

12. Section 2.1. The OR Model assessment report indicates "There are never labor constraints on PT, HLW and LAW". Was any factor used to assess labor inefficiency due to human limitations or operating requirements particularity for the mechanical handling operations? (LH)

    No, labor inefficiencies are not included in the evaluation of the PT, HLW, and LAW, including mechanical handling operations. Labor constraints/inefficiencies are factored in establishing staffing levels.

13. Section 2.1. Please identify the "critical components' that could effect the operation of the processing facilities? (LH)

    Critical components are those that if failed, could directly impact the process throughput. Examples of critical components include ion exchange columns, essential pumps and valves, and melter bubblers. The critical components are detailed in the RAMI reports.

14. Section 2.2, page 6. How are the availability results for the PT facility affected by first wash, second wash and caustic leach process alternatives? (LH)

    PT availability is primarily a reflection of equipment reliability, and not on process variations. If the utilization of equipment, pumps, and valves are similar among various process options such that the equipment utilization warranted similar RAM data, then the change in availability is expected to be insignificant.

15. Section 2.2, page 6. How are the availability results for the PT facility affected by the routing options for the LAW Vitrification facility recycle streams? (LH)

    In all OR Assessment scenarios, the LAW Vitrification recycle stream is transferred to a future Supplemental LAW treatment facility. Therefore, there is no data showing PT availability with the recycle routed back to the PT. However, as responded in Item 14, the PT availability is not expected to be significantly impacted.

16. Section 2.5.2, page 8, third para. Please identify the equipment that has a redundant unit installed. The uncertainty associated with the ability to repair the primary equipment, before the redundant equipment component fails, appears to be quite high, and therefore the conclusion that the required facility availabilities are achievable may not be valid. Why was this affect not evaluated in the OR Model more completely? (LH)

    Examples of redundant equipment include the FEP System, the HLW Offgas Systems HEMEs and HEPAs, the LAW Offgas System HEPAs, and RLD transfer pumps

The assumption of not modeling redundant equipment as critical equipment failures becomes an issue during high PT PIH utilization. The effect of the high crane utilization and the impact on the redundant equipment assumption will be evaluated as the crane utilization issue is resolved.

Redundant equipment can be separated into two categories, those requiring remote handling and those with hands on repair/replacement capabilities. There is no reason to believe that a competent operations crew cannot repair/replace redundant components in a timely manner, before failure of the redundant component in accessible areas. For those requiring remote handling, the number of components in HLW and LAW in remote handled areas (Melter Cell and Wet Cells) are relatively few and existing mechanical handling capabilities are deemed to be sufficient. In the case of Pretreatment, the Hot cell contains only one crane (PIH-004) capable of traverse over the entire area to remove and replace components from several systems, such that conflicting crane priorities, from critical components can limit the capabilities to repair redundant components (which are not currently considered critical). This limitation is recognized in the assessment and efforts are planned to reduce the demands on the hot-cell crane to under 85% utilized to provide capacity to assure timely repair of redundant components.

17. A single PT PIH crane does not appear adequate to support the PT facility operational requirements given the uncertainties identified in the OR Model report and the small margin in the availability between a compliant and non compliant PT facility treatment capacity. Has the design authority formally evaluated a second crane, or other more effective means, to improve PT performance? (LH)

    A formal evaluation has not been performed. Other evaluations that could potentially improve the crane utilization include PT hot cell valve life extension, decrease size reduction activities, and optimizing maintenance schedule and durations. The valve life extension vendor tests are being performed, and the other activities are being scheduled.

18. Table 3-2, page 14. The volume of waste processing in the PT is provided. The OR Model runs also assume that the waste is Envelope A/D. What are the other key assumptions associated with the "volume" of waste process? Please address Na concentration, solids concentration, assumptions on glass factor, and degree of treatment for the solids (e.g. water wash, caustic leach). Please address the appropriateness of these assumptions based on the expected feeds used in the Dynamic Model Assessment. (LH)

    The waste stream input into the WTP PT was Envelopes A/D waste feed. Envelope A/D was selected since it represented the largest volume of waste to be processed during phase 1. Similar to the commissioning feed, caustic leaching of the HLW sludge is not performed. Flow to the HLW Vitrification facility was based on an undissolved solid content of 20 weight percent. Waste loading in the HLW glass was set at 41% waste oxide. Waste loading in the LAW glass was set at 14% Na_2O. LAW concentrate sodium molarity was 8M.

    The OR model is designed to evaluate the impact of component failure and repair, and not chemical process optimization and therefore does not have the capability to readily evaluate various process conditions. Nominal process conditions were selected to provide a baseline flowsheet for the model, but do not drive availability considerations. They only provide a baseline to compare equipment failure and repair demands to. The TUA Dynamic Model is designed to provide the analytical capability for flowsheet options and is utilized to the extent required.

19. Page 14, Please explain how the PT availability of 83% is derived from the PT-LAW availability of 81%, and the PT-HLW availability of 91%. Is the value of 81% the appropriate measure of PT availability? If not, why not? How sensitive are these results to the assumptions used for the waste feed? (LH)

    The PT availability based on waste feed processed through PT was approximately 83%. This evaluation used results from the valve life extension scenario, MRQ 05-028. The PT-LAW train availability is approximately 81%, measured at post CXP based on volumetric flow. The PT-HLW train availability is approximately 91%, measured at post HLP based on volumetric flow. Approximately 80% of the PT feed comes from the LAW feed receipt, and approximately 20% of the PT feed comes from the HLW feed receipt.

    PT-LAW availability contribution + PT-HLW availability contribution = Overall PT availability

    (81%)*(80%) + (91%)*(20%) = 83%. This estimated PT availability is consistent with the availability determined by overall flow processed through PT.

20. Are the MTBF and MTTR rates specific to components and subsystem assemblies used in the WTP design or are these rates generic for typical industrial / nuclear applications? (MJ)

    The MTTR values were established for the specific WTP design taking into account the location and constraints for the individual component and/or subsystem assembly based on drawings or using IGRIP modeling. The MTBF value was based on several sources, that is, using the Savannah River Site Generic Database Development, WSRC-TR-93-262, Relex Reliability Software, Vendor supplied information, and the work experiences of engineers at other vitrification facilities, including DWPF and West Valley, or engineers who had other experiences in chemical processing or in the nuclear industry.

21. How does BNI ensure the procured components and subsystem assemblies meet or exceed the MTBF rates assumed in the OR model? (MJ)

    These are specified in the Engineering Specification and MR. The vendor is required to either meet our MTBF requirement (and document that) or specify (before award) what his equipment MTBF is, so that we (BNI) can consider the potential impact on availability prior to the award.

22. Does the OR model include assessment of oxidative leaching in the UFP system? (MJ)

    Note: Page 6, 2nd bulleted item does not list oxidative leaching as a selection option for the

UFP system. Therefore, it appears oxidative leaching is not assessed in the OR model.

Oxidative leaching is not assessed in the OR Model. The OR model is designed to evaluate the impact of component failure and repair, and not process optimization and therefore does not have the capability to readily evaluate various process conditions. Nominal process conditions were selected to provide a baseline flowsheet for the model, but do not drive availability considered. They only provide a baseline to compare equipment failure and repair demands to. The TUA Dynamic and AES Steady State flowsheet models are designed to provide the analytical capability for flowsheet options and are utilized to the extent required.

23. Page 7, Table 2-1 indicates the revised MTBF and revised MTTR durations for the CXP ion exchange columns are 10 years and 466 hours, respectively.
    a. What is the basis for the revised MTBF and revised MTTR durations for the CXP ion exchange columns?
    b. Are the CXP ion exchange columns or the high failure rate column components listed as critical spare parts that are on hand to support the 466 hour MTTR frequency? (MJ)

Note: Degradation of the B Plant cesium ion exchange organic resin (Duolite ARC-359) resulted in organic residue adhering to the internal components of the column and trapping radionuclides. The B Plant cesium ion exchange column that failed in December 1971 due to breach of the lower resin retention screen (RHO-RE-SA-169, page 8) exhibited excessive radiation dose rates precluding disposal for ~20-years.

The previous MTBF and MTTR for the CXP Ion Exchange columns assumed the columns will last the life of the plant. The revised MTBF is 10 years because it is assumed that the screen inside the column will plug. The 466 hours MTTR allow for the column replacement.

24. Page 8, 2nd paragraph states:

This operating and maintenance philosophy requires the temporary storage of the CXP ion exchange columns and UFP filter trains while the PIH crane is used to repair higher priority equipment.

   a. Does the PT facility have a dedicated area for temporary storage of failed equipment such as the CXP ion exchange columns and UFP filter trains awaiting size reduction?
   b. How long does the OR model predict failed equipment is temporarily stored within the PT facility before being accessed by the PIH crane for repair and/or disposal?
   c. Does the WTP RCRA Part B permit allow for temporary accumulation of failed equipment with the PT facility for the duration analyzed in the OR model? (MJ)

The model does not have the capability to predict the length of time a component spends in lay-up/storage but can monitor the number of items awaiting crane attention. The backlog is a measure of crane unavailability. A high crane availability and subsequent repair/disposal backlog are indicative of the need for design/analytical improvements, which are planned and recognized, in part in the assessment.

The PT hot cell is permitted for hazardous waste storage; therefore, from a regulatory perspective, failed equipment are allowed to remain in this area for extended periods.

25. Does the OR model include downtime for conduct of preventative maintenance and critical lift inspections / certifications for the PT PIH crane? (MJ)

    Yes, as follows:
    Daily: MTBM = 24 hours. MTTM = 1 hour
    Quarterly: MTBM = 2190 hours. MTTM = 24 hours
    Annual: MTBM = 8760 hours. MTTM = 96 hours

26. Page 18, section 3.4.1: BNI states B-27 containers will be used for disposal of failed equipment. The B-27 container will be disposed as radioactive solid waste at the IDF per interface control document 3. The void space within the B-27 containers will need to be filled to meet waste acceptance criteria for disposal at the IDF. Does the OR assessment (model) include the process steps necessary to fill the void space within the B-27 radioactive solids waste disposal containers? (MJ)

    No. The use of the B-27 containers was a recent design evolution and the consideration of process steps to fill package voids was not included because these are not considered process "Critical" activities. Supplemental jib cranes or support staff are considered sufficient to accomplish this task, without any demands on the PIH-004 crane impacting process throughput.

27. Appendix B, page B-9: The PIH crane is listed as a single component used in the OR flowsheet reliability data whereas other cranes and hoisting devices are identified with additional subcomponents (e.g. limit switches and cameras). The BARD (24590-WTP-RPT-PT-02-005, Rev. 3, page D-27) lists RAM data for the PIH crane as single system whereas RAM data is provided for limit switches and cameras associated with other WTP crane / hoisting systems.

    Was the OR Assessment conducted analyzing the PIH crane as a single system and not using individual components of the PIH crane such as limit switches, cameras, switchgear, and trolley motors? Is so, what is the rationale for analyzing the PIH crane as a single system instead of conducting the analysis using individual components of the PIH crane? (MJ)

    The RAM data associated with the PT PIH Crane is as follows. These RAM data are in addition to those stated in Item 25.

Breakdown item	MTBF	MTTR
PIH CRN 4	21900 hours (2.5 years)	120 hours
PIH RCVY 3	87600 hours (10 years)	720 hours
PIH RCVY 4	87600 hours (10 years)	720 hours

Because the PIH crane is recognized as important to PTF availability, frequent crane maintenance and inspection is included in demands on the crane availability to provide for regular replacement of failed equipment. With the PIH crane so highly utilized, failures will be identified on an ongoing basis, and repair included in regularly scheduled maintenance. Failures in other cranes, not so highly utilized would not be detected until the next demand, and would impact crane availability.

28. Inputs to the three RAM analyses include the "P-rate" and "Q-rate" associated with each component in the component database. All three analysis assume that these are set to unity (1.0) because of lack of applicable information or engineering judgment:
    a) What is the basis for these assumptions?
    b) How sensitive are the calculated availabilities for each scenario to this assumption? Has a sensitivity analysis been performed? What would happen to the calculated availabilities for each scenario if, say, both rates were set to 95%? (PC)

    Establishment of appropriate P and Q rates are a function of facility operating programs, procedures and practices, established over an extended period of operation and not appropriate for design basis considerations. No industry standard information is available for a facility of complexity similar to the WTP project.

29. It is stated that "Whenever possible, RAM data was verified by comparison of two or more sources":
    a) How was this done?

       The first order RAM data was compiled using the WTP Risk Analysis - Risk Goal Confirmation [24590-WTP-U7C-50-00001], The LAW Vitrification Capacity and Availability Study [24590-LAW-RPT-ENG-01-001], The Savannah River Site Generic Database Development [WSRC-TR-93-262], and the engineering experience from West Valley, DWPF, and staff with experience in chemical and Nuclear operations.

       The second order RAM data still considered the database information, but honed the data to WTP specific by including vendor information, R&T testing, radiation, temperature, and usage to refine the data.

    b) Provide a table (or point us to it) that includes the RAM data for each component with traceability to source data and verification data.

       Source data and references are provided in facility specific RAMI reports. Because of the one-of-a- kind nature of the WTP facilities, industry available verification data was used as initial input and supplemented through multidiscipline reviews with facility specific design attributes and the experience of engineering and operations staff. .

    c) What fraction of components in the database were so verified?

       In the RAM first-order most components were verified using *The Savannah River Site Generic Database Development*, and *The LAW Vitrification Capacity and Availability*

Study. During the second-order the verification went one step further and verified the values from the first-order, plus any new components being added to the RAM analysis to the datasheets, specifications, purchase orders, R&T, and vendor information. In some cases the value was validated by the new sources. In other cases the value changed because of the new information. Any two of these sources above was used to verify the values, in addition engineering experience and judgment was used in all instances.

d) What fraction of components (not counting multiple instances or clones of a "template" component) were so verified? (PC)

Most components were verified. A specific fraction has not been determined.

30. How does the OR model address process upsets. For example:
   a) What is the anticipated frequency of pluggage of various components, including pipeline, tanks, columns, pneumatic transfer equipment, melter 'pour spout', etc.
   b) What are the corresponding recovery strategy and times? (PC)

   The OR Model does not include process upsets. Failure items due to pluggage are addressed as failures (MTBF), and the time to recovery is considered as repairs (MTTR). Review of SRS Generic Database found that abnormal events (normally due to passive failures) occur at a much lower rate (1/100) than active failures such that active failures are the primary failure mechanisms.

31. How does the OR model address misrouting of waste by either transfer to the wrong destination or transfer before a sample hold point has been met. What is the expected misroute (misvalving, or other procedural error rate) in industry and in the DOE community? What are the consequences and recovery times? (PC)

   Process upsets and abnormal events are not addressed in the OR model. We are not aware of readily available industry documents for such occurrences at facilities comparable to the WTP.

32. How was the OR model verified? (PC)

   Model Verification & Validation (V&V) are performed in accordance with WTP Procedure 24590-WTP-GPP-PT-013, Lifecycle Control of Process Models. Verification consists of an independent review to ensure that source data has been properly entered into the computer program. Validation consists of an independent review of the program output to ensure that the results are representative of the changes/inputs to the software. The V&V test plan and test results are documented in project reports.

33. Clarify what is meant by "first-order" and "second-order" RAM assessments. (PC)

   To simplify the approach "First Order" can be defined as "system level", that is identifying those systems (process vs utilities) that can directly impact facility performance, and reviewing the complexity of the systems for impact on process throughput. "Second Order" takes the review to the major/critical component level to evaluate available reliability data and selected non-critical components that could indirectly impact throughput, such as non-critical PTF hot-cell valves and redundant pumps.

34. Have sensitivity analyses been performed to show how the various RAM assumptions impact the resulting availabilities? Please provide the results. (PC)

    Sensitivity reviews have been conducted on an as needed basis to support project design and procurement decisions. Sensitivity reviews were the basis for pursuing valve life extension and size reduction as potential means to alleviate the high demands on the PTF hot-cell crane.

35. Provide a ranked list or tornado plot of which components, classes of components, assumed failure modes, or recovery evolutions, drive the calculated availabilities. (PC)

    This information is not currently available. However, further studies are planned to address the critical components that drive the crane utilization and Pretreatment availability.

36. What process was used during the facilitated sessions to develop the RAM input data? What steps were taken to insure the objectivity of the participants? What oversight was provided? (PC)

    A cross-functional group of multi-discipline personnel with many years of experience with similar equipment located at West Valley, NY and DWPF at SRS reviewed and assessed the failure and availability data from several industry sources, and after making allowances for the particular environment of the WTP, reached a consensus on the values. Experienced systems engineering staff facilitated the sessions to ensure the discussions were focused with results/meeting minutes reviewed by systems engineering management staff.

37. The estimated availabilities for potentially significant BOF systems were near 100% (typically 99.5% or greater). From this, it was concluded that the BOF systems could be omitted from the WTP OR flowsheet. Were consequences considered in concluding that the BOF systems could be omitted from the WTP OR flowsheet? {In order to make that conclusion, the impact of these low-probability outages on the main WTP facilities needs to be of relatively low consequence. For example, if a short-term loss of electrical power would result in a failed melter (I'm not saying it would!), that would be a high-consequence impact. If however, there was a simple loss-of-production during the outage, that would be a low consequence impact. Likewise with loss of air resulting in a plugged tank due to loss of mixing.} (PC)

    The BOF analysis identified a high degree of redundancy in essential components resulting in a high (99.5%+) reliability for the utility systems leading to the conclusion that incorporating such low probability events into the OR model would not be cost effective. Safety consequences of BOF failures are considered in Integrated Safety Management (ISM) reviews and control features incorporated into the facility design as required.

38. Have HAZOP or similar analysis been performed. Have the results of these analysis (the range of potential deviations) been included as failure modes in the OR assessments? (PC)

    HAZOP has been done, but not included as failure modes in the OR Model. The results of HAZOP/ISM reviews have been included in the facility design and are documented in the authorization bases. Critical equipment added to the facility to mitigate such events are included in the OR model and anticipated failure modes incorporated in MTBF allocations. Other process upsets and abnormal events are not addressed in the OR model. WE are not aware of any readily available industry documents for such occurrences at facilities comparable to the WTP.

39. Have the OR assessments been used to allocate reliability requirements (MTTF, MTTR, etc) to the various systems, subsystems and components to be used for design and procurement purposes? How is this done? (PC)

    No. The OR assessments are confirmatory of engineering reliability requirements by incorporation of vendor specific data into the RAMI analysis and subsequently the OR model. Design changes such as the addition of a second HLW Decontamination Vessel have resulted because of OR analysis results.

40. Resolution of HPAV issues may result in increased number of valves, drains, and instrumentation in the hot cell. When will an OR assessment be performed assessing impacts to facility availability? How is RAMI analysis being considered in HPAV studies? (RG)

    Results of HPAV issues will be incorporated into RAMI analysis subsequent to safety and design issues being resolved and design changes issued. Impacts will be incorporated in the subsequent scheduled OR assessment. Safety implications of the HPAV issues need to resolved before RAMI considerations are appropriate.

41. How does the Operations Requirements Document (Table C.5-1.1, Deliverable 3.4) support the OR assessments or visa versa? Please provide a copy of the version of Deliverable 3.4 consistent with the OR assessments under review. (PC)

    The latest Operations Requirement Document, ORD (24590-WTP-RPT-OP-01-001) was issued in May 2003. There are no specific requirements in the ORD to be included in the OR Model. However, C&T team members participated in all RAMI sessions, providing input to maintenance data and repair times, which were included in the OR Model.

42. Appendix D of the BARD (24590-WTP-PT-02-005, Rev. 3) contains RAM data for the LAW Vitrification Facility Radioactive Liquid Waste Disposal (RLD) system (page D-41). Does the OR Assessment include RAM data for the Pretreatment and HLW Vitrification Facilities RLD systems and where is this data documented? (MJ)

    RLD system RAM data was evaluated and documented in first order RAM assessment data development reports. RLD RAM evaluations were performed for PT, HLW, and LAW. Only the stated LAW RLD failures were included in the OR Model because these failures were determined to be the only RLD failures that could impact WTP production.

43. Appendix D of the BARD (24590-WTP-PT-02-005, Rev. 3) contains RAM data for the LAW Vitrification Facility C5 Exhaust system (page D-42) and stack discharge monitoring systems (Page D-43). Does the OR Assessment include RAM data for the Pretreatment and HLW Vitrification Facilities C5 systems and stack discharge monitoring systems? Where is this data documented? (MJ)

    The HLW Vitrification offgas systems did consider stack discharge, but concluded that a stack monitoring failure would not immediately impact permitted operation, thus no immediate impact to production (CCN 068386). The PT offgas stack discharge was considered, but the failure was not included in the OR model for the same reason.

44. Appendix D of the BARD (24590-WTP-PT-02-005, Rev. 3) contains RAM data for NO_x and NH_3 analyzers associated with the LAW Vitrification Facility Secondary Off-gas Treatment system (LVP-SCR-00001, page D-41). Does the HLW Vitrification Facility Secondary Off-gas Treatment system include similar NO_x and NH_3 analyzers and does the OR Assessment include RAM data for these analyzers? (MJ)

    RAM review of the HLW Vitrification offgas system is documented in CCN 068386. All offgas equipment are considered. The OR Model contains failures for TCO and SCR (MTBF = 2 years; MTTR = 336 hours.) The TCO is to treat VOCs, and SCR is to treat NO_x.

45. The Appendix D of the BARD (24590-WTP-PT-02-005, Rev. 3) does not contain RAM data for the fresh resin addition system (CRD). Does the OR Assessment include analysis of the CRD system? (MJ)

    The OR Model includes RAM data associated with the fresh resin addition system.

46. Appendix D of the BARD (24590-WTP-PT-02-005, Rev. 3) does not contain RAM data for C3 ventilation systems, electrical, instrumentation, and control (EI&C) systems (with the exception of a few thermocouples, pressure transmitters, level transmitters associated with some systems). Does the OR Assessment include analysis of the C3 ventilation systems and EI&C systems? (MJ)

    No. C3 ventilation is not considered critical to facility throughput. Some electrical, instrumentation and control systems were considered as part of the overall RAM analysis on equipment failures. Additional reviews of I&C components are anticipated.

47. How does the composition of the A/D composite feed vector used in the OR assessment compare to the overall composition of the waste in the ORP-provided feed vector? To the extent that these are different in key parameters (total Na, total waste oxides, average glass factor), how can an OR assessment using the A/D composite reflect the availability of the WTP over the full mission using the existing waste as feed? (PC)

Feeds have little impact on equipment availability. The waste that was fed to the OR model is similar to a commissioning feed that is washed only. Full mission analysis have not been assessed in OR. Availability is not expected to be significantly different for different waste feeds. Tank utilization has a larger dependence on waste feed type.

WTP Tank Utilization Assessment, Deliverable 2.6

Questions

1. Page 5, Section 1.4.1, 4[th] bulleted item states "A variable permeate flux through ultrafiltration that is based on wt% solids and *viscosity of the waste*". However, the Flowsheet Bases, Assumptions and Requirements document (page 2.3-5, section 2.3.3.2) states the flowsheet contains a variable flux rate depending on wt% solids and sodium molarity.

   Is the UFP filter flux a function of the waste viscosity or the waste sodium molarity and if a function of waste viscosity how does the G2 model estimate waste viscosity? (MJ)

   The filter flux is a function of sodium molarity in the flux equation. Experimental data shows a linear relationship between sodium molarity and viscosity. Permeate flux rates are physically dependent on viscosity, but the model does not calculate and track viscosity so a sodium molarity dependence has been used. The BARD will be updated to clarify that a sodium molarity relation has been used to simulate viscosity dependence.

2. Page 9, Section 1.4.4, 5[th] and 6[th] bulleted items indicate a decision rule was used to determine when alkaline leaching and/or oxidative leaching is applied to HLW batches. Alkaline (oxidative) leaching is applied only when Al (Cr) is an HLW glass limiting component and if alkaline (oxidative) leaching will reduce the quantity of HLW glass by 10% or more for a waste batch. WTP contract specification 12 does not specify the use of this decision criterion. This decision criterion could lead to the production of up to 1,000 to 2,000 additional HLW canisters, relative to the Development Run results of ~11,000 canisters (RPP-RPT-23412).

   What is the technical basis for using 10% or more increase in HLW glass as a decision criterion for alkaline leaching or oxidative leaching? Has BNI conducted assessments assuming all waste batches that are Al and Cr limiting in the HLW glass undergo alkaline and/or oxidative leaching? (MJ)

   10% was selected as a starting point. We would expect that using this (10%) criteria would lead to more canisters being produced, however, it would also lead to less reagent (permanganate and caustic) being consumed, and less reaction time for those batches that are not leached.

3. Page 21, Table 2.3: This table indicates the LAW glass produced from the reconciled AP-101 and AY-102 / C-106 feed contains 0.0159 wt% MnO_2 – process, that is manganese oxide added during waste processing. The assumption for the reconciled AP-101 and AY-102/C-106 feed assessment (see section 1.4.1 on page 5) state no caustic leaching is performed, nor are oxidative leaching and the SR/TRU precipitation conducted.

   What is the source of the MnO_2 – process identified in the LAW glass produced from the reconciled AP-101 and AY-102 / C-106 feed? (MJ)

The source is glass former impurities. If you look at table 3.4 on pg 52 (data from TFC feed), the quantity of process Mn is also much higher than the glass former impurity quantity.

4. Section 2.3.4, page 23: The tank utilization assessment states "Most of the flowsheet's mineral demands are within or slightly outside the specification's range [for the glass former facility]. Sending slightly smaller batches of waste from the CRV to the MFPV will accommodate the difference. This will result in an increase in the number of batches during these periods." A similar finding/recommendation is presented in section 2.4.4 (page 26) with regards to the glass former demand during HLW vitrification of the AP-101 and AY-102 / C-106 feed. Sections 3.3.4 (page 57) and 3.5.6.2 (page 69) contain similar analyses.

   Does the OR Assessment incorporate this finding/recommendation from the Tank Utilization Assessment? (MJ)

   No it does not. The statement above says that "most are within..." Note: the number of cycles in the OR model will not impact availability.

5. Section 3.1.2, page 30, 5th full paragraph: The analysis indicates that the LAW and HLW Vitrification facilities both experience periods of idle time due to one of two conditions; (1) the TFC LAW feed list gets more than 1 year ahead of the TFC HLW feed list or (2) an excess of pretreated HLW solids in the HLW lag storage vessels. Section 4 of the Tank Utilization Assessment address a scenario where unlimited HLW melter feed storage is assumed to determine the impacts of mitigating condition (2).

   Has BNI assessed a scenario where no restrictions are applied to the TFC LAW and HLW feed lists to assess the implications of condition (1)? (MJ)

   If no restrictions were applied to the TFC LAW feed list, LAW feed would continue to be blended with HLW with the total LAW feed expiring at an earlier date. This would lead to longer continuous periods of ILAW melter usage because HLW feed would be the only feed to the plant. This also leads to shorter concentration times in ultrafiltration, which leads to less permeate and less ILAW production. This complication could possibly be improved by feeding less LAW to the WTP during phase 1 production when HLW waste loading is high. The LAW could then be fed to the plant during phase 2 when the waste loading is lower.

6. Section 3.1.2, page 31: Based on the assessment in section 3.1.2 (TPA Phase 1 Milestone with HLW Melter at 6 MTD), BNI has concluded the WTP LAW Vitrification facility would experience idle periods during years 5 through 8 of the WTP operation due to an excess of pretreated HLW solids in the HLW lag storage vessels causing stoppage of the UFP system. The average ILAW production rates are only 22 MTD in year 5, 21 MTD in year 6, and 11 MTD in year 7, compared to 30 MTD for years 1 through 4.

   The BNI assessment does not address that the Supplemental LAW Treatment facility would also experience idle periods in years 5 through 8 as well due to the same conditions that idle the WTP LAW Vitrification facility.

BNI recommendations to mitigate this include: (1) delivering less LAW feed in years 1 through 4 and delivering more LAW feed in years 5 through 8, which results in less pretreated LAW being sent to Supplemental Treatment, (2) a lower throughput of the Supplemental LAW Treatment, (3) optimization of the UFP blend, or (4) higher waste loading in the HLW glasses. Additional mitigating action could be (5) addition of Supplemental LAW Pretreatment to independently supply pretreated LAW feed to the Supplemental LAW Treatment facility or (6) conducting Sr/TRU precipitation in the DST system and blending the Sr/TRU precipitate with HLW sludges in the DST system. DOE should consider evaluation of these mitigating actions in future assessments. (MJ)

Acknowledged.

7. Section 3.1.4, page 36, last paragraph. BNI incorrectly has assumed that the waste sodium present in the candidate CH-TRU and RH-TRU tanks is processed with the TRU wastes component and transferred to WIPP for disposal, crediting the processing 1,800 MT of sodium. Only the ~300 MT of sodium present in the candidate CH-TRU wastes (B-201 thru B-204, T-201 thru T-204, T-104 T-110, and T-111) are planned for transferred to WIPP for disposal. The candidate RH-TRU wastes are assumed to be water washed to remove soluble components / radionuclides before packaging for disposal at WIPP. (MJ)

   The water washing explanation was not included in the referenced document (HNF-SD-WM-SP-012). If there is another document please reference. If the "RH-TRU" tanks are water washed and the sodium is returned to the WTP the filtration would be fast due to the absence of solids. Future evaluations will address the delivery of the remaining sodium.

8. Section 3.3.3, page 55, Figures 3-13 and 3-14: The predicted ^{90}Sr and TRU concentrations in the ILAW glass produced in year 4 exceeds the contract requirements of 20 Ci/m^3 and 100 ηCi/gram. From Table 3.3, it appears the LAW and HLW feeds sources during year 4 are batch group 6 (AN-107 and HLW-PH2-11). What batch group causes the predicted ^{90}Sr concentration in the ILAW glass to exceed the contract limit of 20 Ci/m^3? Can pretreatment process adjustments (e.g. additional strontium and permanganate precipitation reagents, longer digest period, etc.) further reduce the soluble ^{90}Sr and TRU. Process conditions necessary to meet ILAW glass contract requirements should then be incorporated into appropriate process models. (MJ)

   The data point in figure 3-13 (High Sr) is due to the AN-107 feed. There was a partial batch in UFP-VSL-00001A/B that was not treated with the Sr/TRU strike. The treated LAW that was fed forward was high in dissolved Sr and TRU. This will be processed differently in future model runs.

9. Section 3.3.3, pages 54 - 55: BNI states the reason for the predicted TRU concentration in the ILAW glass exceeding the contract requirements of 100 ηCi/gram periodically in years 4 through 8 as the TFC feed delivered should be classified as Envelope C, not Envelope A. BNI further states "The waste loading in the LAW glass could be reduced to bring the TRU concentration down to acceptable limits during these periods. This means approximately

40% more glass would be made during the last peak in Figure 3-14".

The waste loading in the ILAW glasses would need to be reduced to meet TRU concentration limit, which could affect the Pretreatment Facility production rate. The validity of the Tank Utilization Assessment results is potentially in question since BNI did not analyze the effect of producing additional ILAW glass to meet the TRU concentration limit.

Pretreatment facility production rate is not affected by this, because an alternate facility is available to send the excess treated LAW. There are also time periods during years 4 through 8 when the LAW melter has the capability to process 40% more glass.

Did BNI apply the Sr/TRU precipitation process conditions and appropriate glass formulations to all feeds BNI identified as Envelope C as part of the Tank Utilization Assessment?

Sr/TRU precipitation was applied according to the TFC tank designation as previously agreed to with ORP. Only tanks AN-102 and AN-107 were treated for Sr/TRU.

Does feeding the HLW sludge leachate permeate forward to the cesium ion exchange process contribute to the TRU concentration exceeding 100 ηCi/gram periodically in years 4 through 8? (MJ)

The 100 ηCi/gram is exceeded because the LAW glass model does not currently limit the amount of TRU loaded into LAW glass. Feeding the leachate forward to ion exchange does not contribute to the high TRU levels fed to IX because the TFC does not provide leach factors for TRU, Pu, or Am (so they are not leached). The periods of high TRU feed to IX is dependent on the high TRU levels in the tank farm feeds. The levels during these periods classify the waste as envelope C waste (see Appendix E) according to the contract, but the TFC classifies the waste as envelope A waste.

10. Section 5.1, page 89: The average LAW glass production rate is stated as 14.8 MTD for the no oxidative leaching scenario analyses for the completion of the mission. What is the annual average treatment capacity for the LAW Vitrification facility in terms of Na waste units per contract specification 7.2.3 over the mission duration? (MJ)

    This was not assessed.

11. Section 5.2, page 90: What is the annual average HLW canister production in terms (canisters per year) over the mission duration? (MJ)

    This was not assessed.

12. Section 5.3, page 99: The average LAW glass production rate is states as 19.6 MTD for the oxidative leaching scenario analyses for the completion of the mission. What is the annual average treatment capacity for the LAW Vitrification facility in terms of Na waste units per contract specification 7.2.3 over the mission duration? (MJ)

This was not assessed.

13. Section 5.4, page 99: What is the annual average HLW canister production in terms (canisters per year) over the mission duration for the oxidative leaching case? (MJ)

    This was not assessed.

14. Section 5.5.2, page 114: The oxidative leaching process is assumed to dissolve 1% of the plutonium present in the HLW sludges, per page 23 of the G2 Model Design Document (24590-WTP-MDD-PR-01-002, Rev. 8). What is the projected TRU concentrations in the ILAW glasses produced over the mission duration for the no oxidative leaching and the oxidative leaching cases? (MJ)

    This analysis was not performed. The data is indirectly available, but extensive manipulation is required to obtain this result.

15. BNI appears to report pretreatment throughput for LAW units of sodium based on the maximum adjustment in Specification 7.2.3 instead of the actual based on waste composition and achievable waste loading. What are demonstrated PT facility throughputs when assessed using the Contract Specification 7.2.3 LAW unit definition? (RG)

    It is not possible to track waste envelope types through the model. After the waste feed batches are received (in the model) the waste is tracked by chemical components, not by waste type. This makes it difficult to determine which waste oxides correspond to envelope B feed.

16. The volume of flush solution to operate the Pretreatment facility on an annual basis is 4 to 5 Mgal. Please provide a representative breakdown of the flush solutions which includes: source (e.g. flushing line XXX of flushing vessel XXX), volume generated during each event and number of flushes on an annual basis. If there is a better method to demonstrate that the flushing operations and volume of flush solutions is understood please provide this. (LH)

    The volume of line flushes is shown in appendix H of the G2 Model Design Document (MDD). The logic for these line flushes are described in sections 4.7 and 4.8 of the MDD. The Model Change Request number for vitrification line flushes is 24590-WTP-MRQ-PO-04-0029. The MCR number for PT line flushes is 24590-WTP-MRQ-PO-04-0025.

17. Please provide a volume balance for the liquid flows in the WTP that demonstrates that the liquid flows are understood and that there is adequate closure on the volume balance. Please select a representative years in which there is near normal operations. (LH)

    This has been provided to Langdon.

18. Please confirm if the data files provided to ORP during the Oxidative Leaching Oversight that show the MFPV chemical batch compositions for the no oxidative leaching and

oxidative leaching case are the same as from the current model deliverable. If not please provide these files. (LH)

The files for Figures 5-3, 5-4, 5-13, and 5-14 are the same as the files that were provided in the Oxidative Leaching Oversight paper by Slaathaug.

19. How does the composition of the reconciled AP-101, AY-102/C-106 feed vector compare to the average or median composition of the waste in the ORP-provided feed vector? (PC)

    There is less sodium and nitrite in the reconciled feed than in the AP-101, AY-102/C-106 feed vector from the TFC. This is probably due to the fact that sodium nitrite was added to the waste, and the reconciled feed is based on sample data that was taken prior to the reagent addition. An extensive comparison has not been done.

20. How many curies of I-129 and Tc-99 are expected to be transferred to Supplemental LAW Treatment via the "LAW SBS/WESP Recycle" stream (labeled "LAW Collection 2" in Figure 1-2) for the full mission. How many curies of I-129 and Tc-99 were in the feed to the WTP? How many end up in the WTP ILAW product? (PC)

    This has not been assessed.

21. How much additional solids storage capacity is needed to store solids pretreated from Envelope C processing pending blending with other pretreated HLW without impacting the HLW throughput? (PC)

    This has not been assessed.

22. Was a consistent basis used throughout the assessment:
    a) Waste Envelope determined by waste composition

    Waste Envelope was specified by the TFC, but there were many occurrences where the TFC envelope designation exceeded the Specification 7 and 8 limits.

    b) Units sodium per MT Na determined by waste composition and contract-permitted influences

    Units of sodium were calculated based on TFC classification and Specifications 7 and 8 limits (see pgs 80-85). These units were calculated based on the feed.

    c) Sr/TRU removal performed for the subset of Envelope C batches with high Sr or TRU to Na concentrations.

    AN-107 and AN-102 were classified as envelope C by the TFC. There were other batches that exceeded Sr and TRU contract limits, but they were treated based on the TFC classification.

d) Cs IX pump rate reduced only for the subset of Envelope B batches with high Cs:Na ratios.

IX pump rate was 7.5 gpm for envelope B and 15 gpm for all other envelopes. The envelope designation was based on the TFC classification, which was frequently out of spec.

e) Ultrafilter operating modes and cycle times consistent with a-d and decision to caustic leach or oxidative leach. (PC)

There is not a consistent cycle time to concentrate an ultrafiltration batch. A variable flux equation is used that is dependent on the viscosity and solids in the waste feed (See BARD). There are constant reaction times associated with caustic and oxidative leaching. The time to reconcentrate after leaching will be variable dependent on the variable flux equation and the leach factors.

23. Concerning the M-62-00A milestone evaluation: The evaluation of the pretreatment and vitrification of 800 MT of HLW waste oxides has traditionally[3] been based on the waste feed oxides incorporated into the HLW glass (i.e., after pretreatment and vitrification). Was this same basis used in the tank utilization assessment? (PC)

Yes. See the first paragraph on pg 36 of the Assessment. The vitrification of 800 MT HLW oxides was met 6 months after hot operations began.

[3] TFCOUP Revision 3A, page 35, note on Figure 3-2: "The M-62-00A milestone requires 10% of the mass and 25% of the activity to be processed by 2/28/2018. It has been interpreted as: immobilize 6000 MT of {waste from delivered feed} sodium in LAW glass canisters and 800 MT of {waste from delivered feed} oxides in HLW glass canisters." {braces mine}

WTP Steady State Flowsheet Assessment, Deliverable 2.7

Questions

1. The Tank Utilization Assessment incorporated changes to the caustic leaching process that improve the effectiveness of removing Al from the tank waste solids. The Material Balance and Process Flowsheet Assessment did not include similar flowsheet changes. Why do the two assessments utilize different leaching processes? (RG)

   Both the TUA and Material Balance Assessments utilize the feed-forward concept for caustic leaching, in which the caustic leachate is fed-forward to the LAW facility instead of being recycled back to the PWD system. In the TUA, a correlation for aluminum solubility in the leachate is solved iteratively to determine the amount of caustic required to dissolve the equivalent amount of aluminum specified in the feed vector. This approach was used because G2 is not a chemistry model. For the Material Balance Assessment, caustic was added per the System Description consistent with Specification 12 to reach 3M free hydroxide in the slurry. Studies using the Steady-State Rigorous Chemistry model to determine how much caustic to add for optimal aluminum dissolution have not yet been performed. These studies will be performed for a future assessment. The reason the leachate is fed forward instead of being recycled back to PWD is to reduce aluminum re-precipitation in PWD/FEP.

2. Section 3.1.1.3 states that if caustic leaching is successful "aluminum will not be the waste limiting component in IHLW." Section 3.1.3.2 stated the waste from 241-AZ-101 was aluminum limited. The flowsheet presented in the Material Balance and Process Flowsheet Assessment resulted in increased solid aluminum in the feed to HLW vitrification relative to the feed from tank farms (See figure 3-1). BNI's Process Flowsheet Assessment does not result in plant performance conforming to the Contract Specification 12 performance specification for caustic leaching. How will BNI correct the flowsheet to efficiently leach aluminum from tank waste solids? (RG)

   First, it is important to note that solid aluminum in AZ-101 WTP feed is 252% of the Specification 8 expected maximum. The solid aluminum increases over that in the feed when it is mixed with recycle from the FEP evaporator, due to the precipitation of gibbsite as the temperature is reduced from >50°C to 25°C. During treatment of the filtered solids with caustic, 64% of the aluminum is dissolved, however, 33% of the aluminum that dissolved re-precipitates during cooling and washing due to the reduction in temperature and hydroxide concentration. Increasing the sodium hydroxide concentration in the wash water and reducing the volume of wash water will reduce the amount of aluminum sent to HLW Vitrification. Preliminary analysis using only the UFP rigorous chemistry model indicates that less gibbsite will precipitate if the volume of wash water is reduced by 25%. Additional rigorous chemistry modeling is needed to determine caustic addition requirements to substantially increase the overall aluminum dissolution effectiveness.

3. The assessment of AP-101/AY-102 utilized parallel UFP system operation to achieve required processing throughputs. Has tank utilization been assessed to determine if this

mode of operation is feasible? (RG)

Parallel UFP operation is feasible and is consistent with present operating options for UFP. (See 24590-PTF-RPT-ENG-05-002. Note that in this evaluation, what the Material Balance Assessment refers to as Parallel Operation is referred to as Simultaneous Operation.) The work scope for version 4.1 of the dynamic model includes parallel train UFP operation.

4. Section 3.2.3.1.3.1 states 5.8 w/o solids are created in the TLP evaporator and are stored in TCP-VSL-00001. Can this vessel mix waste with this quantity of solids? Can these solids be mobilized and transferred to LAW vitrification? Can these solids be mobilized and transferred to supplemental LAW treatment facilities and can supplemental LAW facilities accommodate these solids? (RG)

   The steady state run results have been preliminarily evaluated by Process Engineering for the mixing systems, as well as Hydrogen Mitigation. No mixing, transfer, or HGR issues are anticipated. Supplemental LAW Treatment is undefined.

5. Under what conditions can WTP achieve required throughput rates? It appears WTP cannot attain required throughputs while caustic leaching and oxidative leaching based on the material balance assessment. Are the AZ-101 and SY-102 assessments representative of typical waste to WTP and expected performance while caustic leaching and oxidative leaching? (RG)

   AZ-101 and SY-102 are not representative of typical waste to WTP. AZ-101 has a low solids content and high Cs content and, based on direction from ORP, will be blended with other feed tanks. SY-102 is especially high in chromium, at 1810% of the Specification 8 expected maximum. It is an HLW feed that would be processed with a LAW feed, rather than being processed alone as the only feed to the WTP.

6. Sodium oxalates limit throughput in the UFP system while treating AP-101 and AY-102. Are the concentrations of oxalate in this waste representative of the balance of tank waste? Where do they rank with respect to the other batches processed over the mission? What can be inferred from this analysis regarding WTP throughput while treating the spectrum of tank waste? (RG)

   Oxalate did not impact throughput in AP-101/AY-102, however it did impact SY-102 throughput. Going to the TWINS database, downloading the measured oxalate concentration in all tanks, and sorting by oxalate concentration in the solids from highest to lowest, indicates that there are six tanks that have higher measured oxalate concentrations than SY-102.

7. Table 3-1, page 35. Please explain why the solids tracked for each of the three waste compositions evaluated are not identical. (LH)

   If we track every solid in the flowsheet the thermodynamic model will take an unreasonable amount of time to converge. A sensitivity analysis was performed on each waste type to determine which solids would most likely occur in each stream and only those solids most likely to form for each particular chemistry were included.

8. Section 3.3.3.1.2.1. Will chromium be reduced (re-preciptiate) [following oxidation in the UFP system] as it is recycled in the PWD/FEP systems due to the presence of significant concentrations of nitrite? (LH)

   We believe that it is unlikely that chromate will be reduced in the short time available, because chromate has been relatively stable in the presence of nitrite in the Hanford waste tanks for tens of years. Any chromate that is reduced will be re-oxidized when it is recycled back to the ultrafilter.

9. General: The Mass balance provides estimates of waste treatment rates, that in some cases, are greater than the design basis (e.g. Basis of Design) and estimates made by the Dynamic Model. These estimates may be unrealistic. For example Section 3.1.3.1.1.2 indicates that the LAW treatment rate is 4050 Na units per year which is higher than the design basis and estimated in the dynamic model. Please explain how BNI is ensuring that the projections from the Dynamic and Mass Balance models are a realistic representation of the capability of the WTP. Please explain how BNI is ensuring the results from the models are consistent between each other and represent the capability of the WTP. As presented, the model deliverables present significantly different perspectives of the capability of the WTP. (LH)

   Note that Table 3.3, page 39 of the TUA Assessment shows that the LAW treatment rate for AZ-101 is 3980 sodium units per year, compared to 4050 units per year from the Material Balance Assessment; so the number of sodium units predicted by both models is essentially the same. For this tank feed, it is possible to exceed the design basis for LAW throughput.

10. General. A number of chemical compounds are indicated as being present in the tank waste or formed during waste processing. As presented it is not clear if the chemical compound is a thermodynamic projection, an assumption, or is actually present in the tank waste based upon chemical analysis. Please clarify this critical conclusion in future versions of this document, and in future thermodynamic analysis. (LH)

Acknowledged.

11. Executive Summary, page viii: Precipitation of sodium carbonate is predicted to occur in the pretreated LAW evaporator (TLP) during processing of Envelope A/D (AP-101/AY-102). The OLI/ESP modeling conducted using AP-101/AY-102 feed for the semi-integrated pilot plant (WSRC-TR-2004-000403, March 2005, page 16) indicates that 97.9 wt% of the solids predicted to form in the TLP concentrate are sodium oxalate and no sodium carbonate solids are predicted. The OLI/ESP model for the semi-integrated pilot plant included simulated LAW and HLW Vitrification recycle waste streams as well as the AP-101/AY-102 pretreatment process streams. Please explain the why sodium carbonate solids are predicted to form in the TLP concentrate during processing AP-101/AY-102? (MJ)

Sodium carbonate is predicted form in the TLP evaporator for this flowsheet case investigated because sodium carbonate is thermodynamically stable. The amount of sodium carbonate formed is highly sensitive to the concentration of carbonate in the TLP feed when the concentration is near the sodium carbonate saturation point. Most of the carbonate comes from AY-102, so the amount of sodium carbonate is highly dependent on the relative amount of AP-101 and AY-102 in the blend. For the SIPP modeling, a blend of 70 % AP-101 and 30 % AY-102 was used. In contrast, for this Assessment, a blend of 40 % AP-101 and 60 % AY-102 was used.

12. The Tank Utilization Assessment (24590-WTP-RPT-PO-05-008, page 4) states the LAW SBS and WESP waste streams, along with excess concentrated pretreated LAW from the TLP are routed directly to the Supplemental LAW Treatment system. However, the Material Balance and Process Flowsheet Model (24590-WTP-RPT-PO-05-009, page 3) routes the LAW SBS and WESP waste streams to the Treated LAW Evaporator and only the excess concentrate pretreated LAW from the TLP is routed to the Supplemental LAW Treatment system. BNI should use a consistent approach to modeling the WTP unit operations and interfaces. (MJ)

Acknowledged.

13. Section 3.1.3.1.2, page 15, 2nd paragraph: The caustic leaching analysis for tank AZ-101 states: "After leaching, the vessel contents must be cooled, filtered and washed. While cooling and washing, 33% of the aluminum that dissolved re-precipitated, due to reduction in the hydroxide concentration and temperature. As discussed in the HLW section, the combined effect of the HLW feed being 252% of the aluminum acceptance limit and the re-precipitation of aluminum during washing results in aluminum limited IHLW". The Statement of Work does not include an aluminum acceptance limit in Specification 8, Table TS-8.4:

> The HLW feed components identified in Table TS-8.4 are also important to HLW glass production. The concentrations of these components in the waste are not expected to exceed the maximum values listed in Table TS-8.4. Information on these components will be provided to support product and process qualification but will not be used as a basis for determining if the feed meets specification requirements.

Why was sufficient sodium hydroxide not added during the leaching and washing of the AZ-101 solids to maintain aluminum in solution after cooling the leachate to 25°C? (MJ)

See answer to question No. 1 for the Material Balance and Process Flowsheet Assessment.

14. Does the WTP Material Balance and Process Flowsheet model include estimates of the relevant secondary streams such as spent ion exchange resin, radioactive solids waste, radioactive liquid waste discharge to the LERF/ETF and assessment against acceptance criteria? (MJ)

Discharge to LERF/ETF is reported in the Assessment. Solid wastes are forecast in a separate WTP report.

15. Does the WTP Material Balance and Process Flowsheet model include the chemicals used to condition the fresh cesium ion exchange resin and the discharge of these chemicals to vessels RLD-VSL-00017 A/B, as described in section 2.9 of the BARD? (MJ)

    Yes. CRP and RDP are included in the model.

16. Section 3.2.3.1, page 21: The Tank Farm contractor has conducted mixing tests with tank AP-101 supernate and tank AY-102 solids with supernate (see letter 7S110-RWW-04-029 dated October 14, 2004). These tests indicate dawsonite will dissolve from the AY-102 solids. Does the WTP Material Balance and Process Flowsheet model predict similar behavior during processing the combined AP-101 / AY-102 feeds? (MJ)

    We do not have dawsonite in the chemistry model. Given that AP-101 has a higher hydroxide concentration than AY-102, we do predict that aluminum will dissolve when they are blended when all other things (such as temperature) are constant.

17. Page 35, Table 3-1: Studies conducted by the Tank Farm Contractor with tank AY-102 solids have resulted in the identification of several solids phases, including dawsonite ($NaAlCO_3(OH)_2$) and cancrinite ($Na_6Ca_{1.5}Al_6Si_6O_{24}(CO_3)_{1.6}$) (see letter 7S110-DLH-03-007 dated October 17, 2003). Please explain why these solid phases do not appear to be tracked nor thermodynamically modeled in the WTP Material Balance and Process Flowsheet? (MJ)

    The WTP was not provided this mineralogical data until after the AY-102 chemistry model was developed.

18. Section 3.2.3.1.3.1 and 3.2.3.3, pages 23 and 24: The TLP evaporator concentrate is predicted to contain 5.8 wt% solids during pretreatment processing of the AP-101 and AY-102 feeds. Section 3.2.3.3 states "Most of the sulfate in the LAW CRV for the blend is solid NaFSO4. Knowing the precise amount of sulfur in the LAW Vitrification feed is crucial for LAW glass formulation. In order to recover a representative amount of solids, and hence sulfate during sampling, good mixing in the LAW CRV will be required". The BARD (page 3.1-3) states the LAW CRV is equipped with a 40-hp agitator.

    a) Have the results of the Material Balance and Process Flowsheet Assessment been used to verify the adequacy of the WTP design and where is this documented? (MJ)
    b) Specifically, has the CRV design been reviewed to verify the predicted quantity of solids in the TLP concentrate can be adequately suspended, mixed, and representative samples obtained? (MJ)

    See answer to question No. 4, above.

Flowsheet Bases, Assumptions and Requirements, 24590-WTP-RPT-RT-02-005, Rev. 3

Questions

1. Section 2.3.3.2, page 2.3-2, 1st paragraph: This section states that after digestion at 176°F to 194°F, the HLW solids leachate solution is cooled to 77°F and filtered. The leachate permeate is then fed forward to the cesium ion exchange process.

   a) The kinetics of aluminum precipitation is often slow. What analyses have been conducted to determine if aluminum precipitation will occur in the cooled (77°F) leachate permeate?

   R&T testing did not include collecting data for determining the impact of delayed aluminum precipitation. However, the extended cool down of the concentrated slurry (cooling for ~20 hrs) provides favorable conditions for supersaturated aluminum to precipitate on the solids present. Maintaining a higher hydroxide concentration will also reduce the likelihood of post filtration aluminum precipitation. (EL)

   b) Feeding the leachate permeate forward to the cesium ion exchange process could result in the feed composition changing during the loading cycle. Changing the feed composition during the loading cycle of the cesium ion exchange process will result in changing the equilibrium between competing cations (e.g. Na, K and Cs) with the resin and may result displacing cesium from the resin. What assessment (e.g. ion exchange modeling, simulant lab testing, etc.) has been conducted to evaluate the effect to the cesium ion exchange process from changing the feed composition from LAW permeate to leachate permeate during the loading cycle? (MJ)

   No specific testing or modeling has been done. However, the IX feed tank is large, batch volume about 78,000 gal, much larger than an IX column charge. Therefore blending occurs that reduces the variation in feed composition. Leachate will have less K, Cs and higher Na and hydroxide. Therefore switching from a LAW feed to feed containing some leachate is likely to result in improved IX performance. A comparison was made for K, Na and Cs ratios in UFP- 62A/B snapshot compositions for a leachate forward run and a leachate recycled run (2005 G2 run to 2003 G2 run). The magnitude of the batch to batch cation changes appear to be very similar for the leachate forward and leachate recycle runs. (EL)

2. Section 2.9, page 2.9-1: The cesium fresh resin addition process contacts resin with de-mineralized water, 0.5M nitric acid and 0.25M sodium hydroxide. The de-mineralized water and 0.5M nitric acid contacted with the fresh resin are decanted to vessels RLD-VSL-00017 A/B. Vessels RLD-VSL-00017 A/B receive LAW caustic scrubber solution and discharge to the process condensate collection vessels (RLD-VSL-00006 A/B), which discharge to the LERF/ETF.

   a) What are the quantities of de-mineralized water, 0.5M nitric acid and 0.25M sodium hydroxide used to condition the resin?

2180 gallons of de-mineralized water, 600 gallons of nitric acid, and 460 gallons of caustic per batch of resin.

b) The cesium fresh resin addition process should specify the assumed chemical reactions that occur from contacting the resin with de-mineralized water, 0.5M nitric acid and 0.25M sodium hydroxide. (MJ)

Concur. Will add to the next revision of the BARD.

APPENDIX E

DESIGN PRODUCT OVERSIGHT PLAN
WTP OPERATIONS RESEARCH, TANK UTILIZATION, AND STEADY STATE FLOWSHEET ASSESSMENTS

U.S. Department of Energy, Office of River Protection

DESIGN PRODUCT OVERSIGHT PLAN

WTP OPERATIONS RESEARCH, TANK UTILIZATION, AND STEADY STATE FLOWSHEET ASSESSMENTS

November 2005

Design Oversight: D-05-DESIGN-021

Team Lead: Rob Gilbert

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1.0 BACKGROUND, PURPOSE AND OBJECTIVES

1.1 Background

The U.S. Department of Energy (DOE), Office of River Protection (ORP) will design, construct, commission, and operate a Waste Treatment and Immobilization Plant (WTP) to treat and immobilize waste contained in 149 single-shell tanks and 28 double-shell tanks (DST) at Hanford. These tanks contain approximately 54 Mgal waste with 190 MCi radioactivity. The WTP will receive waste in batches from the DSTs through transfer pipelines. This waste will be concentrated in an evaporator; strontium and transuranic will be precipitated from select waste streams; solids will be water washed, caustic leached, oxidative leached, and separated from the soluble fraction in an ultrafilter system; and cesium will be removed from the soluble fraction with an ion exchange system. The radionuclide rich solids and cesium ion exchange eluant will be combined and immobilized in High Level Waste (HLW) glass. The low-activity waste supernatant will be further concentrated and immobilized in Low Activity Waste (LAW) glass or in a supplemental LAW immobilization facility.

The Contract requires Bechtel National, Inc. (BNI) to periodically provide WTP Operations Research, Tank Utilization, and Steady State Flowsheet assessments. BNI delivered 24590-WTP-RPT-PO-05-008, Revision 0, "2005 WTP Tank Utilization Assessment," and 24590-WTP-RPT-PO-05-001, Revision 0, "2005 WTP Operations Research Assessment," to ORP for comment on August 31, 2005. The "2005 Material Balance and Process Flowsheet Assessment" is anticipated to be delivered to ORP in mid-November 2005. ORP WTP Engineering Division planned to conduct an integrated review of all three deliverables at one time.

The 2005 Deliverables Concept Paper (24590-WTP-RPT-PO-04-0025, Revision 1) provides partial clarification and objectives for the 2005 Operations Research, Tank Utilization, and Steady State Flowsheet assessments.

1.2 Purpose

This design oversight will assess the 2005 WTP Operations Research, Tank Utilization, and Steady State Flowsheet assessments. The review team should address the specific objectives defined below.

1.3 Specific Objectives

1.3.1 The contractor **Operations Research** assessment should be evaluated considering the following lines of inquiry:

<u>Contract Compliance Questions</u>

1. Does the Operations Research assessment determine that the facility design incorporates appropriate design and operational features to meet plant capacity

requirements and reduce construction and/or operations costs? Plant capacity requirements include:

a. Pretreatment
    i. Basis of Design (BOD) availability of 80%
    ii. HLW Pretreatment shall support vitrification of an average of 480 canisters of IHLW per year.
    iii. LAW Pretreatment shall process and average of 2,200 Na waste units per year. BNI shall notify DOE if the governing unit operation drops below 3400 total Na units per year or predicted availability drops below 2950 total Na units per year (~86% availability if governing unit is 3400 total Na units per year).
b. HLW
    i. BOD availability of 70%
    ii. Produce an average of 480 canisters per year assuming 1.16 cubic meters of glass per canister
c. LAW
    i. BOD availability of 70%
    ii. Produce glass with an average of 733 Na waste units per year.

2. Does the Operations Research assessment include sampling and analysis requirements including sample turnaround times?
3. Does the Operations Research assessment include tank capacities and times to conduct individual process steps in unit operations?
4. Does the Operations Research assessment include time for mechanical handling steps?
5. Does the Operations Research assessment include equipment reliability?
6. Does the Operations Research assessment include time estimates for maintenance and repair of facility and process systems?
7. Does the Operations Research assessment include estimated spare equipment inventory?
8. Does the Operations Research assessment include recommendations to improve reliability and throughput of the production facilities?
9. Does the Operations Research assessment ensure appropriate reliability, availability, maintainability, and inspectability for the WTP balance of facilities?
10. Does the Operations Research assessment reflect the latest design and information from research and technology?
11. Has BNI maintained configuration control to manage the models and analyses?
12. Has BNI established facility design capacity through its engineering processes?

<u>Other Technical Questions</u>

1. Does the Operations Research model support BNI's commitment in their two HLW melter and two LAW melter proposal (CCN: 039390) to process all Hanford tank waste in a seventeen year operational period? If not, why not?
2. Does the Operations Research model identify the limiting unit operation or handling steps to achieve production goals?

3. Can LAW vitrification support ORP's stretch case goal of 45 metric tones glass per day? If not, what changes are required?
4. Can HLW vitrification support ORP's stretch case goal of 6.0 metric tones glass per day? If not, what changes are required?
5. What are the limiting operations or handling steps that prevent the Pretreatment facility from achieving a 3,400 unit Na/7.5 metric tonne HLW and 2950 unit Na/7.5 metric tonne HLW production rate?

1.3.2 The contractor **Tank Utilization** assessment should be evaluated considering the following lines of inquiry:

Contract Compliance Questions

1. Does the Tank Utilization assessment assess utilization of process tank capacity and supporting equipment capability and operational characteristics, to ensure that the tanks are appropriately sized to support process operations, sampling and analysis turnaround times, process control requirements and waste form qualification needs?
2. Does the Tank Utilization assessment reflect the latest design and information from research and technology?
3. Has BNI demonstrated WTP waste treatment capacity using process modeling? Plant capacity requirements include:
   a. Pretreatment
      i. Basis of Design (BOD) availability of 80%
      ii. HLW Pretreatment shall support vitrification of an average of 480 canisters of IHLW per year.
      iii. LAW Pretreatment shall process and average of 2,200 Na waste units per year. BNI shall notify DOE if the governing unit operation drops below 3400 total Na units per year or predicted availability drops below 2950 total Na units per year (~86% availability if governing unit is 3400 total Na units per year).
   b. HLW
      i. BOD availability of 70%
      ii. Produce an average of 480 canisters per year assuming 1.16 cubic meters of glass per canister
   c. LAW
      i. BOD availability of 70%
      ii. Produce glass with an average of 733 Na waste units per year.
4. Has BNI established facility design capacity through its engineering processes?
5. Has BNI maintained configuration control to manage the models and analyses?

Other Technical Questions

1. Does the Tank Utilization Assessment model support BNI's commitment in their two HLW melter and two LAW melter proposal (CCN: 039390) to process all Hanford tank waste in a seventeen year operational period? If not, why not?

2. Can management of secondary waste support potential increases in flush volume due to hydrogen in pipes and ancillary vessel control strategies?
3. What opportunities exist to simplify the Pretreatment flowsheet to increase effectiveness of process operations?
4. Do material balances for key streams close?

1.3.3 The contractor **Steady State Flowsheet** assessment should be evaluated considering the following lines of inquiry:

Contract Compliance Questions

1. Do the material balances estimate the quantity of ILAW, IHLW, and relevant secondary streams for the three feed tank compositions analyzed?
2. Does the Steady State Flowsheet assessment provide annual estimates for ILAW, IHLW, and relevant secondary streams?
3. Is the Steady State Flowsheet consistent with the latest process verification testing, product qualification activities, and feed characterization information, as appropriate?
4. Has BNI demonstrated WTP waste treatment capacity using process modeling? Plant capacity requirements include:
   a. Pretreatment
      i. Basis of Design (BOD) availability of 80%
      ii. HLW Pretreatment shall support vitrification of an average of 480 canisters of IHLW per year.
      iii. LAW Pretreatment shall process and average of 2,200 Na waste units per year. BNI shall notify DOE if the governing unit operation drops below 3400 total Na units per year or predicted availability drops below 2950 total Na units per year (~86% availability if governing unit is 3400 total Na units per year).
   b. HLW
      i. BOD availability of 70%
      ii. Produce an average of 480 canisters per year assuming 1.16 cubic meters of glass per canister
   c. LAW
      i. BOD availability of 70%
      ii. Produce glass with an average of 733 Na waste units per year.
5. Has BNI maintained configuration control to manage the models and analyses?

Other Technical Questions

1. Are precipitation reactions predicted and observed in the Steady State Flowsheet results? Do precipitation reactions present operations issues?
2. Have solutions to precipitation issues been proposed and implemented?
3. Do material balances for key streams close?
4. What opportunities exist to improve the capability of the Pretreatment process flowsheet?

1.3.4 The Team should make recommendations regarding the future frequency and scope of Operations Research, Tank Utilization, and Steady State Flowsheet assessments.

1.3.5 Contract requirement quotations

Standard 2, C.6

(b) Process and Facility Modeling Requirements:

The Contractor shall develop and use analytical models to support the design of the process and facility system, support pre-operational planning assessments, and provide technical integration with Tank Farm Contractor waste feed staging and product acceptance activities. The Contractor will, at a minimum, use the following models:

(1) Operations Research Assessment of the Waste Treatment and Immobilization Plant: The Contractor shall conduct Operations Research assessments based on the WTP for the Pretreatment/HLW Vitrification Plant and LAW Vitrification production facilities and the Analytical Laboratory to determine that the facility design concept incorporates appropriate design and operational features to meet plant capacity requirements and reduce construction and/or operations costs. The scope of the assessments shall include: sampling and analysis requirements including sample turnaround times; tank capacities and times to conduct individual process steps in unit operations; time for mechanical handling steps; equipment reliability; time estimates for maintenance and repair of facility and process systems; estimated spare equipment inventory; and recommendations to improve reliability and throughput of the production facilities. The Operations Research Model shall also ensure appropriate reliability, availability, maintainability, and inspectability (RAMI) for the WTP balance of facility. The Operations Research Model results, assumptions, and model input parameters shall be clearly documented and provided to DOE for review and comment (Table C.5-1.1, Deliverable 2.5). The Operations Research Model and outputs shall be updated at least annually, or more often, as necessary, to support design change assessments and reflect the latest design and information from R&T.

(2) Waste Treatment and Immobilization Plant Tank Utilization Assessments: The Contractor shall develop, document, and use G2 based on the WTP Design. The primary software used to run the dynamic flowsheet shall be agreed to by DOE. The Contractor shall assess utilization of process tank capacity and supporting equipment capability and operational characteristics, to ensure that the tanks are appropriately sized to support process operations, sampling and analysis turnaround times, process control requirements and waste form qualification needs. The assessments shall include the baseline

plant capacity and the expanded plant capacity. Results shall be provided to DOE for review and comment at least annually (Table C.5-1.1, Deliverable 2.6) or more often, as necessary, to support design change assessments and reflect the latest design and information from R&T.

(3) Material Balance and Process Flowsheet: The Contractor shall use the ASPEN model to conduct and document process and flowsheet material balance analyses for the treatment of tank waste Envelopes A/D, B/D and C/D. The data sources for the material balances will be reviewed by DOE for acceptability and will be based upon the compositional limits defined in Specification 7, *Low-Activity Waste Envelopes Definition* and Specification 8, *High-Level Waste Envelope Definition*, tank waste inventory estimates, and the results of testing with actual tank waste samples. The flowsheet and material balances shall estimate the quantity of ILAW, IHLW, and relevant secondary streams on a feed tank-by-feed tank basis, as well as, annual estimates. The material balances will be based on three standards for chemical composition estimation. The Standards are:

(i) Best available information that is based upon the analysis of tank waste samples planned to be treated in the WTP;

(ii) Agreed to waste input inventory; and

(iii) Specification 7, *Low-Activity Waste Envelopes Definition* and Specification 8, *High-Level Waste Envelope Definition* concentration maximums.

The flowsheet and material balances shall be sufficiently detailed to support permitting and safety activities under Standard 7, *Environment, Safety, Quality, and Health*, and to track DOE-supplied feed through the Hanford system for product acceptance and establishing that the waste treatment was performed.

The Material Balance and Process Flowsheet shall be updated at least annually, as significant changes occur and provided to DOE for review and comment (Table C.5-1.1, Deliverable 2.7). The material balance shall be maintained consistent with the latest process verification testing, product qualification activities, and feed characterization information, as appropriate. The flowsheet and material balances shall also be updated during cold commissioning, and prior to and following hot commissioning operations.

As part of Deliverable 2.7, an electronic copy of the modeling data for the flowsheet and material balance shall be provided to DOE for review and comment at initial issuance and upon each revision, thereafter.

(4) Configuration Control: The Contractor will establish and maintain a configuration control system to manage the models and analyses. The models and analyses will be subject to the QA and configuration control requirements imposed upon the Design Process in Section C.4, *Environment, Safety, Quality, and Health*, and Standard 1, *Management Products and Controls.*

Facility Specification C.7

(b) Waste Treatment Capacity Requirements: Waste treatment capacity requirements are specified below:

Waste treatment capacity for each major facility is defined as a product of the facility design capacity (facility nameplate design capacity) multiplied by the overall individual facility availability factor. The Contractor is to establish the facility design capacity through its engineering processes. The Contractor is to establish the facility availability factor from the Operational Research Assessments as defined in Standard 2 (b) (1) Operational Research Assessments of the Waste Treatment and Immobilization Plant.

During the design process the WTP waste treatment capacity shall be demonstrated using process modeling. The WTP waste treatment capacity will be verified through the plant testing performed during commissioning tests conducted in accordance with Standard 5, Commissioning.

The WTP waste treatment capacity requirements are specified below:

(1) Pretreatment shall be sized to meet the following waste treatment capacity requirements:

(i) LAW Pretreatment shall be sized to process an average 2,200 Na waste units per year; (this is equivalent to 2,277 total Na units per year assuming 3.5% non waste sodium additions). The governing unit operation as defined in the Basis of Design (Deliverable 3.3(a)) will yield at least 3400 total Na units per year. The Contractor shall notify DOE if the predicted availability drops below that required to achieve 2950 total Na units/yr or the governing unit operation drops below 3400 total Na units/yr. The contractor shall not intentionally alter the current Pretreatment design in any way that would reduce theoretical capacity below 3400 total Na units/yr without the express written consent of the government.

(ii) HLW Pretreatment shall be sized to vitrify waste to produce an average 480 canisters of IHLW per year.

(2) The LAW Vitrification facility shall be designed to vitrify treated waste Envelopes A, B, and C feed in accordance with Specification 2.2.2.2, *Waste Loading* with an average waste treatment capacity of 733 Na waste units per year. Waste units for Envelopes A, B, and C feed are defined in Specification 7.2.3.

(3) For (1) and (2) above, the waste treatment capacity is based upon units of LAW originating from waste Na. Waste Na is defined as Na from the following sources: Na from the LAW Feed Envelopes in accordance with Specification 7, *Low Activity Waste Envelopes Definition* and soluble Na from the HLW Envelope in accordance with Specification 8, *High Level Waste Envelope Definition*. In addition, the chemical Na added to wash and leach the solids within the limitations identified in Specification 12, *Number of High-Level Waste Canisters and estimated volume of ILAW glass per Batch of Waste Envelope D* is included in the definition of a Na waste unit.

(4) The HLW Vitrification facility shall be designed to vitrify waste Envelope D feed in accordance with Specification 1.2.2.1.6, *Product Loading*. The HLW Facility waste treatment capacity shall be capable of producing an average of 480 canisters per year assuming 1.16 cubic meters of glass per canister.

(5) Capability to receive and store 1.5 Mgal (5680 m^3) of LAW feed. The design shall include the capability to receive without interruption 1.125 Mgal (4260 m^3) of LAW feed while processing from the remaining capacity of 0.375 Mgal (1420 m^3) of LAW feed. The tanks shall be connected to allow blending if necessary.

(6) The Pretreatment facility shall have sufficient feed forward capability for 60 days of HLW operations, based upon the facility design capacity while capable of receiving without interruption no less than 600 m^3 of HLW feed per batch. HLW feed batch receipt facilities shall be designed to allow receipt without interruption to waste feed processing.

(7) The Pretreatment facility shall have the capability to prepare at least 81,000 gallons of transferable and blended HLW feed within a single vessel for transfer to the HLW Vitrification facility.

(8) The Pretreatment Facility will have the established capability to conduct oxidative leaching on HLW sludge and entrained solids to selectively remove Cr and sulfate for the HLW vitrification feed in accordance with the procedures to be established by Specification 12, *Number of High-Level Waste Canisters and estimated volume of ILAW Glass Per Batch of Waste Envelope D.*

Standard 3, C.6

(2) Basis of Design: The Contractor shall prepare for DOE review and concurrence (Table C.5-1.1, Deliverable 3.3(a)) and as significant changes occur, a Basis of Design Document that identifies directly or by reference design requirements and design codes and standards that will serve as a basis for the continued design of the WTP. The Basis of Design shall be based on the WTP Conceptual Design, (including the Basis of Design directly developed in that phase), and supporting documentation.

2.0 PROCESS

This oversight shall be conducted within the guidelines of ORP PD 220.1-12, "Conduct of Design Oversight."

2.1 Scope

This oversight shall include reports, data, models, safety analysis, and design documentation related to WTP waste processing and operations.

2.2 Preparation

1. Identify the BNI and ORP Points of Contact for this review. Transmit this plan to the points of contact and meet with appropriate personnel to review the plan and establish a working relationship to complete the review.

2. Identify the WTP process and facility structures, systems, components, and other factors associated with the WTP as they pertain to Operations Research, Tank Utilization, and Steady State Flowsheet assessments.

3. Collect documentation, e.g., test reports, flowsheets, process flow diagrams, calculations, system descriptions, and models that support the Operations Research, Tank Utilization, and Steady State Flowsheet assessments.

4. Review current BNI open issues with Operations Research, Tank Utilization, and Steady State Flowsheet assessments.

2.3 Review and identify, resolve, or document issues

Review the collected documentation, evaluate the selected attributes, and discuss with appropriate contractor personnel.

2.4 Reporting

De-brief ORP and BNI management as required and prepare a draft report that summarizes the activities, results, conclusions and recommendations of the review. The draft report will be issued for review and comment. The final report will resolve comments received on the draft report.

3.0 SCHEDULE OF ACTIVITIES

Activity Description	Responsibility	Complete By
Develop Oversight Plan	Gilbert	11/23/05
Advise BNI of planned oversight and provide oversight plan to BNI	Gilbert	11/28/05
Collect preliminary information to prepare for the review	Team/BNI	12/2/05
Kick off meeting for design oversight	Team/BNI	12/5/05
Review documents and meet with BNI and ORP personnel as required	Team	12/16/05
Prepare Draft Design Oversight Report	Team	12/23/05
ORP and BNI review draft report	ORP and BNI	1/6/06
Resolve comments and issue final report	Team	1/13/06

4.0 DOCUMENTATION

The final report of this design oversight will be issued addressing the lines or inquiry and identify open issues requiring further action.

Team Assignments

Rob Gilbert	Review Leader Steady State Flowsheet Tank Utilization Operations Research
Langdon Holton	Steady State Flowsheet Tank Utilization Operations Research
Michael Johnson	Steady State Flowsheet Tank Utilization Operations Research
Paul Certa	Steady State Flowsheet Tank Utilization Operations Research

Team Assignments

Don Alexander	Steady State Flowsheet
Nicholas Machara	Steady State Flowsheet Tank Utilization Operations Research

5.0 CLOSURE

The Team Leader with concurrence of the Director shall confirm that the open items from this oversight are adequately resolved.

6.0 REFERENCES

1. Contract No. DE-AC27-01RV14136.

2. 24590-WTP-RPT-PO-04-0025, Revision 1, "2005 Deliverables Concept Paper," dated September 13, 2004.

3. 24590-WTP-RPT-PO-05-009, "2005 WTP Material Balance and Process Flowsheet Assessment," dated November 10, 2005.

4. 24590-WTP-RPT-PO-05-008, Revision 0, "2005 WTP Tank Utilization Assessment," dated August 8, 2005.

5. 24590-WTP-RPT-PO-05-001, Revision 0, "2005 WTP Operations Research Assessment," dated August 29, 2005.

6. BNI letter from R. F. Naventi, BNI to R. J. Schepens, ORP, "Rightsizing for Acceleration," CCN: 039390, dated August 23, 2002.

Task# ORP-WTP-2006-0014

E-STARS™ Report
Task Detail Report
02/02/2006 1228

TASK INFORMATION

Task#	ORP-WTP-2006-0014		
Subject	CONCUR: (06-WED-009) TRANSMITTAL OF WASTE TREATMENT AND IMMOBILIZATION PLANT (WTP) OPERATIONS RESEARCH, TANK UTILIZATION, AND STEADY STATE FLOWSHEET ASSESSMENT DESIGN OVERSIGHT REPORT (D-05-DESIGN-021)		
Parent Task#		**Status**	CLOSED
Reference	06-WED-009	**Due**	
Originator	Almaraz, Angela	**Priority**	High
Originator Phone	(509) 376-9025	**Category**	None
Origination Date	01/20/2006 1036	**Generic1**	
Remote Task#		**Generic2**	
Deliverable	None	**Generic3**	
Class	None	**View Permissions**	Normal

Instructions

Hard copy of the correspondence is being routed for concurrence. Once you have reviewed the correspondence, please approve or disapprove via E-STARS and route to the next person on the list. Thank you.

bcc:
MGR RDG File
WTP OFF File
J. J. Short, OPA
R. A. Gilbert, WED
W. F. Hamel, WED
J. R. Eschenberg, WTP

ROUTING LISTS

1 Route List Inactive

- Gilbert, Rob A - Review - Concur - 01/20/2006 1237
  Instructions:
- Hamel, William F - Review - Concur - 02/02/2006 1228
  Instructions:
- Short, Jeff J - Review - Concur - 02/02/2006 1228
  Instructions:
- Eschenberg, John R - Review - Concur - 02/02/2006 1227
  Instructions:
- Schepens, Roy J - Approve - Approved with comments - 02/02/2006 0810
  Instructions:

ATTACHMENTS

No Attachments

COLLABORATION

COMMENTS

RECEIVED
FEB 0 2 2006
DOE-ORP/ORPCC

Task# ORP-WTP-2006-0014

Poster Schepens, Roy J (Deutsch, V Genie) - 02/02/2006 0802

Approve

Shirley Olinger concurred in Schepens' absence.

TASK DUE DATE HISTORY

No Due Date History

SUB TASK HISTORY

No Subtasks

-- end of report --

Task# ORP-WTP-2006-0014

E-STARS™ Report
Task Detail Report
01/20/2006 1038

TASK INFORMATION

Task#	ORP-WTP-2006-0014		
Subject	CONCUR: (06-WED-009) TRANSMITTAL OF WASTE TREATMENT AND IMMOBILIZATION PLANT (WTP) OPERATIONS RESEARCH, TANK UTILIZATION, AND STEADY STATE FLOWSHEET ASSESSMENT DESIGN OVERSIGHT REPORT (D-05-DESIGN-021)		
Parent Task#		**Status**	Open
Reference	06-WED-009	**Due**	
Originator	Almaraz, Angela	**Priority**	High
Originator Phone	(509) 376-9025	**Category**	None
Origination Date	01/20/2006 1036	**Generic1**	
Remote Task#		**Generic2**	
Deliverable	None	**Generic3**	
Class	None	**View Permissions**	Normal

Instructions Hard copy of the correspondence is being routed for concurrence. Once you have reviewed the correspondence, please approve or disapprove via E-STARS and route to the next person on the list. Thank you.

bcc:
MGR RDG File
WTP OFF File
J. J. Short, OPA
R. A. Gilbert, WED
W. F. Hamel, WED
J. R. Eschenberg, WTP

CHANGE to Eschenberg's Signature.

ROUTING LISTS

1 Route List Active

- Gilbert, Rob A - Review - Awaiting Response RAG 1/20/06
  Instructions:
- Hamel, William F - Review - Awaiting Response WFH 1/20/06
  Instructions:
- Short, Jeff J - Review - Awaiting Response 1/23/06
  Instructions:
- Eschenberg, John R - Review - Awaiting Response 1/31/06 DA
  Instructions:
- Schepens, Roy J - Approve - Awaiting Response
  Instructions: for SPO 2/1/06

ATTACHMENTS

No Attachments

COLLABORATION

COMMENTS