Technical Review of the Waste Treatment and Immobilization Plant Low-Activity Waste Facility

October 21, 2015

Prepared by U.S. Department of Energy
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EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE), Office of River Protection (ORP) has conducted a technical review of process and functional systems associated with the Low-Activity Waste (LAW) Facility at the Hanford Site. The purpose of the technical review was to fulfill the ORP's obligations under Standard 3 – "Design," of the Waste Treatment and Immobilization Plant (WTP) Project Contract (DE-AC27-01RV14136), which has the intent to ensure that the contractor has the necessary systems, processes, information, and deliverables in place to allow evaluation that the WTP LAW Facility is proceeding appropriately. It is a snapshot in time from which the ORP makes early identification of items that are potential project vulnerabilities that require attention prior to project completion and facility startup. Vulnerabilities are considered to be comments on the design; they flag potential future operational challenges, and reflect a work in progress where ORP has the opportunity to make any necessary adjustments in their oversight of the contractor. Through identification of system and potential programmatic challenges, this report is structured to provide the Assistant Manager/Federal Project Director, WTP (AMWTP) with specific recommendations in order for him to make timely forward-looking decisions to avoid, mitigate, or prevent potential mission risks from being realized.

The LAW Facility is comprised of 26 major systems. Thirteen systems and topical areas were identified as the candidate subjects for evaluation and a team of Subject Matter Experts identified to conduct a LAW Facility Design and Operability (D&O) Review on behalf of the AMWTP. The LAW D&O Review Team was chartered by the AMWTP with the intended purpose of furthering the understanding of the LAW Facility's design status with respect to design completion and operability. The selected systems are:

- LAW melter off-gas system
- Confinement ventilation systems
- Electrical distribution systems
- LAW melter equipment support handling system
- LAW container pour handling system
- Melter handling system
- LAW container finishing handling system
- Radioactive solid waste handling system
- Concentrate receipt and melter feed preparation system
- Container export handling system
- Container receipt handling system
- Instrument and control network
- Radiological control and industrial safety and hygiene.

The LAW Facility D&O team review[1] was completed and the team's final report was transmitted to the AMWTP in a memorandum dated September 3, 2015. A high level summary of the

[1] 15-WTP-0137, "Transmittal of the Official Use Only Waste Treatment and Immobilization Plant Low-Activity Waste Facility Design and Operability Review and Recommendation Report," dated September 3, 2015.

vulnerabilities as identified by the D&O Review Team are tabulated as an Appendix A to this report. The AMWTP requested the WTP contractor complete a factual review of this submittal[2] on September 14, 2015, which was immediately followed by a letter of direction to resolve the ORP recommendations and design comments[3] and subsequently to develop an Action Plan to address those issues[4]. An initial factual accuracy response[5] was received from the WTP contractor on September 18, 2015 with a detailed response[6] transmitted on October 16, 2015, together with their proposed Action Plan methodology for addressing the 10 recommendations. The WTP contractor provided a significant number of factual accuracy comments on the main body of the D&O Review Team's submittal to the AMWTP. In summary, there appeared to be broad factual accuracy discrepancies and concern with the review process on both sides.

At the request of the AMWTP, this report was prepared by WTP staff using input data provided by the LAW D&O Review Team, factual accuracy feedback from the WTP Contractor, and input and observations from WTP Project staff to address these anomalies. In addition, the report includes ORP consideration and assessment of corrective actions being undertaken by the WTP contractor that were initiated prior to completion of the review in October 2014. Thus the recommendations presented in this report reflect a broader view of the LAW Facility vulnerabilities.

While the technical review was ongoing, the AMWTP took action to:

1. Accelerate BNI's hazard control selection and safety classification of the LAW Confinement Ventilation Systems;
2. Sponsor an Independent Expert Review Panel for the Integrated Control Network Software quality classification and requirements flowdown; and
3. Direct the WTP contractor to begin dispositioning the vulnerabilities and responding to the 10 recommendations as identified in this report.

Overall, the D&O Review Team considered that, for 9 of the 13 systems, future production capability, operations, and potential throughput may be adversely affected if action is not taken to remediate/mitigate them. They considered that some of these impacts could potentially extend to future facility operator's safety and health, secondary waste handling, and operations and maintenance if action is not taken. The WTP contractor had over 120 factual accuracy comments on this one section of the D&O Review Team's results[6].

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[2] 15-WTP-0138, "Factual Accuracy Request of the Waste Treatment and Immobilization Plant Low-Activity Waste Facility Design and Operability Review and Recommendation Report," dated September 14, 2015.
[3] 15-WTP-0143, "Direction to Resolve Recommendations and Design Comments from the Low-Activity Design and Operability Review," dated September 15, 2015.
[4] 15-WTP-0155, "Request for Bechtel National, Inc. Initial Action Plan to Address the Waste Treatment and Immobilization Plant Low-Activity Waste Design and Operability Review Comments on the Design and U.S. Department of Energy 10 Recommendations," dated October 1, 2015.
[5] CCN: 276205, "WTP Low-Activity Waste Facility Design and Operability Review and Recommendations Report," dated September 18, 2015
[6] CCN: 276207, "Detailed Response of Bechtel National Inc., to the ORP Report, "Waste Treatment and Immobilization Plant Low-Activity Waste Facility Design and Operability Review and Recommendations," dated October 16, 2015.

The 519 vulnerabilities identified by the D&O Review Team, however, are tabulated in their entirety in Appendix A. The vulnerabilities range in coverage, and complexity; and not all comments carry an equal degree of significance; some pose a greater potential risk than others to the success of the LAW mission. With a number of concerns surfacing over the review process, ORP staff further reviewed these vulnerabilities and determined that at least 52 percent of the vulnerabilities were previously known to the WTP contractor, less than 5 percent are new issues, approximately 6 percent are not within the contract scope and approximately 37 percent require further review to determine their validity. This is consistent with the findings of the WTP contractor. Based on this assessment, ORP considers that the vulnerabilities identified are manageable as part of design and safety basis completion.

In March 2014, Bechtel National, Inc. issued the 24590-WTP-PL-MGT-14-0006, *Managed Improvement Plan*, whose stated purpose is to establish processes, procedures, and metrics for an effective quality assurance program that results in a WTP that meets all ORP requirements and operates safely. In July 2014 the adequacy of design reviews and restatement of ORP's expectations were addressed in a letter of direction requesting specific actions by Bechtel National, Inc. (ORP letter 14-WTP-0107, "Contract No. DE-AC27-ORV14136 – Request for System and Facility Design Reviews"). Rev. 1 of the Managed Improvement Plan was issued in August 2014 and ORP approved the Managed Improvement Plan in November 2014. Since then, ORP has monitored progress with a program of assessments developed and led by ORP staff as part of its continued oversight of the contractor. In addition, the Department is in the early conceptual planning phase evaluating direct feed LAW from the Hanford tank farms to the LAW Facility, which will impact the direction taken to address the basis of design for the LAW project, with the inclusion of a supplemental Effluent Management Facility.

The report's ten recommendations were developed by ORP with input from the LAW D&O Review Team to provide a basis for the AMWTP to make timely forward-looking decisions to avoid, mitigate, or prevent potential risks from being realized within the LAW Facility.

The ten recommendations are:

- Disposition each design and operability comment in Appendix A as appropriate as part of the WTP process to complete the LAW Facility design and document this disposition for review by the ORP LAW Federal Project Director
- Perform an engineering investigation to determine the most appropriate confinement ventilation systems safety classification
- Develop, validate and implement an air-flow simulation model for further investigation of heating, ventilation, and air conditioning-related vulnerabilities
- Review the current software quality classification and conformance of the integrated control network design to industry best practices
- Assess the thermal analysis of the LAW melter pour cave and transfer tunnel and identify any required design or operational changes
- Develop comprehensive facility worker environmental, safety, health and chemical/radiological protection programs that recognize the need for a contamination

control methodology and implements as low as reasonably achievable principles prior to facility startup

- Perform detailed task analysis in select areas to confirm the viability of the maintenance methods proposed
- Reassess the carbon bed fire safety risk and associated control measures
- Support the development of an improved operational research model for selected feed scenarios
- Evaluate system testing that could be accelerated to remove risk from the startup and commissioning phase.

As stated above, two of the ten recommendations were being actively managed while the technical review was ongoing. In addition, the WTP Contractor Action Plan provided in their October 16 submittal to the AMWTP is considered to be part of the basis for development of a final plan after alignment is reached with the LAW Federal Project Director on all comments on design (see Appendix C for the WTP contractor response). This is an ongoing activity.

ORP considers that effective implementation and completion of these recommendations in parallel with ongoing improvement initiatives will provide the Department sufficient confidence in the adequacy of the LAW design and operability, while mitigating potential risks associated with this workscope.

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ACRONYMS AND ABBREVIATIONS

ALARA	as low as reasonably achievable
AMR	ammonia reagent (system)
AMWTP	Assistant Manager, Waste Treatment and Immobilization Plant
BNI	Bechtel National, Inc.
BOF	Balance of Facilities
CFD	Computational Fluid Dynamics
CO	carbon monoxide
CO2	carbon dioxide
COx	carbon monoxide and carbon dioxide
CSLD	control system logic diagram
D&O	design and operability
DBE	design basis event
DOE	U.S. Department of Energy
DSA	documented safety analysis
EPC	engineering, procurement, and construction
HEPA	high-efficiency particulate air
HLW	high-level waste
HVAC	heating, ventilation, and air conditioning
I&C	instrument and control
ICN	Integrated Control Network
ILAW	immobilized low activity waste
ITS	important to safety
J3	job control system preapproved support request form
LAW	low-activity waste
LBL	Low-Activity Waste Facility, Balance of Facilities, and analytical laboratory
LCP	LAW concentrate receipt process (system)
LEH	LAW container export handling (system)
LFH	LAW container finishing handling (system)
LFP	LAW melter feed process (system)
LOP	LAW primary off-gas process (system)
LPH	LAW container pour handling (system)
LRH	LAW container receipt handling (system)
LSH	LAW melter equipment handling (system)
LVP	LAW secondary off-gas/vessel vent process (system)
MFPV	melter feed preparation vessel
MIP	managed improvement plan
OR	operational research (model)
ORP	U.S. Department of Energy, Office of River Protection
OSHA	Occupational Safety and Health Administration
PDSA	preliminary documented safety analysis
PPE	personal protective equipment
RCRA	*Resource Conservation and Recovery Act of 1976*
RSW	radioactive solid waste

ACRONYMS AND ABBREVIATIONS (CONT.)

RWH	LAW radioactive solid waste handling (system)
SBS	submerged bed scrubber
SSC	structure, system, and component
UPS	uninterruptible power supply
WTP	Waste Treatment and Immobilization Plant

1.0 INTRODUCTION

This report documents the results of a technical review of the U.S. Department of Energy (DOE), Office of River Protection's (ORP) Waste Treatment and Immobilization Plant (WTP) Low-Activity Waste (LAW) Facility and makes a number of recommendations to provide a path forward that if implemented, would give ORP sufficient confidence in the adequacy of the LAW design, while mitigating potential risks associated with this workscope. Key process and functional systems were reviewed to provide ORP with increased confidence that the LAW Facility would successfully achieve its mission objectives.

The LAW Facility is comprised of 26 major systems. Thirteen systems and topical areas were identified as the candidate subjects for evaluation and a team of Subject Matter Experts identified to conduct a LAW Facility Design and Operability (D&O) Review on behalf of the Assistant Manager, WTP (AMWTP). The LAW D&O Review Team was chartered by the AMWTP with the intended purpose of furthering the understanding of the LAW Facility's design status with respect to design completion and operability through the identification of "vulnerabilities. The selected systems are:

- LAW melter off-gas system
- Confinement ventilation systems
- Electrical distribution systems
- LAW melter equipment support handling system
- LAW container pour handling system
- Melter handling system
- LAW container finishing handling system
- Radioactive solid waste handling system
- Concentrate receipt and melter feed preparation system
- Container export handling system
- Container receipt handling system
- Instrument and control network
- Radiological control and industrial safety and hygiene.

For the purposes of this report, "vulnerabilities" are considered to be comments on the design that may signal future operational challenges. Once a "vulnerability" has been identified, ORP then has the opportunity to make appropriate and necessary adjustments; these adjustments will occur over time prior to facility startup. The ORP LAW Federal Project Director will review and concur the basis for vulnerability closure. It is anticipated that all identified vulnerabilities can and will be addressed during the planned work to complete the LAW Facility design.

The LAW Facility D&O team review was completed and transmitted to the AMWTP on September 3, 2015. A listing and high level summary of these vulnerabilities as identified by the D&O Team is included as an Appendix A to this report. The AMWTP requested the WTP contractor complete a factual review of this submittal on September 14, 2015, which was immediately followed by a letter of direction to resolve the ORP recommendations and design comments and subsequently to develop an Action Plan to address those issues. A factual accuracy response was received from the WTP contractor on October 16, 2015, together with their proposed Action Plan methodology for addressing the identified recommendations. The WTP contractor provided a significant number of factual accuracy comments on the main body of the D&O Review Team's submittal to the AMWTP. Examples were provided of incomplete or inaccurate information being used, a potential lack of understanding of WTP's unique document hierarchy, a lack of agreement within the team on the issue, or a difference of opinion in what conclusion may be drawn from the evidence that was not resolved or recorded during the review cycle. In summary, without further analysis, there appeared to be broad factual accuracy discrepancies and concern with the review process on both sides.

At the request of the AMWTP, this report was prepared by WTP staff using input data provided by the LAW D&O Review Team, factual accuracy feedback from the WTP Contractor, and input and observations from WTP Project staff to address these anomalies. In addition, the report includes ORP consideration and assessment of corrective actions being undertaken by the WTP contractor that were initiated prior to completion of the review in October 2014. Thus the recommendations presented in this report reflect a broader view of the LAW Facility vulnerabilities.

While the technical review was ongoing, the AMWTP took action to:

1. Accelerate BNI's hazard control selection and safety classification of the LAW Confinement Ventilation Systems;
2. Sponsor an Independent Expert Review Panel for the Integrated Control Network Software quality classification and requirements flowdown; and
3. Direct the WTP contractor to begin dispositioning the vulnerabilities and responding to the 10 recommendations identified by WTP staff.

In March 2014 BNI issued the WTP 24590-WTP-PL-MGT-14-0006, *Managed Improvement Plan* (MIP), whose stated purpose is to establish processes, procedures, and metrics for an effective quality assurance program that results in a WTP that meets all ORP requirements and operates safely. In July 2014, the adequacy of design reviews and restatement of Departmental expectations were addressed in a letter of direction from ORP requesting specific actions by BNI (ORP letter 14-WTP-0107, "Contract No. DE-AC27-ORV14136 – Request for System and Facility Design Reviews"). Rev. 1 of the MIP was issued in August 2014 and ORP approved the MIP in November 2014. Since then, the Department has monitored progress with a program of assessments developed and led by ORP staff as part of its continued oversight of the contractor. Timing of these initiatives precluded them from evaluation by the D&O Review Team, but they have been included latterly in developing the path forward in this report. In addition, ORP is in the early conceptual planning phase evaluating direct feed LAW from the Hanford tank farms to the LAW Facility, with the inclusion of a supplemental Effluent Management Facility. These changes while in development or ongoing during the D&O Review, were not added to the workscope of the D&O Review Team in FY-2014 and again the AMWTP recognized the value in doing so in the final technical review.

The Assistant Manager, WTP (AMWTP) determined it would be more beneficial to him to have a suite of recommendations focused on the present LAW project status. The recommendations were prepared on this basis to allow the AMWTP to make timely forward looking decisions to avoid, mitigate, or prevent potential risks from occurring.

The remainder of this report is organized as follows:

- Section 2.0 describes the project status and management controls.
- Section 3.0 provides a summary of the system review results and follow on ORP evaluation of the data.
- Section 4.0 summarizes the overall conclusions.
- Section 5.0 provides ORP's recommendations based on the conclusions of the review.

1.1 OBJECTIVE

The objective of this review was to identify potential issues or vulnerabilities on the design and flag potential future operational challenges, the resolution of which is a work in progress where ORP has the opportunity to make any necessary adjustments in their oversight of the contractor. They take into account the remaining work that continues and, as necessary, what additional activities remain to be incorporated within the revised project baseline for completion of the LAW Facility, Balance of Facilities (BOF), and analytical laboratory (LBL) and to make actionable recommendations for consideration by the AMWTP, the completion of which will support ORP's expectations for timely LAW Facility completion and startup.

Consistent with this approach, the review results are a snapshot in time of the LAW engineering, procurement, construction, and commissioning process. The results derived herein are not a predictive tool of LAW Facility cost or schedule.

1.2 SCOPE AND APPROACH

The LAW Facility is comprised of 26 major systems. After conducting an initial review, ORP selected the systems considered to be of greatest concern with regard to design vulnerabilities. In general, the systems chosen to undergo further review were found to:

- Include complex unit operations for which there is a scarcity of operating precedent
- Could present potential single-point failures that could lead to long repair/maintenance periods, with attendant impacts to facility production
- Represent a risk to LAW Facility functionality based on the number and significance of issues identified during the outcome of WTP reliability validation process reviews
- Include hazards requiring safety class or safety-significant controls based on the analysis in 24590-WTP-PSAR-ESH-01-002-03, Preliminary Documented Safety Analysis to Support Construction Authorization; LAW Facility Specific Information (PDSA)
- Require complex testing to demonstrate compliance with environmental permits
- Are relied upon to maintain or demonstrate confinement of radiological and non-radiological hazardous materials.

Based on the above parameters, the AMWTP directed the D&O Review Team to assess 13 following LAW systems:

- LAW container export handling (LEH) system
- LAW container finishing handling (LFH) system
- LAW melter handling system
- LAW container pour handling (LPH) system
- LAW container receipt handling (LRH) system
- LAW melter equipment handling (LSH) system
- LAW concentrate receipt process (LCP) system
- LAW melter feed process (LFP) system
- Confinement ventilation systems (C1V, C2V, C3V, and C5V)
- LAW primary off-gas process (LOP) system
- LAW secondary off-gas/vessel vent process (LVP) system
- LAW radioactive solid waste handling (RWH) system
- Ammonia reagent (AMR) system.

In addition, the following facility-wide systems were also reviewed:

- Electrical distribution systems
- Instrumentation and controls
- Radiological control and industrial safety and hygiene
- Third melter bay (currently vacant).

The D&O Review Team grouped those systems by common technical disciplines and assigned reviewers for each group with expertise in related disciplines. The common system groups are shown in Table 1-1. Functional reviews were also performed for vulnerabilities that could impact several selected systems, and these groups and functional review areas are also shown in Table 1-1.

Table 1-1. Low-Activity Waste Facility Design and Operability Review Areas. (2 pages)

SYSTEM REVIEWS			
Container Systems	**Mechanical Handling Systems**	**Process Support Systems**	**Ventilation Systems**
• Container export handling • Container finishing handling • Container pour handling • Container receipt handling	• Melter handling • Melter equipment handling • Radioactive solid waste handling • Third melter capability	• Primary offgas process • Secondary offgas/vessel vent process • Concentrate receipt process • Melter feed process	• C1V • C2V • C3V • C5V

Table 1-1. Low-Activity Waste Facility Design and Operability Review Areas. (2 pages)

SYSTEM REVIEWS			
Container Systems	**Mechanical Handling Systems**	**Process Support Systems**	**Ventilation Systems**
		• Ammonia reagent	

FUNCTIONAL REVIEWS		
Electrical Distribution	**Instrumentation and Controls**	**Radiological Control and Industrial Safety and Hygiene**
• Feed to the low-activity waste (LAW) offgas process (LAW primary offgas process/LAW secondary offgas/vessel vent process) exhauster fan motors • Feed to both melter power supplies • Feed to both LAW melters • Feed to the C2V, C3V, and C5V confinement system (heating, ventilation, and air conditioning) exhaust motors	• Integrated control network • Programmable protection system	• Implementation of radiological control by each process system, collective significance, and systemic effects • Implementation of industrial safety and industrial hygiene by each process system, collective significance, and systemic effects

The team reviewed documentation provided by BNI and conducted interviews and site visits with the BNI subject matter experts.

1.3 REVIEW LIMITATIONS

This review provides important input to completing the LAW Facility. However, ORP identified some limitations in the D&O process that should be kept in mind when evaluating the original vulnerabilities table as provided in Appendix A:

- Not all LAW systems were reviewed. As noted earlier, ORP decided to assess 13 of the 26 systems based on the parameters set forth above.
- Snapshot in Time: If this review were to be conducted earlier or later in the engineering, procurement, construction, and commissioning process, the list of vulnerabilities may have been different. For example, ORP is in the process of evaluating the impacts and scope changes necessary for direct feed from the tank farms to the LAW Facility, by-passing the Pretreatment Facility. To implement this strategy requires a change to the WTP Contract. This strategy would also change the existing WTP flowsheet. At the time of the review, ORP had not directed any changes to the WTP Contract or input assumptions to the WTP operational research model to accommodate any new system analysis.

- Independent of Many WTP Programmatic and Contractual Issues: Since this was a technically based exercise, the D&O Review Team did not review the contract, except for specific relevant technical requirements. Additionally, the D&O reviewers did not consider the ongoing BNI initiatives associated with the MIP (24590-WTP-PL-MGT-14-006) or safety and design basis realignment.
- The Basis for Ranking Vulnerabilities Was Not Specific to the LAW Facility Schedule or Total Project Cost: The focus of this review was on the possible impact on the WTP mission based solely on the consequence and likelihood of issues developing. Cost and schedule impacts were not considered.
- Vulnerability Determination: In making a vulnerability determination, the D&O Review Team did not take into consideration items that were not part of the existing BNI Contract (e.g., a third melter); items self-identified by BNI and/or already being tracked to closure by the contractor; known WTP risks; and known uncertainties relative to the Documented Safety Analysis (DSA) prior to design completion.

2.0 PROJECT STATUS AND MANAGEMENT CONTROLS

The WTP is comprised of five major, interrelated facilities, which were originally intended to be constructed simultaneously under a design-build engineering, procurement, and construction (EPC) model begun in 2000 and were to be commissioned in close succession (with the Pretreatment Facility first). Under this original plan, the LAW Facility was intended to be the first of two plants to complete the Hanford tank waste mission and was expected to treat about 40 to 50 percent of the waste. This plan was modified, subsequent to a review commissioned by Energy Secretary Abraham in 2002, which increased both total project cost and the completion date, increased individual melter design production capacity (derived from ongoing pilot scale testing), and added a second high-level waste (HLW) melter in the HLW Facility. It was anticipated that these changes would allow the project to complete the HLW treatment mission and required only supplemental LAW treatment to completely treat all LAW and accomplish the entire tank waste mission.

In 2006 Secretary Bodman commissioned the External Flowsheet Review Team to review the WTP engineering flowsheets and also the baseline cost and schedule. This led to a revised baseline cost and schedule that still exists. The External Flowsheet Review Team identified a number of technical issues regarding functionality and safety compliance, which led to an ongoing External Flowsheet Review Team issues closure initiative. It became apparent from this work that the majority of technical issues were concerned with Pretreatment Facility and to a lesser degree with the HLW Facility. Consequently, the WTP commissioning strategy was revised (still within the same baseline) to individually commission and begin operations of the LBL, while continuing to resolve Pretreatment Facility and HLW Facility technical issues. This was identified as Critical Decision 4a, under DOE O 413.3B, Program and Project Management for the Acquisition of Capital Assets. Later, Energy Secretary Chu commissioned an effort to close out eight remaining technical issues under a Design Completion Team, also within the same baseline plan to complete the WTP.

Considering that under Critical Decision 4a and the Design Completion Team's approach LBL would be completed well in advance of the Pretreatment Facility and the HLW Facility. It has been proposed that the LAW Facility will now integrate with LBL and any additional facilities under a revised baseline which is currently in development. It will immobilize the liquid fraction of the tank waste, after removal of targeted radionuclides that must be mitigated prior to immobilization.

Hanford waste is considered a characteristic and listed hazardous and radioactive waste (i.e., mixed waste) that is subject to regulation under both the *Resource Conservation and Recovery Act of 1976* (RCRA), as amended, and the *Atomic Energy Act of 1954*, as amended; RCRA regulation of the radioactive constituents as well as nuclear safety is limited by an express provision in RCRA that prohibits such regulation if it is inconsistent with the *Atomic Energy Act of 1954* as well as a long line of judicial decisions based on Constitutional concerns including, sovereign immunity, preemption, and the dormant Commerce Clause. WTP will treat and store the tank waste, low level and mixed low level waste, and waste generated from those activities will be disposed of onsite, consistent with the Tank Closure and Waste Management Environmental Impact Record of Decision (78 FR 75913).

At the end of calendar year 2014, LAW EPC was greater than 72 percent complete, based on work completed versus work budgeted. The major commodities, such as concrete, steel, pipe, and architectural finishes are greater than 90 percent complete – leaving electrical and instrumentation work, upgrades to preserve installed equipment, and any requisite rework resulting from extent-of-condition reviews as the main EPC remaining scope. LAW startup and commissioning, being less than 10 percent complete, will be an increasing focus as EPC nears completion. Since percent complete is calculated on the basis of work completed versus work budgeted, these percentages frequently change over time as they are adjusted in accordance with ongoing rebaselining efforts, realization and/or mitigation of risks, and changes in the scope of work.

In accordance with Standard 9 of the BNI contract, BNI developed a plan (which ORP approved) to advance the LAW Facility from the PDSA to the DSA, as required under 10 CFR 830, "Nuclear Safety Management." Subsequently, in response to a recent quality assurance audit, BNI developed a plan to improve quality implementation and prepare the MIP to enhance DSA-related work processes, which impact alignment between safety and design. ORP agrees with the work proposed by BNI in the MIP and that BNI will perform and the sequence in which it will be performed (24590-WTP-PL-MGT-14-0006). A draft of the LAW Hazard Analysis Report is near completion, but the portions of the DSA that derive the control set have not yet been developed. The potential impacts of moving from the PDSA to the DSA, could impact this reclassification of controls or systems. As part of the ongoing LBL rebaseline effort, ORP requested BNI prepare a resource-loaded schedule, which would allow the LAW Facility to be fully operational consistent with the DOE direction. This schedule includes a revised milestone for when LAW Facility construction will be complete and available for turnover to operations. In addition, to determine when the DSA would need final approval to support this schedule, preliminary planning was performed for commissioning and startup. This planning was integrated into the schedule to complete the draft DSA to obtain DOE concurrence. The due date for finalizing the DSA has been extended to 2017.

2.1 WASTE TREATEMENT AND IMMOBILIZATION PLANT CONTRACT REQUIREMENTS

As outlined in the WTP Contract, ORP will oversee the design, construction, and commissioning of the WTP. As such, ORP is both the owner and the regulator of the WTP. Its responsibilities are depicted in Figure 2-1. As the prime contractor, BNI is both the Design Authority and the Design Agent. This same contract assigns a number of important responsibilities to DOE, including implementation of an aggressive oversight process to ensure BNI engineering and quality assurance programs are effective and that work is performed in accordance with BNI's engineering and management processes. The WTP Contract contains nine standards, which are depicted in Figure 2-1. A complete listing of the nine WTP Contract standards follows the diagram.

Note: The LAW D&O review was conducted under Standard 3, "Design"; where ORP is to "Perform design, construction, safety reliability/availability/maintainability/inspectability, and operability oversight of the WTP."

Standard 1 Management Products and Controls: Describes the management products and controls necessary to meet the requirements of DOE O 413.3B; to enable DOE to meet the data requirements of the integrated planning, accountability, and budgeting system; and to ensure transparency in project performance and efficiency in project execution. This standard includes the requirement for management and technical information to be accessible electronically by the government.

Standard 2 Research, Technology, and Modeling: Describes the Research and Technology Testing Program requirements, as well as process and facility modeling requirements. Except for testing at the Vitreous State Laboratory, this standard has limited applicability for LAW with its current design status.

Standard 3 Design: Describes the contractor's responsibilities for conducting facility design functions, maintaining design documentation, and conducting regular periodic design reviews. The intent is to ensure that the contractor has the necessary systems, processes, information, and deliverables in place to allow DOE evaluation of the WTP Project.

Standard 4 Construction, Procurement, and Acceptance Testing: Describes additional requirements for construction, procurement, and acceptance testing. Acceptance testing refers to the testing and acceptance of systems, components, equipment, etc. as needed for mechanical completion of the WTP, including those actions conducted at vendor facilities on the government's behalf. However, it does not refer to DOE acceptance of the WTP from the contractor.

Standard 5 Commissioning: Describes the requirements and deliverables for the startup testing and commissioning of the WTP. Startup testing begins with a planned turnover of systems from construction, including component and system level tests, and precedes cold commissioning of the facility.

Standard 6 Product Qualification, Characterization, and Certification: Describes the quality assurance documentation requirements to qualify the immobilized waste products and secondary wastes. These activities and deliverables require integration with all technical, regulatory, and operability aspects of the WTP, including the specifications of feed provided either from the Pretreatment Facility or additional direct feed facility.

Standard 7 Environment, Safety, Quality, and Health: The purpose is to define contractor responsibilities and deliverables for conventional non-radiological worker safety and health; radiological, nuclear, and process safety; environmental protection; and quality assurance.

Standard 8 Safeguards and Security: Describes the safeguards and security requirements relevant to the WTP facility and operations.

Standard 9 Nuclear Safety: Describes the contractor requirements for implementation of an integrated standards-based safety management program, to ensure that radiological, nuclear, and process safety requirements are defined, implemented, and maintained. The standard also documents requirements, including applicable DOE orders, for nuclear safety so ORP can fulfill its safety and quality responsibilities.

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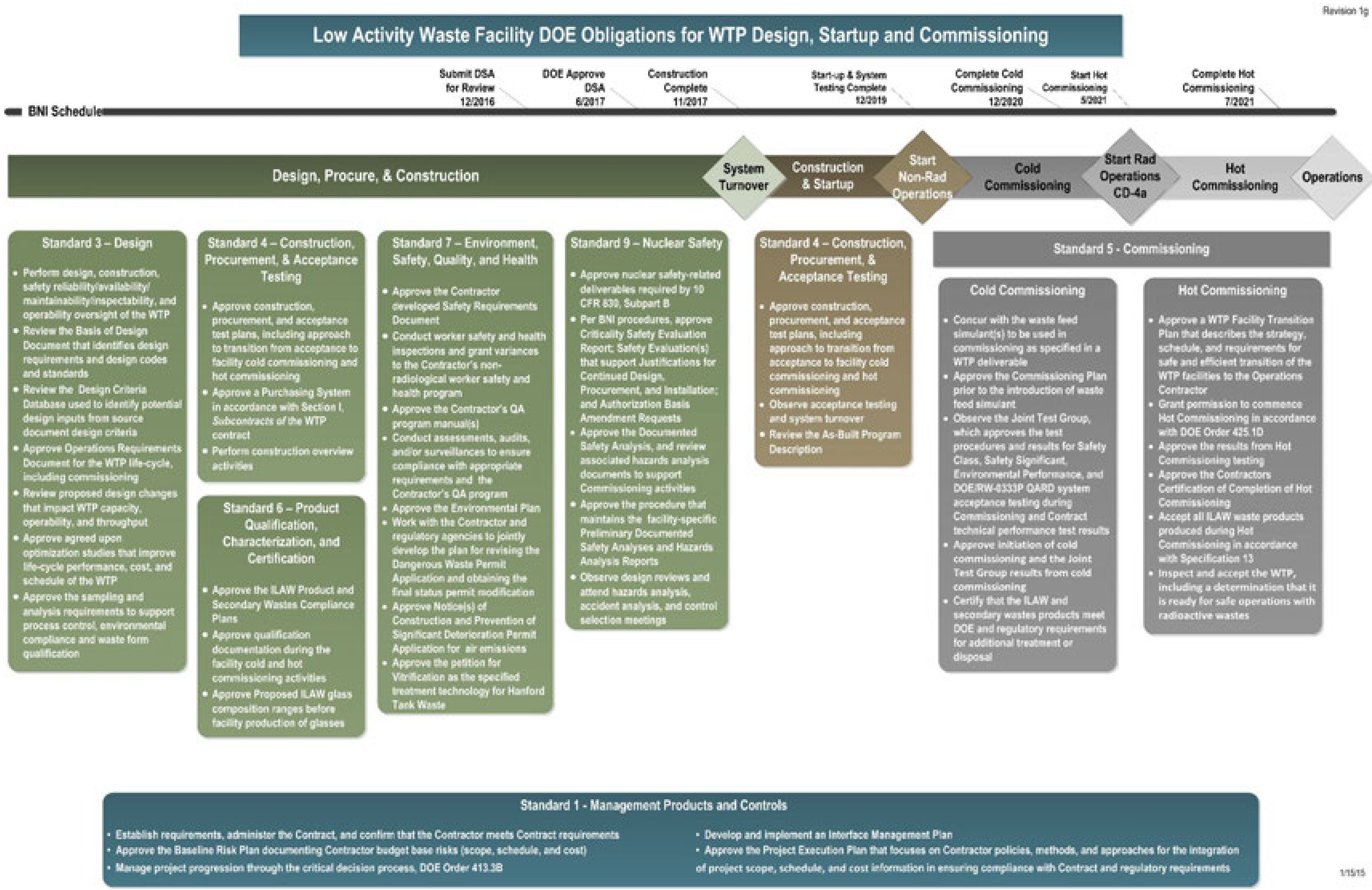
Figure 2-1. U.S. Department of Energy Obligations for the
Waste Treatment and Immobilization Plant Low-Activity Waste Facility Contract.



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2.2 BECHTEL NATIONAL, INC. MANAGEMENT ACTIONS, MANAGEMENT IMPROVEMENT PLAN, SYSTEM ENGINEERING, DESIGN/SAFETY BASIS PROCEDURES

In February, 2014, ORP directed BNI to prepare the MIP to address certain Priority Level 1 findings. BNI issued the MIP (24590-WTP-PL-MGT-14-006) on August 28, 2014, and ORP approved in November 2014. The MIP provides a roadmap for resolution of quality issues including findings associated with material selection, the Quality Assurance Manual (24590-WTP-QAM-QA-06-001), erosion/corrosion, margin management, systemic integrated management concern, vendor submittals, calculations, a quality assurance program, and a corrective action program. The MIP established the processes, procedures, and metrics used to ensure an overall quality program to complete the WTP Project that can safely operate in compliance with DOE-approved nuclear safety requirements.

Elements of the MIP include:

- Implementing a comprehensive program to determine extent-of-condition to insure past work complies with requirements. ORP will be provided feedback from BNI's quality engineering over-check process on the effectiveness of these changes as design of the WTP continues.
- Resolving issues identified through the reliability validation process, project issues evaluation reports, Priority Level 1, and significant Priority Level 2 findings as documented in closure actions for these issues within a the MIP.
- Implementing a process to establish and control requirements flowdown using a systems engineering approach. BNI is developing procedures and processes that will identify requirements for facility criteria documents and system design documents.
- Completing multi-disciplined system level design reviews.

The great majority of equipment for the LAW Facility has been engineered, procured, and/or installed over several years while the design and authorization basis were diverging from each other. ORP and BNI recognized that this divergence of the design and safety basis was a significant project risk. For the HLW Facility, BNI integrated the design basis and safety basis by preparing a Safety Design Strategy, which was reviewed by representatives from ORP, EM-40, and the Chief of Nuclear Safety, and developed a process to align the design and safety bases. Although BNI would have been able to integrate the design and safety basis for the LAW Facility by preparing a similar Safety Design Strategy, ORP concluded, given the advanced state of the project, it was more important to complete the DSA rather than any interim step.

Several similar technical issues for a number of critical systems and similar systematic or programmatic issues have been identified within the HLW and LAW D&O Reviews.

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3.0 SYSTEM-BY-SYSTEM REVIEW SUMMARY

This section provides a summary of results for the 13 reviewed LAW Facility systems as reviewed by the D&O Review Team as well as the subsequent ORP binning analysis of results after their "field work" was completed. It contains a brief overview of each system and includes some opportunities for improvement. Appendix A tabulates the full list of vulnerabilities identified by the D&O Review Team. For the purposes of this report, "vulnerabilities" are considered to be comments on the design that may signal future operational challenges. Once a "vulnerability" has been identified, ORP then has the opportunity to make appropriate and necessary adjustments; these adjustments will occur over time prior to facility startup. The AMWTP is aware of a significant number of potential factual accuracy comments from the WTP contractor that the D&O Review Team did not appear to resolve or document dispute of and this section focuses on important attributes that require further attention from the LAW Federal Project Director who will oversee resolution of any potential disputed items and review and concur on the basis for vulnerability acceptance (or otherwise) and hence closure. It is anticipated that all identified outstanding vulnerabilities can and will be addressed during the planned work to complete the LAW Facility design.

Appendix B provides the supplemental data that was used by ORP to generate the overall recommendations of this review. A key consideration in developing the recommendations was to provide the AMWTP with clear actionable guidance that would be of benefit to WTP and the ongoing DFLAW initiative. A basic process flow description for the LAW Facility is depicted on Figure 3-1. The functional role of each LAW reviewed system and the functional interfaces of those systems can be derived from Figure 3-1.

Appendix C provides a summary of the WTP contractor October 16, 2015, response to the WTP Contracting Officer's request that they provide the Department with an initial Action Plan to address the 10 recommendations derived from these results.

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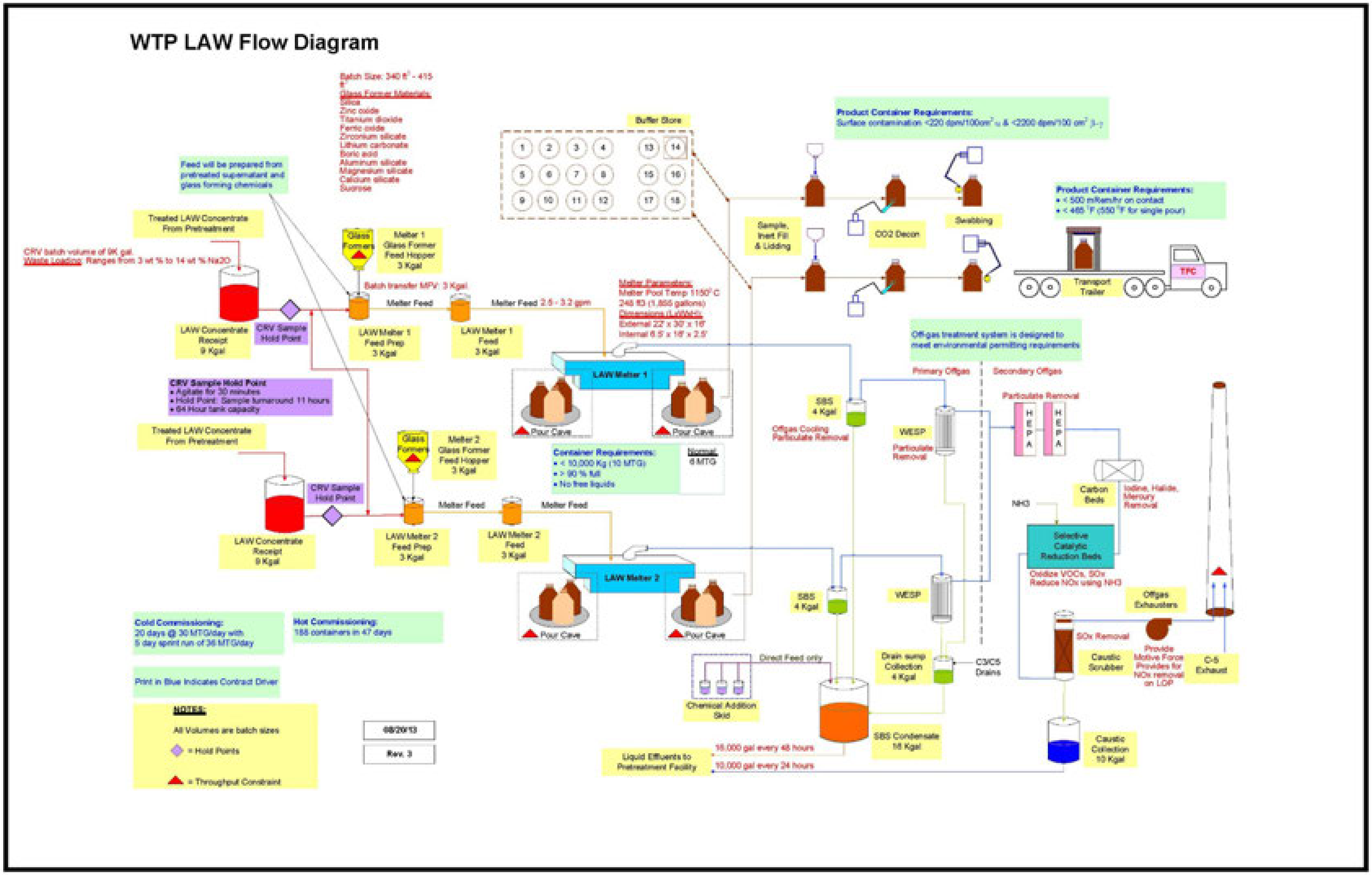
Figure 3-1. Waste Treatment and Immobilization Plant Low-Activity Waste Process Flow Diagram.



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3.1 PRIMARY OFFGAS PROCESS, SECONDARY OFFGAS/VESSEL VENT PROCESS, AND AMMONIA REAGENT SYSTEMS

The combined function of the LAW primary off-gas process (system) (LOP), LAW secondary off-gas/vessel vent process (system) (LVP), and ammonia reagent (system) (AMR) systems is to confine and safely treat LAW melter and vessel ventilation off-gas emissions to protect human health and the environment from radionuclide and chemical exposure. Off-gas treatment requirements are met prior to release from the LAW Facility stacks for each of the two melters.

There are separate and duplicate LOP system trains for each LAW melter. These trains are physically combined into a single LVP train that serves both melters. These LOP trains are to cool the melter off-gas emissions and remove radioactive particulates.

The LVP off-gas consists of the combined LOP and vessel ventilation off-gas streams. The primary functions of the LVP train are to provide high-efficiency particulate air (HEPA) filtration of radioactive particulates, treat/abate nonradioactive chemical constituents, and cool the off-gas prior to discharge to the environment.

The AMR system supplies ammonia to the nitrogen oxides abatement equipment within the LVP system.

Although the LOP, LVP, and AMR systems are separate systems, they are considered together for purposes of this review due to their functional interdependence.

There were no substantive functionality or operability vulnerabilities identified in the review of the BOF component of the AMR system, and this system is considered by the D&O review team to meet functionality and operability requirements. Therefore, it is not discussed further in this review. The ammonia skid, which is within the LAW Facility, was reviewed separately as part of the LVP system.

Without mitigating actions, the D&O Review Team considered there is some evidence that the current design of the combined LOP/LVP systems may limit the overall production capability of the LAW Facility. Worthy of note:

- A reliable and technically defensible strategy for safe operation of the carbon-bed absorber units under normal and abnormal operating conditions has not been documented (see Section 5: Recommendations).
- The thermal qualification of the SBS requires review because the O-ring gasket provided by the vendor for the SBS top flat head and mating flange may not be able to withstand the thermal loading from the Off-gas System during some operating conditions (see Section 5.0, Recommendations).

3.1.1 Opportunities for Improvement

The combined LOP/LVP systems require mitigating actions through BNI's design process to ensure the system will meet its intended functions, that is equipment (e.g., carbon-bed units) can be safely operated and treatment throughput requirements can be met (see Section 5.0).

During cold commissioning, this system will be subjected to a maximum achievable control technology performance demonstration test. Maximum achievable control technology tests will be on the critical path of starting up and commissioning the LAW Facility, and any unmitigated issues could impact this commissioning schedule (see Section 5.0).

3.2 INSTRUMENTATION AND CONTROL

The project uses an instrumentation and control network (ICN), comprised of several subsystems, to monitor and control the great majority of plant equipment and processes. The ICN is a large, distributed, control system for all five facilities. While the review was only performed on the LAW control systems and their components, the vulnerabilities for the ICN apply to the entire project.

The programmable protection system is the safety instrumented system for the WTP, including LAW. This system must be developed under rigorous life-cycle requirements commensurate with the safety-related nature of the application.

Without mitigating actions, there is a risk the ICN may delay startup and commissioning, increase the risk of safety and regulatory noncompliance, and limit the throughput capability of the facility (see Section 5: Recommendations) but is currently or faceplates.

3.2.1 Opportunities for Improvement

The design of the ICN system requires mitigating actions through LAW design completion to ensure the system will meet its intended functions and can be safely operated so that treatment throughput requirements can be met. ICN vulnerabilities documented in Appendix A should be addressed during the remainder of work to complete the LAW Facility (see Section 5.0).

3.3 CONFINEMENT VENTILATION SYSTEMS (C1V, C2V, C3V, C5V)

The LAW Facility confinement ventilation systems are designed to confine radiological material by maintaining a prescribed differential pressure among confinement zones. These systems control radioactive contamination by providing airflow from areas of lesser contamination potential to areas of greater contamination potential to confine contamination at or near the source. Consequently, LAW Facility rooms and corridors are classified based on their potential for radiological contamination. The LAW confinement philosophy is to sweep air from the least contaminated zone inward to the most contaminated (C5V). The contamination classification zones are C1, C2, C3, and C5. Zones classified as C1 have the lowest potential, followed by zone C2, then C3, with zones classified as C5 being the most contaminated. Based on a review of system design documentation, the LAW Facility confinement ventilation system may not be capable of meeting its intended confinement function unless identified vulnerabilities are effectively resolved. In addition, the extent and number of perturbations induced in the ventilation system as a result of routine and transient operations are may result in system performance instability. These issues associated with the currently documented design may cause delays to facility startup and commissioning and impact operation during the life of the facility.

3.3.1 Opportunities for Improvement

To strengthen the LAW Facility confinement ventilation system design, the D&O team suggested a number of remedies, which included review of the HVAC systems and associated systems, simulation modeling, and performance of hazard analysis, and safety classification Due to the significance of these comments a separate recommendation was developed specific to confinement ventilation (see Section 5: Recommendations).

3.4 ELECTRICAL DISTRIBUTION SYSTEM

The LAW Facility obtains electrical utility power via the BOF (Building 87) or LAW Facility switchgear buildings. Service power enters the LAW Facility at two different voltage levels: 13.8 kV and 480V. The LAW Facility melter power supplies obtain power from the LAW switchgear building at 13.8 kV, while the rest of the LAW Facility obtains power from the BOF switchgear, after being transformed from 13.8 kV to 480V via four transformers. Two transformers are also connected to a BOF standby diesel generator that provides backup power to the transformer inputs in the event of loss of off-site power. This electrical distribution system provides power to all LAW Facility electrical loads.

The following systems were evaluated by the team to provide a representative review of the LAW Facility's electrical distribution system feeding:

- LOP/LVP exhauster fan motors
- Power to both LAW melter power supplies
- Power to both LAW melters
- C2V, C3V, and C5V confinement ventilation systems exhaust motors.

The team reviewed these systems and their supporting electrical equipment, tracking backwards from the system loads and backtracking to the facility service transformers. The review included all four facility service transformers, all four facility feeder buses, all four facility switchboards, two melter power supplies, the melter electrode supply bus, melter assemblies, and the facility's important-to-safety electrical equipment.

The electrical distribution system at the LAW Facility is capable of supplying the electrical equipment currently identified, with the exception of the facility service transformers (which are loaded at or above design capacity). The electrical system is generally sound, but there are a number of design comments identified, which should be addressed prior to startup testing.

3.4.1 Opportunities for Improvement

The electrical design could be strengthened in a number of ways to include consideration of the spare capacity needed to complete the facility design and to support facility modifications after construction: battery sizing; inclusion of spare convertor sections, and thermal analysis.

3.5 RADIOLOGICAL CONTROL AND INDUSTRIAL SAFETY AND HYGIENE

The application of radiological control and industrial safety and hygiene was evaluated for each system. Individual radiological control and industrial safety and hygiene vulnerabilities were evaluated with a focus on potential systemic or significant challenges. A summary of comments noted during the review is provided below.

Radiological Control: The potential for contamination to migrate overtime to adjacent, lower-classification contamination zones was a concern of the review team. The design of the low-flow ventilation system further compounds this issue. The potential inability to meet contamination control limits for container release was another concern of the D&O Review Team. The project is developing radiation dose rates for specific areas of the facility, however there has been no assessment to understand the ability to perform hands-on maintenance activities under lower levels of PPE for the higher-risk tasks. Confinement ventilation system design philosophy may drive the need for frequent radiological cleanup to maintain radiological control and confinement, in excess of that anticipated.

Industrial Safety and Hygiene: There was insufficient evidence of compliance with operational safety and health requirements in the design process. Walk-throughs of the constructed facility found several locations where code requirements were overlooked as part of system design on individual pieces of equipment and, more importantly, on the system as a whole.

There was inadequate implementation of hazards analysis. Examples include:

- Limited analysis of planned, hands-on maintenance tasks to assess the viability of the existing design to support safe maintenance/operations. Lack of a defined chemical source-term input to the LAW Facility and analysis of LAW chemical process operations in accordance with applicable OSHA standards.
- Lack of chemical area monitoring throughout the facility, and engineered features to ensure workers are appropriately protected from fugitive emissions of potentially hazardous materials from treatment of LAW feed (the highest risks are in work areas upstream of the melter).
- Two completed WTP chemical-exposure assessments used incorrect data, which only considered the off-gas component and ignored the incoming waste feed.
- Worker heat stress should be considered in the design and task analysis. The assessment for replacement of the melter implies level-A PPE will be required, but design engineering has assumed that minimal PPE would be needed. Several radiological control concerns were identified that are applicable to more than one process system (e.g., the need to address future contamination control and controlling and reducing exposure of personnel to radiation). The project is currently in the process of implementing a revised hazard identification and control process that needs to be expeditiously implemented; however, equipment that has been previously installed will need to be reevaluated to ensure engineering controls are appropriately considered as part of the design process.

3.5.1 Opportunities for Improvement

The project needs to have a defined chemical source term coming to the LAW Facility, so the design can demonstrate compliance with OSHA worker safety standards and exposures can be appropriately monitored and mitigated. Where an engineered or administrative control cannot be reasonably achieved due to design issues, the project should develop clear guidance for worker protection in these circumstances.

3.6 MELTER EQUIPMENT SUPPORT HANDLING SYSTEM

The LSH system provides the equipment necessary to complete maintenance tasks on the LAW melters and on other equipment located in the melter gallery. The LSH system provides the mechanical handling equipment to remove spent consumables from the melters, package spent consumables, and install new consumables. It also provides equipment for replacement of the off-gas spray nozzle and various thermocouples, removal of startup heaters, replacement of bubblers, and loading of glass frit into the melter during startup. The LSH system equipment includes the truck bay crane, two melter gallery cranes and their associated maintenance cranes, and the equipment for importing, replacing, and exporting melter consumables.

The LSH system design may limit the production capability of the LAW Facility. The LSH system has not been demonstrated to meet immobilized LAW throughput requirements.

The suitability of equipment for contact maintenance above the melter has not been demonstrated. The D&O Review Team did not find any evidence of integrated and interdisciplinary design reviews that incorporate operations, industrial safety, industrial hygiene considerations, and system interfaces. It was also noted equipment refurbishment prior to commissioning may be required or equipment replaced due to equipment obsolescence and/or limited preventive maintenance.

3.7 CONTAINER POUR HANDLING SYSTEM

The LPH system accepts empty containers from the LRH system, move empty/filled containers into and out of the pour caves, places containers under the melter pour spouts to be filled with glass, and allows preliminary container cooling prior to transporting filled containers to the LFH system. The containers are then transferred to the LEH and exported from the facility.

The current LPH system design may limit the efficient production capability of the LAW Facility based on potential thermal issues within the LPH system; container filling operations requiring maintenance and abnormal container handling; and overall contamination control.

The most complicated and highest impact to the LPH system is related to the thermal issues. The complexity of the thermal interaction of the containers within the system, coupled with the current HVAC design, indicates that sustained operation of the LPH system at the design production rate cannot be assured. Further analysis is needed to define where additional cooling and controls are necessary. If left unchanged, it is anticipated that melter feed operations may experience frequent interruption and system intervention achieving a limited level of operability, thereby leading to significant throughput impacts.

3.7.1 Opportunities for Improvement

The following opportunities for improvement were identified:

- Review and/or revise the computational fluid dynamics (CFD) thermal or calculational analyses of the container transfer corridor, buffer stores, and all four pour caves at full

LAW Facility throughput, also considering anticipated upset conditions, to assess HVAC system interaction with container operations.

- Install additional cooling, if necessary, and modify the HVAC C5V system to preclude temperatures beyond the current design basis for affected SSCs based on the CFD analysis. Convert all the process delay time requirements in the container handling HVAC CFD scenarios to actual container temperature requirements to ensure all system and equipment thermal limitations are clearly articulated. The OR model can then assess any impacts on throughput based on CFD generated data.
- Consider improving the direct cooling of the filled-container flange area following a container pour to reduce the time it takes for the flange to cool and regain its structural strength.
- Install an instrument to measure the temperature of the filled container flange in the pour cave cooling position on the turntable.
- Conduct a thermal analysis, validate the concrete surface temperature of the container transfer corridor walls near designated position 15, and assess the need for additional insulation material and stainless steel liners in this area during the construction phase to comply with thermal design functional specifications (similar to the wall configuration at the east end of the corridor near the export stands). Alternatively, the design basis for the container hold position 15 could be evaluated to eliminate the hold requirements at this position by identifying an alternate insulated position to perform the required delay function.

3.8 MELTER HANDLING SYSTEM

The LAW melter handling system provides the mechanical handling equipment associated with the import of new locally shielded replacement melters and the export of failed or spent melters. The LAW melter handling system includes the rails and associated winch and pulley blocks.

Prolonged LAW Facility outages with attendant impacts to LAW production are considered to be a potential challenge based on the following:

- The decision not to develop and demonstrate the capability to replace melters prior to startup and commissioning of the LAW Facility presents a significant vulnerability to sustained facility operations.
- Spent melter decontamination functional capability and specifications have not been adequately addressed. Failure to demonstrate the melter replacement process prior to active operations is a vulnerability.

The failure to plan and design for the replacement of a melter presents a risk to the mission. Undertaking the melter change out during hot operations—without demonstrating key features prior to startup and commissioning—may reveal problems (which could have been addressed earlier when their disposition was less constrained), and take a period to resolve, with attendant losses to productivity and increased risks to personnel.

Other concerns arise from melter decontamination activities, including questions about where it will be done, what medium will be used, what additional capital facility capabilities will be required, etc. In addition, there are gaps in delineating responsibilities for all aspects of spent melter removal and the resulting impact on operability of the replacement melter.

3.9 CONTAINER FINISHING HANDLING SYSTEM

The LFH system receives filled containers from the LPH system, provides glass sampling functionality, measures container fill level, adds inert fill, installs the lid, and decontaminates, swabs, and monitors contamination dose prior to transporting containers to the LEH system.

The LFH system may not meet throughput requirements, unless significant changes are made. Decontamination issues, thermal issues, contamination control, and product container handling design comments, if not effectively dispositioned, could impact production efficiency.

3.9.1 Opportunities for Improvement

The following opportunities for improvement include: demonstration the capability of the CO2 container decontamination system to decontaminate containers, grapples, and turntables, while completely capturing the mobilized contamination; develop a method to decontaminate and export a nonconforming ILAW container.

3.10 RADIOACTIVE SOLID WASTE HANDLING SYSTEM

The purpose of the RWH system is to provide the mechanical handling equipment necessary to handle and package secondary radioactive solid waste (RSW) (e.g., failed equipment, consumable items, and maintenance wastes).

The functionality of the RWH system may not be fully adequate to support life-cycle operations. Specifically, inadequacies in the RWH system may prevent the LAW Facility from achieving operational efficiency objectives.

The RWH system does not have the capability to handle projected waste volumes in high maintenance years, and does not address export of all secondary waste forms. The lack of adequate system capability could quickly result in a backlog of secondary RSW. This backlog could potentially be significant enough that the RWH system can no longer accommodate additional waste generation. Resolution of RWH system gridlock situations may require frequent and prolonged stand down of operations to clear out waste material inventory.

3.11 CONCENTRATE RECEIPT AND MELTER FEED PREPARATION SYSTEMS

The objectives of the combined LCP and LFP systems are to receive, prepare, and deliver LAW feed to the melters. The functions of the LCP system include receipt of LAW concentrate from the Pretreatment Facility; storage, mixing, and sampling of LAW concentrate; transfer of LAW concentrate forward to the LFP system or back to the Pretreatment Facility via the radioactive liquid waste disposal (RLD) system; and provision of a flush capability for vessels, piping, and in-line components to prevent plugging and provide decontamination.

The specific key functions of the LFP system include (1) receipt of LAW concentrate from LCP in the concentrate receipt vessel; (2) mixing of glass formers in the feed preparation vessel to meet product-compliance requirements; sampling of melter feed is performed to verify correct glass-former mixture; transferring concentrate to the melters by air displacement slurry pumps located in the feed vessel; and flushing of transfer lines is performed to prevent plugging and provide decontamination capability.

Each melter has two independent and duplicate arrays of LCP and LFP components to transfer process fluids among vessels for process flexibility. Although the LCP and LFP systems are separate, they are considered together due to their high degree of interdependence. However, no major design changes were identified, and most of the identified vulnerabilities have simple disposition actions available.

3.11.1 Opportunities for Improvement

Contact maintenance approaches for complex or high-risk activities have not been developed to the extent necessary to confirm that maintenance can be performed in an efficient manner consistent with current OR model assumptions, and that unacceptable production efficiency impacts will not be identified using this OR model. The combined LCP/LFP systems are considered to be capable of meeting their intended functions with some limitations, including:

- Weaknesses associated with undemonstrated equipment availability
- Restricted process cell access to perform contact maintenance (due to thermal, hazardous chemical, and radiological conditions).

3.12 CONTAINER EXPORT AND RECEIPT HANDLING SYSTEMS

The LEH system provides mechanical handling equipment to remove filled and lidded containers from the finishing line and place them on tank farm contractor-supplied transport vehicles.

The design of the LEH system should meet production goals if container temperatures are kept low and a viable transportation system is developed. The overall effectiveness of system operations may be most significantly impacted by container handling and contamination-control issues.

The LRH system receives empty containers into the LAW Facility and transfers the containers to the LPH system, where glass-filling operations are performed. The system consists of two redundant and parallel conveyor lines that work together to inspect and stage containers prior to transfer to the LPH system.

The LRH system design may limit the overall production capability of the LAW Facility, based on some common themes observed in the vulnerabilities. These include empty-container-handling operations, container-receipt-inspection operations, and design calculations/component-testing issues.

The LRH system generally has the ability to import containers into the LAW Facility, but it does not have the equipment necessary to perform all intended functions for the system. The system will be challenged by the inspection requirements, and in the (off-normal) event of foreign material within a container, there is no equipment in place to easily clean/remove it. The use of a shared overhead crane with LSH system, and space constraints within the import bay will also challenge operations.

3.13 ASSESSMENT OF THE D&O VULNERABILITIES

ORP reviewed each of the 519 vulnerabilities identified in Appendix A as part of an assessment of the LAW D&O review results. The purpose of this review was to determine more accurately and completely the status of the LAW Facility design and the true vulnerability that exists in the design. Thus it was important to determine how many of the vulnerabilities were new, how many were known to the LAW project and the number that would necessitate a WTP contract change if determined required.

ORP recognized that the design and safety basis are still in development for the LAW Facility. The number of vulnerabilities identified by the LAW D&O Review Team was anticipated by the Project. For the purposes of this report, “vulnerabilities” are considered to be comments on the design that may signal future operational challenges. Once a “vulnerability” has been identified, ORP then has the opportunity to make appropriate and necessary adjustments; these adjustments will occur over time prior to facility startup. The ORP LAW Federal Project Director will review and concur the basis for vulnerability closure. It is anticipated that all identified vulnerabilities can and will be addressed during the planned work to complete the LAW Facility design. The design is targeted for completion in the summer 2016 and the safety basis is targeted for completion by submission of the Documented Safety Analysis in the summer 2017.

The vulnerabilities in each of the 13 systems and cross cutting areas were reviewed and assigned to one of four areas. They are:

1. Newly identified vulnerabilities not previously known to the WTP Project
2. Vulnerabilities previously identified by the LAW project having either: Open Actions, Completed Actions, or Scheduled Work to be completed
3. Vulnerabilities for which a Contract Change/Direction is required
4. Vulnerabilities that require further review to determine their validity.

Table 3-1 below presents summary data for each of the system areas that categorize the Vulnerabilities. This summary shows the following:

- Less than 5 percent of the vulnerabilities identified were new or not previously known to the LAW project.
- Approximately 52 percent of the vulnerabilities are known to the LAW project and either have been or are in the process of being resolved.
- Approximately 6 percent of the vulnerabilities will require a contract change because they represent scope changes.
- Approximately 37 percent of the vulnerabilities require additional review to determine if they are valid. A number of these vulnerabilities are based on a misunderstanding of document hierarchy.

Appendix B provides a crosswalk between the vulnerabilities identified in Appendix A and the vulnerability categories summarized in Table 3-1 below.

Table 3-1. Summary of System Area Reviewed, Number of Vulnerabilities Identified and Vulnerability Category.

System Area	Newly Identified	Previously Identified	Contract Change Required	Validity Requires Further Review	Total
LAW Primary and Secondary Off-gas process system (LOP/LVP/AMR)	3	26	4	13	46
Instrumentation and Controls (ICN)	0	1	1	12	14
Facility Ventilation System (C1V, C2V, C3V, C5V)	7	19	1	43	70
Electrical	2	16	6	5	29
Radiation/Chemical Control	0	8	0	0	8
LAW melter equipment support handling system	6	39	5	11	61
LAW container pour handling system (LSH)	3	39	2	44	88
LAW melter handling system (LMH)	0	9	4	1	14
LAW container finishing handling system	0	40	3	27	70
LAW radioactive waste handling system (LRWH)	0	12	0	1	13
LAW concentrate receipt process system (LCP/LFP)	2	8	1	5	16
LAW container receipt handling system (LRH)	1	37	1	15	54
LAW container export handling system (LEH)	0	19	4	13	36
Totals	24	273	32	190	519
Percentage	4.60%	52.60%	6.20%	36.60%	

4.0 CONCLUSIONS

The LAW Technical Review was conducted as part of ORP oversight to assess implementation of the contractor's responsibilities under Standard 3, "Design," of the WTP Contract (DE-AC27-01RV14136), which states that the intent of this Standard is "to ensure that the contractor has the necessary systems, processes, information, and deliverables in place to allow ORP evaluation that the WTP Project is proceeding appropriately."

Between February and October, 2014 the D&O Review Team looked at 50 percent of the systems within the LAW Facility and identified 519 vulnerabilities. The vulnerabilities identified ranged in significance and complexity (i.e., some pose a greater risk than others to the success of the LAW mission).

The D&O Review Team considered there were some weaknesses in work processes relied upon to deliver a final facility design that fully meets all functional requirements and ensures compliance with the authorization basis (DSA and environmental permits). Similar weaknesses were previously reported in the reliability validation process conducted by BNI. The team considered that the vulnerabilities, if not mitigated, could potentially result in the following the development of unsafe future operating conditions; loss of waste material confinement; issues with future system performance and maintenance; restrictions on waste management and handling capability; projected impacts to the facility startup and commissioning schedule; and restrictions on production capability, throughput, and performance.

Additional observations by the D&O Review Team indicated that the impacts may go beyond individual systems and the broader operation of the LAW Facility. There was a general concern expressed by the D&O Review Team members with respect to the ability of the LAW Facility to adequately protect worker safety and health and meet regulatory requirements (i.e., compliance with OSHA, ALARA, and the facility fire hazards analysis requirements). ORP reviewed these concerns with members of the D&O Review Team and used this feedback in the development of the 10 recommendations in this report.

In addition, the AMWTP requested the WTP contractor complete a factual review of this submittal on September 14, 2015, which was immediately followed by a letter of direction to resolve the ORP recommendations and design comments and subsequently to develop an Action Plan to address those issues[4]. A factual accuracy response was received from the WTP contractor on October 16, 2015, together with their proposed Action Plan methodology for addressing the 10 recommendations. The WTP contractor provided a significant number of factual accuracy comments on the main body of the D&O Review Team's submittal to the AMWTP. In summary, without further analysis, there appeared to be broad factual accuracy discrepancies and concern with the review process on both sides.

ORP accepted all 519 vulnerabilities, while concurrently acknowledging that the D&O Review Team did not evaluate other WTP Contract provisions and work process improvements, including the parallel development and issue of the MIP (24590-WTP-PL-MGT-14-0006). The D&O Review Team also did not evaluate technical direction provided by ORP with respect to expectations for design reviews (July 2014) and associated ORP ongoing oversight activities. General issues of concern to ORP include minimization of any potential rework, which is not safety related; schedule challenges that have yet to be verified or validated; and startup, commissioning, and operability requirements, which have a direct impact on the LAW Facility pertaining to the direct feed LAW program.

In addition, ORP acknowledged an underlying concern raised with respect to the status of LAW Facility essential design documents. ORP concluded BNI should continue to optimize their configuration management processes to remove redundant and conflicting details to support the ongoing facility design and prior to the upcoming 90 percent design review.

ORP reviewed the D&O Team comments as presented in Appendix A and determined that at least 52 percent of the vulnerabilities were previously known to WTP, less than 5 percent were new issues, approximately 6 percent are not within the contract scope and approximately 37 percent require further review to determine their validity. Based on this assessment ORP considers that the vulnerabilities identified are manageable as part of design and safety basis completion.

With this broader perspective, ORP derived a suite of recommendations that modeled a forward looking mindset that supported the current WTP mission philosophy. The recommendations in this report focus on worker health and safety, programmatic improvements, and capture the hard work and effort that went into this review.

5.0 RECOMMENDATIONS

ORP developed the following recommendations with the intent to ensure that the WTP contractor has the necessary systems, processes, information, and deliverables in place to allow DOE evaluation of the WTP Project. The recommendations are structured to allow the AMWTP to make timely forward-looking decisions to avoid, mitigate, or prevent potential mission risks from occurring within the LAW Facility.

5.1 RECOMMENDATION 1: DISPOSITION EACH IDENTIFIED VULNERABILITY AS PART OF THE WTP PROCESS TO COMPLETE THE LAW FACILITY DESIGN AND DOCUMENT THIS DISPOSITION FOR REVIEW BY ORP LAW FEDERAL PROJECT DIRECTOR

Each vulnerability identified in Appendix A should be dispositioned in a manner that is integrated into the work process to complete the LAW Facility design. ORP will review the basis for closure of each vulnerability. This disposition process should include:

- BNI providing a determination of when it expects to disposition each vulnerability within its baseline schedule to complete LAW engineering and communicate this timeline to ORP.
- The disposition should include a description of, and the basis for, any actions taken to resolve each vulnerability.
- BNI should indicate which open actions are related to a given vulnerability and provide documentation of successful closure.
- To the extent BNI believes a responsive action to any vulnerability is not necessary to complete engineering or operational planning, it should justify this position (with specific reference to the vulnerabilities), and submit this justification to ORP for review.
- Disposition of each vulnerability should not be considered complete until the ORP review is completed and/or additional requisite actions are agreed upon and their completion is documented.
- Ensure consistency in LAW Facility design media to support ongoing design activities prior to design completion.
- Vulnerabilities requiring contract action should be identified to ORP for action.
- Due to the safety significance, complexity, and number of vulnerabilities associated with the LOP/LVP system, identified by both BNI and the Technical Review Team, ensure these are comprehensively evaluated.
- Update design documentation consistent with the Systems Engineering Management Plan (24590-WTP-PL-ENG-14-002) requirements.

5.2 RECOMMENDATION 2: CONDUCT AN ENGINEERING EVALUATION TO DETERMINE THE MOST APPROPRIATE CONFINEMENT VENTILATION SYSTEMS SAFETY CLASSIFICATION

The review identified a number of vulnerabilities related to the LAW Facility confinement ventilation system design. Remedial actions in response to the ventilation system vulnerabilities could be impacted by the final safety classification of the confinement ventilation system, particularly if any of the SSCs are determined to be safety-significant. This determination would normally be expected as an outcome of the ongoing effort to complete the hazard analysis and control selection as part of the effort to realign the LAW safety and design bases. However, the current schedule for this action would not achieve this determination until later in the project schedule. The delay in implementing any requisite remedial measures could result in a potential need for rework, which could have a substantial impact on project cost and schedule.

The WTP contractor should therefore determine the safety classification of the confinement ventilation system using standard processes including:

- Reviewing the current hazard/accident analysis and control selection documentation including SSCs previously identified as providing additional protection class functions.
- Assessing the confinement ventilation system likelihood to perform a function that may be considered a major contributor to defense-in-depth in accordance with the criteria set out in DOE-STD-1189-2008, Integration of Safety into the Design Process, Section D.2, “Criteria for Selecting SS Major Contributors to Defense-in-Depth.”
- Identifying candidate safety-significant functions and the SSCs in the current design, which may be designated safety-significant.
- Based on the results, assessing the impacts on the LAW design and procured and/or installed SSCs and identify remedial measures.

5.3 RECOMMENDATION 3: DEVELOP, VALIDATE, AND IMPLEMENT AN AIR-FLOW SIMULATION MODEL FOR FURTHER INVESTIGATION OF HVAC-RELATED VULNERABILITIES

The HVAC system design and the lack of airlocks to support pneumatic isolation of ventilation systems has created issues in maintaining adequate flow across contamination zone confinement boundaries. This has the potential to result in migration of contamination between zones during the performance of normal operations and maintenance activities.

Therefore, the following actions should be taken by BNI:

- Develop a LAW ventilation system simulation model to aid in validation of the confinement ventilation system design.
- Use this model to investigate those aspects of HVAC system vulnerabilities that relate to dynamic air flow, including:
  - Maintenance of minimum flow velocities across confinement boundaries.
  - Sensitivity of differential pressure for normal operating activities.

- Reassess the adequacy of the design basis in specifying confinement velocities and which contamination zone boundaries require a minimum confinement velocity.
- Identify aspects of the design that may have difficulty meeting functional requirements for performance and/or control and evaluate possible design measures, which could facilitate compliance with functional requirements.

5.4 RECOMMENDATION 4: REVIEW THE CURRENT SOFTWARE QUALITY CLASSIFICATION AND CONFORMANCE OF THE ICN DESIGN TO INDUSTRY BEST PRACTICES

The software associated with the plant process control system process control system is currently classified as software quality level D with a lower level for the operating system. Although this is compliant with an NQA-1 graded approach, a question has arisen as to whether this classification is consistent with its intended process control functions, which include:

- Non-safety-significant defense-in-depth functions
- Functions credited in ISA-84 analysis
- Environmental permit affecting functions (DOE P 450.4A, Integrated Safety Management Policy and Department of Energy Acquisition Regulation clause related)
- Non-nuclear safety functions (DOE P 450.4A and Department of Energy Acquisition Regulation clause related)
- Functions supporting required operator responses
- Functions supporting the programmable protection system inappropriate for a non-safety system
- Support for mission critical, non-nuclear safety-significant operations.

The instrument and control (I&C)-related functional requirements do not drive development of logic diagrams and I&C design specifications. It was further determined that the anticipated implementation of system design descriptions might not be sufficient to bring the I&C design process into alignment with current industry best practices. Following these practices is important as a proven method to minimize errors in design, allow for future upgrades commensurate with technology advances, and facilitate turnover to operations. To address these issues:

- BNI should assemble an independent team of I&C design and related software quality assurance experts, who can provide a constructive opinion as to the adequacy of the WTP approach to safety software classification and software quality assurance requirements, to ensure all hazards (nuclear and non-nuclear) are identified, analyzed, and controlled at nuclear facilities, per 10 CFR 830. The team should also review how the current LAW I&C design process compares to current industry best practice, and methods that might be employed to bring this design process into better alignment with these practices.

- Given this feedback, BNI should reassess the basis for current software quality classification and provide justification for either maintaining the same classification or modifying this classification.
- Given this feedback, BNI should assess the potential implementation of recommendations for conformance to industry best practice for design and determine suitable measures to implement those remedial actions.

Note: ORP and BNI co-sponsored an expert panel to review the adequacy of the ICN software quality. The final report was issued April 2015. BNI is committed to developing and maintaining formal project records to memorialize the disposition of all of their recommendations. ORP is already committed to engaging with the subject matter experts to ensure that the dispositions are transparently developed.

5.5 RECOMMENDATION 5: ASSESS THE THERMAL ANALYSIS OF THE LAW MELTER POUR CAVE AND TRANSFER TUNNEL AND IDENTIFY ANY REQUIRED DESIGN OR OPERATIONAL CHANGES

A review of thermal design documents indicates inconsistencies in calculations for thermal (nominal and limiting) conditions where human access would be permitted. In addition, these calculations rely on non-prototypic models to determine ambient room temperatures for either routine or emergency worker access. Calculations using these models for concrete, near-surface temperatures and SSCs in the affected area show that in some conditions they are close to established limits for compliance with structural integrity standards and component temperature limits appear to lack a clear demonstration of design margins. To fully assess the thermal impacts, the thermal conditions in the pour cave and thermal transfer tunnel should be evaluated as part of the 90 per cent design review. The 90 per cent design should include:

- Confirm the validation of the computational fluids dynamics model and/or calculations performed.
- Analyze steady state and transient thermal conditions for both worker exposure and concrete structural limits
- Determine the best steady state and transient thermal predictions for ambient room temperatures where human access may be possible and near-surface temperatures for all areas where structural integrity compliance is necessary
- Determine if additional controls might be necessary to comply with established design limits and/or worker safety standards

5.6 RECOMMENDATION 6: DEVELOP COMPREHENSIVE FACILITY WORKER ENVIRONMENTAL, SAFETY, HEALTH, AND RADIOLOGICAL PROTECTION PROGRAMS THAT RECOGNIZE THE NEED FOR A ROBUST CONTAMINATION CONTROL METHODOLOGY AND IMPLEMENTS ALARA PRINCIPLES PRIOR TO FACILITY STARTUP

The review determined that BNI is taking action to evaluate hazards for chemicals stored onsite for industrial use, but compliance planning for other applicable OSHA standards (as per

10 CFR 851, "Worker Safety and Health Program") regarding chemical process systems and RCRA remedial actions requires improvement.

Compliance with OSHA requirements that evaluate LAW Facility as a chemical process facility and/or a RCRA hazardous waste operational facility can impact D&O and should be considered as part of the hazards' analysis process. In fact, these standards require integration of a chemical management plan within the design effort and the inclusion of operations personnel in the development of the plan. The chemical model of feed stored in tank farms contains more than 1,800 chemicals, of which approximately 50 are managed as chemicals of potential concern for hazardous exposure. This chemical array includes those identified within the Contract Standard 2 data quality objectives document, in addition to other chemicals. The chemical array may potentially become more variable with LAW as feed passes along the process flow.

BNI should:

- Develop a chemical management plan consistent with the LAW Facility process flow design, in compliance with 29 CFR 1910.119 and 29 CFR 1910.120
- Submit this plan to ORP for concurrence regarding adequacy of design and compliance with OSHA standards
- Integrate this concurrence and plan within the engineering work process, as required by these standards
- Provide a backward look regarding EPC work already completed, to determine any conflicts with this plan and potential need for corrective action of the design and/or operational control.

5.7 RECOMMENDATION 7: PERFORM DETAILED TASK ANALYSIS IN SELECT AREAS TO CONFIRM THE VIABILITY OF THE MAINTENANCE METHODS PROPOSED

Develop radiation dose calculations and maintenance assumptions for select areas where personnel are expected to work (e.g., wet process cells, melter gallery, transfer corridor, finishing line etc.:

- Develop and document management strategies and time commitments for these areas (e.g., de-inventory before entry, flushing requirements, remote tooling etc.).
- Develop or use existing task analysis to estimate the radiation exposure to the work force to establish if dose management is a significant concern, which requires mitigation through design changes. Undertake a critical analysis of the tasks required to be completed in high temperature areas using a conservative assessment of the expected ambient working temperature. This should identify if there are areas where maintenance tasks may be significantly restricted.

Evaluate the viability of maintenance of electrical systems particularly associated with the melter and melter power supplies for feasibility of isolation, access, and the capability to execute the maintenance on a schedule to maintain the melter with power.

5.8 RECOMMENDATION 8: REASSESS THE CARBON BED FIRE SAFETY RISK AND ASSOCIATED CONTROL MEASURES

The PDSA (24590-WTP-PSAR-ESH-01-002-03) postulates an accident scenario consisting of a carbon bed fire with attendant release of adsorbed mercury. The unmitigated consequence of this event is calculated to exceed the public exposure thresholds for mercury at the offsite boundary. Therefore, safety-significant controls are required, consisting of fire detection and physical isolation of the bed. Fire extinguishment using water deluge is available but is not a credited safety control strategy.

Documentation reviews and surveys of relevant industry experience indicate there is an historical safety risk concerning detection ability and difficulty of extinguishing fires within large carbon beds. In such large beds, internally localized conditions can remain unnoticed and become difficult to address.

For LAW, the response to a carbon bed fire, or the more likely false positive indication of a fire, can result in activation of a water deluge system with potential for extensive impacts to equipment and personnel safety hazards. Therefore, it is imperative that the approach for detection of a carbon bed fire is robust, reliable, and proven.

Alternative fire detection methods may be available that could enhance detecting such localized events. In addition, the physical location of this bed within the LAW Facility creates some difficulty of a rapid and effective response to a fire. Being already installed, its size and constrained location will cause remedial measures for this carbon bed to become progressively more difficult as the EPC process advances. Therefore, it may be advisable to maintain a more robust fire prevention approach through aggressive early detection methods and to make this determination regarding detection strategy as soon as practicable. Consequently, BNI should confirm that the carbon beds are necessary to comply with regulatory requirements. The evaluation should consider alternatives available to achieve regulatory compliance without the carbon beds and evaluate scenarios that could be implemented to minimize the use of the carbon beds. If the carbon beds are found to be required, BNI should:

- Investigate the feasibility of utilizing alternative fire detection mechanisms and/or a combination of detection methods.
- Investigate and evaluate alternative fire extinguishing methods, mindful of the carbon bed physical location and the impact of extinguishment methods on the remainder of the facility and personnel hazards involved with both extinguishment and recovery from extinguishment.
- Define the conditions indicative of an incipient fire and the processing conditions required to prevent the development of a carbon bed fire (e.g., minimum flow conditions).
- Define the maintenance requirements to ensure reliability of the fire detection instrumentation such that the potential for spurious or false activations are minimized and the appropriate safety integrity level is achieved.

- Use the results of these investigations to analyze the risks and benefits of alternate remedial measures.
- Input the results of this analysis in the safety case and design basis realignment process.
- Maintain the carbon beds as necessary for pollution control, including the evaluation of carbon bed replacement and removal. Consider methods to improve the accessibility and ergonomics associated with filling and particularly emptying the carbon bed media.

5.9 RECOMMENDATION 9: SUPPORT THE DEVELOPMENT OF AN OPERATIONAL RESEARCH MODEL FOR THE DIRECT FEED LAW PROGRAM

BNI should support the development (by the Tank Operations Contractor) of an integrated operations research model for Direct Feed LAW (DFLAW) to enable a combined DFLAW Program throughput analysis to be developed. The support required will be to provide data to enable an accurate representation of the operation of the LAW/BOF/Lab Facilities in the direct feed configuration. This integrated DFLAW Program model will:

- Be used for scenario analysis and as such should not be constrained by the 70 percent availability requirement in the WTP Contract;
- Evaluate the DFLAW integrated throughput capabilities and provide a more detailed understanding of the key interactions between the Tank Farms, the LAW Pretreatment System, the LAW Facility, and the Integrated Disposal Facility as they effect individual facility operations and maintenance strategies;
- Use common industry data for mean time between failures and mean-time to repair values for the DFLAW Program SSCs, where site-specific data are not available. This should be based on standard databases such as the Savannah River Site Generic Database Development (WSRC-TR-93-362);
- Consider the impact of other losses (i.e., performance and quality losses) to enable an overall equipment effectiveness (OEE) assessment of areas of improvement with maximum potential;
- Undertake what if and bottleneck analysis to support an informed decision on the cost benefit of identified improvements;
- Analyze the operation of the LAW Facility in the direct feed configuration only and be integrated with the LAW Pretreatment System Facility, DST Waste Feed Delivery and other DFLAW Program scope models through the One System Organization;
- Compare the results with analogous facilities to assist in model validation.

5.10 RECOMMENDATION 10: EVALUATE SYSTEM TESTING THAT COULD BE ACCELERATED TO REMOVE RISK FROM THE STARTUP AND COMMISSIONING PHASE

A number of equipment or system testing activities, if completed earlier, could potentially reduce cost and schedule risk in the startup and commissioning phase of the LAW Facility. Examples include the LAW canister decontamination system and lid recovery tool, and integrated control system testing. Consequently BNI should:

- Identify on an equipment and system basis, the equipment that has not been completely or effectively tested as an equipment component or as part of an integrated system test in prototypic and relevant operating conditions.
- Assess the potential benefit, on an equipment and system basis, of advancing the equipment and/or system startup and commissioning schedule for this equipment or system.
- Based on these evaluations present to ORP:
  - Equipment and system testing opportunities including testing objectives and schedule to reduce technical and operating risks.

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APPENDIX A
SUMMARY OF THE DESIGN AND OPERABILITY REVIEW TEAM VULNERABILITY RESULTS

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APPENDIX A TABLE OF CONTENTS

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ACRONYMS AND ABBREVIATIONS

ACFM	Actual cubic feet per minute
AHU	Air handling unit
AHA	WTP Hazards Analysis Procedure
ALAR	As low as reasonably achievable
ASD	Adjustable Speed Drives
ASEE	American Society for Engineering and Education
ASM	Abnormal Situation Management
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Material
BOD	Basis of Design
CAM	Continuous Air Monitoring
CAP	Corrective Action Plan
CCB	Consumable Changeout Box
CCN	Correspondence Control Number
CD	Critical Decision
CDI	Configuration Data Index
CFD	Computational Fluid Dynamic
CRV	Concentrate Receipt Vessel
CSLD	Control System Logic Document
CT	Current Transformers
DAC	derived air concentrations
DBE	design basis event
DOE	Department of Ecology
DP	Differential pressure
DPD	Design proposal drawing
DRE	Destruction and removal efficiency
EA	Exposure Assessment
ECCN	Export Control Classification Number
EDR	Electronic Data Record
EDMS	Electronic Document Management Systems
EPDM	Ethylene Propylene Diene
EOP	Emergency Operation Plan/Emergency Operation Procedure
EQ	Environmental Qualification
ES&H	Environmental Health and Safety
ESP	Electrostatic precipitator
FAT	Factory Acceptance Testing
FCU	Fan coil units
FEMCA	Failure Effects Maintainability Criticality Analysis
FFKM	Perfluoroelastomer
FRS	Functional requirements specification
GFR	Glass Fiber Reagent
HMI	Human machine interface
I&C	Instrument and Control

ACRONYMS AND ABBREVIATIONS (CONT.)

ICN	Integrated Control Network
IDF	Integrated Disposal Facility
ILAW	Immobilized Low-Activity Waste
IH	Industrial hygiene
IR	Infrared (Transmitter)
ISA	International Society of Automation or Instrument Service Air System
ISA	Imaging sensor autoprocessor
J3	JCS pre-approved support request form
JCS	Job Control System
HMI	Human/Machine Interface
HP	Health Physics
LAW	LAW Low activity waste
LCP	LAW Concentrate Receipt Process
LEH	LAW Container Export Handling
LFP	LAW Melter Feed Preparation
LSH	LAW Melter Equipment Support Handling
LOI	Local operator interface
Lolo	Low-Low condition
LOOP	Loss of offsite power
LOTO	Lock-out/ tag-out
LP	Layer(s) of protection
LPS	Low Pressure Steam
LRH	LAW Container Receipt Handling
MCC	Motor Control Center
MDD	Model Design Document
MHD	Mechanical Handling Diagram
MFV	Melter Feed Vessel
MFPV	Melter Feed Preparation Vessel
MSD	Mechanical Sequence Documents/Diagram
MSM	Master Slave Manipulator
MTBF	Mean Time between Failures
MTTF	Mean Time to Failure
MTTR	Mean Time to Repair
NFPA	National Fire Protection Association
NFPA 70	National Electrical Code
NIST	National Institute of Science and Technology
NRTL	Nationally recognized testing lab
O&M	Operations and Maintenance
OFI	Opportunity for Improvement
OR	Operational Research (modeling)
ORD	Operations requirements document
P&ID	Piping and instrumentation diagram
PDSA	Preliminary documented safety analysis

ACRONYMS AND ABBREVIATIONS (CONT.)

PI	Proportional-Integral
PLC	Programmable logic controller
PPE	Personal Protective Equipment
PPJ	programmable protection system
PRC	Plateau Remediation Contractor
QAM	Quality Assurance Manual
RadCon	Radiologic Control
RAM	Reliability, Availability and Maintainability (report)
RCRA	*Resource Conservation and Recovery Act of 1976*
RFI	Request for Information
RLD	Radioactive liquid waste disposal
RSW	Radioactive Solid Waste System
RTM	requirements traceability matrix
RWH	Radioactive Solid Waste Handling
RVP	Reliability Validation Process
S&H	Safety and Health
SAT	Software Acceptance Testing
SBS	Submerged bed scrubber
SD	System Description
SDD	System Design Description
SDG	Standby Diesel Generator
SFC	sequential function chart
SIPD	Standards Identification Process Database
SIF	Safety instrumented function
SIL	Safety integrity level
SIS	Safety instrumented system
SME	Subject Matter Expert
SPP	Site sustainability program
SQA	Software Quality Assurance
SS	Safety Significant (interlocks) (air conditioning equipment)
SSRS	Safety software requirements specification
TCO	Thermal Catalytic Oxidation
TOC	Tank Farm Operations Contractor
TSR	Technical safety requirement
UBC	Uniform Building Code
UBC SC/SD	Very Dense Soil / Stiff Soil
V&V	Validation and Verification
VFD	Ventilation flow diagram
VOC	Volatile Organic Chemicals
VRLA	Valve-regulated lead-acid
VSL	Vessel
WIPSD	WTP Integrated Processing Strategy Description
WIR	Waste Incidental to Reprocessing
WESP	Wet electrostatic Precipitator

ACRONYMS AND ABBREVIATIONS (CONT.)

w.g.	Water Gauge (pressure)
WTP	Waste Treatment and Immobilization Plant

A.1 SUMMARY OF THE DESIGN AND OPERABILITY VULNERABILITY RESULTS

A.1.1 INTRODUCTION

The LAW Facility is comprised of 26 major systems. The LAW D&O Review encompasses 13 systems that met one or more of the following criteria:

- Have historically experienced functionality issues in comparable facilities leading to commission delays or maintenance and operations challenges.
- Include complex unit operations for which there is a lack of operating precedence.
- Present potential single point failures that could lead to long repair/maintenance periods with attendant impacts to facility production
- Represent a risk to LAW Facility functionality based on the number and significance of issues identified during the outcome of WTP Reliability Validation Process (RVP) reviews
- Include hazards requiring safety class or safety significant controls based on the analysis in the Preliminary Documented Safety Analysis (PDSA).
- Represent complex testing evolutions to demonstrate compliance with environmental permits.
- Are relied upon to maintain or demonstrate confinement of radiological and non-radiological hazardous materials.

A comprehensive listing of vulnerabilities is presented below, system by system, in 14 tables. Each table represents one system and delineates; the vulnerability by number, a description of the vulnerability, the basis for the finding, the consequences if left unresolved, and opportunities for improvement.

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A 1.2 TABLES

Table A-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (21 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LOP/LVP-01	The collective significance of project self-identified issues indicates overall functionality of LOP/LVP systems is indeterminate	• RVP process identified 275 issues • Approximately 70 of the 275 were directly related to plant functionality/operability – a number would be considered high impact using the design and operability team impact analysis process. • RVP concluded that: - Some issues were identified that could potentially impact the overall function of the system. - The system is not fully in alignment with the requirements and its design documentation to meet configuration control • See RVP discussion in Background section	LOP/LVP system functionality is indeterminate with unaccounted impacts to plant throughput.	• Complete self-identified actions. • Implement independent confirmation of effectiveness of issue resolution actions.
LOP/LVP-02	The complex abatement system design with numerous safety and permit affecting controls is likely to impact ability to sustain operations and meet throughput requirements.	• Abatement system equipment/unit operation selection decisions made early in project (circa 2001) based on preliminary and evolving process information (flowsheet) • Abatement system results in postulated safety events with Hg off-site consequences that otherwise would not exist (e.g., carbon bed fire event). • Pilot testing indicates the highest known potential for experiencing a carbon bed fire occurs, as indicated by carbon bed temperature increases, during MACT/DRE testing when high concentrations of organic are intentionally introduced to the melter feed. Other operating periods with higher fire risk, is after replacement of the carbon bed material and during transition from an idled melter to steady state operation • Postulated safety events and associated confinement requirements result in complex control schemes (e.g., bypass interlocks, low flow reconfiguration, etc.) exacerbated by associated permit affecting controls. • Abatement requirements basis and equipment selection not formally revisited to consider flowsheet evolution and technology developments in intervening decade.	• In this case, the usually mutually reinforcing objectives of safety and environmental protection appear to be in conflict, thereby resulting in potentially unnecessary hazards to workers and the public. • Likely significant throughput impacts due to inability to maintain operability of necessary safety and permit affecting equipment and control systems. • Failure to pass MACT/DRE test during commissioning or during operations could lead to prolonged delays (months).	Revisit permit conditions and abatement system requirements to consider: • Current/evolving safety concerns and flowsheet conditions. This may justify elimination, substitution or simplification of the equipment selected to address some constituents of concern. For example, substitution of the carbon beds with alternatives for Hg abatement that are less hazardous and more compatible with achieving throughput objectives. • Costs associated with throughput impacts as part of any associated economic evaluation. • Regulatory basis for including abatement equipment currently identified in the permits, and eliminate from the permit those that do not clearly perform an abatement function (such as the WESP which removes particulates from the offgas, thus reducing changeout frequencies of HEPA filters). Equipment such as the WESP would then be operated as non-permit affecting. • Crediting the inherent/overall abatement effectiveness of the melter in combination with the LOP/LVP system (such as for halides and organics). This may justify elimination, substitution or simplification of the equipment selected to address individual constituents of concern.

Table A-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (21 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
				• Potential to implement alternative regulatory strategies to minimize risks associated with MACT testing.
LOP/LVP-03	There appears to be insufficient redundancy available to avoid single point equipment failures affecting both melters	• Dual LOP trains but intrusive maintenance on one train (e.g., WESP, SBS) will require feed shut-off to both melters (until train under maintenance can be isolated/placed in safe state). • Single LVP train serves both melters. Failures impact both melters. • As per the RVP findings, the LVP bypass valves are not considered maintainable because these valves cannot be adequately isolated, thereby requiring both melters to be idled.	Unaccounted throughput impacts	• Generally, the single point failures are an inherent aspect of the design and therefore specific meaningful OFIs are not apparent. OR modeling would aid in understanding the full extent of the throughput impacts and potential options to minimize those impacts. • Evaluate the viability of installing a reduced flow capacity bypass line around the entire LVP system downstream of the HEPA filters as a possible means to improve the ability to safely perform intrusive maintenance on the LVP system bypass valves and equipment.
LOP/LVP-04	Single point instrument failures, interlocks, required calibrations and surveillances can result in unaccounted throughput impacts.	• 50 LOP/LVP system feed trip interlocks were identified that will initiate termination of feed to one or both melters upon exceeding defined operational parameters. • Other factors such as instrument failures, maintenance, bad quality signals or spurious trips associated with these interlocks will also likely result in terminating feed. • There are currently ~50 individual draft TSRs defined that will likely drive some level of periodic calibration and testing (e.g., stroke testing) of the safety instrumentation and interlocks. • Permit requirements will also likely result in additional conditions, instrument testing and calibrations that could interrupt melter feed operation (permit driven automatic waste feed cut-offs not fully defined). • Where redundant instruments are provided, either of the two instruments can initiate a melter feed cut-off interlock trip (no voting system which would require additional instrumentation to achieve acceptable spurious trip frequencies). • Spurious trip analysis not complete but will likely exacerbate this vulnerability (estimate of spurious trip rate is underway and will be reported separately).	Throughput reductions, loss of production and availability	• Confirm, via hazard analysis and discussions with regulators, that all interlocks are required or warranted. • Verify that the OR Model considers impacts due to maintenance and calibrations. • Plan mini-outages for instrument maintenance, loop calibrations, and surveillances (account for these in OR model). • Consider procedural approach to allow one loop out of service for redundant loops (i.e., designate primary and secondary loops in the DCS).
LOP/LVP-05	Adequacy of design to support control of integrated system equipment/components under various expected operating conditions (e.g., startup, shutdown, low flow, melter	• Lack of evidence of full-scale analysis or prototypic testing to confirm ability to control heat, moisture, flow, gas composition such that the integrated unit operations are controllable	• Unanticipated but recognizable abnormal events result in loss of control and prolonged shut-down for recovery (unaccounted throughput impacts)	• Develop a dynamic process model with control features to aid planning of commissioning, operational start up and shut down and as a tool to aid future alternate process operating scenarios.

Table A-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (21 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	surges, etc.) and abnormal operating conditions not demonstrated.	under start-up, shutdown and recognizable abnormal conditions. • Generally a lack of understanding of flowsheet dynamics and control interactions under various start-up and shut down modes/scenarios. - The design basis flowsheets are all at steady state conditions. For sizing equipment these are valid in that they consider a number of cases and in general the use of the 2 melter maximum case provides conservatism in design but does not support looking at what-ifs across the process or aiding in developing start-up and shut down strategies. Further, evaluation of a flowsheet condition for which both melters are in idle mode (expected condition) was not evident. - Equipment design generally based on nominal and maximum flowsheet conditions. Therefore, equipment performance and control under low flow conditions is not typically analyzed. -	• Ineffective equipment performance or equipment damage (due to high heat, humidity, elevated corrosive constituents, etc., during start-up and shutdown). • Start up and shut down may be more difficult to establish with extensive trial and error required to understand the dynamic system interactions thereby resulting in extended commissioning durations and/or unanticipated throughput impacts. • Future changes to operating conditions cannot easily be evaluated prior to their implementation and thus increase the risk of maloperation and greater than anticipated throughput impacts	• Continue development of “Technical Manuals” as a means to develop and integrate start-up/shut-down sequences and responses to abnormal conditions. • Consider developing a “reduced scope” WTP Integrated Processing Strategy Description (WIPSD) to develop system level integrated start-up/shut-down sequences and responses to abnormal conditions.
LOP/LVP-06	Lack of functional testing of LOP equipment performance at vendors.	• No evidence was found that sufficient individual or collective LOP equipment environmental performance tests were undertaken at vendors prior to delivery and installation. Although procured against a performance specification, the first time this will be demonstrated will be during start-up and commissioning. • The RVP review specifically identified the lack of vendor performance testing for the WESP.	• Unanticipated but recognizable abnormal events result in loss of control and prolonged shut-down for recovery (unaccounted throughput impacts). • Ineffective equipment performance or equipment damage (due to high heat, humidity, elevated corrosive constituents, etc., during start-up and shutdown). • Start up and shut down may be more difficult to establish with extensive trial and error required to understand the dynamic system interactions thereby resulting in extended commissioning durations and/or unanticipated throughput impacts. • Future changes to operating conditions cannot easily be evaluated prior to their implementation and thus increase the risk of maloperation and greater than anticipated throughput impacts. • Lack of known performance on individual unit operations may make fault finding during start-up and	• Review compliance with the performance specifications for each piece of equipment to determine if some level of performance testing should be completed prior to commissioning • Establish performance criteria on individual units and overall system as part of start-up and commissioning planning. • Develop a dynamic process model as a tool to improve confidence that equipment performance requirements can be achieved.

Table A-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (21 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
			commissioning more complex and lengthy. • Without prior environmental performance testing the functionality of the system is indeterminate until operated collectively	
LOP/LVP-07	Intrusive maintenance performed on the LOP System (including the Condensate Receipt vessel) will require both melters to be in idle with the cold cap burned off. Other non-intrusive maintenance requiring a process cell entry could also result in idling both melters.	• In order to perform maintenance on the LOP system, the offgas system must be diverted to the other melter and SBS for cooling. Opening the maintenance by-pass valve (YV-1002) will automatically shut-down both melter feeds. • Due to the interconnected nature of the LOP, Wet Process Cell, C5 Ventilation, and the Vessel Vent System it is indeterminate as to the impacts on system throughput when a process cell entry is required for non-intrusive maintenance. The current project perspective is that only the associated melter will be idled when entry into the process cell is required for non-intrusive activities. • Requirements for entry into an area with the Special Relief Devices that may vent melter off-gas as result of a pressure event have not been fully defined but may ultimately require idling of both melters.	Unaccounted production impacts	• Add associated maintenance to the OR Model which reflects both melters off-line. • Determine if additional design features are necessary to facilitate maintenance on the LOP system. • Conduct detailed task analysis and methodically identify potential hazardous situations to confirm that entry to wet process cell vessels (LCP and LFP) is possible without shutting down both melters. • Consider relocating the pressure relief devices to another C5 area (3rd wet process cell), or piping them directly into the C5 header would decrease the exposure potential to the maintenance workers during an entry into the wet process cell and would allow one melter to be operational during wet process cell maintenance activities (note that this may drive re-evaluation of the safety significance of the C5 system). • Consider crediting the C5 ventilation system in the melter annulus as the final mitigation of a pressure event. This would allow for the removal of the pressure relief devices, thereby eliminating the hazard of off-gas releases into an occupied wet process cell (note that this may drive re-evaluation of the safety significance of the C5 system).
LOP/LVP-09	The Melter Film Cooler, Offgas lines (including Wall Penetrations) and the SBS Down-Comer can be removed and replaced mechanically (i.e., bolted and threaded connections) but these components are currently reflected to last the life of the melter. WTP has not demonstrated that these components can be removed and replaced with active melters during operations.	• VSL testing showed that increasing the melter glass production rate (increase temperature and/or more aggressive bubbler operation) has an adverse effect on deposition of solids in the vent path to the SBS. • A request for technology development was submitted for additional VSL testing. This recommendation was declined. • The Final VSL test report stated "film cooler blockages requiring mechanical clean-out occurred less frequently as compared to previous tests due to lower feed and bubbling rates."	• Unaccounted throughput impacts due to the potential need to remove solids or replace film cooler and other off-gas piping. • Since features to facilitate cleanout of solids accumulations or film cooler and off-gas piping replacement are not evident, throughput impacts to conduct these activities could be significant. • If the Film Cooler, Offgas Line (including Wall Penetrations) or SBS Down-Comer cannot be cleaned or replaced during operations, in a worst	Demonstrate during commissioning that the Film Cooler, Offgas line (including Wall Penetration) and SBS Down-Comer can be removed, cleaned or replaced and put back in service under operational conditions. Note that this will further challenge the commissioning durations. This risk to commissioning could be reduced through additional testing at VSL.

Table A-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (21 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		• Upon post-test inspection of the film cooler it was discovered to be damaged/corroded to the extent that it could not be reused. • VSL recommendation was that although testing showed improvement from plugging through the process changes, this observation should not be considered definitive given the short duration of the tests. Thereby implying a potential open issue.	case, it could prematurely limit the life of the melter.	
LOP/LVP-10	The “special” pressure relief devices (LOP-SP-00003/8) that vent melter gas in an off-normal event to the C5 Wet Cell cannot be isolated for maintenance, calibration or replacement.	• Although these devices (LOP-SP-00003/8) are non-safety, they provide overpressure protection to the melter by relieving at plus 10 (+3/-0) in. w.g. to the C5 Wet Cell. The assumption is that these devices protect the equipment from either damaging the melter refractory material and/or prevent an inadvertent glass pour. • There is not an identified means to isolate the special relief devices. • The DM 1200 test work (24590-101-TSA-W000-0009-166-00001 Regulatory Off-Gas Emissions Testing on the DM1200 Melter System Using HLW and LAW Simulants) showed a continuous accumulation of solids in the SBS with no trend towards a steady-state. • The suction line end effector design in the SBS was modified to a simpler design but there is only one 2-inch line for transfer of solids located near the center of the tank. Similarly there is only a single eductor in the condensate vessel to promote mixing and any return of solids back to the SBS in the recirculation line. Both are single point failure items. • While accumulation of solids in the SBS can be inferred from increases in pressure drop over time there is no direct measurement of solids. • The capability to remove solids with the procured equipment was not demonstrated as part of an integrated factory acceptance test so the first proof will be in commissioning or operation.	• Both melters would likely need to be idled to support maintenance/replacement, thereby resulting in unaccounted throughput impacts • If not maintained or maintenance is extended to support production operations, the devices may not relieve pressure when challenged thereby damaging the melter and/or an inadvertent glass release into the pour tunnel.	• Since these are non-safety devices, consider installing duplicate relief devices that include isolation devices to minimize impacts to production during maintenance. • During commissioning, develop and demonstrate method for replacement and/or testing of the special relief devices. Note that this will further challenge the commissioning durations. This risk to commissioning could be reduced through additional testing at VSL.
LOP/LVP-11	The impact of solids accumulation and the effectiveness of their removal within the SBS and SBS Condensate Vessel is not demonstrated other than over limited pilot scale test durations.	• The DM 1200 test work (24590-101-TSA-W000-0009-166-00001) showed a continuous accumulation of solids in the SBS with no trend towards a steady-state. • The suction line end effector design in the SBS was modified to a simpler design but there is only one 2-inch line for transfer of solids located	• Investigation and/or entry for ad-hoc solids removal or modifications into either of the SBS and condensate vessels would require both melters to be shut down and is likely to be a protracted event with unaccounted production impacts.	• The use of surrogate solids to demonstrate solids recirculation and removal behavior should be factored into commissioning of the SBS system prior to taking the melter into cold operation. This would provide the earliest opportunity to identify and make any modifications to vessel internals or potentially

Table A-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (21 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		near the center of the tank. Similarly there is only a single eductor in the condensate vessel to promote mixing and any return of solids back to the SBS in the recirculation line. Both are single point failure items. • While accumulation of solids in the SBS can be inferred from increases in pressure drop over time there is no direct measurement of solids. • The capability to remove solids with the procured equipment was not demonstrated as part of an integrated factory acceptance test so the first proof will be in commissioning or operation.	• Production level/full-scale issues associated with solids accumulation and removal will be not encountered until commissioning or nuclear operations, thereby prolonging commissioning or impacting throughput.	adding additional instruments or sensors using existing spare nozzles. Further checks should then be made in cold commissioning to minimize the risk of needing changes later in hot operations. Note that this will further challenge the commissioning durations. This risk to commissioning could be reduced through additional testing. • Convert a spare SBS vessel port to allow periodic camera inspection of the internals.
LOP/LVP-12	The cooling margins for the SBS cooling jacket, cooling coil and condensate vessel appears to be eroded. This condition also impacts the current/expected margin on the associated BOF chilled water exchangers CHW-HX-00003A/B.	• The calculation for the maximum heat duty for the SBS system only included sensible heat and omitted the latent heat of condensation component. This effectively doubles the duty. • The chilled water at minimum flow cooling capability will not be sufficient to cool the SBS contents much more than a couple of degrees below the maximum operating temperature of 140°F. Using maximum chilled water flow will be able to achieve the normal operating temperature of 122°F but may not reach the 104°F minimum. • The associated BOF chilled water exchangers were incorrectly assessed on a maximum duty associated with the low flow chilled water cooling case for the SBS. Consequently rather than each having a 6 % margin they will likely needed to be operated simultaneously rather than as a duty and a stand-by system.	• The chilled water supply to the SBS system will need to be run much closer to maximum flow to achieve the desired normal operating temperature (i.e., reduced operating margin). • The increase in required cooling duty on the chilled water will require both exchangers to be run simultaneously rather than as a duty and stand-by. This may require modifications to valves, piping and control systems. • If there is a need for a stand-by unit, then a third exchanger may need to be installed which would further complicate equipment and control. • Higher operating temperatures in the SBS system increases the absolute humidity of the off-gas in the downstream systems and potential for causing condensate in lines if the off-gas is inadvertently cooled (e.g., using LVP equipment bypasses).	• Confirm via project analysis that the sizing of the BOF chillers is adequate and that there is adequate cooling margin for control of the SBS system. • Evaluate the impact of operating the chillers simultaneously rather than in a duty/standby mode on the plant availability, power demands, control approach, etc. • Evaluate the need for equipment changes and the revised control approach if simultaneous operation of the chillers is an acceptable work around.
LOP/LVP-14	It is indeterminate if the O-ring gasket provided by the Vendor for the SBS Top Flat Head and Mating Flange can withstand the thermal loading from the Offgas System during operations.	• The Top Flat Head Gasket (Ø ½” X 78-7/16” OD) is made of Ethylene Propylene Diene Monomer (EPDM). • The gasket has a maximum temperature rating of 250°F and the Top Flat Head and Mating Flange are currently rated at 1250°F and 400°F respectively • When the SBS is receiving offgas from the secondary offgas line (Nozzle N1), the 1250°F flange is less than 4 linear inches away from the O-Ring gasket.	• During operations, the SBS Top Flat Head could exceed the temperature rating of the O-Ring resulting in premature failure of the seal thereby allowing excessive air in-leakage into the SBS head space and potentially stopping the flow of melter offgas through the SBS due to lack of adequate differential pressure available for gases to pass through the SBS. This could result in release of untreated hazardous	• Consider alternative high temperature gasket materials compatible with existing flange surfaces such as Perfluoroelastomer (FFKM) or High Temperature Resistant Silicone. • In conjunction with new O-Ring material, re-analyze thermal worst case-steady state calculation to see if temperature at the flange can be reduced. • If necessary, reanalyze and remanufacture SBS Top Flat Head flange and mating flange to support high temperature flat gasket (such as

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		• Evidence was not available that indicated radiant and conductive heat effects on the O-ring gasket have been adequately considered.	off-gas into the C5 ventilation system (non-safety). • Unanticipated throughput impacts due to recovery and replacement of the O-ring gasket.	Metaflex used on the SBS inlet line connections). • Review hazard analysis for SBS to confirm that potential failure of O-ring has been considered
LOP/LVP-15	VSL SBS down-comer testing design changes not carried forward or incorporated into SBS design	VSL SBS experienced pressure pulsations as much as 3-4 inches water column which heightened their concern that at high gas flow rates the overall off-gas and melter system pressure may become positive. VSL made a design change of a perforated down comer which greatly reduce the liquid displacement underneath the diffuser plate and de creasing the magnitude of the pressure pulsation. The modified VSL SBS down-comer design does not appear to be incorporated into the WTP SBS design.	• Offgas pulsation through the SBS could create pressure surges creating difficulties in control of downstream equipment or more importantly the melter plenum pressure thereby tripping feed to the melter. • Unaccounted throughput impacts	Evaluate and incorporate proposed VSL design changes to the offgas down-comer (i.e., adding perforations at the bottom of the down-comer).
LOP/LVP-16	Documented analysis not evident to discount Ozone as a potential corrosion agent within and downstream of WESP.	• VSL Testing did not identify Ozone generation in the WESP (a known event). Appears sampling not deliberate for ozone. • Configuration differences between VSL test rig and full scale unit may contribute to Ozone generation (i.e., 10 tubes in test rig vs. 123 in full scale unit, 100-250 cfm in test rig vs. 2000 cfm full scale) • Ozone is highly reactive and may not survive to become an issue but no analysis evident.	Potential deleterious effects to downstream equipment such as the HEPA Filters or carbon beds.	Conduct and document analysis to determine impact of ozone generated in WESP
LOP/LVP-17	Inconsistencies in design documents could lead to design errors that impact the functionality of the equipment or impact future design changes.	• Isometric drawings were used to evaluate pipe line lengths from WESP-0001 to the combined header (LOP-PW-00004) and from WESP-0002 to the combined header (LOP-PW-01506). The evaluated lengths were compared to same line lengths provided in the project calculation “Offgas Pipe and Exhauster Sizing for LOP and LVP Systems” (24590-LAW-M6C-LVP-00004, Attachment D). The evaluated pipe lengths did not match those given in Attachment D of the project calculation. The length of one segment of pipe (PW00004) was under estimated by 10% while another segment (PW01506) was under estimated by 13%. • Three ECCNs against the project calculation were reviewed. The changes did not correct the table in Attachment D of the calculation. There are at least twelve RVP issues dealing with isometric drawing issues.	• The discrepancy between the evaluated pipe lengths and those provided in the project calculation indicates that the validity of some design information is questionable. • Engineering and designs are based on information and data presented in documents such as that given in the project calculation for offgas pipe sizing (24590-LAW-M6C-LVP-00004, Attachment D). • Using outdated information may lead to the propagation of design errors. If these errors are not identified and resolved, then engineering margins may be eroded that may ultimately impact the operation of the facility.	An extent of condition review should be conducted to determine if there are other design media problems.

Table A-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (21 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LOP/LVP-18	Ammonium nitrate formation may be possible in the preheater and HEPA filter systems and also downstream of the caustic scrubber (i.e., in the exhaust stack and stack sampling/monitoring system). The rate of build-up, if any, is unknown but, based on lessons learned could require periodic removal/flushing in the future.	• Ammonium nitrate formation has been a problem in facilities such as PUREX, 242-A Evaporator and 241-AZ-702 Primary Vent systems. There is significant collective evidence that ammonium nitrate may present a slow developing (years) "nuisance" regardless of conditions that normally indicate that ammonium nitrate will not form. • The Design Basis flowsheet shows that NH3 and NO2 gases are present in the LVP offgas system. • If the Design Basis flowsheet models are indeed accurate and ammonia gas is present in WESP units discharge stream, then this facility will need some type of an ammonium nitrate cleaning system for the LVP Preheater and HEPA filter systems • Above 93ºC ammonium nitrate formation is not likely. However, the operation of the preheaters will range between 50ºC to 70ºC which is a very favorable temperature range for ammonium nitrate to form. • Ammonia slip coupled with SCR NOx reduction inefficiencies and off-gas temperature conditions are considered likely to result in conditions favorable to ammonium nitrate formation downstream of the caustic scrubber (especially during transient conditions such as startup and shutdown). The mitigating impact of the caustic scrubber is indeterminate.	• Based on experience, after ~3 to 6 years of LAW production, the preheater elements or piping could be fouled with ammonium nitrate solids reducing heat transfer efficiency. • Fouling could also lead to the failure of heating elements. The heating element surface temperature may be hot enough to allow ammonium nitrate to melt and drip off the heating elements or cause decomposition of ammonium nitrate. • Consequently, the bottom of the preheater housings and possibly the heating elements could become coated with ammonium nitrate or decomposition products. HEPA filter elements may plug faster requiring more frequent HEPA filter replacements. In addition, there are no drains or flushing capability for the HEPA filter housings as well. • There is currently no design for flushing these systems. The preheater drain valves can only be opened in the HEPA filter room and drain into a container. • There are no drains for the HEPA filter housing shown in the P&IDs. In addition, there are no inspection ports for detection of the ammonium nitrate buildup in any system.	• Evaluate the need for an ammonium nitrate detection and removal system for the preheaters and 1st stage HEPA filter units. This could be as simple as a view ports (either sight glass or ball valve ports for fiber optic cameras could be used) and a water flushing systems since ammonium nitrate is water soluble. A drainage system into a collection tank may be needed for the flushing option but this could be retrofitted into the plant when and if needed. • Evaluate means to flush the exhaust stack and associated sampling and monitoring system piping. • Consider incorporation of periodic inspection of selected systems on an opportunistic basis. • Evaluate other areas of potential ammonium nitrate accumulation and determine if inspection and/or clean-out capability should be incorporated prior to start-up.
LOP/LVP-22	The HEPA filter qualification limits for low flow may be challenged under certain operating conditions thereby impacting filter performance.	• The HEPA filter low flow requirement is set by ASME AG-1, section FK, ASME Code on Nuclear Air Gas Treatment, at 20% the capacity of the HEPA filter housing or 20% for each filter element. Based on Flanders test data the LVP HEPA filters are typically tested at 1600 and 8000 ACFM. So operating below this range is unqualified by Flanders and not acceptable by AG-1 requirements. • Five Design Bases Flowsheet cases are identified that could apply to LAW Facility operations. Assuming the plant will operate using the A train HEPA filters, the one melter nominal flowsheet case and the two melter minimum flow case would not meet the 1600 AFCM low flow requirement.	If operated outside the minimum AG-1 flow rate for any length of time the filter may not be adequately efficient, which may lead to possible contamination which could spread to the secondary HEPA filters.	• Exhauster controls could be preset for minimum flow rate of ~4600 ACFM at the exhauster (accounts for additional air introduced downstream of the HEPA filters). This would ensure minimum flow requirements for A train is always being met. In addition, provide an alarm for low flow conditions at the HEPA filters. • Below are several other options to be considered for improvement in HEPA filter Operation. - Switch operations to the backup HEPA B train during periods of low flow (Admin Control). - Remove one of the HEPA Filter banks in parallel making both the main and backup banks identical (Engineering Control).

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		• Melter idle could be another potential condition that may not meet the low flow requirement for the HEPA filters. • The other flowsheet cases would meet the low flow requirement. • A minimum flow of around 3200 ACFM (1600 through each of the two parallel filters in train A) is required to ensure the facility is always operation the LVP offgas system above the minimum flow requirement for the HEPA filters.		- Add additional valves around HEPA filters 1A and 2A to allow operation of each one separately (more operational flexibility) so 2 trains in parallel is still viable for the higher flow conditions. DP monitoring equipment would also have to be added so each unit could run independently. • If the second or third option (above) is implemented then the minimum flow rate of ~4600 ACFM could be reduced to ~2800 ACFM at the exhausters.
LOP/LVP-24	Monitoring a COx concentration difference across carbon beds as an indication of fire may prove to be difficult to successfully implement.	• During pilot scale testing: - Observed off-gas concentrations ranged from 30 to 500 ppm CO and 6,000 to 28,000 ppm CO2. CO concentration differences ranged from < 0 to 220 ppm and COx concentration differences ranged from < 0 to ~6,000 ppm. - Melter off-gas COx composition variability observed during testing indicates a set point for defining the presence of a fire, with minimal false positive indication, could be difficult to develop. • Vendor information indicates the currently proposed guard bed material (Sofnolime RG) has the potential to react with CO2.	Inlet gas composition variability increases the potential for observing false positive fire indications, while guard bed reactions produce the potential to under-estimate the COx concentration difference across a carbon bed and delay the indication of an actual fire.	• Revisit the decision to rely on a COx concentration difference rather than a CO concentration difference as an indication of a potential carbon bed fire. The pilot scale test experience indicates that a CO concentration difference is more stable to measure, is consistent with recommendations from the literature, and would be less likely to be affected by interactions with the currently proposed guard bed. However, safety basis development may require testing of actual oxidation reactions in a configuration equivalent to the plant equipment to define a bounding ratio between CO and CO2 reaction products in order to use a CO concentration difference as a fire detection set point. • Consider a multi-attribute monitoring approach for fire detection. This could involve something like a 3 out of 4 voting approach using gas temperature difference, combined with CO, Hg, and SO2 concentration difference. • Continue with planned testing to identify performance of the proposed guard bed material. It is possible that the guard bed material will not adsorb CO2 after a predetermined "conditioning time period" and not interfere with COx concentration differences (depends on air flow through guard bed producing complete reaction of lime bed to CaCO3 prior to being placed into service). Use currently planned test data as input to address the identified vulnerability.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LOP/LVP-25	The carbon bed temperature elements have not been demonstrated to be a sufficient or effective means to determine the progress/condition of a fire or support recovery efforts.	• Carbon bed temperature probes may not provide reliable fire indication of localized hot spots due to insulating properties of the carbon material. • Not evident that design features have been formally considered that support safe recovery and restart of the carbon beds following trips (real or false) of the SS interlocks that isolate the carbon bed.	• Once the adsorber units are isolated by bypass activation, operating personnel will not have a tool to determine whether a fire has occurred or is continuing. • Creates the potential for prolonged interruption of plant operation due to a false positive fire indication.	Consider developing a method for determining if carbon oxidations are occurring within the isolated carbon beds as an indication that a fire is actually occurring or, if occurring, has stopped. Possible alternatives could be • Modeling the actual plant equipment to determine if carbon bed or gas phase temperature probes could become a more accurate indication of a localized hot spot when gas flow through the bed is stopped • Determine if gas pressure monitoring could be used as a method for evaluating the isolated carbon bed equipment for localized oxidation reactions, recognizing the potential for leakage of the isolation valves. • Determine if some type of thermal scan (e.g., infrared) could indicate the presence of localized carbon oxidation reactions. • Determine if monitoring for convective gas flow from bed could be used to indicate the presence of localized carbon oxidation reactions. • Determine if a gas sample loop, with CO gas composition monitoring, that is activated only when an automatic carbon bed bypass has occurred, could be used to indicate the presence of localized carbon oxidation reactions.
LOP/LVP-26	No clear definition of a carbon bed fire has been found in the documents reviewed.	• The vendor has proposed one definition that is equivalent to a carbon oxidation rate of 0.2035 lb/min. The project fire analysis suggests another factor to consider in the definition of a fire, but does not yet expand the observation into a monitored set point. • It appears that the project has deferred definition of a fire to a later date as part of a set point analysis, but this can influence and impact the identification of the appropriate monitoring instrumentation.	Impacts selection of the fire detection approach and instrumentation selected to implement the approach.	• Complete planned set point analysis to define a carbon bed fire. • Consider developing and implementing a test program, combined with modelling, where carbon bed fires are actually generated to define the system characteristics expected to be observed during a real fire.
LOP/LVP-27	There is only a limited definition of the operating conditions that minimize the potential for experiencing a carbon bed fire.	• A systematic evaluation of potential conditions to avoid/prevent a carbon bed fire was not found in the reviewed documents. • The current control input appears to rely heavily on data from test equipment, without scaling to the geometry used by actual plant equipment. Tests were performed in cylindrical beds with vertical, axial flow. Actual equipment	Potential for plant operations to perform activities that create carbon bed operating conditions that increase the likelihood of experiencing a fire.	• Develop a system testing approach that avoids passing off-gas through the carbon beds during DRE Testing. This would likely involve establishing the carbon bed performance for organic removal in an off-line equipment set-up (not installed plant equipment). • Develop a model of the actual plant equipment for evaluating conditions that could result in a

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		represented by slab bed with horizontal flow and potential regions for stagnant gas [charge and discharge bins]at top and bottom • Evidence exists that some activities are being pursued to partially resolve this vulnerability. Inlet gas temperature monitoring and response control (set point not yet developed) represents one aspect. Another is represented by a carbon bed conditioning procedure identified based on the pilot scale melter test program.		carbon bed fire in the actual plant scale equipment/geometry. • Based on input from project personnel, it appears that some consideration of simulation tools to accomplish this activity has been considered in the past, but not implemented. Input data to validate modeling would be available from the VSL pilot-scale tests (24590-101-TSA-W000-0009-166-00001) and the ongoing test program described in 24590-WTP-3PN-MWK0-00010, Scope Changes To Warranty (Appendix B) and Permit (Appendix C) Carbon Media Testing. Factory acceptance flow distribution tests are available to approximate the flow characteristics of non-ideal bed packing. It would be anticipated that the model could be used to: - Determine a minimum total gas flow rate to avoid the potential for gas mal-distribution. - Determine if an actual plant equipment test with high risk gas component compositions is warranted - Identify organic, nitrate/nitrite, and other component limits in the melter feed that could be evaluated on a batch by batch basis during operation to reduce the risk of experiencing a carbon bed fire - Identify potential constraints on transients that occur during changes in the operating mode. Examples include: carbon bed start up after adsorbent replacement and transition of the melter from idle to operating mode (the carbon bed characteristics may impose a limit on how rapidly the melter feed rate can be increased) - Evaluate the risk of fire for the guard bed material ultimately selected
LOP/LVP-28	No minimum gas flow rate has been defined for safely operating the carbon beds.	• Reduced gas flow rate increases the potential for mal-distribution of gases passing through the carbon bed and increases the potential for experiencing a fire by generating local regions with decreased convective cooling. • No basis has been found for defining a minimum gas flow rate for operating the carbon bed adsorbers.	Condition that increases the potential for experiencing a carbon bed fire.	• Once a flow mal-distribution condition is identified by modeling, incorporate a gas distribution test, similar to that performed by the vendor acceptance test, in the bed replacement procedures that determines the minimum gas flow required to avoid conditions that increase the potential for experiencing a fire (could vary each time a bed is replaced).

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		• Vendor tests of gas distribution have only been performed at the equipment design (maximum) total gas flow rate.		• Incorporate control logic into the current system that precludes operation of the carbon bed units in a parallel configuration. • Consider addition of a controlled air (or inert gas) purge to maintain a minimum gas flow rate through the carbon adsorber to protect against gas flow mal-distribution. The set point for a controlled air bleed could be revised based on a flow distribution test each time the carbon bed media is replaced.
LOP/LVP-29	There are no gas temperature monitoring instruments evident in the piping between adsorber units.	• Exothermic reactions in the lead unit primary or guard bed have the potential to increase gas temperatures entering the lag carbon bed. • The current plant equipment configuration produces an un-monitored inlet gas temperature for a carbon bed operating in the lag position. • Vulnerability likely only exists if all adsorber beds are new at the same time. There appears to be a potential for significant heat to be generated by the proposed guard bed material during startup after bed material replacement due to reaction with CO_2.	Condition that increases the potential for experiencing a carbon bed fire.	Consider installation of gas temperature monitoring and control response instrumentation on off gas lines between the two adsorber units (LVP-ADBR-00001A and LVP-ADBR-00001B) or only allow operation of a single adsorber unit at a time (preclude lead-lag operating configuration).
LOP/LVP-30	There is no evidence that limits are identified/established for allowable rate changes of component concentrations in the carbon adsorber inlet gas.	• This is partially considered in current project documentation as described by the conditioning procedure identified from test program experience. • Selected component heats of adsorption reactions have the potential to modify the heat balance within the carbon bed. • No evidence was found that investigations are planned to determine if carbon bed constraints may restrict the melter operation to control off-gas composition changes.	Rapidly changing off-gas conditions may increase the potential of a carbon bed fire.	Based on plant equipment modelling proposed in OFI- LOP/LVP 27[.2], adjust operating procedures as needed to eliminate operating conditions that could initiate a carbon bed fire.
LOP/LVP-31	It appears that the current OR model understates the potential impact of carbon bed operation on the calculated plant availability.	The current OR model does not appear to identify the potential impact of observing a carbon bed fire indication, whether real or false positive indication, which is likely to result in substantial downtime.	Unaccounted throughput impacts.	Define a documented basis for a false positive indication of a carbon bed fire, or an actual fire, based on experience with carbon beds in other industries. It is likely that there will be considerable uncertainty in application of this type of input to the plant equipment configuration. Consider addressing the carbon bed fire issue as part of a sensitivity study in the OR modelling effort as a method of evaluating the uncertainty in input information.
LOP/LVP-32	The presence of carbon fines representing a source of ignition has not been thoroughly analyzed	• A discussion of carbon fines was not found in the documentation reviewed.	• Potential for initiating a carbon bed fire is increased. • Carbon bed fire indication upon initial startup after bed replacement.	• The Donau BAT37 bulk material is reported to have a measured ignition temperature of 409 °C. It appears that fines accumulations in the carbon adsorber system would not be a fire

Table A-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (21 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		• Equipment design information indicates that carbon fines, on the order of 10 µm. can be collected on the discharge filters. • Literature data indicate that fines are expected to exhibit an ignition temperature that may be on the order of 100 °C less than the bulk material. • Fines collection does not currently appear to represent a problem beyond representing a topic that has not been discussed by the safety analysis documentation due to the high (409 °C) reported ignition temperature for the bulk material. • However, fines generation does have the potential to separate carbon from the heat sink zeolite. In this case, carbon fines would likely be captured on the face of the guard bed where the fines could become susceptible to heating from exothermic guard bed reactions. • The proposed guard bed material currently appears to be susceptible to the largest heat generation rates when first exposed to air flows (after replacement). • Carbon fines generated during bed replacement have potential to collect on front face of guard bed. These carbon fines potentially have a reduced ignition temperature.		ignition temperature issue based on the simplified evaluation. However, it is recommended that a formal consideration of carbon fines accumulation be added to the project safety documentation for completeness. This issue could become more important upon collection of more information on the guard bed material based on the currently planned configuration (with guard bed following the carbon bed). • There is an indication that there may be a preferred order for bed replacements during unloading/loading sequence. The scenario is potentially controlled by replacing the carbon bed first (depositing carbon bed fines on the front face of a used guard bed), the guard bed second (removing carbon fines that may have deposited with the discarded guard bed), and the discharge filter last.
LOP/LVP-34	The mercury monitor represents a single point failure.	• Equipment layout drawings and the size of temporary equipment used during bed loading and unloading activities indicates that personnel egress may be limited • The current P&ID indicates that a high mercury concentration indication on the mercury monitor (AE-0423) results in a control action to stop feed to both melters. • Only a single mercury monitor is provided.	Potential to reduce plant availability and result in unaccounted throughput impacts.	Install a duplicate mercury monitor.
LOP/LVP-35	There appears to be inadequate isolation of carbon beds upon detection of a potential fire.	The mercury monitor sample transfer line represents an open path to the carbon bed interior. This line compromises the carbon bed isolation boundary unless the valves (YV-0423A and YC-0423B, or YV-0423) are integrated into the isolation valve control system.	Isolation requirements defined by PDSA are not satisfied.	Expand the carbon bed isolation control system to include valves YV-0423A and YV-0423B, or YV-0423C.
LOP/LVP-36	Shrinkage of the proposed guard bed particles could occur after loading.	Vendor information reports that the proposed guard bed material reacts with air converting calcium hydroxide to calcium carbonate. Particle density differences indicate particle shrinkage on the order of 15% could occur during the chemical conversion process.	Guard bed shrinkage during operation could result in mal-distribution of the gas passing through the bed, thereby reducing halide component removal efficiency.	• The significance of this vulnerability should be indicated by the currently defined test program. • Consider investigating a guard bed material that begins as calcium carbonate.

Table A-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (21 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LOP/LVP-37	Condensed water may collect within the carbon beds during time periods when the carbon bed is bypassed and cooled, thereby impacting the ability to complete bed replacement activities.	• Bypassing isolates adsorber unit gas phase within equipment such that the water vapor inventory can condense on cooling to ambient temperature. • Reduced gas phase water vapor pressure in isolated units produces conditions to partially desorb water captured by carbon during operation, producing additional condensate beyond that from the isolated gas phase inventory. • Rough estimates indicate that potential for condensate generation could range from 0.3 to 6 gal water each time adsorber units are bypassed and cooled, depending on quantity of water desorbed from carbon.	• The impact on function is indeterminate due to potential competing effects. • Significance depends on where condensate can physically collect. Potential for water to collect in regions that do not evaporate on equipment restart (e.g., carbon bed discharge bin condensed water accumulations = carbon does not flow when attempting to replace carbon). This may complicate bed change out procedures.	• The significance of condensate collection in the carbon bed is indeterminate at this time and the location of condensate collection is difficult to predict. It is likely that operating experience will be required to identify if condensate collection will become an actual issue. If identified in the future, some potential methods of resolution could be considered: • Operate the off-gas system at a reduced SBS temperature for a time period prior to by-pass of the carbon beds during a routine shut-down. • Periodic monitoring/purging of differential pressure/sample lines and addition of insulation to instrumentation lines prone to collecting condensate. • Develop a dry air purge of bed discharge ports as part of the bed replacement procedure.
LOP/LVP-39	The basis for carbon bed sizing appears to be uncertain.	• Uncertainties in data from mercury pathway assessments/reports coupled with inaccuracies/miscalculation of factors applied for conservatism appear to result in potentially non-conservative values for mercury concentration in the nominal LAW flowsheet. • The potentially non-conservative mercury values were provided to the carbon bed supplier for sizing calculations. • Therefore, the sizing basis for the carbon beds is questionable and could require more frequent replacement of the carbon media than planned.	The frequency of carbon media replacement could be greater than anticipated (if mercury loading on the bed is higher due to higher mercury concentrations in the off-gas) thereby resulting in unaccounted throughput impacts.	• Re-evaluate the Hg basis for the LAW Facility flowsheet. Consider updating 24590-WTP-RPT-PR-01-011, Mercury Pathway and Treatment Assessment for the WTP, as a means to re-evaluate the mercury pathway and concentrations at LAW and to re-visit the viability of previously discounted alternative technologies/approaches for mercury removal and abatement (see notes section above regarding potential alternatives for mercury removal/abatement). • Re-evaluate and confirm the accuracy/adequacy of the sizing basis for the carbon beds.
LOP/LVP-41	Heat-up and cool-down temperature profiles for TCO skid not considered in OR model.	• From a cold state, the heater takes about 11 hours to heat to operational temperature (750°F). • Required heat up time for gas flow increases when transitioning the melters from idle mode to operation or under other transient conditions is undefined but will likely be a requirement of the system. • Heat up time will likely be required following an event that results in bypassing the TCO skid. The TCO bypass is interlocked with Caustic Scrubber operation. Therefore, the TCO bypass may be activated by control or operational	Unaccounted start-up/shutdown and throughput impacts	• Consider the ability to invoke operational conditions/controls that would reduce the need to cool down the TCO skid. • Model the startup sequence of the LVP equipment to see if the 11 hour heat up time is a critical time for system start up. If this time is prohibitive for startup consider installing higher capacity heaters (this could be done as a post CD-4 modification). • Conduct analysis to determine the maximum flow increase that can be accommodated by the electric heater to remain above the catalyst

Table A-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (21 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		issues with either the TCO skid or the Caustic Scrubber. When the TCO bypass is initiated, the heaters are turned off, and the skid will begin to cool down. • Getting the heater to operational temperature seems to be the longest single startup operation in the LVP system. As the LVP startup sequence is undefined, the knock on effects of this long startup operation is unclear. • There may be additional requirements imposed upon startup/operations/maintenance activities with regards to flow rate increase. This will impact the time required to restart melter operations		operating temperature. A new limit on flow rate increase may result.
LOP/LVP-42	The viability of the current TCO maintenance approach and associated throughput impacts are indeterminate.	• Waste disposal paths for removed equipment (160 catalyst modules for full replacement) have not been developed. It is not clear that the 60 hours allotted for catalyst change in the OR model is adequate given the large number of modules and the potential for waste packaging impacts. • Method of testing for requalification of equipment as functional and operational has not been developed. This may also impact the maintenance time allotted in the OR model.	Unaccounted throughput impacts	• Complete evaluation of maintenance evolutions so impacts are understood and included in the OR model. • Determine the disposal paths for removed equipment (e.g., catalysts) • Generate plans for qualifying replaced or repaired equipment/components.
LOP/LVP-08	Over time, the film cooler may build-up insoluble vitreous deposits not removed by the existing water sprays. Ability or need to manage the vitreous build –up is indeterminate based on the length of testing and a lack of quantification of the quantity of the vitreous deposits.	• VSL testing noted that in the short period of their test some vitreous deposits were observed, although for the bulk of the deposits water flushing was generally effective. • Film cooler was designed and installed to be removable, but no procedure has been prepared for such an eventuality.	Film cooler life is less than required/expected i.e., does not last the life of the melter and requires changeout or a mechanical cleaning. Control of vitreous build-up may result in unaccounted throughput reduction.	• Demonstrate and confirm whether vitreous build-up is a problem or not (rate of accumulation not quantified in testing). • Write procedures to perform inspection of film cooler during annual spray nozzle replacement. • Prepare design for device/procedure to remove build up in film cooler/offgas lines – if required.
LOP/LVP-13	The Vendor changed the SBS design temperature inputs for the top head without formal WTP approval. Therefore, the design may be out of conformance with requirements.	• The SBS Vendor submitted a "Request for Information" (RFI) to deviate from the datasheet that specified that the SBS Top Flat Head temperature be analyzed at 1250°F because at that temperature it "produced undesirable results in seismic and nozzle load analysis". • The Vendor performed a thermal analysis through unconfirmed/unapproved inputs that reduced the maximum temperature of the SBS Top Flat Head to 1100°F to be able to then produce acceptable results for the seismic and nozzle load analysis.	• The design inputs provided to the vendor (by WTP) and the vendor adjusted inputs used for analysis of the heads are not in alignment. • Temperature tolerance of the SBS vessel top flat head may not meet design requirements.	Verify design inputs to the Vendor calculation are valid and the Vendor Thermal analysis outputs are accurate and reasonable per project approved procedures.

Table A-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (21 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		• The current SBS Datasheet still reflects that the SBS Top Flat Head temperature is 1250°F.		
LOP/LVP-19	Replacement and repair of pre-heater elements will likely require both melters to be placed in idle mode, thereby potentially impacting throughput.	• Replacing, repairing or cleaning the preheaters without both melters in idle mode would be beneficial to the operational goals of the LAW Facility. • Room L-0304H layout for the HEPA filters and preheaters may not be favorable for preheater maintenance work. The common outlet pipe may be very hot (including radiant heat) especially if one of the preheaters is still operating. If any of the closed manual valves leak and a pressure spike were to occur then hot gases could affect the work and personnel safety. • Double valve isolation is not evident in the current design. Although it may be possible to replace the preheater without double valve operation, by relying on negative pressure in the system, there isn't assurance that maintenance without double valve isolation will be acceptable. • The following factors contribute to the difficulty to work on one heater while the other one is operating: - Close proximity to each other with common outlet - High temperature pipe - Single isolation valve - Tight space to work around HEPA Filters	It is possible for 18 inch butterfly valves over time to leak. Consequently, single valve isolation may not provide enough personnel safety when replacing preheater elements with one or both melters operating. If double valve isolation is required, melter throughput will likely be impacted since both melters would need to be placed in idle mode.	Install additional isolation valves to allow preheaters to be changed out whenever needed without having to place both melters in idle (however, it is recognized that there may be space constraints to implement this option). This approach may give personnel more buffer space from the operating preheater system. It would be practical to install isolation valves during construction to ensure there is adequate room to install additional valves.
LOP/LVP-20	A number of instruments, valves and test ports for the HEPA filters are elevated (10-14 feet off the HEPA filter room floor). Using ladders or temporary scaffolding to perform maintenance at elevation will be less efficient and potentially more dangerous to personnel.	• The LVP off-gas piping drawings indicate the elevation of the piping, valves and instrumentation is 10-14 feet from the floor. • With the current design, HEPA filter instrumentation (flow meters and pressure transmitters) and automated valves as well as performing aerosol testing of the HEPA filters will require personnel on ladders or on scaffolding to perform routine maintenance.	Likely unaccounted throughput impacts as a result of maintenance inefficiencies.	Design permanent scaffolding or mezzanine to allow safe access to all instrumentation, valves and test ports in the HEPA filter room L-0304H. Other LVP areas may have similar piping configurations and permanent scaffolding or mezzanines will have to be installed here as well.
LOP/LVP-21	There may be an insufficient number of isolation valves to safely replace the B train HEPA filters without placing both melters in idle mode.	• The WTP Operations Requirements Document indicates that filter system design should allow for change out of either HEPA train while the other HEPA train is still on line. • No manual isolation valves were evident for the B train that would enable double valve isolation in conjunction with the control valves.	Although it may be possible to replace the B train HEPA filters without double valve operation, by relying on negative pressure in the system, there isn't assurance that maintenance without double valve isolation will be acceptable for all operational modes thereby resulting in unaccounted throughput impacts.	• Double valve isolation should be required to protect people from the potential gas temperature hazard in all types of operational scenarios. • Manual valves across the B train HEPA filter banks need to be installed similar to the ones planned for A HEPA filter train.

Table A-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (21 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		• The control valves are interlocked to allow only one train at a time to be operated. The 2 manual valves can be closed in conjunction with 2 of the 4 control valves to isolate A train. With the 2 control valves and 2 manual valves closed this would achieve double valve isolation for A train. • The control system allows all control valves (for both the A and B trains) to be open at the same time. This situation is possible if the operating train becomes plugged, then the alternate train control valves will open. If B train was being changed out when this happens then an unsafe condition is possible. • Even with the control valves locked out for B train its possible for these valves not to be fully closed thus potentially exposing personnel to a high temperature (120ºF-170°F) gas stream. This situation could also be made worse if a gas surge from a process upset occurred during B Train filters change out.		• The manual valves and control valves for A train could be swapped around to allow the manual valves to isolate the control valves. This will provide better isolation to repair/replace the internals parts of the control valves when needed.
LOP/LVP-23	Vendor requirements for minimum straight pipe lengths needed to achieve accurate flow measurements do not appear to be met for the flowmeters located downstream of the HEPA filters	• There appears to be conflicting information between the HEPA Filter isometric drawings, the Control Instrumentation drawing and manufactures recommendations for the minimum length of straight pipe before and after a flow meter. • For thermal insertion type flowmeters (as those used for the HEPA filters), project documents require 10 pipe diameters of straight pipe before the flow meter and 5 pipe diameters of straight pipe after the flowmeter. Most manufactures also generally require the same 10 and 5 pipe diameters but other manufacturers may be able to custom fit their flowmeters for a specific piping arrangement. • For 18 inch (schedule 10) pipe used to house the flowmeters, the minimum straight pipe sections needed is 14.7 feet and 7.35 feet respectively. . None of the three flowmeters evaluated meet these requirements	The main consequence is flowmeter accuracy. Inaccurate flow measurements could result in operating the HEPA outside their qualified flow range of 1600 to 8000 ACFM with associated potential contamination control issues downstream.	Review minimum straight piping requirements for flowmeters manufacturer/vendor to ensure performance under current piping configuration. Modify piping drawings and/or Control and Instrument drawing 24590-WTP-JO-50-00012 as required.
LOP/LVP-33	Maintaining personnel egress routes during carbon bed replacement activities may be challenging.	Equipment layout drawings and the size of temporary equipment used during bed loading and unloading activities indicates that personnel egress may be limited.	• May require redesign of loading/unloading equipment or use of smaller package sizes to maintain personnel egress routes.	• There appear to be limited opportunities to address the limited space available around the adsorber units. One approach could be to perform an evaluation of the loading and unloading procedures to identify where the required temporary equipment, supporting the

Table A-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (21 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
			• If egress not suitable, could prolong adsorber bed replacement process with unaccounted throughput impacts.	activity, can be located while maintaining required egress routes throughout the activity. As an alternative, the carbon bed supplier does appear to offer a smaller package for receipt of fresh material. It may be possible to design a loading system that uses a smaller receipt package that can be directly maneuvered over a carbon bed inlet port and eliminate the intermediate transfer from super sack to hopper (followed by transfer of hopper to the inlet port) as a method to reduce loading equipment space requirements at the expense of needing to handle additional receipt packages.
LOP/LVP-38	No dedicated ports supporting the carbon bed loading bypass test were found.	The vendor procedures indicate a bypass test, introducing a challenge gas upstream and challenge gas detection downstream of the bed, should be performed anytime adsorbent is loaded into the adsorber units.	Inadequate loading of replacement adsorbent beds results in excessive gas bypass and poor contaminant recovery efficiency.	Install or identify ports for challenge gas detection equipment installation.
LOP/LVP-40	Underestimation of TCO skid thermal cycling	According to the mechanical data sheet, the number of thermal cycles assumed for the TCO skid is 100 for the 40 year life of the equipment which appears to be low given that this is equivalent to 2.5 thermal cycles per year. It is judged that start-up and shut-down evolutions contributing to the thermal cycles will on average likely be more frequent than 2.5 times per year.	Extra thermal loads will be experienced the TCO skid due to start up and shut down of the heaters. This unanalyzed condition of operation can cause unexpected wear and degradation of the equipment. The assumed life of the equipment could be in question.	• An analysis of the thermal loading on the TCO skid should be performed to determine whether the materials of construction can accommodate the stresses imposed by the thermal cycling. Although considered unlikely, this analysis may result in redesign of equipment. • Use the DCS to track thermal cycles of the equipment, if this is determined to be an important parameter for equipment longevity. • Consider opportunistic based periodic inspection of stress points to confirm that thermal cycling is not affecting equipment.
LOP/LVP-43	The current and proposed design of pH control suffer from an unknown lag time between addition of caustic and the resulting change of pH as indicated by the pH meter. The WTP proposed change relies on the operator to observe changes in the pH reading and react accordingly.	• The basis for this can be found in the LVP Caustic Scrubber System Technical Manual (draft) and is shown on the current P&ID, 24590-LAW-M6-LVP-00002003 LVP, Systems Technical Manual –P&ID LAW – LAW Secondary OffGas/Vessel Vent Process System Caustic Collection Tank LVP-TK-00001. • Due to (unknown) lag time between adjustments to caustic addition and response of pH. Operator adjustments are relied upon versus automatic control. Operator has no guidance or variable other than pH.	• Depending on the operator's response, the scrubbing liquor may become acidic if insufficient caustic is added. This could have corrosion issues in the scrubber system or downstream in the RLD system. If too much caustic is added, the pH would rise above 10 leading to more CO_2 removal and could result in precipitation issues. • May require significant tuning of controller during commissioning.	• pH control could be improved if caustic addition is carried out in the suction line of pumps LVP-PMP-00003A/B (using a vortex mixer) upstream of the pH meter. This will ensure a minimum lag time between caustic addition and the pH meter. • Adding mechanical agitation to the vessel would improve mixing and may allow for automatic control in current configuration.

Table A-1. Vulnerabilities Identified for Primary Off-Gas Process, and Secondary Off-Gas/Vessel Vent Process (LOP/LVP). (21 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LOP/LVP-44	There is no way apparent to remove an accumulation of insoluble solids, potentially, in LVP-TK-00001 (caustic scrubber recirculation vessel).	• The basis for this can be found in the draft LVP Caustic Scrubber System Technical Manual (draft) and on the current P&ID (24590-LAW-M6-LVP-00002003). • Solids could be corrosion byproducts or particulates from upstream Carbon Bed or SCO/SCR catalysts.	Slow buildup of insoluble solids could lead to eventual blockage of the packed bed, increased erosion in lines and/or valves. Could lead to increased wear on pump internals. Potential unaccounted throughput impacts to remove solids.	• Consider alternate means of agitating the tank inventory to ensure insoluble solids stay suspended so that they are removed during transfers to RLD-VSL-00017A/B. • Consider periodic/opportunistic inspections to determine if solids are accumulating.
LOP/LVP-45	The effects from other unit operations on the startup and shutdown of caustic scrubber have not been fully analyzed/determined.	No mention in the System Description (24590-LAW-M6-LVP-00002003) or Technical Manual (draft) of how the caustic scrubber system startup or shutdown impacts other LOP or LVP systems.	Consequence to plant wide startup or shutdown is unknown at this time. Design features may be necessary to support compatible startup/shutdown – could prolong commissioning period.	Consider performing a system wide study/model on the effect of startup/shutdown of individual units has on the whole LOP/LVP system.
LOP/LVP-46	There is no direct means evident to monitor the condition of packing or mist eliminators within the caustic scrubber.	Both the Corrosion Evaluation (24590-LAW-N1D-LVP-00001, LVP-SCB-00001 (LAW) - LAW Melter OffGas Caustic Scrubber – Corrosion Evaluation) and the Safety Evaluation (24590-WTP-SE-ENS-12-0068, Safety Evaluation - LAW Melter Offgas Caustic Scrubber) state that the column “packing and mist eliminator filters are considered consumables”.	Packing could collapse on itself after prolonged corrosion if not detected.	Consider periodic/opportunistic inspections of packing integrity.

Table A-2. Vulnerabilities Identified for Instrument and Control (I&C). (9 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
IC-CO-01-V-01	Industrial HMI Human Factor Engineering principles have not been adequately implemented in HMI screens. Situational awareness of the operator will be reduced hindering the ability to make operational or process decisions quickly and accurately.	• Review of SDD's, for the HVAC system specifically, has highlighted a lack of process related data and its relevance to overall normal operation. Basic informational aids such as fan speed, system trip levels and device status are missing from certain HMI screens but are then included on others indicating a lack of consistency in implementation. • Process related functional descriptors appear to have been omitted altogether further reducing the user's ability to obtain situational awareness. • There are no process related trends on control graphics to assist operators in determining the predicted status of the system. Only current process values are displayed.	Potential for mistakes to be made during normal and, more importantly, off-normal operations which could reduce or interrupt operational throughput of the facility. Equipment protection could be compromised if the current system state is not adequately represented and displayed to the operator with appropriate context.	• Modify HMI objects to include all relevant information for equipment and instruments. Add English worded equipment status to all objects. (Stopped, Running, Failed etc.) • Incorporate process relevant trends on overviews that include process goals and alarm/trip levels. • Only include information on overviews relevant to the goals for the system. Indicate system trip status, process status and equipment status. Omit information not relevant to the operation of the system such as miscellaneous room temperatures. • Perform assessment of current HMI configuration for all systems and implement NUREG-0700 Rev 2, Human-System Interface Design Review Guidelines, recommendations for HMIs. Review other industry standards for HMIs including ASM Consortium recommendations for HMIs, OPTO 22 White Paper – Form 2061-140306 Building an HMI that Works: New Best Practices for Operator Interface Design and ASEE HMI Good Practices.
IC-CO-01-V-02	• A requirement of the BOD is that 'Simple, common-sense design modes of operational control to ease operability in both normal and abnormal situation will be factored into the design'. • System wide implementation of parallel device operation (fans, pumps etc.) utilizes a non-standard approach as identified in CLIN 3.2 Table 2 – 16 Error analyses following testing Error Ref #2, 3. This approach has not changed and is still present in the LAW parallel operation of devices.	• For all instances of parallel operations into a common header, regardless of the process medium, the control has been split by device resulting in multiple PI controllers for a single process variable (i.e., flow, pressure). Since each device controls independently, and is unaware of the influence the other device has on the process, the requirement to control devices in a 50% duty arrangement cannot be accomplished. • The intended operation to mitigate this process control difficulty is to operate the fans outside of their intended design. In order to modify any process set points for the system a procedure will need to be followed similar to the following: - place Device A in Manual mode - change the set point of Device B (in Auto) - wait for Device B (in Auto) to adjust to new set point	• The system requirements have not been implemented such that the normal operations can be accomplished in a simple, common-sense fashion. The requirement for parallel operation is that the two devices operate at the same speed; the implementation guarantees that they cannot be sent the exact same speed. • In order to operate the system and maintain some control of the process a procedure is required to ensure the set points for each fan are changed individually. Normal operations, such as changing a set point for a	• Implement single PI controllers logically for all instances of dual controllers for parallel devices into a common header with single process variable feedback. • Remove all dual control faceplates from the HMI screens, CSLDs, CDIs and other related documentation prior to startup and commissioning. • Assess controls for basic day to day operations to determine if procedures will be required to accomplish the tasks. If simple tasks require procedures to ensure that they are completed without error then they should be re-worked to assist the

Table A-2. Vulnerabilities Identified for Instrument and Control (I&C). (9 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		- place Device B in Manual mode - adjust set point of Device A - place Device A in auto mode - wait for Device A to adjust to new set point - place Device B in Auto to allow normal system control • The steps required to prevent the system from becoming unstable are unwieldy and will still result in the two fans operating at different speeds. This intended method for operational control of these systems is in direct conflict with the BOD requirement to ease operability in both normal and abnormal situations.	process, will not be simple or common sense. • Without simple and common sense controls the likelihood of human error, resulting in off normal operations, increases greatly. The system is currently not designed to maximize the probability of operator success.	operators to be successful in operating the system.
IC-CO-01-V-03	CLIN 3.2, Ref RPP-44491 3.8.7, Semi-Annual Waste Treatment and Immobilization Plant (WTP) Operational Readiness Evaluation Report(S) identified an issue regarding the supervisor override of interlocks. This issue has not been addressed within the current system and will be exacerbated by the lack of functional descriptors within the system.	• Due to the lack of automation within the control system, interlocks are being relied upon to dictate normal operational control. If an off-normal event occurs it is likely that a supervisor override will be required to return to normal operations. Interlock overrides can be accomplished in one of two ways, all interlocks for a device can be overridden or a single interlock can be overridden but the override applies for all instances of that interlock. • When an interlock is required to be overridden the onus will be on the supervisor to determine which interlock is causing the problem and also how that interlock affects other operations. Since there is no differentiation between interlocks and their importance, nor are there sufficient descriptors for information on HMI screens, this determination will be cumbersome and will be prone to human error.	• Without differentiating interlock importance the supervisor will not be able to make an informed decision regarding the validity or consequences of the specific override. An override of an interlock, even for a brief period of time, could allow another device to perform an unintended function that was not considered. • The minimal automation within the systems has created an excess of interlocks to drive correct operation of systems. When off-normal events occur overriding interlocks will become common place fostering a culture of convenience regarding interlock overrides.	Enhance all graphics to display English word descriptors for interlocks and create a standardized method for determining at a glance hazard assessment for the interlocks.
IC-O-01-V-01	There appears to be no protection from an event that could cause an excessive depression in a C5 area. Any obstruction of flow could create a situation where the cell depression exceeds the readable range of the pressure instrument.	Analysis of the HVAC SDD, CSLDs, PDSA and CDI documents has failed to identify any mitigation of an excessive depression in a C5 area. The system design is such that the C5V fans will continue to operate after the rest of the ventilation system has shut down. In this situation there is no protection from cascade airflow blockages rapidly increasing the depression beyond the readable limits of the instruments.	Potential to damage structural components of the building (windows, doors, in-bleed assemblies and associated components) due to excessive differentials between zones.	Include additional requirements in the functional requirements specification (FRS) and requirements traceability matrix (RTM) for prevention of excessive depression in C5 areas. Prevention can be achieved either logically (via ICN), hardwired (power interrupts to the drives) or preferably using both methods in a nested fashion.
IC-O-02-V-01	The cascaded startup of the HVAC system is an entirely manual process. The onus is completely on the operating user to perform the repeatable steps, in the correct order, at the correct time to facilitate a successful startup	• The HVAC system description details the prerequisites and steps required to perform the startup of each of the HVAC systems individually. The startup description does not reference the startup of the HVAC system as	If the startup of the HVAC system remains a manual operation the likelihood of unsuccessful startups is increased. If the HVAC system is not running the plant operations will stop	• Author a master procedure to start the HVAC as a coherent system that considers the expected flows and depressions throughout the system during startups and what initiators

Table A-2. Vulnerabilities Identified for Instrument and Control (I&C). (9 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	of the HVAC system. Furthermore the startup is not sufficiently defined to establish steps for a coherent HVAC system startup.	a cohesive set of equipment with process related triggers that link independent system startups. • For example, according to the CSLD requirements, logically the C3V fans may be started once the C5V fans are running but there will be additional process triggers/prompts that will need identification such as the relevant zone depression/flows to meet or exceed a threshold value. These thresholds are currently not identified in the CDI documents or on the CSLDs.	until an operational HVAC system is re-established. Without a HVAC system startup procedure, or a reliable startup sequence that can perform the repeatable steps required to establish HVAC operations, the operator is placed under un-due pressure to perform complex steps to establish cascaded confinement.	are required to provide cascaded startup of the system. • Once a satisfactory procedure is established new sequences should be programmed that will initiate the HVAC startup based on a combined set of system prerequisites and a step/transition based sequential function chart (SFC) logic. Each fan set startup routine will comprise its own 'sub-sequence' that will be initiated by a master scheduler.
IC-O-02-V-02	The cascaded shutdown of the HVAC system is not controlled in a manner to ensure cascaded confinement of radiological materials. Certain logical trips will shut down the C2 supply and extract fans simultaneously with the remaining equipment tripping out of service due to process anomalies.	• The HVAC system description details the procedure required for a manual shutdown of each system individually. The CSLDs indicate a cascaded shutdown of the fans under certain conditions. However the fan override trips only stop individual pieces of equipment and rely on the cascade shutdown to stop all other equipment. The shutdown of the pieces of equipment, once initiated, does not consider any process conditions as part of the shutdown. • The cascade occurs once the fans required as part of the startup prerequisites are no longer running. For example, C2 extract fan cannot run without C3 extract fan running first, consequently the C2 extract fan will not cascade stop until the running signal from the C3 extract fan is removed. The cascaded shutdown of the HVAC system appears to consist with a semi-controlled crash since it is not based on any process variables and thresholds, instead being based on the running feedback of ASD's. • There are other trips of fans that initiate override stops of fans simultaneously which are independent of running feedback of fans. These situations will only exacerbate the lack of cascaded confinement. The C2V supply and extract system is an example of simultaneous trips. • (IC-O-02-N-01, 02, 03, 04, 05)	Without process considerations as part of the cascade shutdown and an actual shutdown sequence to manage the fan stop commands a controlled shutdown of the HVAC cannot be guaranteed or controlled. The lack of cascaded management of the shutdown could challenge the ALARA principal applied to cascaded confinement in the BOD (Section 12.3.1.1 - Confinement).	• Author a master procedure to shut down the HVAC as a coherent system that considers the expected flows and depressions throughout the system during shut downs and what initiators are required to provide cascaded shutdown of the system. • Once a satisfactory procedure is established new sequences should be programmed that will initiate the HVAC shut down based on a combined set of system/ fan set trips and step/transition based logic. Each fan set shutdown routine will comprise its own 'sub-sequence' that will be initiated by a master scheduler. In the event that the shutdown sequence does not operate correctly a set of bounding fan trip conditions will exist to override-stop the fans to ensure the system is ultimately shut down.
IC-O-02-V-03	• The currently proposed parallel fan operation is fundamentally flawed in its execution. Industry engineering practices indicate dual process control into a common header with a single process variable to result in unstable control. • This issue was identified in CLIN 3.2 RPP-50775 Rev: 2 (CLIN 3.2), Annual Waste Treatment and Immobilization	• Although this control philosophy has been identified in previous reviews as problematic the issue persists in the current design and implementation. The issue has been identified, tracked and resolved through the PIER process but the resolution was not underpinned by engineering principles. The use of an integral term for control will result in diverging fan speeds if the performance characteristics between fans are different.	• If the system is not intended to be operated using PI controllers then the design documentation (CSLDs, system descriptions etc.) must be updated to reflect this. This task would be substantial and is not in the best interests of controlling the HVAC equipment. Alternatively the current control method should be	• Eliminate all instances of independent PI control throughout the project (WTP in its entirety) as identified in CLIN 3.2, Table 2-16. • Simulate situation conforming to target environmental conditions to provide adequate proof of concept for control of parallel fans into a

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	Plant (WTP) Operational Support Report, and is still present system wide (not restricted to LAW systems).control.	• The PIER applied the principle that each fan control loop will see the same error between the set point and the feedback value and will therefore send the same speed to each fan (proportional to the ratio of the output response and the error). Using a proportional term only will result in 'droop' (offset from set point) since the controller requires a non-zero error to work. The 'droop' can be compensated through the use of a bias or dynamically using an integral term. All the design documentation for LAW implies the use of an integral term for pressure control of HVAC fans. The integral component sums the error over time resulting in a small error causing the integral component to increase over time and the system to meet its intended set point. Using proportional and integral terms (as implied by the design) is the best way to control the closed loop system in this instance. The PIER however seems to imply that the chosen controls will not be of this type. • There are multiple industry articles that state the reasons for proportioning parallel fans at the same rate. CLIN 3.2 stated that 'If variable speed control is used, then all fans must proportion at the same rate. In other words, if fan #1 is running at 50% then fan #2 and every other fan in parallel must be running at 50% also. If this is not done you run a very high risk of the faster fan stalling the slower fan.' • A second reference states 'It should be understood that pumps in parallel must always operate at the same speed. There may be some unusual, sophisticated cases where parallel pumps are operated at different speeds, but only experienced pump designers should make evaluations for such a proposed operation. Variable speed pumps should be controlled so that pumps operating in parallel never have over a 1 percent difference in actual operating speeds.'	replaced by a single controller per process variable feedback, regardless of the number of devices being controlled. This solution also involves considerable work since this implementation is defined on a CSLD for each instance instead of being defined in a requirements specification only once. • If PI control is to be used then the independent controllers per device will result in unstable and unpredictable operations. The instability may be avoidable through modification of tuning parameters (although unlikely) but the system will then be optimized aiming to avoid the loss of control rather than aiming to control effectively and efficiently. • The only way to ensure parallel devices operating in unison is to drive them to a single speed set point derived from a single feedback loop.	common header using new control scheme.
IC-O-02-V-04	The current control schemes identified in the CSLD requirement documents identify responses to process anomalies re: fan trips, failed dampers etc. that will likely not provide adequate response times necessary to maintain HVAC operations without interruption.	• During process upsets that require changeovers of the duty extract/supply fans the response time will be critical. The triggers for a duty changeover include: - Duty inlet & discharge dampers not open w/ fan running - High bearing temperatures - 2oo3 conditions for lolo DP, lolo fan speed and lolo flow, all conditional on fan running • Since the majority of the above conditions are conditional on the fan running they will not be detected rapidly if a failure were to occur during startup of each	Without an immediate response to process anomalies the probability of successfully maintaining HVAC operations, and therefore plant throughput is reduced.	• Establish new baseline for initiating a duty/standby changeover. The AHUs and Fan Sets should be treated as a single operating unit of which any failed component constitutes a failure. For example, a failed discharge damper during startup should initiate the changeover, currently the damper failing would only cause a failover once the fan running signal is on which could cause a delay of seconds or minutes.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		system. If there is a system failure during operations, and the fan running signal is on, the process trips will not initiate the standby fan until the process is already shutdown to some extent triggering the Low Low trips (the set points for these trips are to be determined and refined during startup and commissioning). • If a fan is determined to be failed via the error handling in the drive or other deterministic methods and the changeover is not initiated immediately then the window for a successful changeover will be considerably smaller and the probability of maintaining normal HVAC operations is reduced		• Expand error trapping for devices associated with fans to capture failures as soon as possible. For example, a discharge damper that fails to move off the closed limit could be captured with a secondary, shorter, timer. This would allow a response to a predictable outcome to be almost instant (within 5s) without waiting for the fan to be running and the process to be insufficient to maintain pressure differentials.
IC-S-01-V-01	• System descriptions (SD) are no longer the source for system requirements. Since the CSLDs are used as both the requirements and the basis for test documents there is no longer complete correlation back to system requirements defined in the SD. • Discrepancies between upper tier documents and implementation documents indicate that requirements, critical or non-critical, could have been overlooked and will not be identified as incorrect during testing.	• There are multiple instances of discrepancies between the SD and the implementation defined on the CSLDs for the HVAC system. There are currently no processes in place to validate and verify that the requirements are implemented and tested beyond the scope of the CSLDs. Without a Requirements Traceability Matrix (RTM) that contains the explicit requirements for a system, the baseline documentation and the derivation of those requirements the software testing cannot take full credit for requirements implementation, verification or testing. • The current method for specifying requirements (CSLDs) is not conducive to inter-discipline understanding that the implementation meets the design intent. Other disciplines that must review the requirements to ensure correct and full implementation must first be trained how to read the CSLDs before they can assess their completeness. Once the related disciplines have been trained there is no guarantee that their interpretation of the logic diagrams will be the same and that they will conclude the same functional requirements after reviewing them.	• Without functional requirements derived from baseline documentation that are easily reviewed by disciplines other than the software group there cannot be a guarantee that the software is accomplishing the system requirements. Furthermore without validation to upper tier requirements implementation errors/discrepancies will persist through to the software being installed on plant. • A disconnect between the functional requirements and the software requirements and their associated testing documentation will guarantee that the testing of the software will not demonstrate the required performance of the system over the range of operation of the controlled function or process. • NQA-1 2000, Quality Assurance Requirements for Nuclear Facility Applications, compliance cannot be accomplished without detailed flow down of requirements. Therefore adequate testing to verify and validate the functions of the software cannot be demonstrated.	• .Identify critical design requirements from baseline documentation and create a requirements traceability matrix (RTM) that can be used to re-validate the software to verify functionality of each system per NQA-1 2000 Requirement 3, Section 400. • Re-evaluate test acceptance criteria on a functional system basis to ensure that the functional requirements of each system are met based on the derived requirements from upper tier documents. • For computer programs used for operational control, computer program test procedures should be created that demonstrate the required performance over the range of operation of the controlled function or process per NQA-1 2000 Requirement 11, Section 400.
IC-S-02-V-01	The Integrated Control Network, the plant system control system, has been developed using an inappropriate software QA level because the software QA grade was determined incorrectly.	• The process used to grade software is documented in a CCN and is not equivalent to the process specified in project procedures, which is not allowed by WTP QAM. The software level, resulting from the grading process, was determined without analysis of hazards and risks. This analyses are only performed if the	Incorrect grading of the plant control software discovered during a readiness review or preparation for one will result in a reclassification to a higher software level, which will require software, equipment, and embedded software to be extensively reviewed and documented or	• Define the ICN boundaries and interfaces, consistently and commensurate with the functions attributed to the ICN. • Define (or redefine) the WTP specific functions requirements

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		initial assigned level is not Level D (i.e., Level A, B, or C), which is an inadequate implementation of DOE O 414.1C, Quality Assurance. • Software Quality Assurance Level evaluation is insufficient to demonstrate that 10 CFR 830 "Nuclear Safety Management" Code of Federal Regulations, or DOE O 414.1C, Quality Assurance , requirements have been met. • The ICN is used to monitor, alarm, log, or control hazards incommensurate with its current software QA level. • The ICN is used to provide additional SIL protection incommensurate with its current software QA level. • The ICN is used to ensure adherence to permitting requirements, which are imposed to protect the environment, incommensurate with its current software QA level. Recourse to originators or maintainers is necessary to obtain necessary information, contrary to NQA-1, 2000 and the WTP QAM requirements.	replaced and rewritten. Plant control software will not be of sufficient quality to support the operation and throughput requirements, jeopardizing mission success. Continued work will result in more rework.	performed and controlled by the ICN. Flow down of requirements from upper-tier documents will provide the test criteria when functionality is confirmed during software development. • Evaluate (or reevaluate) the hazards, risk, safety, and permitting compliance controlled or affected by the ICN and its subsystems without regard to the likelihood or credibility of accident scenarios or consequence mitigation, per 10 CFR 830. Generate a full list of questions to evaluate software compliance. Use a full implementation of DOE O 414.1C and ask all the compliance questions generated above prior to assigning a software grade. • Use a standard set of documents, such as ISO/IEEE, to organize required software documents, descriptions, etc. An experienced software engineer would then be able to navigate without recourse to the originators or maintainers.
IC-S-06-V-01	• The programmable protection system (PPJ) control system is Level A software which requires full implementation of DOE Safety Software Guide and Software Quality Assurance (SQA) Work Activities. • The requirements being supplied to the contractor do not contain traceability to upper tier documents and do not convey the requirements in a manner that is clear and concise to any discipline that may be required to perform a review.	• The procurement specification for the PPJ control system does not provide, and does not plan to provide, the safety software requirements specification (SSRS) and traceability to upper tier documents. Furthermore the spec requests that the supplier derive the requirements from the supporting documentation for approval by BNI. This is not in compliance with the software lifecycle identified in ISA-84 or IEEE 1012-2004 Standard for Software Verification and Validation which defines a V-model lifecycle (adopted by the WTP Project) where development and testing procedures are derived from requirements, not the other way around. • Without a clear set of requirements derived from hazard and risk assessments and allocation of safety functions to protection layers it is not clear how the CSLDs were created in the first place or how their development has been verified against upper tier requirements.	• There is not a clear software life cycle implementation for the PPJ software. Without a cascade of upper tier requirements derived from hazard analyses and control selection the validation and verification of the safety software cannot be accomplished. • ISA-84, NQA-1 and the V-model lifecycle cannot be implemented in a robust defendable manner using the currently proposed method in the PPJ Engineering Specification. Software requirements cannot be derived from logic diagrams and then implemented, after approval from BNI, without breaking links to upper level requirements. The risks associated with hazard analysis cannot be actively managed unless	• Derive PPJ requirements from baseline documentation, hazard, risk assessment and allocation of safety functions to protection layers. This can be accomplished through updates to the SSRS or generation of new SSRS that define what the requirements are but not how they are going to be accomplished. • Base all software development and testing criteria on software requirements to ensure functionality is met and hazards identified during risk assessment are implemented, verified and validated. • Eliminate the use of CSLDs as requirements for PPJ software development. They do not clearly define the requirements or their delineation from upper tier

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		• Section 3.1.2.7.1 of 24590-WTP-QAM-QA-06-001, 2008, Quality Assurance Manual, states that 'Design analyses shall be sufficiently detailed such that a person technically qualified in the subject can review and understand the analyses and verify the adequacy of the results without recourse to the originator. (NQA-1-2000, RQMT 3, 400; DOE/RW-0333P, 2008, Quality Assurance Requirements and Description, Rev. 20, Rev 20, 3.2.3.C).'The use of CSLDs as definitions of requirements does not comply with the above statement. There are several support documents that define the symbols, functions and structural components that comprise a CSLD and its functions that cannot be reviewed and verified without recourse to the originator.	they are the driver for the requirements. • The current method for developing software does not appear to be in compliance with the WTP QAM.	documentation. The SSRSs already developed (used in conjunction with Desk Instructions to develop the CSLDs) are a clear, concise, traceable, English worded document set that can be used to derive the requirement of an individual SIS/SIF and remain independent of the actual implementation. The current proposed mechanism for development of the PPJ software requires the supplier to recreate documentation that already exists in the SSRS documents.
IC-S-07-V-01	Current life cycle documentation will be cumbersome to maintain and update during startup, commissioning and operations*	• The SPP for the ICN lists the life cycle documentation, all of which will need to be kept up to date during startup and commissioning. Every change to the plant installed software will incur a modification to some or all of the documentation. Specifically, any logic changes that also affect the functional requirements of a system will have an effect on the CSLDs, CDIs and SDDs for the Plant System Sub-Projects and possibly the SDDs for the Facility Systems. • During startup, commissioning and initial operation phases the number of changes to the facility control system, given previous experience, will be in the order of hundreds or thousands a year (estimate of 10-20 software modifications per week). The changes may be driven by software errors that were not tested during development, by enhancements requested by operations, by anomalies between plant equipment and software as configured or any combination thereof. • In either case the documentation associated with any change will become difficult to manage and track if the current document set is continued into those phases of the project. A requirements traceability matrix for the software functions, paired with the current software specification and implementation documents, would allow plant changes to be made without affecting the fundamental requirements and therefore would minimize document changes. Any changes to requirements would be captured and flowed down into the software implementation.	• During startup and commissioning, when multiple personnel are working on systems at the same time, the paperwork required as part of making software changes will create delays to the changes themselves or will create configuration issues for associated lifecycle documentation. • It is probable that software changes would affect multiple requirements documents (CSLDs) simultaneously which would require updating in order to maintain configuration control. The additional tasks associated with the documentation updates will increase the startup and commissioning durations for the facilities.	Eliminate and/or replace all requirements and design documentation that will be affected by software modifications that do not affect higher level requirements. Day to day software modifications to meet functional requirements, as designed, should not incur additional paperwork. Review design document sets for the control system software to establish the level of effort required to make a software change and how the accumulation of these types of changes will impact the commissioning schedule.
IC-S-09-V-01	There is currently no scope or procedure for implementing cyber security for the WTP control system. Compatibility and implementation issues related to the control	• The current scope of work for the WTP software and hardware does not include considerations for cyber security outside the scope of the EDMS. The ICN and	• Adequate consideration of cyber security from the perspective of external or internal malicious intent	Establish a means of providing adequate cyber security measures for the selected software and hardware that comprises the ICN for WTP that complies with DOE

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	system software could result in extended implementation of NIST and DOE requirements.	PPJ software and hardware (both computer equipment and controller hardware) remains part of the critical infrastructure for the WTP mission and should have security implemented beyond the scope of username and passwords. • The username and password access to the ICN system will be used to restrict access to system functions but this level of security cannot be considered cyber security since the user would already have been added and have access to the system. Consideration must be given to inadvertent security breaches such as the use of personal USB thumb drives with ICN computer equipment. • Cyber security must be assessed from an external perspective and any potential weaknesses mitigated through the use of administrative or engineered controls. Industry standards and practice should be given due consideration as part of the development of an implementation plan	must be considered in order for the WTP control system to comply with DOE and NIST requirements for critical infrastructure. • The advanced state of the design of the LAW control system makes integration of security features more difficult and may only occur during or after commissioning. • The WTP mission could be compromised through an external or internal malicious attack if the control system is compromised.	Order 205.1B, Department of Energy Cyber Security Program
IC-S-10-V-01	The documentation that defines the SIS and corresponding layers of protection does not appear to be consistent with the CSLDs or CDIs in all cases.	• The LPS SIS interlock definition takes credit for functionality within the ICN that is not represented on the CSLDs or in the CDIs. There is no additional equipment indicated in design documents that would provide interlocking functions using the ICN software. • The SIS requires a SIL-2 level of protection from the PPJ safety significant software. This level of protection is being provided by that system according to PPJ logic diagrams. The level of protection was SIL-2 because of the additional layer of protection provided by the ICN but this layer of protection is not provided by ICN logic according to the CSLD and CDI documentation. • The caustic scrubber high differential pressure interlock contains two layers of protection to reduce the SIL required to SIL-1. The high differential pressure interlock (ICN) does not appear to be represented on the P&IDs, only the caustic collection tank low low level is represented on the P&IDs. The CSLDs (PPJ and ICN) indicate that the safety interlock, derived from PDSHH-0047 & 0094, initiates an override stop of the pumps. There is a discrepancy between the requirements documents (P&ID's and CSLDs).	• The SIS will not provide the level of protection expected without the functionality defined in the layer of protection. In some cases functionality is not reflected in the documentation and is expected to be missing from the logic. In other cases there is functionality in the logic that is not represented in the documentation. • The functions defined for the SIS and the functions required of and implemented in the ICN software do not appear consistent. • Without full implementation of SIS layers of protection the probability of the accident scenario occurring increases.	• Re-evaluate LPs identified within the SISs to verify their implementation in the respective systems. Create functional requirement documents linking LPs with ICN design documents to provide traceability and tracking of these functions. • Eliminate any ICN functions that are part of an SIS to establish a clear delineation between the safety systems and the plant control system.

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Table A-3. Vulnerabilities Identified for Ventilation Systems (HVAC). (18 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
HVAC-01-1	Instrument uncertainties are calculated incorrectly to control loop design challenging instruments ability to work properly	Failure to calculate individual instrument and complete control loop uncertainties has resulted in: • Zone to zone monitors (C2/C3) will routinely be breached. • Instrument datasheets with incorrect instrument accuracy statements. Twenty three datasheets examined twenty three with incorrect instrument accuracy statements. • Alarm and Interlock Set Points in the Configuration Data Index (CDI) database that cannot be met	C2/C3 Zone Differential Pressure Monitors not working will lead to Plant Production interruptions.	Perform an evaluation that includes uncertainty analysis for all fan control loops including alarm and interlock set points. This ensures chosen set points are reasonable and control loops can operate as designed without routinely challenging interlock setpoints.
HVAC-01-2	The C2/C3 DP monitor scheme, as currently designed, will not work.	The Foxboro instruments selected are as good as any and probably better than most on the market. However the small differential design pressures between the rooms being monitor coupled with the instrument uncertainties does not allow sufficient margin to establish workable alarm and interlock set points, per the guidance in 24590-WTP-GPG--J-0057, Setpoint Calculations. Consequently if the current C2/C3 DP monitoring design is implemented it will result in frequent ventilation shutdowns resulting in interruption of plant production and/or undetectable flow reversals.	Frequent breaching of C2/C3 DP Monitoring will shut the fans down resulting in production stoppage.	Perform a market search to find instruments with less uncertainty or raise the C2 depressions particularly in the rooms where DP Monitors are located.
HVAC-02-4	Controlling parallel fans with two separate controllers results in unstable fan control	C2V, C3V and C5V exhaust fans each have their own unique controller. Even though the fans are using the same process variable, differences in the integral term of the PI controller will result in different fan speeds. This arrangement is difficult to tune and is expected to result in erratic control when other attributes of the system are taken into account. Perturbations in the system will cause the fans to respond differently as they are operating on different fan curves. This can result in the fans producing different pressures and erratic control.	One fan will be running at max speed while the other fan is operating at lower speed.	Use one control and split the signal between the two Adjustable Speed Drives (ASD).
HVAC-12-3	Zone C2 to C3 doors have less than 100 fpm	Section 12.3.4 of the Basis of Design states the flow rate through a single open door should be at least 100 fpm. If this is not practicable for routine operations, a compensatory process should be developed and documented. Several doors in the LAW Facility between C2 and C3 areas have been identified as having less than 100 fpm air velocity through them, which increases the risk of spreading contamination from C2 to C3 areas.	Low velocities through the doors remove the level of protection against radioactive contamination	Make sure volumetric flow rate into C2/C3 areas is 100 fpm (minimum) through a single open door.
HVAC-11-4	Risk of contamination backflow in a Swabbing/Finishing Line	Low flow velocity, missing airlocks, undersized in-bleed, and no interlocks make this flow path vulnerable for contamination spread from finishing line.	Contamination spread to outside environment	Increase flow from swabbing cells to finishing line, provide airlocks when feasible, increase in-bleed filter capacity.
HVAC-12-4 HVAC-31-6	No airflow parameter identified for the open doors between C3 and C5 zones	Doors and hatches between C3 and C5 areas are routinely opened during operation of the LAW Facility. While a parameter has been given for single door openings between C2 and C3 and for "gaps" between C3 and C5, no parameter has been identified for open doors and hatches between C3 and C5. There is not a consistent application of flow rate between these openings. This increases the potential for	Low velocities through the doors and hatches remove the level of protection against radioactive contamination spread between C3/C5 zones during both normal and abnormal operations	Provide at least 125 linear fpm through the open C3/C5 door and hatch to ensure adequate inflow to prevent the escape of contamination.

Table A-3. Vulnerabilities Identified for Ventilation Systems (HVAC). (18 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		contamination migration from C5 to C3 areas when these door and hatches are open.		
HVAC-32-2	Airflow through the canister import hatch has not been evaluated	The design shows airflow of 2200 cfm into rooms L-0117B and L-0117D. The hatch openings are approximately 5.5'x 5.5', which is 30 square feet. With an airflow rate of 2200 cfm, the flow rate across the open hatch is approximately 75 fpm. This has not been documented and evaluated to determine if it is sufficient in this application.	Potential migration of contamination from the transfer tunnel into the canister import areas.	Define the flow rate through the rollup doors and add it to the design flow rates. Make other adjustments to depression values and transfer grill and inbleed flow rates to reflect modified depression values.
HVAC-25-1 HVAC-25-2	C2 supply fan bypass not adequately evaluated and appears it will not work	The V&ID does not account for in-leakage when the ventilation is operating with only the C5V exhaust fan and C2 supply bypass operating. It indicates the total exhaust fan flow will be through the bypass and does not include in-leakage. In addition, the depression in the various zones does not appear to be calculated. The V&ID indicates the C5 flow will be equal to the normal operation flow, which does not appear practical.	• C5 flow will be less than the minimum operating speed of the C5V exhaust fans when bypass is in service. • C2 zone pressure will exceed allowable limits when bypass is in service.	Evaluate airflow through the open hatches to determine if it is acceptable. Provide justification for airflow rate or revise design to increase airflow rate to an acceptable level.
HVAC-31-1	Lack of engineered controls for cell entries through sub-changes	Each entry into cell areas will require manual adjustment of the transfer gill damper in order to balance the depression between the sub-change and the corridor or the cell. Both the timing of the damper adjustment and the position of the damper are administratively controlled.	• Loss of confinement due to sudden increase in airflow into the cell area through the sub-change. • Concurrent zone entries through different sub-changes may challenge the ventilation system.	• Convert sub-change rooms to cell entry rooms with standalone airlocks. Airlocks would eliminate the need to adjust the dampers. They can be set up so there is virtually no opportunity for operator error. • Develop a system model to determine the impact of opening sub-change doors. • Add indicating lights to the damper and door position to indicate the door and damper are in the correct position prior to opening the door or adjusting the damper. • Add positioning equipment to the cell doors and sub-change dampers that prevents the door from being opened prior to the damper being in the correct position and prevents the damper being adjusted before the cell door is closed. • Add engineered positioning equipment to the damper to position the damper automatically based on cell door position.
HVAC-31-2 HVAC-31-3	Life safety and emergency response issues related to sub-changes	• While breaker bars are included on the cell entry door, no breaker bars have been included on the sub-change doors even though the sub-change will be subject to depressions that will prevent the door from being opened without a breaker bar.	• Delay in providing emergency care. • Delay in egressing from the cell during an emergency. • Personnel become trapped in the sub-change during an emergency.	• Convert sub-change rooms to cell entry rooms with standalone airlocks. This would allow personnel to enter the cell entry room from the corridor and vice versa without having to adjust damper or door position.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		• Emergency response, whether responding to an emergency in the cell or egressing from the cell, is delayed due to manual adjustment of the transfer grill damper.		• Convert sub-changes to airlocks to eliminate the need to install breaker bars. • Install breaker bars on sub-change doors
HVAC-31-4	Sub-change rooms too small to accommodate all personnel and equipment associated with typical entries	Sub-change rooms are too small to accommodate all of the personnel and equipment expected to be part of the entry without having to make multiple adjustments to the doors and dampers.	• Reduced production and delays in facility operation due to extended or delayed entries into the cell area. What may be done in a single entry may require multiple entries to complete. • Sub-change crowded with personnel and equipment, which impacts worker productivity, comfort, and safety.	Convert sub-change rooms to cell entry rooms with standalone airlocks. This would allow personnel to enter the cell entry room from the corridor and vice versa without having to adjust damper or door position.
HVAC-31-5	Cell entry doors to not have hose pass-throughs	Hose pass-throughs are necessary to allow the cell door to be closed when personnel in the cell are wearing supplied air respirators and additional personnel or equipment need to enter the sub-change from the corridor.	• Delays in cell entry activity in order to bring all entry personnel back into the sub-change so sub-change door can be opened. • Reduced production due to entries that may be cancelled or extended to another shift in order to include necessary personnel or material that cannot be included because of lack of access through the sub-change door.	• Convert sub-change rooms to cell entry rooms with standalone airlocks in order to allow personnel to enter the cell entry room from the corridor and vice versa without having to close the cell entry door. • Note: This would eliminate the need to close the cell door during entries.
HVAC-31-8	Adjusting of subchange dampers along with opening and closing doors causes changes in the C5V flow	Each time a damper is adjusted or a cell entry door is opened or closed, the C5V airflow changes. While the changes may be a small percentage of the total C5V airflow, these changes will cause the system to adjust to compensate for the change in flow. The changes in airflow and impacts to the cell depression and the depression to adjacent areas have not been quantified and documented. Depending on the amount of the change in flow, these changes would result in upsets to some facility areas. This issue is magnified when two or more areas are accessed at the same time.	• Changing flow rates challenge the flow balance between the cell and adjacent areas. • Changing flow rates may challenge the C5 ventilation system.	Develop a ventilation system model to demonstrate the change in airflow and the impact on depression when adjusting sub-change dampers and opening and closing cell entry doors. Convert sub-changes to airlocks where the cells are completely isolated from the corridors.
HVAC-31-9	Function of transfer duct between L-0108 and L-0109 (and L-0114 and L-0115) is not evaluated	The current design for sub-changes L-0108 and L-0109 shows a nominal flow of 1100 cfm through each sub-change during normal operating conditions – neither sub-change is accessed. There is a transfer duct between the two sub-changes. It appears the purpose is to divert airflow from the sub-change not being accessed to the sub-change being used for cell entry in order to achieve the 2200 cfm flow rate through the open cell door. No evaluation has been performed to confirm this operation is possible without adjusting dampers in both sub-change rooms. The same condition exists for sub-changes L-0114 and L-0115.	• Reduced airflow through sub-change door results in contamination migrating from the cell area into the sub-change. • Adjustments to the damper in the adjacent sub-change are required in order to make cell entries.	• Develop a model to validate the current system configuration. • Provide evaluation to demonstrate the proper function of the transfer duct between rooms L-0108 and L-0109 (and L-0114 and L 0115).

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
HVAC-32-1	Airflow through canister import rollup doors is not included in the design.	The current design anticipates no leakage through the doors. It shows all flow between room L-0117 and rooms L-0117A and L-0117C as passing through transfer grills. The size of the rollup doors is such that flow through the doors will be considerable. This is not as critical as the flow through the inbleed between rooms L-0117A and L-0117C and rooms L-0117B and L-0117D. While these rollup doors are smaller, leakage through the doors will be significant, especially at the pressure drop shown between these rooms. The depression in rooms L-0117A and L-0117C is -0.2 inches w.g. while the depression in rooms L-0117B and L-0117D is -1.4 inches w.g. At this pressure differential, if it can even be maintained, all flow will be through the rollup doors and there will be no flow through the inbleed. Flow through the inbleed is critical since it provides cooling for the transfer tunnel.	• Excessive flow through the canister import doors will result in excess air cascading into the transfer tunnel. C5V fan capacity may not be sufficient to maintain the transfer tunnel at the design depression. • Lack of flow through the inbleed results in a lack of cooling in the transfer tunnel.	• Define the flow rate through the rollup doors and add it to the design flow rates. Make other adjustments to depression values and transfer grill and inbleed flow rates to reflect modified depression values. • Modify or replace rollup doors to eliminate leakage through the doors.
HVAC-33-1	Variation in airflow through the finishing lines as a result of opening and closing finishing line doors is not quantified as part of the design.	Variation in airflow through the finishing line will affect the overall C5V airflow. Calculations or evaluations of the change in finishing line flows that result from the opening and closing finishing line doors was not performed as part of the design.	• Excessive flow through the canister import doors will result in excess air cascading into the transfer tunnel. C5V fan capacity may not be sufficient to maintain the transfer tunnel at the design depression. • Lack of flow through the inbleed results in a lack of cooling in the transfer tunnel.	• Define the flow rate through the rollup doors and add it to the design flow rates. Make other adjustments to depression values and transfer grill and inbleed flow rates to reflect modified depression values. • Modify or replace rollup doors to eliminate leakage through the doors.
HVAC-42-1	C5 exhaust fans are not sized based on the latest calculated exhaust temperatures at the exit of Pour Caves	CFD analysis of Pour Caves and Finishing Lines.	C5V exhaust temperature may rise above their design requirements and may impact capacity margins of C5V exhaust fans, ductwork, insulation and stack monitoring instruments based on temperature criteria shown in Change Notice 24590-LAW-MAE-C5V-00005.	• Revise calculations to incorporate a maximum realized exhaust air temperatures based on the worst case off-normal operating condition with a margin of safety assigned to the pressure drop calculations and determine if redesign of the current C5V exhaust fans is required. • Investigation and validation is required to ensure that all confinement ventilation system instruments, wiring and sensors are specified to meet the temperature limits as calculated by the optimum off-normal condition to achieve the required performance and reliability.
HVAC-44-2	Lack of redundant cooling in Buffer Storage and Canister Rework areas	The buffer storage area and container rework area each have single general service commercial grade fan coil units that provide area cooling. The buffer storage and canister rework areas have the potential to contain up to 18 thermally hot containers. If one of these fan coil units fails under certain anticipated load conditions, the temperatures in these areas will exceed design temperatures.	• The Buffer Storage Area and the Rework Area space temperatures will be substantially higher than design temperature of 113°F. • Pour Cave C5V exhaust air temperature will be higher than the CFD analysis calculated figures due to rise in supply air temperature to	• Evaluate the feasibility of installing 100% standby FCUs for the Container Buffer Storage and the Container Rework Area. Availability of additional space to house redundant FCUs and associated ductwork must be investigated.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
			the Pour Cave from the Container Transfer Corridor. • Container Transfer Corridor space temperature will exceed 113°F.	• Investigation and validation is required to ensure that ASTM (24590-WTP-DB-ENG-01-001, Basis of Design) requirements are complied with for all Buffer Storage ventilation system which may be exposed to temperatures higher than 140^0 F. External surface of Buffer Storage ventilation system will be provided with adequate insulation to protect the workers from contact with hot surfaces above 140°F where applicable.
HVAC-45-1 HVAC-46-1	Off-normal operations analysis not performed	Several off-normal events, such as …., are described in the System Description. These events have not been analyzed to determine the impact on facility ventilation to determine if zone pressures and flow rates can be maintained at levels needed to ensure confinement.	• Elevated C5 space temperatures above design requirement of 113°F. • Elevated C5V exhaust air temperature may impact ductwork, insulation, exhaust fan and stack monitoring margins. • Pressure and air flow imbalance may result in loss of confinement. • Concrete temperature limits may be exceeded in certain C5 areas.	• Identify all possible off-normal conditions • Provide evaluation for each off-normal condition to determine impact on facility depression and temperatures. This evaluation may include assessing C5V component capacities. • Provide facility modifications or work around to ensure facility confinement and temperature limits are satisfied. • Evaluate the impacts on the balance of plant chilled water system flow, pumps and power requirements. • Analyze the recovery mode after occurrence of an off-normal event with any control modifications and system hardware modifications if any.
HVAC-48-1	Unverified cooling capacity for safety significant equipment rooms and Non-Safety Battery Rooms	The DX cooling units were sized for certain loads. It appears some of the loads have changed yet the sizing has not been verified to be adequate for the revised heat loads.	Excess heat in safety significant equipment rooms and Non-safety battery rooms may exceed equipment rating temperature, resulting in failure of equipment.	• Evaluate the current electrical heat loads and verify the capacities and available margins of all purchased SS Air Conditioning equipment serving SS spaces as well as Non-safety battery rooms • Redesign the SS Units as necessary to meet the SS functional requirements.
HVAC-51-1	Radial HEPA filters are not qualified for use	Radial flow HEPA Filters for nuclear facility applications have been used in Europe for some time, however, a limited amount of data exists with respect to the performance of the radial HEPA Filters to the AG-1 new section FK. Of particular concern is the lack of particle loading and structural failure data for the radial flow HEPA Filters. Radial HEPA Filter	• Potential redesign of radial HEPA filters and housings for the C2V, C3V, C5V, LOP, Buffer Storage and Canister CO2 decontamination systems.	Radial HEPA Filter technical issues and testing is managed by a separate engineering design group. WDOH approval will be required for use of radial HEPA filters in LAW.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		Testing in 2011 at the Institute for Clean Energy Technology at Mississippi State University revealed that the filters failed within 5-minutes when exposed to environmental conditions of 130°F, 50% relative humidity and loading of 4-inches water column.	• Frequent or premature failure of Radial HEPA Filters can cause spread of contamination to the C5V ducting or eventual release of radionuclides to the environment.	
HVAC-53-1 HVAC-53-3	Lack of redundancy in stack sampling and monitoring equipment results in increased downtime since these components require extensive maintenance	ANSI N13.-2012 Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities requires that sample probes and sample transport piping be inspected, cleaned and leak tested on quarterly and annual frequencies. Additionally, quarterly calibration of flow control valves and stack monitoring interlocks is required. Maintenance requires shutdown of the C5V exhauster which required the melter be idled. Calibration or maintenance while the C5 ventilation system is operating can cause personnel to be exposed to hazardous chemical vapors and high temperatures. There is no redundancy to allow one set of components to be put into service while the others are taken off-line for maintenance.	• Violation of the Radioactive Air Emissions Notice of Construction Permit Application for the Hanford Tank Waste Treatment and Immobilization Plant. • Potential failure and shutdown of the stack monitoring system can lead to idling of the melters.	• Revise Radioactive Air Emissions Notice of Construction Permit Application for the Hanford Tank Waste Treatment and Immobilization Plant. • Add redundant stack sampling and monitoring systems so that inspections and maintenance can be performed while the standby system operates. Install inspection ports and develop remote inspection techniques using boroscope cameras. • Design an enclosure to capture thermally hot hazardous chemical vapors to protect employees during removal of sample probes for inspection. • Add redundant stack sampling and monitoring systems so that maintenance can be performed while the standby system operates
HVAC-53-2	C5V air stream temperature exceeds stack monitoring equipment rating	Elevated C5V exhaust air temperatures result in elevated stack discharge temperatures (greater than 130° F). High temperatures can cause premature failure of CAM detectors and Masstron Flowmeters and Hastings flow control valves.	• Potential failure and shutdown of the stack monitoring system, resulting in shutdown of melter feed.	• Develop a computer simulation of the facility HVAC System and evaluate thermal loads going to the C5V exhaust system.
HVAC-54-1	Low Air Flow Confinement ventilation design	One of the challenges of a low flow HVAC system is the contaminants in the air stream to settle out of the air and onto the surfaces of the work area. This results in increased housekeeping, especially when the facility is a contact-maintenance facility.	• An operating policy of housekeeping that requires regular cleaning of surfaces and cleanup campaigns is needed to remove the buildup of contamination. • Air locks are needed at the entrance and exit from ventilation zones to prevent or mitigate upsets in the ventilation air flows. • Inability to perform maintenance due to reduced worker stay times caused by elevated temperatures and contamination buildup. • Routine decontamination will cause generation of radioactive waste and increased combustible loading.	• Develop remote decontamination techniques such as HEPA vacuum cleaners deployed from the overhead crane. • Prior to hot commissioning operations should perform detailed clean-up and inspect and repair any damage to cell coatings.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
HVAC-55-1	LAW C1V, C2V, C3V and C5V Cascade Low Air Flow HVAC System design causes the control system to be complex	Designing a Cascade low flow HVAC system causes control systems to be complex.	Difficult start-up testing and operability testing during commissioning. Redesign the LAW ventilation control system during startup and commissioning	A recommended design change would be to combine the C1V, C2V, C3V and C5V ventilation systems into a separate, independent dedicated PLC. Having a separate PLC for the C1V, C2V, C3V and C5V ventilation systems will allow early start-up testing and identification of control systems deficiencies. Modifications to the ventilation system controls could be completed earlier in the commissioning phase to minimize cost and schedule impacts
HVAC-55-2	LAW HVAC control Systems are currently combined with 32 other process control systems	Startup and commissioning activities require the operational testing of the LAW C1V, C2V, C3V and C5V ventilation control systems. Software control changes from the 32 other process control systems can affect the LAW ventilation systems and potentially cause uncontrolled shutdown of the LAW Ventilation systems.	Vent system shutdowns can result in the loss of confinement and release of radioactive contamination to the environment. Ventilation shutdown could expose the on-site worker to hazardous chemical vapors and airborne radioactive contamination.	A recommended design change would be to combine the C1V, C2V, C3V and C5V ventilation systems into a separate, independent dedicated PLC. Having a separate PLC for the C1V, C2V, C3V and C5V ventilation systems will allow early start-up testing and identification of control systems deficiencies. Modifications to the ventilation system controls could be completed earlier in the commissioning phase to minimize cost and schedule impacts
HVAC-56-1	The LAW Ventilation system needs to have a Hazard analysis performed to identify the Failure Modes and Effects for normal and off normal operations, start-up, production, clean-out & flushing and maintenance	• ORP Letter 267961 Assessment Report S-13-NSD-RPPWTP-003 Functions and Requirements of the Environmental Monitoring System for the LAW Primary/Secondary Off-gas system, states that the LAW Preliminary Documented Safety Analysis identified numerous (over 100) off-gas hazardous chemical events with facility worker "HIGH" and co-located worker above threshold for unmitigated consequences. • When any melter maintenance requiring removal of hatch cover occurs, ventilation becomes the only engineering control between personnel in the melter bay and the off-gas system, potentially containing high levels of NOx exceeding the NIOSH IDLH.	• Potential for major redesign of the LAW HVAC systems if the Ventilation systems are determined to be safety significant. • Failure to perform Hazards Analysis could cause uncontrolled shutdown of the LAW Ventilation systems resulting in loss of confinement and release of radioactive contamination to the environment. Ventilation shutdown could expose the on-site worker to hazardous chemical vapors and airborne radioactive contamination.	It is recommended that a hazards analysis be performed on the LAW Ventilation system to identify the Failure Modes and Effects for normal and off normal operations, start-up, production, clean-out & flushing and maintenance. Functions and Requirements and accurate V & IDs with alarms and interlock set points must be developed and documented
HVAC-01-3	Instrument range should be a compound range (e.g., -5 to +5) rather than recording only one direction (e.g., 0 to +5)	The pressure differential recording instruments are set to record only from zero to some numerical value. At times it is useful to know the magnitude of the reversal. Since these instruments are capable of recording both sides of the zero mark, the range should be set up to capture both sides.	Current control system differential pressure monitor cannot measure range of pressure reversal.	Re range the differential pressure transmitters to include a compound range. This would capture the magnitude of differential pressure reversals.
HVAC-01-4 HVAC-02-5 HVAC-02-6 HVAC-03-1 HVAC-11-5	Documentation Discrepancies	There are a variety of errors in documentation. For example, there is inconsistency between drawings such as different flows, different part numbers, and so forth. Some calculations reference other calculations that have been modified. J3 documents reference things that are not on drawing and vice	Design rework.	Review and fix documentation discrepancies.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
HVAC-24-1		versa. System description not consistent with J3s and V&IDs. Etc. See individual RORs for specific issues.		
HVAC-02-1	C2V fan control will not work	• The C2V supply fan senses room/zone depressions and modulates the supply fan in an effort to maintain the zone depression at -0.10 inches w.g. Instrument uncertainty coupled with the low set point makes this control system unlikely to function correctly. • The C2V exhaust fan is controlled by a differential pressure transmitter sensing exhaust header pressure. The goal is to maintain 0.10 inches w.g. in the C2 areas. Measuring the header pressure is far too insensitive to adequately control the C2 zone at 0.10 inches w.g. Exhaust Header pressure expected to be in the range of -4.0 to -6.0 inches w.g.	C2V control philosophy will result in frequent shutdown of the C2V supply and exhaust as well as the C3V exhaust system because of zone to zone interlocks.	Consider using a different control scheme. Perhaps running the C2V AHUs at a fixed speed and control the exhaust by sensing header pressure. Or consider controlling on flow using a flow element.
HVAC-35-2	C2 exhaust flow control method will not provide accurate flow control	The LAW C2 exhaust is maintained at a constant flow rate while the C2 zone pressure is maintained by controlling the C2 supply fan speed and flow rate. The C2 exhaust flow is controlled by monitoring the duct pressure at a single point upstream of the C2 HEPA filter banks. While there is a correlation between duct pressure and flow rate through the duct, this correlation is not always constant or consistent. Depending on the upstream and downstream duct pressure, the flow could vary with the same duct pressure. If the upstream dampers are adjusted, the flow to pressure correlation will need to be adjusted. If inlet grills get dirty, the pressure drop across them will vary, which is equivalent to adjusting the C2 exhaust inlet dampers. This will all have an impact on the C2 exhaust flow rate. The more practical option for controlling C2 exhaust flow is to install a flow element downstream of the HEPA filters. This will ensure a constant C2 exhaust flow regardless of the variation in HEPA filter loading, adjustment of dampers, or any other system change.	Variation in C2 exhaust flow resulting in zone pressure and flow variation and inconsistent heating and cooling control in C2 areas.	Switch C2 exhaust flow control from maintaining duct pressure to a using flow element
HVAC-02-2	Lack of safeguards against excessive depression	There do not appear to be any interlocks or alarms for excessive depression.	Equipment failure could cause a fan to continue to ramp up and develop excessive depression which could cause structural damage or cause personnel to be trapped in rooms.	Add interlocks and or alarms to prevent excessive depression due to loss of control of the fan.
HVAC-02-3	As currently designed C3V Fan Control Pressure Transmitter (C3V-PDT-2117) will not work to control C3V depression	One of the C3 depression transmitters is located in room L-202, which is a C3 space exhausted by the C5V system.	If the signal from this transmitter is used to control C3V fan, varying the speed of the C3V fan will have no effect on the depression in this room.	Place C3V-PDT-2117 in a C3 area or room that is exhausted by C3V.
HVAC-02-7	Loss of Power results in C5V at a fixed speed rather than controlling flow or zone differential pressure	During a loss of power event, the C5V exhaust fan defaults to a fixed speed rather than controlling to a fixed flow or fixed depression. There does seem to be any analysis to establish a basis for the fixed speed. Final fixed speed must consider the impact maintaining confinement as well as heat removal to protect equipment and structures from damage due to excess temperatures.	Setting the fixed speed too low could result in insufficient heat removal or jeopardize confinement. Setting the speed too high could result in personnel access issues or physical damage to the facility.	Determine the driving factors (heat removal, confinement etc.) for determining the fix speed value and establish the fixed speed value.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
HVAC-11-1	The LAW Facility secondary to tertiary zone differential pressure exceeds the recommended differential pressure range of- 0.1 to -0.15 inches w.g. from DOE-HDBK-1169-2003, Nuclear Air Cleaning Handbook, resulting in excessive door opening pressures (life safety concern).	Review of the LAW Facility design indicates the nominal Tertiary (C2) zone has a nominal differential pressure of -0.1 inches w.g. and the Secondary (C3) zone has a nominal differential pressure of -1.5 inches w.g. (and -1.4 inches w.g.); both relative to atmospheric pressure. This results in a differential pressure of -1.4 inches w.g. and -1.3 inches w.g. between the Secondary and the Tertiary zones which is not consistent with DOE-HDBK-1169-2003. DOE-HDBK-1169-2003 identifies a differential pressure range for Secondary/Tertiary of -0.1 to -0.15 inches w.g. Using this high of a differential pressure creates issues with respect to life safety requirements related to force required to open doors across zone boundaries.	Life safety concern.	Evaluate the basis for the nominal differential pressure requirement identified for the Secondary (C3) zones of 1.6, -1.4, and -1.5 inches w.g. relative to atmospheric pressure. Lowering the differential pressure between C2 zones and C3 zones will result in a lower force required to open zone transition doors. If it's not feasible install breaker bar for each door exceeding force (above required) to set door in motion.
HVAC-11-2	Low duct air velocities will result in deposition of radionuclides in the ductwork	• Air velocities through many of the C5V ducts is significantly below the recommended minimum duct velocity of 2,500 fpm from DOE-HDBK-1169-2003 increasing the likelihood of hazardous particulates settling within the ductwork. • Ducts for most nuclear exhaust and post-accident air cleanup systems should be sized for transport velocities needed to convey particulate contaminates to filter media while minimizing the settling of those contaminants in the ductwork during operation	Settling of hazardous particulates in the ductwork can lead to unnecessary exposure to workers and potentially require cleaning of the ductwork during the operating life of the facility.	Evaluate ductwork configuration to identify opportunities to modify duct sizes, or air flows, in an effort to improve transport velocities to better align with the recommended 2,500 fpm minimum duct velocity criteria.
HVAC-11-3	Flow cascades directly from a C2 zone to a C5 zone through an inbleed	Current design is not consistent with the confinement zone schematics located in the BOD and DOE-HDBK-1169-2003.	By cascading ventilation flow directly from a C2 zone to a C5 zone removes the level of protection against radioactive contamination spread gained by including a C3 zone in the cascade path during both normal and abnormal operations. Elimination of the C3 zone from the cascade path permits migration of contamination out of the C5 zone directly to the C2 zone.	Evaluate LAW Facility structure to identify opportunities to relocate existing C2 to C5 in-bleeds such that the cascade flow path includes a C3 zone to prevent migration of contamination directly from the C5 zone to the C2 zone. If it is not practical to relocate C2 to C5 in-bleeds, evaluate feasibility for installation of HEPA filtration to minimize migration of contamination through in-bleed.
HVAC-12-1	Combustion and inhalation hazard not considered in establishing ventilation rates	• DOE-HDBK-1169-2003, Section 2.2.9. • Section 2.2.9 Confinement Selection Methodology - "Workroom ventilation rates are based primarily on cooling requirements, the potential combustion hazard, and the potential inhalation hazard of substances that are present in or could be released to the workroom". - "Concentration of the radioactive gases and aerosols on the air of occupied and occasionally occupied areas should not exceed the derived air concentrations (DAC) established for occupationally exposed person under normal or abnormal operating conditions". • Review of the LAW Facility design indicates that the ventilation rates were considered based on cooling requirement only. The WTP CLASSIFICATION OF	Without knowing potential combustion and inhalation hazard of present substances for normal and abnormal operating conditions the whole confinement strategy considered vulnerable.	Evaluate the potential of combustion hazard, and the potential inhalation hazard of substances that are present in or could be released to the workroom (DAC, Hydrogen, CO2, NOx.).

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		AREAS report states that it does not reflect accident conditions (page 4) and does not establish limits on a derived air concentration (DAC) for normal and abnormal conditions that should not be exceeded.		
HVAC-12-2	No HEPA filters on C5V exhaust duct inlet	If a high airborne contamination level is present in processes it does have a potential to build up within the duct. Typically, highly contaminated areas like glove boxes, canyons or cells must have localized HEPA filtration in conjunction with 2,500 fpm velocity to reduce buildup of molecules within HVAC ducts. In the LAW Facility C5V exhaust duct (out of the Pour cave) is routed through the C3 and C2 before it reaches HEPA filters.	Settling of hazardous particulates in the ductwork can lead to unnecessary exposure to workers and potentially require cleaning of the ductwork during the operating life of the facility.	Provide "Out-bleed" HEPA filtration for the primary confinement areas. Increase velocity in the exhaust ductwork
HVAC-12-5	Some areas in the LAW Facility have been labeled as C2/C3 and as C3/C5 resulting in inconsistent application of design values	Typical ventilation design establishes a zone depression depending on the level of contamination within the air space. Areas of higher potential contamination are given a more negative depression to ensure airflow is from areas of less contamination to areas of greater contamination. Dual labeling of areas has resulted in inconsistent application of depression values and has also made it difficult to apply the correct flow rate through open doors, as described in vulnerability HVAC-12-4 and HVAC-31-6.	Low velocities across zone boundaries reducing the protection against contamination migration.	Establish ventilation zones in a three-tiered manner in conjunction with single zoning where each zone is based on the worst case scenario
HVAC-12-6	Potential for flow from C3 to C2 areas upon loss of power	• There are multiple C3 areas exhausted by C3V fans bordering with C2 areas exhausted by C5V fans. • If the C2V and C3V exhaust fans shut down due to the loss of power, it is possible that C3 air migrates to C2 zone exhausted by C5V fans.	C3 to C2 backflow.	Develop a computer simulation (model) of the LAW Facility HVAC system to evaluate the safety and operability of the system. Computer simulation should evaluate the facility HVAC systems ability to accommodate dynamic operations (e.g., personnel access, routing of waste canisters and drums), failure of equipment (e.g., supply and exhaust fans), and safety requirements (e.g., hydrogen mitigation, heat removal and confinement).
HVAC-12-7	C5 exhaust fans/motors could be undersized based on collective vulnerabilities.	• Pre-Filter stage is missing on HEPA filters housings. To resolve this issue an extra 1.5-2 inches w.g. of pressure will be added to the existing exhaust system to overcome resistance. • Low duct air velocities will result in deposition of radionuclides in the ductwork. Increasing velocity in the exhaust duct could increase duct pressure up to 0.5-0.75 inches w.g. per (or 0.2 inches w.g. per 100 ft of duct). • No HEPA filters on C5V exhaust duct may result in high contamination and dose build up in ducts and HEPA filters. Placing nuclear grade HEPA filters would add an extra 3-4 inches w.g. of resistance to the C5V exhaust fans/motors. • C5V exhaust fans are not sized based on the latest calculated exhaust temperatures at the exit of Pour Caves. C5V exhaust fans sized based on the 150^0 F temperature	Collectively, in worst case scenario, all of those vulnerabilities have a significant potential to affect C5V exhaust fans size (approximately by 6-8 inches w.g. of extra resistance). If so, new fans will be needed.	Evaluate all aspects affecting C5V exhaust fans size and capabilities.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		using air density correction factor for that temperature. Temperature increase in the processes (above expected) affects density correction factor and respectively C5V fans size. • Individually, each of this vulnerability has a potential to impact size of C5V exhaust fans.		
HVAC-21-1	Installed inbleed configurations cannot be verified to match pressure drop calculations	The formulas and calculations used in the analysis are imbedded in an Excel spread sheet. Other than the basic methodology, the calculations could not be verified. Also, there are no dimensional drawings describing each Inbleed that was analyzed in the calculations. Since the Inbleeds are the main supply for the C5V ventilation system, the correct geometry is critical for the design air flow rate and pressure drop. The information flow down of the Inbleed design to the sheet metal contractor and the acceptance of the installed Inbleed was not available. The "as-built" design drawings should be verified against the original design and any changes need to be reanalyzed to verify that the installed Inbleeds will perform as designed.	• Reduced airflow in C5 areas. • Inability to balance ventilation zones. • Insufficient airflow for cooling load.	Compare "as built" Inbleed design to the original "as calculated design" and evaluate any changes that may affect performance.
HVAC-21-2 HVAC-21-4 HVAC-21-6	Flow through inbleeds will decrease as inbleed filters load	Zone C5 ventilation flow rate is controlled by the pressure in the transfer tunnel. As the filters load on the inbleeds that cascade to the transfer tunnel, the pressure in the transfer tunnel will be more negative. The fan speed controllers will adjust to maintain the pressure at the predetermined set point. Continual loading of the filters has the potential to significantly reduce the C5 flow rate, which will impact cooling and may affect confinement. The inbleed filter loading is monitored by a differential pressure gauge across the filter. However, this may not be an effective method if there is a low pressure drop across the other components in the inbleed air stream. The flow is measured by a single hot wire anemometer, which will also require some adjusting and tuning to get a representative flow rate. Maintaining consistent flow through the inbleeds will be difficult with the local instrumentation.	• Inadequate flow to maintain confinement. • Reduced overall building cooling. • Labor intensive work to maintain flow through Inbleeds by adjusting dampers and changing filters. • Difficult to troubleshoot control issues.	• Install an automatic damper on the Inbleed to control filter loading by measuring air flow rate through the Inbleed allowing the damper to open as the filter loads increase until the damper is wide open or install fan powered supply on the Inbleed or replace filter with electrostatic precipitator (ESP). • Change C5 exhaust control from zone depression to zone flow
HVAC-21-3	Fire damper inspection and maintenance will result in bypassing the inbleed and may result in surges in C5 flow	The access door for inspecting the fire damper is located downstream of the inbleed filters, cooling coil, manual damper, etc. Opening the inspection door will bypass the Inbleed internal pressure drops allowing the air flow rate to increase substantially. For example Inbleed L-008 operating normally at 2200 cfm, the air flow rate through the inspection door could increase to greater than 4100 cfm.	• Opening the inspection door will increase C5V flow, which will impact the differential pressure. • Unable to inspect fire damper.	• Install "windows" on access doors for visual inspections. • Enlarge access doors to facilitate fire damper maintenance.
HVAC-21-5	Inbleed filter loading affects HEPA filter differential pressure making it difficult to monitor HEPA filter loading	As the Inbleed filters load, the C5 depression will increase. Once the C5 differential pressure exceeds the set point the control system will decrease the C5 depression by reducing the speed of the C5V fan, which decreases the airflow rate through the primary and secondary filters. This will cause the HEPA filter differential pressure to drop. The opposite occurs	Inaccurate assessment of HEPA filter loading.	Modify Inbleed for automatic damper control, supply fan to eliminate the effect of filter loading or replace the filter with an electrostatic precipitator (ESP).

Table A-3. Vulnerabilities Identified for Ventilation Systems (HVAC). (18 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		when the Inbleed filters are changed and the air flow rate through the Inbleeds increases. In this case, the C5V exhaust fan speed is increased and the primary and secondary HEPA filters pressure increases as the C5 differential pressure returns to the set point. This will make it difficult to determine the actual C5V HEPA filter loading.		
HVAC-21-8	The INBLEED pressure drop calculation did not include dirty filter loading and additional sub-change damper DP	The INBLEED's are designed based on their required air flow rate. The pressure drop through each INBLEED was calculated with a wide open damper and a clean filter. The pressure drop for a dirty filter is 0.5" W.G. per the filter manufacturer submittal 24590-LAW-MKD-C5V-00020, Upstream Filtration for C5V-CCL-00049 at INBLD-L020. The pressure drop from Zone 2 to Zone 3 through a sub-change damper was also not included in the calculation. Based on this differential pressure (outlet-inlet) as shown on the VFDs, the INBLEED filter loading capacity is marginal and many filters cannot be fully utilized.	• Excessive change out frequency needed maintain INBLEED air flow rate. • Limits increasing the C5V depression if needed to balance differential pressures during start up.	Consider alternate means of filtration such as ESPs or roll filters to minimize pressure drop through INBLEEDS.
HVAC-23-1	Strength of walls for L-0305 room may not be adequate for high differential pressure created when opening plenum doors to C2V supply air handlers while the supply fans are operating	• The C2V supply air handlers are located in a closed room (L-0305). The room is a C2 ventilation area balanced to -0.1 inches w.g. (Zone 2) based on a review of calculations, the walls were sized to withstand a differential pressure of 2 inches w.g. creating 10.4 psf loading pressure on the wall. With plenum doors open the fans have the capacity to lower the room depression to -10 inches w.g. creating a ~52 psf loading pressure on the wall. Opening doors while performing inspections, maintenance or trouble shooting is sometimes required when the system is operating. • Room is exhausted by the C3V exhaust. A high differential pressure in the room will also cause a flow reversal where the C3V exhaust will be drawn back into the C2 Zone. • Opening the doors to corridor prior to opening the C2V plenum doors in order to minimize the large differential pressure in the room will exacerbate the problem. When doors are open, the air will short circuit within the fan causing a shortage of air flow to the rest of the building. Control system shut down of the ventilation will result.	• Catastrophic failure of room walls. • Cross contamination. • Life safety code issues for egress through doors.	• Strengthen room walls meet increased differential pressure requirements. • Install relief dampers to connect to outside atmosphere.
HVAC-25-3	Zone pressure controls for cascading zone will be unstable	Control for C2V Supply fans and C2V, C3V and C5V exhaust fans relies on ASDs to control fan speed, which controls pressures within these spaces. Changes in the differential pressures of each air space will affect the other airspaces because of the cascading flows. Any one of the exhaust fans or the supply fans can adjust during one condition while the other fans could adjust for another condition. This could result in unstable ventilation control system operation.	• Continuously varying air flow rates supplying C2 areas and exhausting the C3 and C5 areas • Large variations in C2V and C3V exhaust stack air flow rate.	• Revisit control strategy by utilizing branch dampers to provide pressure control for C2, C3 and C5 areas. • Modify INBLEED s for automatic control for filter loading replacing the pressure gauges.
HVAC-25-4	LAW C2V Supply System Pressure Drop calculation error	LAW C2V Supply System Pressure Drop calculation failed to include additional pressure drop of 1.5 inches w.g. for additional bank of pre filters.	The supply fans may be under sized and will not supply the air flow rate required.	Revise the pressure drop calculation for additional filter differential pressure for the supply fans.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
HVAC-31-10	Opening of door L-0106-2 between subchange L-0106 and buffer crane maintenance area in L-0110 was not considered in subchange operation	When subchange L-0106 is used to access the buffer crane maintenance platform in L-0110, airflow will be diverted from the effluent cell (L-0126) to the buffer crane maintenance room. This is a redirection of airflow into the transfer tunnel, which is where the C5 zone pressure is measured. This will have an impact on the C5 ventilation, which has not been evaluated as part of the design.	Upset ventilation conditions due to airflow diverted from the effluent cell to the transfer tunnel and pour caves when accessing the buffer crane maintenance cell (L-0110) through subchange L-0106.	Develop a model to evaluate the impact of facility operations, such as accessing the buffer crane maintenance through subchange L-0106, on the ventilation system.
HVAC-31-7	Inbleeds don't function during entries	Cooling in cell areas is provided by the inbleeds. During entries airflow bypasses inbleeds and passes directly through the open cell door. Depending on the length of the entry and the amount of cooling by the inbleed, the cell area could become warm without the cooling provided by the inbleed.	• Cell area where entry is taking place could become warm resulting in worker discomfort and fatigue. • Limited cell entry time because of warm work conditions.	Convert subchanges to airlocks where the inbleed is located between the corridor and cell entry room. This would allow the inbleed to function continuously.
HVAC-34-1	Lack of airlocks between rooms of different differential pressures may result in ventilation upsets	Some rooms in the facility that will likely be accessed on a regular basis are adjacent to corridors with C2 depression sensors. These rooms either have more negative depressions than the corridor by design or have the potential to have a different depression when other doors in the room are open. When doors are opened to access these rooms, the pressure in the corridor will be impacted. This will cause the ventilation controller to fluctuate, leading to potential ventilation system upsets.	Ventilation system upset resulting in a potential lack of confinement in some areas.	• Add an airlock for accessing rooms LCB004 and L B009. • Add an airlock for accessing rooms L-0117 from LC0109 and L-0119 from LC0111.
HVAC-35-1	Lack of redundancy of C2V exhaust fans	The LAW HVAC system has only two C2V exhaust fans and both have to be running for normal operation. There is no backup fan and a single fan is not large enough to provide adequate airflow for normal operation. These fans will require regular maintenance. While running a single fan is not a safety hazard, it does require the facility operation to be stopped since the overall ventilation flow is reduced. A single fan is sufficient to maintain adequate zone depression, but it is not sufficient for facility operation.	Failure, or even the planned outage, of a single C2V exhaust fan will require production be stopped until the fan is restored.	• Provide a calculation demonstrating the facility can continue in normal operation with a single operating C2V exhaust fan. • Install larger fans that have the capacity to provide full C2V exhaust flow with a single fan operating. • Install a backup fan. • Construct some sort of protection over the fans to prolong the operating life of the fans and motors.
HVAC-35-3	Lack of pre-filters to protect HEPA filters	It is anticipated that Zone C2 will have dust issues since it is the closest zone to the building exterior and is the most frequently occupied zone with doors opening and closing regularly. As exhaust air is drawn into the C2 exhaust, dust particles will be drawn in as well. There does not appear to be any type of pre-filter in the C2 exhaust airstream to filter out any of the dust and dirt particles that would shorten the life of the HEPA filters.	Frequent loading and changing of C2 HEPA filters.	• Provide an evaluation to demonstrate why pre-filters are not necessary in the C2V exhaust airstream. • Modify the C2V exhaust system design to include pre-filters.
HVAC-41-1	Lack of Deluge Spray System to protect the C5V HEPA from soot loading	Per DOE-STD-1066-2012 Fire Protection Standard, a deluge system is required upstream of the HEPA filters to delay the soot loading of HEPA filters during a fire event. BNI presented the use of a fire suppression system as an alternative approach for PT and HLW and were directed by DOE to implement the alternate approach. BNI carried the alternative approach over to LAW, which does not have fire suppression and soot mitigation systems that are identical to PT and HLW.	Possible rupture of C5V HEPA filters due to fire event and release of radioactive materials to ambient exposing them to public. (Low Dose)	• Investigate if deluge spray system can be added to the current design if the HEPA Filter housings. • Investigate if the current Fire Suppression System reliability can be improved.

Table A-3. Vulnerabilities Identified for Ventilation Systems (HVAC). (18 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
HVAC-41-2	Lack of smoke dampers on inbleeds to protect C5V HEPA filters from soot loading	BNI's alternative approach to mitigation of fire consequences assumed that the majority of the smoke stays in the C3 areas and the propagation to C5 area is stopped via smoke dampers in the inbleed. While this is true for HLW and possibly PT, it is not true for LAW. The LAW Facility does not have smoke dampers in the inbleeds between the C3 and C5 areas.	C5V HEPA will not be protected against fire soot effluents thereby exposing the HEPA directly to soot in the event of fire.	To make the design consistent with the PT and HLW, add smoke dampers and associated controls for the LAW in-bleed assemblies.
HVAC-43-1	Ventilation System Evaluation not performed per the DOE Implementation Plan of DNFSB 2004-2 Recommendation	When the DNFSB 2004-2 recommendation was implemented, LAW was a Category 3 facility and no evaluation was required. It has since been modified to a Category 2 Facility. All Category 2 facilities with active confinement ventilation systems require and evaluation per the DOE implementation plan of DNFSB recommendation 2004-2.	DOE non-compliance may result in performing the needed evaluation at a later date, which may require redesign of certain gap related issues.	• Recommend that the 2004-2 evaluation be performed for the LAW Facility. • Based on the new 2004-2 evaluation reconcile any gaps which are identified.
HVAC-44-1	Inadequate Buffer Storage and Canister Rework area cooling capacity for anticipated heat loads	The calculations show that the purchased fan coil units do not provide adequate cooling to offset the heat loads in the Buffer Storage Area and Canister Rework Area.	• Buffer Storage Area and Container Rework Area temperatures exceed the bulk area design temperature of 113^{0} F. • Pour Cave C5V exhaust air temperature will be higher than the CFD analysis calculated figures in normal operation due rise in supply air temperature to the Pour Cave cascaded from the Container Transfer Corridor. • The C5V exhaust fan flow margin will be reduced.	• Evaluate if the purchased FCUs can be modified to make up for the shortage of cooling capacity. This option will add to the current power requirement including replacing the current motor. This change will also increase the chilled water flow to the balance of plant, thereby impacting the pumps and chiller capacity. • Redesign and replace existing FCUs will be necessary if modifications to purchased FCUs is not achievable. This option will require motors larger than the current 50 HP and 25 HP respectively. This change will also increase the chilled water flow to the balance of plant, thereby impacting the pumps and chiller capacity.
HVAC-47-1 HVAC-47-2	Lack of standby fan coil units in C2 and C3 airspaces	Some C2 and C3 spaces do not have standby fan coil units (FCUs). These are commercial grade units with no backup or standby units. When these units fail, the air temperature in spaces cooled by the FCUs will increase. Some of these are critical areas, such as exhaust fan and HEPA filter rooms.	Elevated temperatures will prevail in the space upon failure of the FCU (greater than 80°F in C2 and greater than 95°F in C3) and will impact maintenance operation.	• A 100% standby FCU is recommended for L0121 C2V Filter Room, L0317- C3V Fan Room, L0319A- C3V Filter Room, LB029-C5V Filter Room and LB028-C5V Fan Room, but if it is not feasible then a high temperature alarm in the space to alert the maintenance staff for repairing the failed FCU in a timely manner. • Evaluate the possibility of increasing the cascade airflow coming into spaces to offset heat loads during failure of the FCU. • Investigation and validation is required to ensure that ASTM requirements are complied with for

Table A-3. Vulnerabilities Identified for Ventilation Systems (HVAC). (18 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
				all exhaust system which may be exposed to temperatures higher than 140^0 F. External surface of Exhaust System components will be provided with adequate insulation to protect the workers from contact with hot surface
HVAC-51-2	C5V design may result in non-uniform loading of the multiple filter banks	The supply and exhaust ducting to the C5V filter housings creates unbalanced air flows to the 10 banks of first and second stage HEPA Filters.	Potential to exceed rated flow if filters do not load evenly or during filter replacement when the standby housing is placed into operation.	Evaluate opportunities to install balancing dampers on the C5V exhaust.
HVAC-51-3	Contamination traps in HEPA filter housings	The design of the C5V Flanders HEPA Filter housing creates a trap in the bottom of the housing where contamination can accumulate	• Radiation levels can increase over time and replacement of HEPA filters will not remove this contamination trap. • Vacuum cleaning or flushing of the filter housing may be required to remove the contamination.	Evaluate modifications that can be made to the filter housing to prevent build-up of contamination or cleaning the housing inner floor
HVAC-51-4	C5V design does not include the ability to balance air flow through filter housing	Design includes isolation dampers but not dampers to balance airflow to the HEPA filters.	Potential to exceed rated flow if filters do not load evenly or during filter replacement when the standby housing is placed into operation.	• Develop technical justification to confirm that the HEPA filter rated flow will not be exceeded during all operation and maintenance modes. • Install balancing dampers. • HVAC Operating procedures will be prepared to monitor HEPA filter DPs and adjust damper positions periodically to balance air flows and pressure drops.
HVAC-52-1	Radiation Source Term values are inconsistent and may require additional evaluation	• LAW Facility Shielding Confirmation Table 7-1 states that the worst case LAW glass unshielded dose rate at 12-inches is 1135 mrem/hour. • Table 2-3 provides a scaled source term on a C5 HEPA Filter resulting in a 2.5 mrem/hour dose rate at 12-inches. • Radiation Safety has stated that the maximum glass canister dose rate is expected to be less than 15 mrem/hour.	• Increased exposure and dose rates for personnel changing HEPA filters and performing maintenance on ventilation equipment. • More frequent changing of HEPA filters due to dose rate.	Perform radiation dose rate calculations for expected normal operating conditions and upset conditions. Evaluate installing HEPA filters on the C5V ducting where the air from the process cell enters the C5 ducting.
HVAC-52-2 HVAC-52-3	C5V HEPA Filter Radiation Source Term and filter operating parameters are not integrated for LAW operation	Replacement strategy for the C5V ventilation system Radial HEPA filters based on radiation dose rates, pressure drop, air flow, shelf storage life, operational life, and filter efficiency needs to be evaluated and documented for LAW Facility. Radiation dose rate may be high enough that shielding is required on filter housings.	• ALARA. Personnel radiation exposures are increased due to elevated dose rates and more frequent HEPA Filter replacements. • Personnel radiation exposures are increased due to elevated dose rates. • Limited facility operations due to increased dose rates.	C5V HEPA Filter operating and replacement strategy needs to be developed for LAW Operation
HVAC-52-4	Lack of HEPA filter replacement strategy for LAW commissioning	A comprehensive plan for HEPA filter replacement has not been developed. Three distinct phases need to be considered with potential replacement of filters at each phase:	HVAC flow balancing can be compromised and testing can be delayed.	C5V HEPA Filter replacement strategy needs to be developed for LAW commissioning and startup. Ducting

Table A-3. Vulnerabilities Identified for Ventilation Systems (HVAC). (18 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		1. Installation of filters to remove duct work debris and dirt from C2V, C3V and C5V ventilation ducting that could damage HVAC components or create flow imbalance or contamination traps prior to flow testing 2. Installation of clean HEPA filters to perform ventilation air flow balancing 3. Installation of installing clean HEPA filters prior to hot startup.		needs to be inspected for debris removal before startup testing is performed.
HVAC-03-2	Temperature Controller does not meet +/-3°F control tolerance required by System Description	Schneider Electric Series TC-4211 Cooling Temperature Controller will not control to the requirements in the System Description (+/- 3°F). No evidence of temperature control testing during Commercial Grade Dedication process.	Temperature control will not meet requirements in the System Description.	Evaluate the design requirements to determine if a broader range of control is acceptable.
HVAC-21-7	Inbleed back draft dampers cannot be checked for leakage	There is no provision to test back draft dampers for leakage making it difficult to ensure confinement is maintained upon loss of ventilation.	Backflow from C5 to C2 and C3 areas upon loss of ventilation.	Redesign Inbleed to facilitate back draft damper testing.
HVAC-22-1 HVAC-22-2	C5V fan motor, bearings, and adjustable speed drive may exceed rated temperatures	It is anticipated that the C5V exhaust air stream temperature will exceed 150^0 F. When the air stream reaches this temperature, high heat loads will be transferred into the room through the duct and the fan housing. While the duct and fan housings are insulated and the room does have fan coil units that are supposed to maintain temperatures at or below 95^0 F, there is the potential that room temperatures will exceed the 104°F rating typical of most adjustable speed drives (ASD) or exceeds the recommended operating conditions of the exhaust fan motor and fan bearing grease. It does not appear these conditions have been evaluated as part of the design.	• Loss of C5 ventilation. • Reduced life of fan motor, fan bearings, and/or adjustable speed drive.	• Evaluate temperatures and heat transfer effect on fan motor, fan bearings and ASD. • Move ASDs to corridor and away from heat sources. • Provide supplemental cooling to the ASD's and fan motors. • Convert fan bearing lubricant from grease to oil.
HVAC-23-2	Lack of filters in the C2V bypass duct	If off-site power is lost, all ventilation fans shut down except C5V exhaust. An outside air bypass duct with a separate intake louver and backdraft damper connects to the supply header to provide makeup air for C5V exhaust in the event of loss of off-site power. This air is not filtered.	High dust loading of Inbleed filters due to dust storms and smoke from range fires during a loss of loss of off-site power occurrence.	Install means of filtration for bypass duct such as an ESP.
HVAC-42-2	C5V duct and equipment burn hazards	C5V airstream temperatures may exceed 140°F. Exposed duct, filter housings, fans, and other ventilation related equipment may reach temperatures high enough to burn maintenance and operating personnel on contact.	Burn hazard to maintenance and operating personnel.	• Investigation and validation is required to ensure that ASTM requirements are complied with for all ventilation system which may be exposed to temperatures higher than 140^0 F. • External surface will be provided with adequate insulation to protect the workers from contact with hot surfaces, where applicable.
HVAC-44-3	Contamination trap in buffer storage cooling ductwork section	The ductwork between Container Transfer Corridor and the inlet to HEPA Housings for the Buffer Storage is unprotected without inlet filter at the entrance. Contamination from the Transfer Corridor could be trapped in this section of duct and could be difficult to remove.	• HEPA Housing may have accumulation of radiological contamination at the base of the units. • Periodic sampling of duct contamination will be required.	Redesign the ducting arrangement for the Buffer Storage Area FCU to avoid accumulation of radiological contamination.

Table A-3. Vulnerabilities Identified for Ventilation Systems (HVAC). (18 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
HVAC-49-1	Code Compliance Matrix did not include Safety Significant Direct Expansion Air Conditioning Units used for the E & I Rooms & Secondary Off-gas Room	Per System Description the Direct expansion Air Conditioning Units utilized for E & I Room and Secondary Off-Gas Room cooling. The safety function of the equipment is to supply filtered and conditioned air to the SS spaces under normal and off-normal condition.	The components design, construction, testing or operation of DX Air Conditioning Units is not approved and if carried out, may not meet the WAC control technology code requirements.	Revise the current Code Compliance Matrix to include SS Air Conditioning Units and their compliance in a timely manner for WDOH approval.

Table A-4. Vulnerabilities Identified for Electrical. (8 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
ROR-ELEC-1: Vulnerability #4, #5, and #6	The ITS UPS units: # UPE-UPS-20301, -20302, and -20303 are undersized for design demand load.	• Calculation 24590-LAW-E1C-UPE-0002, Safety System – Uninterruptible Power Supply Sizing, which was used to size the ITS UPS units, identifies motors for off gas system fans (which are connected to the output of the UPS unit) as having 150hp ratings. Walk-down of these systems revealed that these fans are actually 200hp motors. The review team performed a summation of loading identified in drawings, 24590-LAW-E1-UPE-00003, -00004, and -00005(LAW Vitrification Buildings SS UPS UPE-UPS [20304, 20305, and 20306], Single Line Diagrams), and found that UPS loading now exceeds the rating of the UPS units. • This issue was previously self-identified by BNI, and BNI has issued a white paper recommending replacement of existing 200kVA UPS units with 400kVA UPS units to resolve the issue.	200 kVA ITS UPSs are unable to support Safety Significant loads in the event of loss of offsite power (LOOP).	The Review Team recommends performing the upgrade on ITS UPS units (200 kVA UPS units upgraded to 400 kVA UPS units), as identified in the Bechtel white paper. UPS feeders should be included in the replacement. WTP Electrical Engineering should evaluate feeding both UPS mains and UPS bypass inputs from the same load group to allow additional reductions in the load calculation permitted for "non-coincidental loads". WTP Electrical Engineering should also evaluate replacement of the downstream distribution panel UPE-PNL-20301 along with its panel feeders, which will likely be undersized for the UPS output breaker which protects them once the 400 kVA UPS units are installed.
ROR-ELEC-1: Vulnerability #8, #9, # 18	• UPS battery banks: # UPE-BATT-20301 and -20302 are undersized in the capacity needed to provide the required UPS run time required by the design load profile during a loss of offsite power DBE. • Additionally All ITS UPS battery banks: # UPE-BATT-20301, -20302, and -20303 have not been sized to provide the full UPS rated output for the required run time as directed by 24590-WTP-DB-ENG-01-001 Section 8.4.11.	• Although final procurement of ITS UPS batteries UPE-BATT-20301, -20302, and -20303 have not yet been completed, it appears that the space available within the LAW Facility is insufficient for installation of battery banks (when using the battery model number shown in drawings) with the capacity required to support the design requirements (either UPS rated load, or design profile load) for 2 hours as required by the BOD for a loss of power Design Basis Event (DBE). • Note: this issue will be compounded if the UPS units are upgraded from 200 kVA units to 400kVA units as proposed in the BNI white paper, as battery capacity and battery physical size, will need to greatly increase to meet the requirements of 24590-WTP-DB-ENG-01-001 Section 8.4.11.	UPS will be unable to support Safety Significant loads for length of time required in the design criteria in the event of a LOOP DBE.	• The Review Team recommends that WTP Project perform battery run/capacity calculations for ITS UPS batteries to ensure batteries proposed by the UPS vendor have the capacity to meet the run time requirements for safe system shutdown during a LOOP DBE. • Note: As stated in the basis column, this issue will be compounded if the UPS units are upgraded from 200 kVA units to 400kVA units as proposed in the BNI white paper, as battery capacity, and battery physical size will need to greatly increase to meet the UPS full rated output run time requirements from 24590-WTP-DB-ENG-01-001 Section 8.4.11.

Table A-4. Vulnerabilities Identified for Electrical. (8 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	• This issue is compounded as it appears the equipment rooms in which the batteries are to be installed are too small to accept the number of batteries needed, when using the batteries identified in the drawings.			
ROR-ELEC-1: Vulnerability #16, and ROR-ELEC-4 Vulnerability #8 and #9	Main LAW Facility 13.8kV - 480V service transformers: MVE-XFMR-20603, -20604, and -20606 are undersized for existing design load	The design loads of 3682 Amps, 3645 Amps, and 3852 Amps respectively, calculated in accordance with NFPA 70 2014, National Electric Code, Article 220, "Branch Circuit and Feeder Calculations", exceed each transformer's capacity of 3609 Amps.	This configuration may result in transformer overheating and failure in peak demand situations.	The design team recommends that BNI consider feeding facility UPS Unit Mains, and Bypass Inputs from the same load group which will allow BNI to take a reduction in design loading calculations for non-coincidental loads. This, along with some minor load management, may reduce design loads below the transformer ratings; however, the concern over lack of spare facility electrical capacity identified in the previous vulnerability entry will still exist. Also it should be noted that if the ITS UPS units are upgraded from 200kVA to 400kVA as proposed, the transformer loading would once again be higher than the transformer ratings, and would not be correctable by UPS input changes or simple load management.
ROR-ELEC-2: Vulnerability #1	Elevated ambient temperatures negatively impact electrical equipment operation.	Ambient temperatures in C5 Areas, and areas around the melter galleries, are identified as having anticipated temperatures of 113˚F and 95˚F respectively. However; the Basis of Design (BOD) Table 12-1 states "The indicated summer maximum temperature does not apply to process areas where high radiation heat transfer loads, high container temperatures, or high canister temperatures make it impractical to attain this temperature". The LAW Facility electrical equipment designs seem to be based predominately upon the ambient temperatures identified in the 12-1 table or the Electrical Design Criteria document 24590-WTP-DC-E-01-001, and don't take into account potentially higher ambient temperatures and radiant canister temperatures. .	Conductors and equipment operated at temperatures higher than those identified in the BOD would require additional de-rating to prevent conductor overheating and failure.	The electrical review team recommends that the BNI Electrical Engineering design group re-evaluate the ambient and radiant temperatures anticipated in these areas and ensure equipment is properly rated, or ensure supplemental cooling and/or insulation is added for the equipment as required.
ROR-ELEC-2: Vulnerability #2	Melter Electrode Bus Electrical Ratings may not be adequate for the expected melter loads when operated at potential temperatures in the melter gallery.	The electrode bus voltage ratings appear adequate (1000 V rated vs 321 V actual); however, the amperage rating of the bus in the melter base appears marginal, due to forecast margin, unbalance, and the higher ambient temperature issue raised in ROR-ELEC-2 Vulnerability #1. The design margin for	The external bus in the vicinity of the melter (specifically the south center electrode bus within the base of the melter) may fail to carry melter maximum current.	Re-evaluate bus amperage rating for identified high risk areas. Provide supplemental cooling if justified.

Table A-4. Vulnerabilities Identified for Electrical. (8 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		amperage on the electrode bus is only 6.8%, this design margin can quickly erode if higher equipment, canister, or container temperatures raise the surrounding area above the 104°F design basis temperature of the melter bus.		
ROR-ELEC-2: Vulnerability #4	No evidence of final NRTL listing and labeling exists for the melters.	A UL field evaluation of the melters is in process and identifies numerous deficiencies. The design team recommends that DOE continue to track the field evaluation of this equipment to completion, in order to ensure any discrepancies identified in the field evaluation are adequately addressed and that NRTL product listings are obtained.	Electrical Safety for personnel and equipment reliability may be compromised	Obtain final NRTL Field Evaluation product mark or procure equipment with the NRTL listing and labeling.
ROR-ELEC-3: Vulnerability #1	No spare melter power supply capacity.	The melter power supplies MVE-PSUP-20001 and -20002 do not have installed spare capacity to carry the production current load in the event of component failure or routine maintenance.	Melter power supply capacity will be limited below the production load during equipment failure and maintenance. This configuration impacts facility throughput in the cases of input transformer or inverter failures and maintenance.	The review team recommends BNI install output inverter and transformer units in each of the spare compartments of each power supply's lineups.
ROR-ELEC-3: Vulnerability #2	Melter power supply component isolation is inadequate.	Within the melter power supply cabinets for power supplies MVE-PSUP-20001 and -20002, the three 13.8 kV incoming isolation disconnects (S1, S2, S3) are all located in the same compartment. The output isolation switch is also located in the same compartment with other equipment and all will require maintenance. The load lugs on the output isolation switch cannot be de-energized, therefore it is not possible to isolate this cabinet for maintenance activities. Additionally there appears to be inadequate space for safe worker access.	Complete shutdown of melter power supply will be required for any maintenance activity requiring internal access of the melter power supply line ups	The review team recommends that BNI evaluate the worker safety requirements for these areas and develop barriers, procedures, or alternate isolation points.
ROR-ELEC-3: Vulnerability #4	No evidence of final NRTL listing and labeling exists for the melter power supplies MVE-PSUP-20001 and -20002.	A UL field evaluation of the melter power supplies is in process, but has identified numerous deficiencies in the supplies that still need to be addressed. The design team recommends that DOE continue to track the field evaluation of this equipment to completion, in order to ensure any discrepancies identified in the field evaluation are adequately addressed and that NRTL product listings are obtained.	Electrical Safety for personnel and equipment reliability may be compromised	Obtain final NRTL Field Evaluation product mark or procure equipment with the NRTL listing and labeling.
ROR-ELEC-3: Vulnerability #5	No Melter Standby Power provided.	Standby power for melter heating was removed based on a power reliability, and cost, evaluation. As a result of the evaluation a Trend Notice was issued that justified removing two standby diesel generators siting a cost savings of $1.9 million vs the 80% likely risk (over the 40 year life of the facility) of melter property losses of $27 million, plus $14 million per month of production losses while the melter is being replaced. With	Permanent Melter failures may occur, if utility power is lost for 3-6 hours during the melter 40 year life.	The review team recommends BNI, or DOE, perform another evaluation to determine if potential cost savings still outweigh potential costs of equipment and production losses. Should BNI and DOE decide to provide back-up power to the melters, switchgear MVE-SWGR-20603 and -20604 each have an available "equipped space" to which a standby diesel generator can be connected and configured to back feed the switchgear bus and

Table A-4. Vulnerabilities Identified for Electrical. (8 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		estimated replacement times of 2-5 years per melter, the total anticipated losses would be $363 million to $867 million depending on melter replacement duration. Currently replacement costs of the melters are projected to be substantially higher than previously estimated in the trend notice		provide backup support to both melter power supplies. Connection of a generator at either of the available "equipped spaces" would preclude the use of those spaces to feed a third melter power supply, however, the limited capacity of the LOP/LVP system in the LAW Facility already makes connection of a third melter implausible without expanding the facility.
ROR-ELEC-4: Vulnerability #1	Low Voltage Release	Switchgear MVE-SWGR-87002A/B main breakers and the feeder breakers for LVE-MCC-20001, -20101, -20103, -20002, -20104, -20102, and -20204 (fed from switchboards LVE-SWBD-20101, and -20102) are equipped with low voltage release mechanisms which open the feeder breakers upon Loss Of Offsite Power(LOOP) shedding non critical loads that do not require back up power support from the Standby Diesel Generator (SDG). Once the breakers open they require manual manipulation by electricians to initiate re-closure. This process can take a significant amount of time as it may require paperwork approval, travel time to the switchboard room, donning of Arc Flash PPE, and establishing breaker line up and sequencing to ensure loads are re-instated in the proper order. During this time a large percentage of the facility electrical loads will be without electrical power, including some facility process and cooling systems. The low voltage release mechanisms do not have an adjustable time delay, and will operate in any low voltage situation including brown outs and/or sags on the electrical grid.	This configuration may result in unanticipated interruptions to facility throughput as facility loads are shed following a brown out or voltage sag on the electrical grid or LAW electrical distribution system	Evaluate the addition of time delay circuits to the low voltage release mechanisms to permit the electrical system to ride through electrical grid sags and brownouts.
ROR-ELEC-1: Vulnerability #1	AHJ and NEC inspection Role performed by BNI Design Project personnel	The AHJ and code inspection at the WTP Project is performed by employees of the project, which is not conducive to non-biased regulation.	Inspections and regulation determinations may be less stringent which could compromise the electrical system design and installation.	The review team feels that an independent AHJ and inspection program should be considered by DOE.
ROR-ELEC-1: Vulnerability #2	Lack of Conduit Schedules and Wire Run drawings	There are no conduit schedules or wire run lists in the LAW Facility drawing sets; instead the WTP Project uses a proprietary program called SetRoute to maintain configuration control and conduit runs and wiring information. This software is a wonderful tool for construction however, at the end of construction the project will turn over a database printout from SetRoute to Operations. This data base printout will be extremely difficult for operations to use in continued configuration management of the facility when performing future modifications.	Conduit run system configuration control will be difficult after turn over without having the SetRoute software	The review teams recommend that DOE attempt to negotiate procurement of the SetRoute software from Bechtel.

Table A-4. Vulnerabilities Identified for Electrical. (8 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
ROR-ELEC-1: Vulnerability #10	No post installation service test is planned for ITS UPS system batteries: UPE-BATT-20301, -20302, and -20303 to demonstrate capability of the batteries to provide 2 hours of run time upon LOOP.	Per discussions from the 04/01/14 Electrical Review Team Introductory Meeting (Ref Meeting minutes), the WTP Project plans to use manufacturers calculations and factory capacity tests to demonstrate adequacy of battery capacity instead of performing service testing, this method is unacceptable as manufacturer calculations and manufactures factory capacity tests cannot account for battery cells that may have been damaged in shipping and installation. IEEE-1188-2005 Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (Section 6.4) outlines the requirements for performing service tests on batteries.	Without testing the UPS and Battery system's ability to support the connected load for the design basis run time, there is no assurance the safety significant UPS units will be able to perform their function during a LOOP. If batteries are not installed until the Start-up and Commissioning phase and batteries then fail a service test due to inadequate capacity, the project may be faced with a design that does not meet requirements, and a battery location too small to support the needed battery capacity.	The Review Team feels it is imperative that a battery service test be performed on all ITS UPS batteries, prior to turn over from construction, to ensure batteries were not damaged in shipping or installation.
ROR-ELEC-1: Vulnerability #11 and ROR Vulnerability #12	The feeder conductors for panels UPE-PNL-20301 and -20302 are undersized for the demand load.	NFPA 70, Article 220, "Branch Circuit and Feeder Calculations", and 215-2(a), "Feed Circuits".	Panel feeder conductors are undersized and are not in compliance with the national electrical code.	See OFI on ROR-ELEC-1 Vulnerability #4 and #5 above.
ROR-ELEC-1: Vulnerability #13	UPE-UPS-20301, -20302, and -20303 feeder conductors undersized for UPS full load currents and battery recharge currents.	NFPA 70, Article 215-2 "	Feeder conductor sizing not in compliance with National Electrical Code requirements.	The Review team recommends replacement of the ITS UPS main and bypass feeder conductors with two parallel sets of 500 kcmil conductors as part of the proposed UPS upgrade
ROR-ELEC-1: Vulnerability #14 and ROR-ELEC-4, Vulnerability #7	Very little to no spare capacity provided on Panels: UPE-PNL-20301, -20302, and on Switchboards LVE-SWBD-20101; LVE-SWBD-20102; Switchboard LVE-SWBD-20201; and on LVE-SWBD-20202.	NFPA-70, Article 220	No spare electrical capacity will be available for future process changes and facility modifications	There appears to be no requirement for spare capacity of the electrical system in the LAW Facility, and none has been provided. The is not an issue if no changes are needed within the facility to support operations; however the likelihood of no additional loading being needed seems optimistic
ROR-ELEC-1: Vulnerability #15	General Systemization Layout of MCCs.	MCCs fed from switchboards are intelligent MCCs with single controllers that feed multiple systems within the LAW Facility. This configuration can result in maintenance activities on one system affecting operations on other systems	This configuration may result in impacts to multiple systems when one system is taken down for maintenance or is modified for changes to the facility processes.	MCC systemization was identified as a concern in CLIN 3.2, RPP-44491, Rev 0, Section 3.8.6 and continues to be a concern for potential operability impacts at the LAW Facility. WTP Electrical Engineering Design may evaluate adding additional controllers to the MCCs, or rearrange loads to permit system specific maintenance and control.
ROR-ELEC-1: Vulnerability #17	ITS UPS units not qualified for DBE flood conditions of 0.92 ft. of water.	UPS units are to be qualified for DBE flood conditions of 0.92 feet of water (or 11. 04") The qualification report 24590-QL-POA-EU00-00002-17-00001, Nutherm Qualification Report for Uninterruptible Power Supply (Ups) System for Hanford Site, page 6, states that "the UPS units will be mounted on platforms elevated above the maximum flood height, so flooding is not an event of concern; and, for that reason no	This configuration may result in electrical bus shorting or UPS electrical component failure in the event of DBE flood conditions.	The review team recommends that the ITS UPS units be qualified for 5.04" flood levels or mounted on pedestals that are 11.04" or greater in height.

Table A-4. Vulnerabilities Identified for Electrical. (8 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		flood qualification is performed." The mounting details for the platforms on which the UPS units are to be mounted indicate that the platforms are only 6" in height, which makes the top of the platforms 5.04" below than the anticipated flood height		
ROR-ELEC-2: Vulnerability #3	Single phase AC Bus passes thru ferrous metal enclosure, creating magnetic heating.	The single phase Melter AC Bus passes thru a ferrous metal CT support, creating magnetic heating. This configuration may result in heating of metal around a conductor, which results in damage to the conductor. This issue was previously identified during the UL field evaluation.	Heating of metal around a conductor which results in damage to the conductor.	The review team recommends BNI perform a review of all single phase conductors for inappropriately placed magnetic material.
ROR-ELEC-3: Vulnerability #6	Melter Power Supply Grounding.	The method of grounding the power supply output, as required by NEC Article 250-30 Grounding Separately Derived Alternating Current Systems-(b) "Ungrounded Systems", has not been addressed for the Grounding Electrode Conductor. Worker safety and proper equipment operation is dependent on the correctly engineered grounding system being installed. The National Electrical Code (NFPA-70) Article 250 is specific in requiring grounding and bonding of energized and equipment that could become energized. The melter power supply contains an incoming transformer which has an ungrounded 460 volt transformer secondary; this ungrounded voltage is of concern for detecting and isolating faults. The current NRTL Field Evaluation of this equipment should address this specific concern within the power supply enclosure.	Worker Safety and equipment reliability are compromised.	The review team recommends that BNI re-evaluate the supply output to determine if the melter power bus has been provided with an adequate equipment grounding conductor.
ROR-ELEC-4: Vulnerability #3	There is not currently a formal "Code of Record" for the Waste Treatment Plant.	While the electrical review team did not find extensive contradictory code references within the many separate design basis and system description documents, it was often difficult to ascertain which code revision was applicable, as often codes are referenced within documents without mention of the code's revision or issue date.	Without a formal code of record, application of the wrong standard revision is possible and may result in costly re-work at the time of commissioning	The review team feels that BNI should issue a formal code of record that identifies all applicable codes and revisions used in the design of the facility.
ROR-ELEC-4: Vulnerability #6	C5V-FAN-00005A, and C5V-FAN-00005B circuit conductors are not symmetrically shielded type cable, or not installed in metal conduit that is bonded across each joint, in accordance with manufacturer's instructions.	Per the User Manual for the ABB ACS800 ASD drives feeding these motors [Ref 24590-QL-POA-EV00-0001-01-00004, Installation, Operation and Maintenance Manual for Non-Safety Q Adjustable Speed Drives For C5V-ASD-00001-A/B, page 67(pdf. Page 83)] these ASDs must be used with Symmetrically shielded motor cable, or must be installed in metal conduit	C5V fans may not function properly without motor circuits supplied in accordance with manufactures requirements.	The review team recommends replacement of the C5V motor circuit conductors, between the ASD units and the motors, with symmetrically shielded cables, or recommends the addition of bonding jumpers across conduit joints. In general the review team recommends that all larger ASD supplied motors in the WTP use symmetrically shielded ASD/VFD cable.

Table A-4. Vulnerabilities Identified for Electrical. (8 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		that is bonded across each joint. It appears from the drawings and the SetRoute information provided by WTP Engineering, that these conductors are not Symmetrically shielded cable, and no evidence of bonding across conduit joints was found during system walk downs, therefore the wiring method does not comply with manufactures requirements.		
ROR-ELEC-1: Vulnerability #3	General Drawing Discrepancies	This entry is for general drawing discrepancies found by the DOE Electrical Review Team during the LAW Facility review. • Offgas exhauster motors LVP-EXHR-00001A, -00001B, and -00001C are shown as 150hp on drawings, but were observed at 200hp in the field. • UPE-UPS-20301, -20302, and -20303 Bypass Input Source Locations Conflict between One-line Diagrams and MCC schedules [Ref Section 3(f)] • Battery Circuit Breaker is identified in VI info as being a 900A breaker, but is listed on one-line diagrams as an 820A breaker. [Ref Section 4(f)]	Documentation must be accurate to ensure general industrial safety within the facility.	The review team recommends correction of drawing errors.
ROR-ELEC-1: Vulnerability #7	• No Hydrogen monitoring or ventilation calculations available to demonstrate that potential VRLA battery off gassing can be alleviated. • Following the review period, DOE provided the review team with a draft copy of an initial ventilation analysis performed by BNI to address battery hydrogen venting. The draft calculation was rejected by DOE. Follow up analysis is pending.	IEEE-1187, Recommended Practice for Installation Design and Installation of Valve-Regulated Lead-Acid Batteries for Stationary Applications, Section 5.4.2	VRLA off gassing during recharge could generate enough hydrogen to create a fire hazard.	The design review team recommends finalizing hydrogen ventilation calculations to ensure VRLA potential off gassing is alleviated or add hydrogen monitoring if required.
ROR-ELEC-2: Vulnerability #5	Grounding & Isolation of electrical equipment around melter glass pool not adequately demonstrated or documented.	Proper grounding of selected glass pool isolation equipment is paramount to personnel safety and reliable melter operation. Final equipment grounding and isolation construction and testing documentation has not been identified at this time.	Personnel electrical safety and equipment operation are at risk without addressing these issues.	The review team recommends BNI perform grounding inspection and testing prior to operation to correct any discrepancies
ROR-ELEC-2 Vulnerability #6	Project Documentation may not be accurate, or may be obsolete	With the documentation on this project as extensive as it is and covering the extended	Inaccurate documents contribute to errors by users resulting in additional cost and schedule, in some	Eliminate documentation errors to improve system performance.

Table A-4. Vulnerabilities Identified for Electrical. (8 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	and not marked as canceled or superseded.	period of time that it has, users should be on the lookout for document inconsistencies. Users with unlimited access to the documentation data base are somewhat vulnerable, and must use due diligence.	cases safety and production loss may be compromised.	
ROR-ELEC-3: Vulnerability #3	Current Transformers (CT1s) do not support individual electrode current control in present configuration.	Current Transformers on the melter bus provide only limited control of each bus.	Monitoring electrode current flow prevents bus failure and allows for better electrode current balance between the zones. Direct current control will not be possible on the melter bus unless the power supply system is converted to Individual electrode control	The review team recommends BNI evaluate the recent CT installation configuration to determine if it is complete and incorporated into the control system.
ROR-ELEC-4: Vulnerability #2	Facility Power Study Input Files not in Hanford standard software.	The power study performed on the WTP LAW Facility was performed by BNI using "ETAP" software. The Hanford Site uses a competing program "SKM Power Tools for Windows" (SKM) as a standard for facility power studies. The Hanford site maintains extensive Validation and Verification (V&V) documentation and software license keys for SKM software; but, does not maintain equivalent for "ETAP" Software. Therefore, the ETAP power study input files will be of no use to Operations post construction turn over; and, a duplicate study will likely need to be performed using SKM software, so that future modifications can be performed at the facility.	A duplicate power study will likely need to be performed by WRPS using SKM software, so that future modifications can be performed at the facility.	The review team recommends DOE issue a contract to perform a facility power study using SKM Power Tools for Windows, so that operations has useful input files to use in the facility during commissioning and operations. DOE has informed the review team that the Hanford Site standard software may be changing to ETAP, if that change takes place this vulnerability will go away. However, at the time of the review a discrepancy between software products used for the WTP Project and at the Hanford Site exists; therefore, this will remain listed as a low consequence vulnerability.

Table A-5. Vulnerabilities Identified for Radiologic (RC). (2 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
RC-1-V001	Potential for Contamination to Migrate Due to Adjacent Contamination Zones and Low Flow Ventilation Design	Review of all systems indicates vulnerabilities to facility Operations and Maintenance activities due to the potential for migration of contamination. Examples include maintenance on all systems, transfer of equipment between C2, C3, and C5 areas, painting of walls only up to eight feet, insufficient capture velocity, and movement of "clean containers" into the export area.	• Cannot confirm that contamination will not spread across contamination boundaries (i.e., C5 to C3 to C2) • Increased operational costs and decreased productivity • Unplanned outages for cleanup and significant impact to throughput and productivity • Unknown prediction of Airborne Radioactivity Areas • Potential noncompliance to 10 CFR 835 "Occupational Radiation Protection", Code of Federal Regulations, Subparts .1001, "Design and Control", .1002, "Facility Design and Modifications" and .1102, "Control of Areas:	• Evaluate the currently defined work processes for each process system, identify potential areas where contamination may migrate, and define any additional engineering or administrative controls that will be needed to ensure personnel are appropriately protected while minimizing the use of PPE. To evaluate the Project as a whole it is recommended these actions be documented in a Contamination Control Strategy Document. • The Project should define anticipated airborne levels to be anticipated in the facility and mitigating controls. • The Project should evaluate the use of a mock up facility for work evolutions where potential for significant dose can result.
RC-1-V-002	Inability to Meet Contamination Control Limits for Container Release	The swabbing of the container is performed over preprogrammed areas or patches of the container that are approximately 500 cm2. Per 10 CFR 835.1101(a), " Control of Material and Equipment", containers will be required to achieve less than 20 dpm/100 cm2 for alpha and 1000 dpm/100 cm2 beta/gamma when being released to be transported by a DOE employee (occupation release limit). This results in an inconsistency between the current design criteria and the regulatory limit pertaining to surface area required for release of the canisters.	• Inability to ship containers to IDF • Impact to productivity and throughput • Design currently does not meet regulatory release criteria (as defined in current facility procedure) • Potential noncompliance to 10 CFR 835.1101.	• Develop a technical basis that documents statistical representative sampling and equivalency of surveying at 500 cm2 vs. 100 cm2 (legal release criteria) and also addresses the adequacy of the sampling media used for swabbing the container. The approach for release of the containers should be coordinated with other Hanford Contractors to ensure they understand the survey results prior to their accepting of the containers for disposal. • Evaluate the potential that the container can be contaminated (on the Finishing Line) from the time when the smear samples were taken to when the sample results were received.
RC-1-V-003	Radiation Doses to Personnel are Undetermined for Operations, Maintenance and Waste Management Activities	Little or no radiological implications or planning details have been developed for equipment and instrumentation maintenance/repair dose estimate. This is also true for Operational surveillances and Waste Management activities. PIER no. 24590-WTP-PIER-MGT-13-0825-D, LAW Pour Cave Monorail Hoists-Door Interlock Inadequate to Prevent Pinching Festoon, documents the DOE observation (from their June review) and corrective actions are currently being conducted. Per corrective actions in the PIER the dose assessment document is scheduled to be revised mid-August, 2014, but until the revision occurs accurate values for anticipated dose are not available and the Project remains uncertain as to whether required operational parameters of the facility can be achieved. In addition, although the Project has a corrective	Potential to not meet regulatory requirements related to incorporation of ALARA into the design review process per 10 CFR 835.1001 and .1002, Not meeting contractual requirements related to ALARA and not exceeding the 20 percent of the applicable standards.Increased personnel needed to perform Operations, Maintenance, and Waste Management activities Potential need to redesign if dose is unacceptable Throughput may be impacted and significantly reduced	Accelerate the identification and definition of Operation, Maintenance, and Waste Management tasks and then revise the dose assessment report to accurately reflect anticipated dose. Establish a mockup facility/area to confirm anticipated dose and contamination levels and to reduce exposure to radiation by the workers for tasks expected to be high risk or have high radiological consequences. Reconsider whether the contract limit of 500 mR/hr for the container will allow for contact-handled work (for both Operations and Maintenance)

Table A-5. Vulnerabilities Identified for Radiologic (RC). (2 pages)

Vulnerability No.	**Description**	**Basis**	**Consequences**	**Opportunities for Improvement**
		action due the end of August that would define realistic dose assessments; Maintenance task analyses and work instructions are not scheduled to be completed until 9 months prior to construction turnover of each system– which will not be completed by August, 2014.		
RC-1-V-004	Inability to Effectively Perform Hands-On Maintenance Activities	Because of the undetermined amount of anticipated dose (vulnerability no. 3) and contamination (vulnerability no. 1) that may exist as part of Maintenance and some Operational activities, along with the lack of design controls to address these hazards, the intent to perform Hands-On Maintenance may not be possible. This vulnerability is of greatest emphasis to the following systems: LSH, LMH, LPH, and LMH.	• One or more of Maintenance evolutions may not be able to be performed. • Potential inability to operate the facility. • Throughput will be impacted.	• Accelerate the evaluation of Maintenance and Operational evolutions to understand hazards, mitigation techniques, and ability to perform required tasks. • Evaluate the ability to remotely perform Maintenance tasks (such as spray nozzle replacement). If not possible, identify alternative methods for maintenance. • Establish a mockup facility/area to confirm anticipated dose and contamination levels and to reduce exposure to radiation by the workers for tasks expected to be high risk or have high radiological consequences.

Table A-6. Vulnerabilities Identified for Safety and Hygiene (SH). (3 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
SH-1-V-001	Insufficient Evidence of Compliance with Operational Safety and Health Requirements in Design	Walkthroughs of the constructed facility found several locations where code requirements were overlooked on individual pieces of equipment, but more importantly on the systems as a whole. In particular, specific topical areas that may require additional protective measures include fall prevention, walking and working services, thermal, and means of egress in LRH, LFH, LMH, LPH, LSH, HVAC (not all the topical areas are in need of attention in each system).	• Inadequate design and operational procedures • Potential impacts to throughput and productivity • Not meeting 10 CFR 851.21 and .22 "Worker Safety and Health", Code of Federal Regulations, Subparts "Hazard Identification and Assessment" and "Hazard Prevention and Abatement"	• WTP should verify and validate (i.e., walk down) those systems where design is substantially complete and identify equipment that will need to be retrofitted (engineered solutions) to ensure compliance to regulatory requirements during commissioning activities. • For those activities whereby an engineered or administrative means cannot be achieved to perform the task, develop a technical basis process to seek a waiver from the requirement (i.e., daily crane inspections in the Finishing Line).
SH-1-V-002	Inadequate Implementation of the Hazards Analysis Process	Several examples were observed where the identification and mitigation of hazards was not appropriately implemented. These include design evolutions associated with the LCP, LFH, LPH, LRH, and LSH. Examples include: • Hazards not identified or understood for Operational and Maintenance evolutions for LCP, LFH, LPH, LSH • Lack of understanding of thermal, ventilation, and chemical hazards associated with LCP/LVP, LFH, LPH • Industrial hazards listed above • Lack of identified chemical area monitoring throughout the facility to ensure workers are appropriately protected, in particular in locations upstream of the melter, and downstream of the melter but prior to the offgas being released via the stack. • Lack of a defined chemical source term incoming to the LAW Facility (the Review Team was provided a list of anions and cations, not chemical compounds which are regulated).	• Inadequate design and operational procedures • Impact to throughput and productivity • Not meeting 10 CFR 851.21 and .22	• BNI should define and document the chemical source term coming into the LAW and document for current and future use • As part of 24590-WTP-PIER-MGT-13-0964-C, 2013, Hazards Analysis Process Weakness Related To Standard Industrial Hazards, the Project has drafted a CAP that includes a corrective action to develop a formal process that requires engineering and ES&H, at specific points in the design process, to evaluate the 10 CFR 851.22 (b) hierarchy of controls and provide a basis for how each is being addressed. The process needs to be defined (as just mentioned) • The Project should consider either realigning the safety analysis process to appropriately evaluate industrial and chemical hazards and associated mitigating techniques as part of the design process or expanding the WTP Hazards Analysis Procedure (AHA) to include not only the process for hazards identification to protect workers in the field, but also the newly developed hazards analysis process for design (including EA CPs feeding back into the design process).

Table A-6. Vulnerabilities Identified for Safety and Hygiene (SH). (3 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
				• The Project should also consider revising the title to one or both of the procedures to minimize personnel being confused with the duplicate titles or only have one procedure (versus two) which addresses the hazards identification and mitigation process for both design and field implementation.
SH-1-V-003	Deficient Exposure Assessments for Operational and Maintenance Activities	Review of documented exposure assessments for the LAW Facility found them to be inadequate and in need of revision. Review of the existing exposure assessments (13 total) found they were inadequate due to the following: • Chemical source term of the waste feed into LAW is unknown to S&H and IH. • The source term used on two of the assessments is incorrect; one uses the high-level waste source term and the other uses the offgas source term to be representative of incoming LAW feed. • Inadequate definition of Operational and Maintenance Activities which leads to having the EAs at too high a level to adequately be effective in qualitatively assessing exposures. • The EA for replacement of the melter requires a fully encapsulated Level A suit, yet Engineering has assumed that minimal personal protective equipment (PPE) would be required (huge disconnect). • There is no place in the EA process whereby the recommendations from the exposure control plan are fed back into the Engineering design process (to drive engineering solutions to mitigating hazards).	• Inadequate design and operational procedures • Unnecessary exposure to chemicals • Impact to throughput and productivity • Not meeting 10 CFR 851.21	• Identify and define appropriate source terms for each of the exposure assessments (including defining the chemical source term feed for LAW), revise those incorrect exposure assessments (that currently exist), and complete qualitative exposure assessments for the remainder of the process systems. • It is recommended the Project identify key Operational and Maintenance Activities and incorporate into qualitative exposure assessments • Revise procedure(s) (institutionalize) to ensure controls identified in the exposure assessments are integrated and considered during the design as part of the Engineering and Industrial Hygiene processes.
SH-1-V-004	Potential Weakness in the Systematic Analysis of Thermal Stress/Heat Hazards to Personnel	• In the majority of the systems there is significant potential for personnel to be exposed above acceptable practices, if physically possible, to thermal hazards, in particular because of the hands-on maintenance approach. Examples include: - Securing of containers at LEH - Replacement of melter consumables (in particular bubbler changeout and film cooler spray nozzle replacement – direct exposure to small point-source opening with the melter) - Melter replacement - Pour Cave Maintenance - Finishing Line Maintenance - General Operational and Maintenance activities	• Potential for personnel to be overheated and significant safety and health issue • Inability to effectively and efficiently perform Operations and Maintenance activities • Impact to throughput and productivity • Not meeting 10 CFR 851.10	• The Project should perform a LAW Thermal Analysis Study to define and understand both individual and cumulative thermal hazards and needed mitigating techniques. Results of the evaluation should take into account existing design of the facility and possible needed design changes. • Upon identification of anticipated thermal conditions, it is recommended the Project work with the Medical Department and evaluate industry best practices and revise the existing heat stress program to more aggressively protect the workers

Table A-6. Vulnerabilities Identified for Safety and Hygiene (SH). (3 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		- Potential ineffective cooling by the HVAC system/HEPA changeout • The current basis of design states that the maximum temperature to be encountered is 113°F; however the temperature analysis did not take into account heat generated as part of mechanical systems working together in one area or heat generated from specific maintenance activities such as bubbler change out, film cooler spray nozzle replacement, agitator replacement, maintenance within the Pour Caves and the Finishing Lines. BNI Matrix Comment from the 09/02/14 in support of Roundtable: "This is grossly incorrect as a large volume of work has been completed over many years in all aspects of thermal hazards in all areas of engineering. It also completely disregards the use of a heat stress program. This is summarized in the presentation provided. In addition the heat stress program has recently been commended by DOE in the field yet the review recommends that we revise the program?" D& O Team Rebuttal from BNI Matrix Comment on 09/02/14 in support of Roundtable: "The vulnerability was revised to more accurately reflect both the injury and illness safety and health consequence from being exposed to thermal hazards. A full discussion of the thermal vulnerability and the two separate issues included in this vulnerability is in the ROR. In addition, the ROR discusses the recommendation to work with the Occupational Medical provider and to benchmark the current heat stress program to ensure it is appropriately protective of personnel given the potential that stay times will not be adequate. The vulnerability stands as revised."		(i.e., biological monitoring, medical determination of fitness, hydration requirements, etc.)

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Table A-7. Vulnerabilities Identified For Melter Equipment Support Handling (LSH). (14 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LSH-F-28-V-01	Configuration Management is inadequate	• The incorrect version of the ORD was provided to the review team. • Multiple revisions of the same drawing were provided to the review team. • Obsolete and superseded drawings were provided to the review team.	• Use of the incorrect version of primary documents will result in incorrect requirements applied to the design. • Use of the incorrect version of design documents will result in review and verification of the wrong design.	• Review and evaluate design documentation to ensure correct requirements were applied. Review design verification documents to ensure correct versions of design were reviewed and verified. • Revise configuration management system to ensure that: - Only current revisions of documents are retrievable (with exception for historical reviews) - Controlling documents are identified and maintained current - Applicable documentation is associated to and retrievable by the system designation and/or the equipment number.
LSH-M-14-V-15	• No acceptable means to secure the spray nozzle CCB to the melter surface has been identified. • Detailed spray nozzle changeout requirements, procedures and timelines have not been developed and evaluated. • There is no upper closure on the spray nozzle CCB, which can act as a chimney while lifting the spray nozzle. • The spray nozzle CCB as designed allows direct line of sight with the melter glass pool at some stages of the changeout. • The existing off-gas spray nozzle changeout system and process does not adequately control contamination release, thermal exposure, radiation exposure, air flow, or personnel access.	• No process has been defined for securing the spray nozzle CCB to the melter when positioned on the melter at the off-gas spray nozzle port location. It had been speculated by Operations personnel that the three (3) CCB base flange toggle clamps would be used in combination with eye-bolts threaded into the melter surface. However, no such threaded holes have been identified and the base flange toggle clamps are not adequate for holding the CCB and spray nozzle securely. • The existing off-gas spray nozzle replacement process presents more potential hazards than replacement of other consumables such as bubblers, yet has fewer protections for Ops personnel and equipment during this highly manual operation.	• Failure to secure the spray nozzle CCB to the melter could result in equipment damage and contamination or exposure (radiological or thermal radiation) of personnel and equipment. • The lack of requirements, procedures and timelines could lead to inefficient operations and increased thermal, radiation and contamination hazards, and/or steam explosion. • Melter and spray nozzle CCB containment are compromised. • Equipment damage and personnel hazards presented by uncontrolled contamination release, thermal exposure, radiation exposure, air flow and personnel access.	• Develop a secure method to stabilize the spray nozzle CCB on the melter surface. • Design and utilize a gamma-gate and closed changeout box that is compatible with the spray nozzle. • Develop a method and additional equipment to maximize efficiency and minimize personnel hazards. • Modify spray nozzle CCB and lift method to maintain containment during spray nozzle changeout. • Design and procure a ladder or platform to access the spray nozzle support plate and lid assembly.
LSH-M-14-V-16	During consumable changeout, both the clean and spent CCBs have the potential to become pressurized vessels. The +/- vessel pressures introduce the potential for the spread of contamination, CCB equipment damage and/or operations production impact.	When the bubbler air bottles discharge air inside the sealed CCB, it will potentially become a pressurized vessel. Likewise when a hot spent consumable is raised into the CCB and it is sealed, temperature and pressure will rise and the CCB will become pressurized and potentially leak contaminated material. As the hot spent consumable cools inside the CCB, a vacuum will lock the access panels and lower lid in place. The CCB design does not take pressure / vacuum or venting into account.	• The CCB is not a certified pressure vessel and damage could occur due to pressurization / depressurization. • Clean CCBs could become over-pressurized due to bubbler air system • Spent CCBs could become over-pressurized and potentially leak contaminated material. • During consumable cooldown, the CCB hatches and lid may become locked in	A HEPA filtration system should be considered for design and installation on the CCB to mitigate pressurization / vacuum, and to reduce the potential for equipment damage and the spread of contaminated material.

Table A-7. Vulnerabilities Identified For Melter Equipment Support Handling (LSH). (14 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
			place due to internal vacuum, making hatch and lid removal difficult.	
LSH-F-18-V-04	• The integrated design review of the LAW design is not documented. • The review team requested a copy of the LSH, LMH and RWH integrated design review documents and BNI has not provided the document to date.	• The review team met with BNI representatives on 7/1/14. During the meeting, BNI stated that the LAW integrated design review was complete. However, it was also noted that the current operability review identified an inadequate spray nozzle change-out box design and BNI will address the inadequacies. • The inadequate design of the spray nozzle change-out box may be an example of a larger problem regarding adequate recognition of hazards and design review effectiveness. WTP Contact No. DE-AC27-01RV14136, Design, Construction, and Commissioning of the Hanford Tank Waste Treatment and Immobilization Plant , Section C paragraph C.5(b)(5) states, "Design Reviews: The Contractor shall conduct periodic design, constructability, and operability reviews to status the design activities, and resolve design oversight comments from DOE in accordance with Standard 3, Design." • The review team did identify a memorandum (CCN: 100389) titled "ISM Concerns for System LSH" dated 10/24/04. The memo includes a list of LSH equipment, including the Spray Nozzle Changeout Equipment (24590-LAW-MH-LSH-MHAN-00037). The memo concludes "there are no outstanding issues or concerns with the listed equipment." The memo also notes the Spray Nozzle Changeout Equipment requires temporary ventilation equipment when it is in use, (commonly referred to as tenting).	• There may be additional design issues or concerns if all hazards associated with LAW operation are not recognized. In addition, other design deficiencies may exist if a thorough integrated design review is not completed. • Standard industry practice includes performance of periodic independent external design, construction and operability reviews. This project may or may not include an explicit requirement for such reviews. However, these reviews add value to a project. • The inadequate design of the spray nozzle changeout box was not identified as an issue or concern by the review associated with CCN 100389. ISM Concerns for System LSH. This is an example of an inadequacy that an integrated design review may have identified.	Complete an independent external integrated design review of all LAW systems.
LSH-S-08-V-01	PIER process is inadequate for tracking issues found in earlier reviews.	Previously identified issues resulting from external reviews, such as CLIN 3.2, are not being tracked using the PIER system.	Late rediscovery of these issues while on the critical path to system startup will likely be expensive in terms of cost and schedule.	Pick one tracking system, and log and track all issues that are found via any review process. Further classify the issues and assign closing criteria commiserate with the severity of the issue.
LSH-W-07-V-05	Inadequate Lift Capability in Consumables Import/Export Area	Capability for handling the disposal box lid is not provided.	Inability to safely export melter consumables.	Revise design to add a swing jib crane and specified laydown space for the spent consumable transport boxes.
LSH-M-14-V-09	Temperature limitations of the bubbler neoprene rubber air supply port gasket and Super O-Lube	With the temperature at the top of the glass pool at >1900°F (1050-1200°C) just a few feet away from this	Reduced throughput due to failure of the bubbler air supply port gasket and	Determine anticipated temperatures in the vicinity and resulting temperatures of the

Table A-7. Vulnerabilities Identified For Melter Equipment Support Handling (LSH). (14 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	silicone grease are incompatible for expected bubbler port environment.	bubbler neoprene rubber air supply port gasket and Super O-Lube silicone grease, it is expected the local temperature will significantly exceed the temperature limitations of these two materials.	subsequent inadequate air supply to the bubbler.	bubbler air supply port gasket and utilize appropriate materials.
LSH-M-14-V-08	No criteria or specs have been found for: • Inspection of the bubbler air supply ports during changeout • Application of the Super O-Lube silicone grease • Installation of the neoprene gasket • Verification of proper operation of the bubbler air supply.	The design of the bubbler air supply port requires a neoprene gasket/O-ring between the bubbler and the melter air supply port. To ensure this rubber gasket/O-ring does not gall or roll during installation in the bubbler air supply port, "Apply Super-O-Lube silicone grease to gasket prior to installing into the melter." The last opportunity to apply a lubricant is prior to insertion into the CCB, when the bubbler is in the Consumable Import Cart or as it is lowered into the Import Station. However, requirements for installation of the gasket and application of the silicone grease have not been specified.	Incorrect installation of the bubbler air supply port gasket and lubricant, and subsequent reduced air supply to the bubbler may reduce glass production and process throughput.	• Define specifications for application of Super O-Lube lubricant and installation of the neoprene gasket on the bubbler air supply port. • Develop means to verify proper operation of new bubblers after installation.
LSH-F-01-V-01	Issues found by the review of DOE-HBK-1132-99, Design Considerations, are issues that should be resolved by using this or a similar best practices handbook.	During the design process, following of a best practices handbook will limit the amount of design mistakes that will not be acceptable during operations.	Increase in worker exposure, equipment failure, and the decline of throughput	It is recommended that a best practices handbook be established and followed to limit amount of design errors.
LSH-M-14-V-11	There are no clear requirements for the engineered air gap beneath the gamma gate, and the complex high velocity air flow through the air gap has not been analyzed resulting in an unanalyzed impact to air balance and possible subsequent spread of contamination.	The four adjustable feet on the gamma gate are used to level the gamma gate on the melter and to adjust the engineered air gap between the bottom of the gamma gate and the top of the melter. No criteria or requirements for this engineered air gap or leveling were found.	• Inadequate leveling of the gamma gate and CCB. • Uncontrolled impact to air balance and the resulting uncontrolled spread of contaminated material on and around the gamma gate.	Define criteria for gamma gate engineered air gap and determine impact of turbulent air flow on the spread of contamination.
LSH-M-14-V-05	Alternative equipment is being provided by vendors without an equivalency analysis being conducted to assess the equipment's ability to meet the critical attributes.	The MDS specifies the powered dolly model number "or equivalent". The specified part number has been discontinued so an alternate powered dolly was provided by the vendor. However the critical attributes were not defined and no evaluation was conducted to ensure the new part was truly equivalent.	Alternative equipment may not possess the critical attributes required of the original equipment specified.	• Define critical attributes and requirements for all equipment. • Conduct equivalency analyses for all substitute equipment.
LSH-M-14-V-10	The characteristics of the Kevlar strap at the maximum normal and off-normal temperatures expected should be further evaluated and the basis documented on a Mechanical Data Sheet.	The basis for the choice of Kevlar strap and its characteristics when it reaches the maximum temperature in the CCB are unclear.	Inadequate / inconsistent expectations of the CCB Kevlar strap.	Define criteria for Kevlar strap and document on a Mechanical Data Sheet.
LSH-F-17-V-01	Normal System LSH maintenance evolutions will significantly impact production.	• Radiological control and industrial safety concerns have not been incorporated into the design. Current Radcon perspective is that respirators will be required, significantly lengthening the time required to change out a melter consumable. • Industrial safety concerns have not been incorporated into the design, and different interpretations of Lock-out / Tag-out (LOTO) requirements for personnel safety significantly	• Increased personnel required to change out melter consumables increasing costs. • Increased melter idle time directly impacts throughput.	• Establish a detailed task analysis that addresses industrial safety, radcon, operational, and staffing issues to evaluate impact on production. • Develop a remotely operated method to change melter consumables so that the requirement for de-energizing the melter will be for equipment protection purposes only and LOTO can be eliminated.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		increase the duration of melter consumable changeout.		
LSH-F-17-V-04	Heat-up / Cool-down rates for the melter glass pool have not been calculated for the actual case while doing System LSH maintenance evolutions.	• Cool down rate is derived from pilot data where the melter is in idle and the plenum temperature has been allowed to rise in balance. The case where the plenum is exposed to the C5V and C3V has not been analyzed. • Maximum heat up rate is derived from expected limit to prevent foaming problems.	System LSH maintenance evolutions will have uncertain durations.	Perform pilot melter tests that simulate actual conditions during melter consumable change out: melter idle and simulated C5V and C3V airflows to the plenum space from a bubbler hole. Scale up the results for the full-scale LAW Melter using Computational Fluid Dynamics simulations.
LSH-F-17-V-03	Melters idled for another reason, such as work on LOP or LVP, can't be used to "campaign" System LSH consumables.	• When working on LVP, the melter plenum gasses back up and leak back into the melter annulus to be exhausted by C5V. • When working on LOP in one Wet Process Cell, the bypass loop is open and both melters are connected.	Common campaign strategies will be limited for System LSH.	Identify maintenance evolutions for System LSH interfacing systems that are already compatible with a campaign-type strategy, and investigate mitigations that would enable simultaneous work for the currently incompatible ones.
LSH-F-17-V-02	Serious contamination releases will result in significant production interruptions.	Melter confinement has not been demonstrated during melter consumable replacement. Off normal and accident events have not been completely characterized.	Melters idled while release event is investigated and mitigating processes implemented.	Develop a remotely operated method to change melter consumables while maintaining confinement to the C5V annulus.
LSH-F-26-V-01	Melter containment has not been demonstrated during melter maintenance evolutions.	The LAW Melter is a unique design and there is no pilot or operational experience with an independently exhausted melter annulus. During maintenance evolutions, there is a direct path between the melter plenum and the melter gallery. Confinement depends on the dynamic interaction between C5V exhausting the melter annulus and the LOP exhausting the plenum, which do not seem to be coordinated. A detailed calculation demonstrating that the adjustable air gap between the melter gamma gate and the top of the melter shielded enclosure will provide containment, along with C5V and LOP, was not found.	Contamination of the melter gallery disrupts throughput by slowing down maintenance evolutions by necessary additional PPE and procedural requirements and/or by operations stand-downs for situational reviews as has occurred at other DOE facilities.	• Perform the necessary calculations and simulations to ensure containment, including how to coordinate LOP and C5V as well as what the air gap should be between the melter gamma gate and the melter shielded enclosure. • Redesign the melter consumable change out process to preserve a pressure seal between the CCB / melter gamma gate and the melter shielded enclosure while the melter plenum is exposed.
LSH-W-07-V-04	Hazard Analyses and ALARA Reviews are inadequately addressed for spent consumable handling.	Spent bubblers are enclosed within a plastic sleeve at the export/bagging station. The described bagging operation is a hands-on activity including 'pig-tailing' the bottom end of the plastic sleeve while the component is suspended from the crane. These activities will require personnel to work under a suspended load and to be in very close proximity to the portion of the bubbler that was in the melt pool and now has a coating of ILAW glass. This is not consistent with ALARA principles.	• Personnel exposed to personal injury hazard while working under suspended load. • Personnel exposed to undefined radiation hazard.	Perform hazards analyses and ALARA Reviews; redesign system LSH as required to mitigate industrial and radiological hazards.
LSH-M-14-V-07	• No plans have been developed for cleaning glass spall and drips from the melter shielded enclosure, melter port consumable seating surfaces, bubbler air supply ports,	• As hot spent consumables are raised spalling past the consumable seating surface on the melter port, and through the complex air flow from the gamma gate engineered air gap, the spalled glass will	• Increased rad exposure to personnel and equipment • Failure of CCB lid seating surface and release of contamination	• Develop tools and processes for removing glass from melter and equipment surfaces including

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	CCB lid/interior, gamma gate or bagging station surfaces. • Methods and equipment for decontaminating the interior of the CCB have not been provided.	collect on the consumable seating surfaces as well as the bubbler air supply port. This contaminated material will collect on the melter port seating surface, the gamma gate, the CCB lid and interior, and the bagging station lower gate valve which will increase background exposure and could impact equipment operation. • After multiple uses, the CCB may become contaminated to the extent that personnel dose uptake from the CCB will be an issue. No capability for decontaminating the interior of the CCB is provided.	• Increased contamination spread.	subsequent decontamination and inspection. • Evaluate the radiological issues associated with the CCB and provide capability to decontaminate the interior of the CCB if necessary.
LSH-M-14-V-14	Sufficient details regarding bagging station operations are not available, and the disposition of radioactive bagging station waste not defined.	Numerous questions remain regarding bagging station operations.	Bagging station operations may not be in keeping with Operations best practices and ALARA goals.	Develop processes and procedures for bagging station operations and radioactive waste disposition. A thermal sealing method should be considered.
LSH-M-14-V-02	There are insufficient funds & resources allocated to address; • Equipment obsolescence • Equipment preservation and degradation • Equipment re-inspection, refurbishment and/or replacement effort that will be required (9) months prior to startup.	• Equip. procured early in the project: - Is now becoming obsolete. - Is experiencing degradation such as corrosion and false brinelling. - May require additional re-inspection, refurbishment and/or replacement. • All equipment will be re-inspected and refurbished 9 months prior to plant startup. However, if plant startup is subsequently delayed additional inspection and refurbishment and additional spares may be required.	Increased cost and schedule due to numerous delays in WTP plant startup date projections since equipment procured early in the project is becoming obsolete and warranties have expired (e.g., plant cranes, process control computer software versions [i.e., ABB software, hardware, servers, and workstations])	Develop long term funding and plans that address obsolescence, warranties, and replacement or refurbishment for all equipment procured.
LSH-M-14-V-04	Funding and schedules for all periodic maintenance activities have not been developed, and critical spare parts and consumables such as bubblers are not yet scheduled to be ordered and held in-stock to support commissioning and startup.	Melter consumables will frequently require replacement (e.g., 36 bubblers per melter per year, 2 film cooler wash nozzles per melter per year, etc.). Currently, there is not an adequate number of consumable spares available to support commissioning and startup.	Inability to support commissioning and post commissioning startup activities.	Develop schedules for periodic maintenance activities and procure critical spare parts and consumables to be held in-stock to support commissioning and startup activities.
LSH-F-18-V-02	• Procedure completion and training needs are not aligned. • Operating procedures and maintenance instructions are partially complete and the current scheduled completion date is not aligned with Operations need for operator training, in that, they are scheduled to be complete after they are needed for operator training.	Interview with BNI Operations SME and e-mail from Operations Procedures and Training Manager.	• Initial LAW operational testing, commissioning and operation could be delayed due to unavailability of operating procedures, maintenance instructions and training. • The design of the procedure development process has failed to ensure procedures are developed and validated in alignment with the need for them.	Align procedure completion date, including validation and approval, with the date needed for training purposes.
LSH-M-13-V-03	Equipment and methods for replacement of “life of melter” components have not been provided.	Equipment for replacing a feed nozzle or a film cooler need to be engineered and provided. The capability to replace other melter components should be reviewed from a project risk consideration, including hoses in	• Premature melter failure. • Lost production due to extended melter outage during development of tools and	• Develop engineered tools, equipment, and procedures for replacement of “life of melter” components.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		the melter lid annulus, electrode extension thermocouples, discharge chamber lid and heater, discharge chamber thermowells, and plenum pressure sensors	procedures for component replacement and for procurement of component. • Reduced production throughput due to reduced function (e.g., loss of feed nozzle).	• Procure and maintain "life of melter" components in spares inventory, and equipment necessary for changeout.
LSH-F-21-V-01	System LSH will need defined interfaces with other systems, which are not documented in the system description.	The system has been designed and equipment purchased and installed without detailed task analyses or procedures for significant maintenance evolutions. Important interfaces with other systems are not described or are described in general non-specific ways.	Late discovery of serious operating incompatibilities between important systems just prior to commissioning will be expensive and will, by definition, disrupt the critical path to start-up operations.	• Form an interdisciplinary team with members that are familiar with all melter/throughput interfacing systems and plant operations and task them with developing detailed task analyses that document a safe way to perform all critical maintenance evolutions, using the existing design if possible. • Perform this work early enough to reduce upsets on the critical path as low as practicable and to provide lead time in case extensive redesign and rework efforts are necessary.
LSH-M-16-V-01	Maintenance equipment failure modes and incidents should be identified and understood prior to plant operation to mitigate or reduce equipment/plant down time.	Plant operation on a 24 hour per day, 7 days per week schedule is in jeopardy if maintenance failure modes and incidents are not known and understood.	Increase in off-line operation	Identify maintenance equipment failure modes and accidents prior to plant operation.
LSH-M-13-V-08	Basis of design is not adequately defined or implemented	Hazards analyses and ALARA reviews have not been performed and documented. The radiation dose rates, temperatures, and thermal environments that personnel will be exposed to throughout the maintenance evolutions have not been defined and documented.	Inadequate design	Establish and promulgate design requirements; redesign equipment, as applicable.
LSH-M-14-V-17	Insufficient priority, resources and funding have been given to the LSH maintenance program to ensure successful plant commissioning and startup	• Critical activities have not been adequately detailed, evaluated, or factored back into the plant and system designs. • Critical maintenance program activities and associated funding have been deferred until plant commissioning. • LSH System operability, accessibility, remotability and maintainability of critical O&M equipment has not been sufficiently modeled nor evaluated	• Failure of the LSH system to successfully perform critical path activities on schedule during commissioning and startup: • Failure of the LSH system to achieve glass production estimates and to meet throughput expectations	• Detail, model and evaluate all critical plant activities and factor the results of these evaluations back into the plant and system designs. • Based upon the evaluation above, adequately fund and perform critical plant activities that would challenge the critical path schedule during plant commissioning and startup. • Perform adequate plant modeling and evaluations to ensure operability, accessibility, remotability and maintainability of all critical O&M equipment and spaces.
LSH-M-13-V-07	Equipment testing needs to be done in applicable thermal environment.	Tests need to be done on a thermally hot melter to ensure problems as a result of thermal growth are	Inadequate equipment operation in actual environment.	Test equipment in expected environmental conditions with range of

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		considered and especially for any component replacement to ensure industrial hazards are considered before doing it on a radioactively hot melter.		exposure times to verify equipment operation and to establish constraints on operations, as applicable
LSH-F-10-V-01	• Environmental qualifications have not been conducted or documented on plant equipment. • Most environmental and operating conditions such as temperature, dose rate, evolution sequence, rates and times, etc. have not been determined.	During this evaluation it was noted that most/many of the environmental and operating conditions such as temperature, dose rate, evolution sequence, rates and times, etc. have not been determined for LSH areas or equipment.	LSH equipment may not be designed for the tasks and environmental conditions that it is subjected to.	• All LSH area environmental conditions should be clearly defined and documented. • EQ analyses should be conducted for all LSH equipment to determine that it is qualified for the environments it is subject to.
LSH-W-07-V-01	An engineered solution to provide vertical to horizontal transition of long length equipment has not been adequately defined or equipment provided. Potential loss of confinement due to puncture of or pulling disposal bag off of consumable during bagging, pig- tailing, and export operations.	Vertical bagged consumable are transitioned to a horizontal disposal box while lowering through the hatch. The concept operation is that the bagged bubbler would be lowered through the hatch until the bottom end of the bubbler rests on the floor of the box and the box would be moved horizontally as the crane continues to lower the bubbler into the box. The corroded bubbler tubes will break off due to the imposed moment while laying down the bubbler as was experienced during scale melter testing, resulting in puncturing the confinement bag and uncontrolled movement of the heavy top end of the bubbler.	• Inability to export long length equipment such as spent melter consumables. • Potential loss of confinement due to breach of consumable disposal bag during vertical to horizontal transition.	Provide an engineered system, such as a strongback, to transition long length equipment from the vertical to horizontal position for the potentially structurally fragile spent consumables
LSH-W-07-V-03	Spent melter consumables and other secondary wastes are packaged for transportation but not for disposal.	Since consumables cannot be packaged for disposal in the current LAW Facility configuration, final disposal of this secondary waste cannot be accomplished until a disposal facility is defined or constructed to process the LAW secondary waste packages. The export of consumables from the facility may be restricted and/or waste could be orphaned. The development of work-arounds and equipment mods will also be required.	• An undefined facility is required for repackaging, void volume reduction, and/or treatment of secondary wastes to meet disposal requirements. • Inability to start operations due to insufficient waste disposition. • Orphan waste.	A disposal plan and disposal path for all LSH process waste and spent consumables should be clearly defined. Perform alternatives study including life cycle cost impacts for providing required waste characterization, volume reduction, and waste treatment, and packaging for disposal functions at WTP, existing Hanford facility, new Hanford facility, or offsite vendors. Waste Incidental to Reprocessing (WIR) determinations should also be compiled as necessary.
LSH-S-15-V-01	Maintenance task evaluations and procedures have not been provided. Therefore, it could not be determined that maintenance best practices have been considered nor incorporated.	Most/many of the environmental and operating conditions such as temperature, dose rate, evolution sequence, rates and times, etc. have not been determined for LSH areas or equipment	Maintenance best practices have not been considered nor incorporated	Incorporate maintenance best practices into procedures and processes early and incorporate the conclusions into the design.
LSH-F-18-V-03	Detailed work plans, task analyses and corresponding schedules have not been developed to thoroughly evaluate all anticipated routine and non-routine O&M activities. Therefore realistic timelines and throughput	• Detailed work plans have not been developed for LSH operations, maintenance and repair activities to ensure adequate space, time and resources are available to support glass production rate commitments. Some operations and maintenance	An accurate assessment of process throughput expectations cannot be developed.	Develop realistic expectations for glass production rates, using detailed task breakdowns.

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	expectations for glass production rates have not been established. Previously captured in CLIN 3.2 (see RPP-50775) and not yet resolved.	task analyses may have been conducted, but BNI would not release the documentation of these task analyses to the Review Team. • Critical personnel safety input from Rad Con, HP and ES&H has not been considered in the task analyses.		
LSH-M-14-V-03	The accessibility and maintainability of critical plant components have not been demonstrated, and equipment for O&M activities may not be practical. This issue was previously captured in CLIN 3.2 (RPP-50775) and has not yet been resolved.	The accessibility to critical plant components, has not been modeled or evaluated with regard to performing the design functions and maintenance in support of melter glass production, nor is such an evaluation currently planned. Also, modeling and evaluation have not been conducted of the tools necessary to access equipment components for routine operations and maintenance activities.	• Plant components may not be accessible and/or adequate space may not be available for routine and non-routine operations and maintenance activities. Also lag storage space for tools, equipment, waste boxes, etc. may be inadequate, leading to unsafe conditions and bottlenecking. • Protective garments, respirators, stay times, etc. that could impact operation timelines have not been clearly defined and evaluated.	Realistically model and evaluate anticipated O&M activities. Non-routine ops should be modeled and evaluated as well
LSH-M-14-V-01	Long term preservation maintenance requirements have not been addressed beyond basic storage requirements (environment), for 88% of equipment received to date.	88% of WTP equipment received to date relies primarily on environmental controls for preservation maintenance. Development of the remaining maintenance requirements has been deferred to startup. LAW Facility startup is expected to be delayed until 2022 which increases probability of equipment obsolescence and decay.	Continual ongoing equipment degradation beyond acceptable levels, resulting in uncertain equipment conditions at the time of startup and increased project costs.	Develop long term preservation maintenance requirements and plans for all equipment in storage and upon receipt of new equipment.
LSH-F-20-V-05	Inadequate permitted waste storage area.	WA7890008967, Hanford Dangerous Waste Permit, identifies the import/export area (L-0119B) as the permitted containment building suitable for waste storage. The available area for waste storage in L-0119B is very limited with a practical storage capacity of one shipping box on the transfer cart holding 4 spent bubblers.	Inadequate waste storage capacity will impact efficiency in exporting spent melter consumables and constrain melter consumable replacement schedule resulting in loss of production.	Perform work planning including consideration of schedules for bubbler replacement, spent bubbler export, ILAW container receipt, and RWH exports and evaluate impact from lack of waste storage.
LSH-CO-24-V-01	Workspace environment in and near the melter is not defined for proposed operator/maintenance technician actions to install/remove consumables for service.	Meetings with SME's, operations representatives, and others identified the need to identify the workspace environment regarding temperature and radiation as this information could not be provided when requested. It is reasonable to conclude that elevated temperatures and radiological conditions will be present at a manually operated vitrification facility using nuclear waste in the feed component.	• Operating procedures cannot be produced and used if consideration of PPE, remote handling tools, etc. is not known prior to work performance. • Operators may not be able to perform duties as currently assumed and described in the project documents. • Without a known workspace environment it is unlikely proper PPE can be identified which jeopardizes operator/maintenance technician health and safety.	Define workspace environment and include in operations and maintenance procedures.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
			• Worst case, the work cannot be performed using the current facility design.	
LSH-F-18-V-01	The operations and maintenance procedure (includes: EOP's, abnormal, alarm response, system task and technical safety requirements) development process is fundamentally flawed.	• The plant operations procedures development process, as described on 4/03/14 does not include industrial and radiological hazards in the task analysis process. Field validation, start-up testing and operations approval are scheduled prior to recognition of industrial and radiological hazards. • Hazards identification and task identification are fundamental requirements for determining PPE requirements and procedure development.	• Any procedure developed using this process is at risk of being substantially revised late in the process. This will add cost and extend the schedule to have useful procedures • In addition, 10 CFR 835 and 851 principles must be considered.	Include all job hazards analysis and job task analysis prior to developing procedures. Validate the procedures after all hazards and tasks are known and included in the procedure.
LSH-CO-24-V-04	• The assumption of an operator reaction time of 30 minutes for a casualty response may be insufficient regarding restoration of power and providing an air compressor upon loss of ISA system. • The operation of the bubblers is essential to melter operation per the 4/22/14 tele- con with VSL. • Failure of all bubblers within a single melter will result in loss of temperature control in respective melter.	Calculation 24590-LAW-M6C-ISA-00002 Rev 0, LAW Critical Instrument Service Air Backup Bottles Sizing, assumption.	All bubblers in operation at the time of a loss of ISA plus 30 minutes could exhibit glass backup and limit the operation of the melter.	• Revisit the 30 minute response assumption for operators regarding restoration of ISA or electrical service for reasonableness and validate the assumption by test. • Develop procedures and training regarding loss of ISA. • Identify the supply of back-up air. Identify proper air fittings and hardware to accommodate the supply of back- up air. • Identify the connection to the ISA for the back-up air supply.
LSH-CO-24-V-03	• HMI's and associated proposed operator actions, in aggregate, do not appear to sufficiently incorporate key principles of industry best practice to ensure operator response to normal evolutions. • The current design does not appear to consider Function Allocation (automated vs. human performance), Task Loading (demands of a given task), Precision Requirements (crane operation), error tolerance (interlocks), Environmental Conditions, Workspace Size, Geometry and Layout (Cable trip hazards associated with power and control lines to the Gamma Gate and CCB's).	• The basis for this concern is: the physical layout of the melter operating deck when considered in relation to the tasks to be performed and the number of personnel performing the tasks, equipment design in terms of controls and indications and operator use and operator response, equipment accessibility (CCB's on the racks), dependability of proposed processes in terms of how it will influence operator actions. • Industry data, in general, shows a decrease in operator error rate when HMI and best practices are included in the design.	• Good work space design, good environmental design, and good man-machine interfaces can reduce stresses noted with shift operations which contribute to errors. Consideration of the above elements of human factors engineering should improve operational safety by implementing man-machine interfaces that improve human performance and reduce human error. • The existing design without modification increases the probability of an error being made during installation and removal of melter consumables.	Take necessary steps to incorporate key principles of industry best practice to ensure operator response to normal evolutions.
LSH-S-06-V-01	Conduct of Operations Principles have not been adequately factored into the facility.	• No single shortcoming will lead to an incident but taken as a whole the Operator is not being placed in a position that is success oriented. • The equipment and facility logistics have not been developed with a Conduct of Operations	Lack of incorporation of Conduct of Operations principles will result in equipment damage, production delays, and cost increases.	• Greater attention needs to be paid to incorporating Conduct of Operations principles into the design and logistics of the facility.

Table A-7. Vulnerabilities Identified For Melter Equipment Support Handling (LSH). (14 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		perspective lending the situation to a condition where Operator error is more probable with the resultant equipment damage and delays.		• A simulation/mockup facility would aid in alleviating some of the concern.
LSH-S-12-V-01	Lack of a simulation, mockup, training facility increases the risk of error in performing new and/or complicated evolutions.	• The complexity, work environment, PPE, and extensive hands on nature of the work warrants a simulator or mockup facility to dry run evolutions and accommodate training. • The complexity and conditions of the tasks to be performed are ripe for error without a simulation/training facility.	Lack of a simulation facility combined with the lack of interlocks/alarms will result in operator errors and equipment damage.	Identify or construct a facility that can be used to simulate, mockup, and train on evolutions to be performed.
LSH-CO-24-V-05	• Current LSH mechanical handling equipment design does not include 2 specific elements of the design philosophy that are included in the Operations Requirements Document regarding decontamination and disposal of contaminated equipment. • The absence of space for decontamination and disposal of contaminated equipment will lead to a lack of function and will have a negative impact on operation, throughput, and spread of contamination and radiation exposure.	A tour of the LAW Facility and input from SME's regarding decontamination and disposal of contaminated equipment did not identify space for either decontamination or disposal of contaminated equipment.	The final design may not include general design philosophy regarding space for decontamination and disposal of contaminated equipment	Review the design philosophy for this and other omissions in the LAW design and modify design as necessary.
LSH-F-11-V-05	If the LSH process crane is out of use for maintenance that can be performed using the limited functionality of the west platform, the CCB handler crane will not be able to access import and export hatch.	The trapdoor is the only planned way to import and export melter consumables and this trapdoor will not be able to be accessed by the CCB handler crane if the process crane is in maintenance.	The CCB handler crane will not be able to import or export consumables for routine maintenance on the melter.	• Time maintenance accordingly with delivery of consumables. • Evaluate different methods of importing and exporting consumables to allow access to the hatch during maintenance of LSH process crane.
LSH-F-09-V-01	Lack of info on the operation and failure modes of the Component Carrier (grapple for consumables).	There is very little information on the inner workings, reliability, and failure modes of the Component Carrier other than drawings and FAT testing results.	Lack of information on the inner workings of the Component Carrier may lead to a failed equipment, schedule delays, and additional costs.	Attain more information and operational understanding of the Component Carrier.
LSH-F-11-V-01	The current bubbler crate width (12') will not fit through the entrance door into the truck bay (12').	The width of the crate is equal to the width of the door and will not make it into the facility.	The crate will not fit through the entrance to the facility.	• Unpack bubblers at a different location and design a custom bubbler carrier to transfer consumables for delivery to System LSH. • When a permanent bubbler manufacturer is identified, evaluate a new bubbler transport crate that will be able to meet the requirements of the system design.
LSH-F-11-V-02	Truck bay crane capacity (10 ton) will not be able to lift current bubbler crate (13.5 ton).	The current bubbler crate exceeds the capacity of the truck bay crane.	The crane will not be able to lift the bubbler crate off of the truck and onto the unloading platform.	• Unpack bubblers at a different location and design a custom bubbler carrier to transfer consumables for delivery to System LSH.

Table A-7. Vulnerabilities Identified For Melter Equipment Support Handling (LSH). (14 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
				• When a permanent bubbler manufacturer is identified, evaluate a new bubbler transport crate that will be able to meet the requirements of the system design.
LSH-F-11-V-03	The current bubbler crate width (12') may or may not fit onto the width of the unloading platform (~12').	The width of the crate is approximately equal to the width of the unloading platform and may or may not be able to be placed on the platform.	The platform will not be able to be utilized in the unloading of bubblers.	• Unpack bubblers at a different location and design a custom bubbler carrier to transfer consumables for delivery to System LSH. • When a permanent bubbler manufacturer is identified, evaluate a new bubbler transport crate that will be able to meet the requirements of the system design.
LSH-F-11-V-04	The current bubbler crate height will not allow the truck bay crane to pull the bubblers out of the crate (vertical orientation).	As planned by operations, the bubblers height will impede its ability to be unloaded from the bubbler crate.	The crane will not be able to unpack the bubblers for use as planned by operations.	• Unpack bubblers at a different location and design a custom bubbler carrier to transfer consumables for delivery to System LSH. • When a permanent bubbler manufacturer is identified, evaluate a new bubbler transport crate that will be able to meet the requirements of the system design.
LSH-M-14-V-12	One gamma gate per two melters will not be sufficient to support anticipated plant operations.	Currently only a single gamma gate is planned for consumable changeout on two melters. As per 24590-LAW-3YD-LMP-00001 Rev 3, System Description for the System LMP, Low Activity Waste Melter, Table 8-1, it is expected that this single Gamma Gate will be utilized a minimum of 72 times per year on the two melters for estimated consumable changeout (i.e., bubblers, etc.). No task analysis has been found that demonstrates only one gamma gate will be sufficient.	Operations and glass production rates will be negatively impacted.	Re-evaluate gamma gate usage and consider a second gamma gate for active use or as a spare.
LSH-F-20-V-03	Designated space for storage and local maintenance of contaminated equipment and tools in the melter gallery needs to be defined and maintained consistent with operational travel routes. Storage of lifting equipment needs to be provided in the truck bay and the melter gallery.	• Designated storage spaces for all equipment in the melter gallery should be established to provide a defined workflow and ensure adequate space for routine operations and maintenance activities. • Designated contaminated equipment storage and local maintenance locations need to be defined and maintained for the melter gamma gate, upper bagging shroud, small consumable adapters, and other contaminated equipment. • Lifting equipment and storage racks for lifting equipment will be required in the truck bay and the melter gallery. Laydown space for melter startup heaters also needs to be designated.	• Increased contamination spread. • Operational inefficiencies associated with varied or inefficient workflow.	• Designate storage areas for tools and equipment. • Provide controlled designated storage space for contaminated equipment

Table A-7. Vulnerabilities Identified For Melter Equipment Support Handling (LSH). (14 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LSH-M-13-V-05	Methods and equipment for decontaminating the interior of the CCB have not been provided.	After multiple uses, the CCB may become contaminated to the extent that personnel dose uptake from the CCB will be an issue. No capability for decontaminating the interior of the CCB is provided.	• Increased personnel exposure. • Increased contamination spread.	Evaluate the radiological issues associated with the CCB and provide capability to decontaminate the interior of the CCB if necessary.
LSH-M-14-V-06	The criterion for the consumable cooling rate and time while being raised into a CCB has not been determined.	Per Operations personnel, trial and error will be used to determine the spent consumable hang time above the open melter port to accommodate glass dripping, spalling and cooling as the consumables are raised into a CCB. This delay will have a direct impact on glass production rates.	For every minute hang time, more than a minute will be required during melter reheating, impacting production rates and throughput.	Determine criterion for consumable cooling and factor into operations and throughput assessments.
LSH-W-19-V-01	Failed or spent LAW melters may not meet the requirements of the Hanford Dangerous Waste Permit.	• WTP doesn't have an explicit plan to remove LAW glass from a spent or failed melter. • The permitting requires that "residual molten glass will be removed as immobilized product, as much as is practical".	Failed or spent LAW melter could be out of compliance and may not be disposed of as planned.	Clarify the conditions to satisfy for successful LAW melter disposal when transitioning from construction permit to the start-up/commissioning/operating permit.
LSH-M-14-V-13	No form of thread protectors or covers in melter alignment pin locator holes are planned when the gamma gate alignment pins are not installed.	Currently there are no plans to protect the threaded holes for alignment pins in the melter surface.	When the gamma gate is not present, the melter alignment pin locator holes will be open to collect dirt and debris leading to galling of pin threads.	Design, procure and install threat protector inserts/caps on all unused alignment holes in the melter surface.
LSH-W-07-V-02	No provision for removal of the air bottles on the spent bubblers or rendering them incapable of holding pressure prior to exporting for disposal.	Two air supply bottles are mounted on the top of each bubbler. Disposal restrictions require that such items be rendered incapable of holding pressure. There are no provisions for preparing the bottles for disposal.	Inability to dispose of spent bubblers.	• Provide means for removal of bottles or for rendering spent bottles incapable of holding pressure at WTP or at the yet to be defined secondary waste repackaging/treatment facility. • Delete on-board air supply system from the bubbler design.
LSH-M-13-V-02	Equipment and means for maintenance of the CCB lift head have not been provided; additional equipment needs to be provided.	• Access to the CCB lift head for maintenance and operations is not provided by the existing maintenance platforms. • Additional equipment: portable vacuum, lifting equipment (bare consumable lifting fixture, melter shield gate lift sling, crate slings, export box lifting equipment, frit pallet lifting equipment, and means of handling of offgas ductwork), special tooling (e.g., long reach tools, strongbacks for spent consumables), personnel platforms/ladders, etc.	Increased maintenance durations and personnel exposures due to limited accessibility afforded by temporary ladders or scaffolding.	A designated CCB maintenance station with an appropriate maintenance platform and CCB test panel needs to be provided. Similarly, a test panel should be provided to verify gamma gate function following servicing.
LSH-M-13-V-04	Capability to move equipment from the melter gallery to the contaminated equipment (C3) maintenance room has not been provided.	The access from the melter gallery to the C3 workshop at the 28' elevation is via stairs at the West melter gallery crane maintenance platform; there is no capability to move equipment by cart or to lift equipment to the platform at the 28' elevation.	• Increased personnel exposure to perform maintenance in the melter gallery instead of the C3 maintenance room. • Interruption of planned melter maintenance operations due to space management and work flow conflicts with performing equipment maintenance in the melter gallery.	Provide monorail or other means of lifting equipment from the melter gallery operating deck (19' el) to the 28' el.

Table A-7. Vulnerabilities Identified For Melter Equipment Support Handling (LSH). (14 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LSH-M-13-V-01	Some maintenance activities on the Process Crane must be performed using the crane maintenance platform at the east end of the melter gallery, trapping the CCB Handler Crane, resulting in no crane coverage of the melter gallery while servicing the Process Crane.	The process crane maintenance platform in the West end of the melter gallery provides limited access to the process crane such that some process crane maintenance activities must be performed at the CCB crane maintenance platform at the East end of the melter gallery, trapping the CCB handler crane. The melter gallery will have no crane service during these process crane maintenance activities at the East crane maintenance platform.	• There will be no crane coverage of the melter gallery during some maintenance activities on the process crane • Lengthy interruption of melter support and consumable import/export operations may occur during major maintenance activities on the process crane	• Assess frequency and duration of crane maintenance activities and incorporate into production throughput estimates to determine need for alternate maintenance platform. • As necessary, modify west crane maintenance platform such that most if not all of the process crane maintenance activities can be performed.
LSH-F-20-V-02	Umbilical cables to the CCB while it is on the melter, import station, or export station are laid on the operating deck walking surface, creating a tripping hazard; similarly, umbilical cables to the gamma gate on the melter create a tripping hazard. These cables will also create obstructions for moving rolling platform ladders, shielded cover removal tool, and other equipment.	Four umbilical cables run from the control panel to the melter gamma gate and the CCB. These cables will lay on the walking surface of the melter and will be a trip hazard and an impediment to rolling equipment. Similarly, when the CCB is on the import station or the export/bagging station, 2 cables will run from the control panel to the CCB, presenting a trip hazard and an impediment to rolling equipment.	• Personnel trip hazards. • Operational inefficiencies.	• Provide conduit to import and export stations for the CCB, with junction and short umbilical jumpers for the CCB near the gate. • Provide umbilicals on swing booms or similar to the CCB and gamma gate when installed on the melter.
LSH-F-20-V-01	Access to the top of the CCB needs to be provided while it is on the melter, import station, or export station for routine and recovery operations.	The top access panel of CCB needs to be accessed to open the on-board bubbler air supply when installing a bubbler into the melter. While the CCB is on the melter gamma gate, the import station, or the export station, recovery operations for the component carrier require operation of a hand crank inserted into the component carrier winch. The ability to attach and detach the crane hook to the CCB while it is on the melter gamma gate, import station, or export station will increase operational flexibility.	Inability to safely disconnect the crane hook from the top of the CCB.	• Provide platforms at the import and export stations. • Provide rolling/moving platform for use on the melter.
LSH-F-20-V-04	The design of the consumables cart requires use of fall protection.	Personnel must access the top of the cart for installation of small consumable adapters and for melter consumable inspection. The top of the consumable import cart is approximately 9.5 ft above the floor. A fall protection tie-off point is provided at the top of each access ladder. Personnel will be required to be in fall protection harnesses and work from the access ladders to install the small consumables adapters and perform inspections.	Work process performed by operator while on the consumable cart ladder will be restricted leading to operational inefficiencies.	Verify required operations are consistent with provisions provided.
LSH-CO-24-V-02	Any necessary rotational orientation of the consumables (except the bubbler) is not identified to the operator prior to installation in the melter.	Meetings with SME's, operations representatives, and others identified the need to identify or clarify whether the air lift lance, feed nozzle, and level detector have a rotational orientation requirement as it is not clear whether the service connections (air, water, cables) are fixed. The details regarding the melter service connections are not defined in the documents reviewed. There may be a rotational orientation consideration for the consumables that is not identified.	• Any rotational orientation requirement that is not identified prior to consumable installation in the melter may require the operator to correct the rotational orientation by removing the consumable and installing it correctly. This result could: decrease throughput, increase radiation exposure, increase the spread of contamination and increase the	• Identify rotational requirements. • Make appropriate modifications/markings on equipment that require rotational orientation.

Table A-7. Vulnerabilities Identified For Melter Equipment Support Handling (LSH). (14 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
			operating budget to address the contamination. • Service connections between the Melter and melter support equipment may not be able to be made without consideration for rotational orientation.	
LSH-M-13-V-06	Crane indexing capabilities have not been provided. Much of the crane use involves movement between discrete locations; increased operational efficiencies can be realized by addition of crane index features.	The greater portion of crane use in the melter gallery will be movement of items between discrete locations (e.g., import station, CCB rack, melter bubbler port, export station, import/export hatch). Increased operational efficiencies and reduced probability of human error could be realized by implementing crane indexing capability on the melter gallery cranes.	• Operational inefficiencies and premature crane wear. • Increase risk of operator error.	Provide crane indexing capability; preferably auto-indexing capability.

Table A-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LPH-IC-1-V001	There are many inconsistencies between the requirements documents such as the Mechanical Sequence Diagram (MSD) and the implementation of these requirements on the Logic Diagrams. Since there is no narrative or cross-walk between the requirements and the logic diagrams it is difficult to review, and will be difficult to verify and validate that the requirements are met.	Some interlock requirements are inconsistent, such as preventing a collision between pieces of equipment when going into a maintenance area but not when coming back out. Most often the implementation on the logic diagrams is correct but inconsistent with the requirement on the MSD. Some inputs to interlocks and some interlocks themselves are not correctly labeled on the logic diagrams potentially causing interpretation of how the interlock is implemented. Off-sheet connectors are often incorrectly labeled or inconsistently labeled from one sheet to another.	• This make it difficult for a reviewer to follow the logic and ensure that it performs as expected and performs the functions that are intended. It will also be difficult to write and verify a functional test plan as opposed to software testing. • If off-normal events and failure paths are not tested during commissioning and before, deficiencies in addition to those listed here will only be discovered when they occur.	• Conduct a full review of the J3 Logic diagrams to ensure they meet the requirements of the upper level documents such as the System Description, the Mechanical Sequence Diagrams and the Software Control Narrative. • If the requirements are incorrect, the requirements documents should be updated. • If the implementation is incorrect, it should be corrected. • Add a reference in the MSDs to the J3 Logic Diagrams where the interlock is implemented. • Scrub the logic diagrams to correct the labels and ensure consistency among the off-sheet connectors. • Start-up and commissioning should include exhaustive testing of both success and failure paths and Off-Normal operations to “wring out” errors and identify improvements in operations and operator/control interfaces before operations begin.
LPH-IC-1-V002	Alarms and Interlocks for Elevator position mismatch not described on the Mechanical Handling Diagram can lead to loss of configuration control.	24590-CM-POA-MJW0-00001-11-00001, Turntable and Elevator Operating and Maintenance Manual, requires that the motors for both Serapid chain drives on the pour cave elevator be synchronized. Further, the Functional Diagram for the elevator position indicators, 24590-LAW-J3-LPH-01009, Functional Diagram LPH Elevator Absolute Encoder LPH-ELEV-00001, 00002, 00003, 00004, shows these signals being compared to display a mismatch alarm. However, the Mechanical Handling Diagram 24590-LAW-M7-LPH-00001013, Container Pour Handling System does not show a tie between the Right Hand and Left Hand Drives to synchronize the two drives. If the two drives are not synchronized and the motors operate at slightly different speeds or start/stop at different times, the elevator lift table can crab & cock in the elevator’s guides and bind. This required functionality should be shown on Mechanical Handling Diagram 24590-LAW-M7-LPH-00001013.	• Without proper documentation, operators and maintenance personnel will not be properly trained and software will not be properly tested • Alarms and Interlocks cannot be managed, over-ridden or protected from improper hardware or software changes if they are not properly understood. Software Testing cannot be performed against requirements that don’t appear on requirements documents.	• Conduct a full review of the J3 Logic diagrams to ensure they meet the requirements of the upper level documents such as the System Description, the Mechanical Sequence Diagrams and the Software Control Narrative. • If the requirements are incorrect, the requirements documents should be updated. • If the implementation is incorrect, it should be corrected.

Table A-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LPH-IC-2-V001	The local control panels for the LPH Pour Cave Turntable and Elevator are located in R3/C3 areas. Since they are located immediately behind the Pour Cave Elevator, these rooms will also be thermally very hot. Since these locations do not provide a view of the equipment being operated, there is no reason for the panels to be located in these unhealthy areas.	According to 24590-LAW-P1-P23T-00006, Equipment Location Plan EL. (-) 21' – 0"/Area 6, the local control panels for the LPH Pour Cave Turntable and Elevator are located in rooms L-B012 and L-B014. According to the General Arrangement drawing, 24590-LAW–P1–P01T–00001, these rooms are R3/C3 zones. In 24590-CM-POA-MJW0-00001-07-02, Pour Caves Software Control Narrative for the LAW Vitrification System, Section 4.1 discusses operations at Local Control Panels LPH-PNL-0001/4/7/10. Section 4.1.7 states, "CAUTION: During Local mode, the operator is to visually monitor the elevator and turntable positioning while running locally since hardwired interlocks for stopping the equipment are limited to the elevator LPH-ELEV-0001, up over-travel proximity sensor LPH-ZS-3502 and down over-travel proximity sensor LPH-ZS-3504, which are respectively wired to control relays CR-OTS1 and CR-OTS2 which provide a fail-safe normally open interlock contact wired in series with the operator actuated Emergency Shut Down (ESD) pushbutton and the ASD high temperature switch RS-4L, etc., monitoring the braking resistor." However the panels are located in separate rooms behind the elevators (L-B012 and L-B014). An operator working at these panels will not be able to visually monitor the equipment being operated. The panels provide neither position encoder readouts nor camera views of the equipment.	The location of these panels will expose the maintenance person operating these controls to unhealthy conditions without any benefit from being co-located with the equipment being operated.	Consider moving the Local Control Panels LPH-PNL-0001/4/7/10 to LCB-004 either in the corridor, or across the wall from the current position.
LPH-IC-2-V002	A PIER regarding the pinching of the Monorail Hoist Festoon was closed by changing the operator message described on the logic diagrams 24590-LAW-J3-LPH-02016002/02017002/02018002/02019002, Sequential Function Chart LAW Container Pour Handling (LPH) System Trolley Maintenance (Sheet 2 of 2) LPH-HST-00001, 0002, 0003, and 0004. These changes were not made.	PIER Number 24590-WTP-PIER-MGT-13-0458-C, LAW Pour Cave Monorail Hoists-Door Interlock Inadequate to Prevent Pinching Festoon, identifies an issue with pinching the Monorail Hoist Festoon. The PIER recommended adding to the warning message telling the operator to check hoist and the festoon. The Verification Statement says, "The action has been satisfactorily completed. The sequential logic diagrams were updated to resolve the issue with the maintenance shield doors pinching the monorail hoist festoon. The revised sequence logic was performed by C&I and reviewed by Mechanical Handling, Ops and Start-up. Refer to 24590-LAW-EDR-J-12-0120". The PIER was closed on 08/16/2013. The J3s in question were revised to Rev 3 on 02/02/2013, including a note that said, "Clarify Step Descriptions". They were revised again to Rev 4 on 1/28/2014, the operator messages say,	If the operator signals the Automatic sequence that the Monorail Hoist is clear of the Maintenance Door without checking the Festoon, the sequence could allow the door to close and damage the Festoon. This would render the Hoist inoperable.	Investigate why the correction suggested by the PIER and reviewed, does not appear on the logic diagram. There appears to be a disconnect between the direction to correct a document and its implementation.

Table A-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		"Verify Hoist Clear of MAIN Door". There is still no mention of the Festoon as recommended by the PIER. The EDR referred to in the PIER does not show or specify the changes that were made. There is nothing available for review that shows what was done to close the PIER and the concern is still extant on the current revision of the J3 drawing.		
LPH-HST-1-V002	LAW Pour Cave Hoist Capacity Inadequacy	The current 10 ton hoist capacity limits the items that can be handled by the LPH hoists. The basis for this value is not defined therefore it is unclear if a 10 ton hoist can meet all the lifting requirements of the system. There is a case where the load can exceed 10 tons; specifically an overfilled/non-spec container utilizing the lower overpack and recovery lifting frame (LPH-RCVY-00003).	• Inconsistent design basis • Inadequate design margin • Potential for Operational Impacts and Risks to Commissioning Phase	• Provide a detailed analysis of the lifting requirements of the pour cave hoists. • Establish the bounding scenario that provides the basis for hoist capacity and make changes where appropriate (re-rate the hoists to lift more than 10 tons). • This may also require a specific weight limit be placed in the design of the Container Recovery Lifting Frame LPH-RCVY-00003.
LPH-HST-1-V004	LAW Pour Cave Hoist Design Temperature Inconsistencies	The basis for temperatures within the areas of operation of the pour cave hoists (LPH-HST-00001/2/3/4) is not consistently applied to design documents. 24590-LAW-M0D-LPH-00053, 00054, 00055, 00056, Mechanical Handling Data Sheets - LPH-HST-00001, 00002, 00003, and 00004 Pour Cave Monorail Hoists, do not accurately reflect the correct environmental conditions as documented in the CFD analysis (24590-LAW-M4C-C5V-00001, CFD Analysis of LAW Pour Caves [with Additional Cooling] and Finishing Lines). The elevated temperatures the hoists will be subjected to may lead to premature failure of equipment.	• Inconsistent design basis • Inadequate design margin • Potential for equipment failure • Potential for production impacts	• Provide a detailed analysis of the environmental requirements of the pour cave hoists. • Establish the bounding scenario that provides the basis for temperature values within the pour caves and transfer corridor. Update data sheets and verify with vendor if changes are required to meet the environment. Make changes where necessary (different lubricants, localized cooling, higher inspection frequencies, etc.). . • Review with HVAC if hoist requirements affect HVAC design.
LPH-HST-1-V005	Hoist Specification Requirement Deficiencies	Features and concepts of the pour cave hoists must meet the functional requirements specified in the Engineering Specification for Process Monorail Hoists (24590-WTP-3PS-MJKH-T0002). Validation of these features/concepts is either done through acceptance of vendor deliverables (drawings, calculations, data sheets, etc.) or through physical proof testing. It is assumed that Factory Acceptance Tests (FAT) done by the equipment supplier or Test Acceptance Criteria performed during commissioning will meet all the requirements that are not validated through the vendor submittal process. There are several requirements of the specification that were not tested during FAT and are not covered by a test	• Inconsistent design execution • Inadequate design margin • Potential for undersized equipment • Potential for Operational Impacts and Risks to Commissioning Phase	• Establish the actual requirements of the engineering specification and validate the hoist supplier has met the requirements. • Provide documentation to validate the requirement was met.

Table A-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		requirement in the LPH System Description. The items/functions not tested can impact commissioning or future production when called on to perform.		
LPH-HST-1-V006	LAW Pour Cave Trolley Recovery Design Inadequacies	Based on the LPH Pour Cave hoist engineering specification (24590-WTP-3PS-MJKH-T0002), trolley recovery shall be accomplished through pullback means to the hoist maintenance area. Pullback design is required with safe working load. The lack of vendor calculation to justify the recovery cable sizing prompted a PIER (24590-WTP-PIER-MGT-13-0268-C, LAW Pour Cave Monorail Hoists - Remote Recovery Capabilities Inadequate or Unverified [RVP]). Cable sizing was deemed appropriate by CCN 258131, but the analysis does not include bearing friction forces and the design may not meet the recommended design factor.	• Inconsistent design execution • Inadequate design margin • Potential for undersized equipment • Potential for Operational Impacts and Risks to Commissioning Phase	Reassess recovery scenarios and provide a detailed analysis/calculation for cable sizing. Undertake a proof test to ensure cable and swivel ring design can recover a loaded hoist within the curved section of the monorail beam.
LPH-HST-1-V007	LAW Pour Cave Hoist Recovery Design Inadequacies	Based on the LPH Pour Cave hoist engineering specification (24590-WTP-3PS-MJKH-T0002, Rev. 3), in the event of a hoist drum brake, seizure recovery shall be accomplished by utilizing the hoist motor (sized large enough to overcome the brake force) to drive through the brake and be able to lower the load. Although brake failure is covered in the specification, motor failure is not. Recovery method for a grappled load and a hoist motor failure can only be accomplished through cable cutting. This issue was identified in PIER (24590-WTP-PIER-MGT-13-1090) and is still an open issue.	• Inadequate design execution • Inadequate consideration for maintenance tasks • Risk transfer to operating contractor	• Assess the impacts of load recovery and assess if additional design features should be implemented. If the impact is great enough, it may be necessary to add a secondary motor on the LPH hoists. • Undertake a proof test to ensure the redesign can adequately recover from a seized motor with a full load through remote recovery operations.
LPH-HST-1-V008	LAW Pour Cave Hoist FAT Test Deficiencies	Factory acceptance testing does not fully test the items as specified in the engineering specification for LPH pour cave hoists (24590-WTP-3PS-MJKH-T0002). Of the items tested, the FAT does not validate the performance requirements adequately. Several features are not fully tested to simulate the bounding conditions and the acceptance of the FAT report places a false sense of security on the adequacy of design.	• Inadequate design execution • Inadequate consideration for maintenance tasks • Risk transfer to operating contractor	• Establish an adequate FAT test plan that meets the requirements of the engineering specification. • Undertake a proof test to ensure the existing hoists can adequately meet all the tests required in the plan and document the results.
LPH-HST-1-V009	Monorail Hoist Maintenance Platform Inadequacies	The fixed handrails of the platforms (LPB023A/B) located in the monorail hoist maintenance rooms (L-B023A/B) interfere with the ability to move the hoist trolley over the platforms. The hoist festoon system hangs 42" below the handrail elevation and this will block the trolley from moving over the platform. In addition, the platform is designed with removable grating sections to allow for equipment to pass through the opening to the floor below, but the opening does not allow for use of the existing monorail beam or hoist; they are not in the vertical path of the monorail beam.	• Inadequate design execution • Inadequate consideration for maintenance tasks • Risk transfer to operating contractor	• Modify the fixed handrail section to include a spring loaded gate that can swing open and allow for the festoon to pass through. • Modify the removable grating area and provide an opening directly below the monorail beam to allow for items to pass through utilizing the monorail beam. Another option is to add permanent lifting devices directly above the removable grating sections to aid in maintenance tasks.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LPH-BFSTR-1-V001	Insufficient shield door design basis.	The transfer corridor North and South shield doors, 24590-LAW-AD-LPH-DOOR-00024 and 00026, are required to be 4 inches thick and provide adequate shielding dose rate to R3 (2.5 mrem/hr) radiation levels. 24590-LAW-Z0C-W13T-00002, LAW Facility Shielding Confirmation Calculation, is identified as the basis for the shield door design conformation. However, section 7.2.6 identified as steel walls/doors performs an analysis with a single point source term and this is not the conditions expected in the container buffer storage area.	Potential employee exposure due to unanalyzed source configuration.	The LAW Facility Shielding Confirmation Calculation, 24590-LAW-Z0C-W13T-00002, should be revised to include the shield door design verification. The verification should include the actual buffer storage container configuration and source term to identify if the current door design will perform the expected shielding effect. The verification calculation should drive design modifications, if necessary, to ensure maintenance activities can be performed as intended and safely
LPH-BFSTR-1-V003	Additional cameras needed in container export area.	The container export area, located at East end of transfer corridor, does not have sufficient camera coverage for export operations to the LFH system. According to camera location drawing, 24590-LAW-J0-PTJ-00001, System PTJ Supplemental Instr. Diagram CCTV Equipment Plan @ EL -21’-0”, there is one camera located in the North wall covering the buffer storage room, L-B025C, and the South wall covering the rework area, L-B025D, both camera views are partially obstructed when trying to view the transfer corridor export location.	Operators will have a difficult time engaging and dis-engaging the container grapple with no elevation view of the export location, in the transfer corridor. This could result in a high risk of improperly engaging or dis-engaging a container and result in container, equipment, or facility damage.	Install two additional cameras, located in the container transfer corridor, to provide an elevation view of the container export position.
LPH-BFSTR-1-V004	Incorrect buffer storage and finishing line container import temperature.	Described in 24590-LAW-M4C-C5V-00003, CFD Analysis of LAW Buffer Storage and Finishing Line calculation, the intended operation is to transfer the container directly from the pour cave into the finishing line, after 59.27 hours, in an alternating pour mode. There is no direct container temperature results identified in the analysis, so the Reviewer will assume the container temperature is identical to container temperature profile for the maximum container temperature for alternate pour schedule. That would mean the finish line import temperature is 460°F. In the single pour mode the container is required to be removed from the pour cave at 29.63 hours and using the container temperature for a single pour schedule the container temperature would be 630°F. However, the container cannot be lifted with the current grapple design until it cools to 600°F. Assuming the cooling rate is approximately linear, after 20 hours, the container will not be able to leave the pour cave until hour 34-36. This single pour schedule would result in approximately 18 percent melter throughput reduction.	Using the incorrect model input data could either under or overestimate the effects on the facility or production. The project cannot use obviously incorrect container temperatures and expect that the facility insulation design basis is accurate. Re-performing the analysis with the correct input temperatures may verify an increase in safety factors and improve operations ability to manage container throughput.	Clearly define the container temperature profile, for all operating modes, prior to containers entering temporary storage and re-run the CFD models for long term transient analysis. The model outputs should be used to refine operating limitations, insulation configurations, and HVAC cooling air profiles.
LPH-BFSTR-1-V005	Insufficient Buffer Storage CFD analysis.	The CFD Analysis of LAW Buffer Storage and Finishing Lines, 24590-LAW-M4C-C5V-00003, includes the container rework area, L-B025D, and does not analyze the larger buffer storage area, L-B025C. There is an	The HVAC system may be undersized to handle the total cooling load. The area insulation may be insufficient to protect the facility structure. The storage area	• Clearly define the container temperature profile, for all operating modes, prior to containers entering temporary storage. Update CFD model

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		attempt, in section 6.2.4.4, to justify the modeling choices by saying that although the area to the north has more canisters, the model has the six hottest canisters in the south area, and the air temperature in the north will be less in this situation than the air temperature in the south. This is not a justification for not analyzing the larger buffer storage area, because it has less air flow for convective cooling, twice the potential heat loading, higher temperature effects on concrete structure and worker occupied areas.	may not be large enough to allow operations to achieve the required facility glass production. The correct CFD analysis could validate the current facility design and operations, but without a reasonable analysis of the facility intended operations the basis of design cannot be relied upon.	to accurately analyze all storage geometries, cooling air patterns, and operating conditions. Then re-run the CFD models for long term transient analysis to identify the true maximum temperature locations and the frequency at which they occur. • The model out puts should be used to refine operating limitations, insulation configurations, and HVAC cooling air profiles.
LPH-BFSTR-1-V006	Excessive buffer crane operating temperature.	24590-LAW-M0D-LPH-00003, Mechanical Handling Data Sheet - Top Running, Double Girder, and Buffer Storage Crane 24590-LAW-MJ-LPH-CRN-00002, indicates the operating environment as 59-113°F and a special temperature condition of 130°F max. The CFD analysis of the LAW buffer storage and finishing lines indicate the walls and ceiling temperature maximum well in excess of 130°F, for a single pour schedule. If the buffer storage area, L-B025C, is analyzed the inner wall and ceiling temperatures will be as bad or worse all of which exceed the cranes operating conditions.	The crane will prematurely fail and require increased maintenance and repair. The increased maintenance and repair downtime will affect the facility overall throughput requirements.	Execute the above OFI, for the CFD analysis, and use the output model data to identify the true operating environment and procedures for which the crane will perform. If temperatures are above the cranes design operating conditions then modify the crane to meet the new operating conditions or use the container re-work area as a cold container storage location that could also be designated as the crane park position. Parking the crane in the rework area, between container moves, would ensure the crane is located within its design basis operating environment and only periodically enter elevated temperature zones.
LPH-BFSTR-1-V007	Insufficient Buffer Storage Capacity.	Drawing number 24590-LAW-J3-LPH-02011, sequential function chart, indicate the storage position shall be selected by the ICN using the sequence order identified in note 5. This sequence will fill 11 storage positions located in both the buffer store and container rework areas. This sequence requires the center row, B row, to be kept empty to allow automated crane movements. This operating sequence will reduce the storage capacity from 18 positions to 11, which is a nearly 39 percent reduction. The crane can be operated manually and the additional storage locations be filled with containers, however doing so would require all crane movements to be done manually and with the limited maneuvering area the risk of container collisions would be greatly increased.	The insufficient buffer storage capacity will limit operations ability to manage container throughput and the facilities different operating modes. This will result in reduction in facility overall throughput requirements.	• Expand the container buffer storage area by one of the following: • Increase buffer storage by facility design modifications to expand area designated for container storage both long and short term. • Increase container cooling capability to reduce the storage time for the container to be reduced to target temperature for the finish line import. This would increase flexibility and overall throughput using the current container buffer storage area. • Modify operating procedures to allow more efficient management to current container buffer store to achieve facility throughput and validate these operating procedures through model validations.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LPH-BSMF-1-V001	Container Recovery Lifting Frame issues.	A workable Container Recovery Lifting Frame has not been designed and will not be procured until it is needed. Delaying the final design and procurement of the frame could adversely impact container throughput. Drawings indicate the frame is stored in the Buffer Store Maintenance Area but the conceptual design of the frame is too tall to be moved through the door separating the maintenance area and the Buffer Store Area.	Significant adverse impact on throughput while the lifting frame is being designed fabricated and tested.	Identify an alternate storage location for the Container Recovery Lifting Frame that will allow the current conceptual design to be utilized. Redesign the lifting frame so it can be transferred through the Buffer Store Maintenance Facility door.
LPH-BSMF-1-V002	Transfer of ILAW container and Lower Overpack from the Container Transfer Corridor to LFH issue.	CCN 227163, LPH-CRN-00002 Energy Chain Modifications Required to Remove Container/Overpack through LFH-DOOR-00010 Openings, provides recommended modifications to the LPH-CRN-00002 energy chain trough and support beam that will be necessary to transfer a container and overpack from LPH to LFH through LFH-DOOR-00010. The steps include parking LPH-CRN-00002 in the Buffer Store Crane Maintenance area, removing insulation batts, cutting the energy chain trough and supports before the container and overpack can be moved through LFH-DOOR-00010. This appears to be a lengthy and complex operation that will significantly impact throughput. An alternate method of moving a container and lower overpack through LFH-DOOR-00010 should be considered when the recovery lifting frame is redesigned, or relocate the energy chain trough.	System throughput may significantly impact mission duration. Overly optimistic assumptions result in operational decisions based on inaccurate information.	Prepare a design change to modify the energy chain trough so the modifications can be completed prior commissioning of the facility. The modification needs to ensure minimal work will be required in a contamination area to transfer the ILAW container and lower overpack.
LPH-OR-1-V001	CCN 068381, LAW Facility LPH System - RAM Assessment and Basis, recovery logic inconsistent with equipment operability.	The RAM assessment and basis report for the LPH system contains recovery logic for a failed turntable which is inconsistent the operability and capabilities of the pour cave hoist. The positioning lasers, which are not redundant, and utilized to accurately and safely position the crane are not included in the OR model.	System throughput may significantly impact mission duration.	• Revise the recovery logic for a failed pour cave turntable motor and update the OR Model. • Add the Buffer Store Crane positioning lasers to the OR Model.
LPH-OR-1-V002	24590-CM-POA-MJKG-00003-15-01, Failure Mode, Effects, Reliability, Maintainability, and Criticality Analysis, inconsistencies.	The Failure Mode, Effects, Reliability, Maintainability, and Criticality Analysis prepared by the Buffer Store Crane vendor contain inconsistent values for the operational availability of the crane. The analysis utilized a "normal" environmental factor which is not consistent with the high temperature environment of the Buffer Store Area. Based on a throughput of 5 ILAW containers per day, the duty cycle (crane movements) and time of use per day are underestimated.	Erroneous input data in OR Model results in overly optimistic predictions of system and facility availability.	• Revise the FEMCA for the Buffer Store Crane to include "non-normal" environmental conditions due to the high environmental temperature. • Revise the duty cycle and operation time of the Buffer Store Crane to align with the current container handling and sequencing methods
LPH-CPS-1-V001	Potentially insufficient design margin for working load capacity of Container Park/Export Stands.	If not frequent, there are conditions where the Park/Export Stands will support a weight higher than the design working load. It may result in gradual deformations of the top ring that directly supports the bottom of the containers, which may later become a problem if repair/replacement is needed.	• Inconsistent/inadequate design • Operations concerns • Maintenance concerns	• Perform confirming structural calculation using the redefined working load calculated for the maximum anticipated weight and a 25% design margin. • Re-run the functional test conducted by the Vendor using a 20,000-lbs

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
				simulated Container bottom for the possible higher working load.
LPH-CPS-1-V005	The truncated Container Export Stands will provide an insufficient thermal protection of the concrete floor below.	The truncated sides of the Export Stands will allow radiant heat to shine on the concrete floor below that will result in a risk that a hot Container overheats the floor above the 150°F maximum allowable temperature.	• Inconsistent/inadequate design • Operations concerns • Maintenance concerns	Develop a detailed calculation to verify the temperature conditions of the floor at the east end of the Transfer Corridor and define need for additional localized thermal insulation.
LPH-CTB-1-V001	Bogie thermal shield design differences between the Design Proposal Drawing and the fabricated Bogies are not documented.	There is no justification available that documents the WTP Project's acceptance of the Manufacturer's deviation from the initial design that called for the heat barrier to cover the entire top surface of the Container Transport Bogies.	• Inconsistent/inadequate design • Operations concerns • Maintenance concerns	Re-run the Manufacturer's thermal analysis of the Container Transport Bogies for the expected higher ambient temperature range, and verify that the temperatures of the Bogie most fragile components including the motor and junction boxes remain acceptable.
LPH-CTB-1-V002	No I&C Component prevents a Bogie from colliding with a filled Container standing on an Export Stand.	During normal operations in automatic mode, the Bogie positioning is obtained from a laser-positioning device. There is no way for the system to identify that a filled Container is present on the Export Stands. There is a risk that a bogie will collide with the Container and damage it or move it off-center the top ring of the stand.	• Inconsistent/inadequate design • Operations concerns • Maintenance concerns	Equip the two Export Stands with a Container Presence Detection Instrument signaling to the ICN and the Operator (Manual mode) the presence of a Container on an Export Stand.
LPH-CTB-1-V003	Wall of the Corridor at Column Line 12.5 in not protected from radiant heat dissipated by a filled Container on a Bogie parked at Position 15.	There is a risk that a hot Container parked at Position 15 overheats the non-insulated north and south concrete wall surfaces around Column Line 12.5 above the 150°F maximum allowable temperature for reinforced concrete structures.	• Inconsistent/inadequate design • Operations concerns • Maintenance concerns	Conduct a thermal analysis, verify the surface temperature level of the north and south corridor wall at and near Position 15, and define the needs for adding insulation material and stainless steel liner in this area during the construction phase prior to commissioning (similar to the wall configuration at the east end of the Corridor near the Export Stands).
LPH-CTB-1-V004	Non-finished surfaces of the Corridor walls will trap volatile contamination migrating from Pour Caves resulting in challenging cleanup work.	During operations a natural circulation thermal plume exits each Pour Cave into the upper part of the Container Transport Corridor. These thermal plumes may spread contamination from the Caves to the Corridor in a direction opposite of the C5V cascade airstream. Several elements present in the ILAW glass are volatile and may rapidly condense as a stream of molecular sized particulate contamination exiting the Caves. After a period of operation, this contamination dispersed everywhere in the Corridor will accumulate firstly on the upper surfaces of the Corridor which, as they are not protected by any coating, will greatly complicate access and maintenance.	• Inconsistent/inadequate design • Maintenance concerns	• Conduct a detailed thermal analysis of the Container Transport Corridor focused to the identification of the natural circulation thermal plumes and air temperatures. • Evaluate the needs for applying epoxy coating to the unfinished upper surfaces of the Corridor.
LPH-CTB-1-V006	Maximum temperature requirement for Conductor Bar design is significantly	There are conditions where the conductor bars may see ambient temperatures over the maximum specified operating environment of 113°F.	• Inconsistent/inadequate design • Operations concerns	Verify the acceptable temperature range for the cover material of the installed conductor bars, resume contacts with the

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	lower than anticipated temperatures near filled Container.		• Maintenance concerns	Manufacturer, and evaluate the option of replacing the conductor bars by a product with an alternative cover material resistant to higher temperatures if the durability of the installed material cannot be demonstrated in the expected temperature conditions.
LPH-BMA-1-V001	Bogie Maintenance Hoist not adequate to lift the Container Transport Bogies to access the underside of the Bogies.	The capacity of the Bogie Maintenance Hoist is not sufficient to lift a Bogie from the rails as a whole assembly so that operators can access the underside for repair/maintenance.	• Inconsistent/inadequate design • Maintenance concerns	Develop detailed maintenance/repair procedures for the Container Transport Bogies that minimize the need for a lengthy disassembly of bogie parts prior to lifting the failed bogie from the rails
LPH-BMA-1-V003	Use of Bogie Recovery Systems will pull contamination inside the Bogie Maintenance Area.	The wire ropes of the Bogie Recovery Systems sit between the rails between column lines 2 and 14, with a long length (approx. 208 ft - between column lines 3 and 14) located in the potentially contaminated Container Transport Corridor.	• Inconsistent/inadequate design • Operations concerns • Maintenance concerns	Develop maintenance procedures to wipe-out the contamination from the wire ropes before it is dispersed inside the components of the Bogie Recovery Systems located in the Bogie Maintenance Area
LPH-PC-1-V001	High ambient air temperatures in the pour cave affect pour cave equipment and cause a natural convection air plume out of the top of the open pour cave/bogie tunnel door.	The CFD engineering analysis performed to analyze pour cave temperatures only modeled one pour cave and did not consider ventilation interactions with the bogie tunnel. The Mechanical Systems cooling panel heat exchanger analysis allowed a cooling water temperature rise above 10°F to preclude excessive cooling water flows through the cooling panels and this cooling water temperature rise will cause higher pour cave ambient air temperatures. At molten glass temperatures, Technetium oxides are a volatile gas which will be off-gassed into the natural convection thermal plume. The magnitude of the problem will not be discovered until full production throughput is obtained on a hot summer day with a buffer storage area full of cooling containers.	High ambient air temperatures in the pour cave will affect equipment, container cooling times, and promote the spread of contamination.	• Perform a CFD of the HVAC interaction of the bogie corridor (L-B025B) and all four pour caves at full LAW Facility throughput. Install additional cooling in the LAW Facility and modify the LAW Facility HVAC C5V system as required to preclude excessive temperatures based on the CFD analysis. • Convert all the "delay time" requirements in the canister handling scenarios to actual canister temperatures requirements.
LPH-PC-1-V002	Pour Cave shielded windows are overheated.	By WTP engineering calculations, the shielded windows in the pour caves are overheated by a hot container in the cooling position of the pour cave turntable.	Overheating the windows will cause thermally induced cracks limiting visibility through the window.	Design a thermal barrier to prevent radiant heating of the pour cave windows by hot containers in the turntable cooling position.
LPH-PC-1-V003	Filled containers which cannot be promptly exported from the pour cave will require LAW Facility production to be reduced.	WTP engineering calculations impose time delays on export of filled containers from the pour cave to both the buffer storage area and finishing line to preclude overheating. If the downstream container line is choked with non-conforming containers or thermally hot, filled containers, pour cave operations will have to be suspended.	The LAW Facility Production rate will be reduced.	Install temperature instruments to base filled container movements based on temperature of the containers rather than time since the initial glass pour and allow containers which happen to be cool enough to be immediately processed out of the area.
LPH-PC-1-V004	If the Seal head cameras overheat and fail, pour operations through the	Electronic devices such as cameras have ambient temperature limits. By WTP calculations, the seal head heat exchangers are overloaded for a period of ½ hour	If the Seal head cameras fail, the pours through the respective melter spout must stop until the instruments are replaced.	Increase the cooling to the Seal head camera areas.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	respective melter spout must be stopped until the camera is replaced.	after the fourth pour into a container. This heat exchanger overload period will cause the temperature in seal head to increase and may cause installed cameras to fail.		
LPH-PC-1-V005	Failure of the Seal head cooling water piping will require shutdown of the Seal head and respective melter pour spout. Leaks will mobilize contamination and increase the risk of the spread of contamination.	Piping is stress analyzed to give some assurance the piping will not fail due to excessive piping stresses. A leak in the small diameter seal head cooling water piping would allow cooling water to leak into the seal head area and drip into the pour cave below. The pour cave is expected to be contaminated to C5 levels and dripping/flowing water will mobilize this contamination. There is no collection sump in the LAW pour caves.	A leak in a Seal head cooling water line would require the shutdown of the respective melter pour spout to isolate the cooling water leak. A leak from the Seal head piping would drip/run into the pour cave below. The LAW Facility is not permitted by the State of Washington to have contaminated / radioactive water running over the floor.	Perform a B31.3 piping stress analysis on the Seal head cooling water pipe.
LPH-PC-1-V006	• Air temperatures of up to 650°F on loss of pour cave cooling water will cause severe equipment problems. • Inadequate pipe sizing may cause cooling water supply problems.	• Calculation 24590-LAW-M4C-C5V-00001, CFD Analysis of LAW Pour Caves (with additional cooling) and Finishing Lines, Conclusion 8.10.2, 7th bullet, page 186 reports the air temperature in the pour cave are approximately 650°F upon loss of cooling water. • Rule-of-Thumb pipeline sizing has been successfully used for many years in a large variety of industries. Undersized piping will make itself evident during startup operations with high pipeline velocities. Oversized piping will have low pipeline velocities and accumulate sediment.	• A loss of cooling water may expose pour cave equipment to excessive temperatures. • Improperly sized piping will be discovered during flow balancing and startup operations delaying the correction of pipeline problems to startup and commissioning phases.	• Install backup cooling systems as required to mitigate a loss of pour cave cooling water. • Perform an Engineering calculation to verify the Rule-of-Thumb sizing method chose the correct piping sizes, or accept the risk and wait until startup and fix any incorrectly sized piping then.
LPH-PC-1-V009	• High container temperatures due to inadequate container cooling directly impact LAW Facility throughput. • Excessive yielding of the container flange may preclude sealing of the container with a lid which must be inserted into a round hole and create non-conforming ILAW packages.	Calculation 24590-LAW-M4C-C5V-00001, Figure 49 Sheet 117, plots a graph of the temperature of a filled LAW container flange area versus time. At hour 20, calculation 24590-LAW-M4C-C5V-00001 estimates the maximum temperature of the flange area on the filled container will be just under 1,000°F. This temperature is well above the 600°F temperature required to perform a safe lift of the container with the pour cave hoist/grapple without deforming the container flange.	Lifting a container by its flange before the stainless steel has cooled sufficiently will deform the upper flange. It may well lead to the situation where the container lid cannot be inserted into the flange.	Increase cooling to the filled container flange area to reduce the time it takes for the container flange to cool and regain its strength. Install an instrument to measure the temperature of the filled container in the cooling position on the Turntable
LPH-PC-1-V010	While the container grapples are reliable, failure of the grapple to release a container will shut down operations in the respective pour cave and could require extensive recovery efforts.	The LAW Container grapple can be manually released from the container with an emergency release operated by an MSM as is stated in the system description. However, the MSMs are not procured and not installed. The ability of the MSM to reach the release pins on the grapple will be problematic. Pulling the release pins on the grapple will probably require a manned entry with personnel working off of a ladder to reach the release pins on the grapple stuck on top of the can fifteen feet above the floor.	Pour operations in the affected cave will be stopped until the grapple is removed from the container and a new, operable grapple is installed on the pour cave hoist.	Design and procure a Grapple that can be remotely disengaged.
LPH-PC-1-V011	After cutting the pour cave hoist cable, recovery of the pour cave will involve a	While the pour cave hoist cable can be cut remotely if the pour cave hoist fails when attached to a container in the	Pour Cave operations in the affected cave will be stopped until the wire-rope- fouled	Install a hoist with redundant drives for the trolley wheels, and hoist to allow

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	manned entry with containers in the pour cave.	pour cave, it will require a manned entry into a pour cave with filled containers to secure the load prior to cutting the cable and further manned entries to recover the grapple fouled with the cut cable. Recovery of the grapple will be elevated work from ladders.	grapple is removed and the filled container is recovered. Dropping a full container in the Pour Cave may damage equipment.	independent recovery without cutting the hoist cable.
LPH-PC-1-V012	The contamination levels in the pour caves will be a mystery until a sample is taken or an entry is made.	While the System Description describes a Continuous Air Monitoring (CAM) system installed in the Pour Cave to allow retrospective analyses to be done. However, no CAMs are permanently installed and connections are only provided for portable CAMs. Contamination off-gassed by the hot containers will be distributed throughout the pour cave by the thermally driven natural circulation air plume.	Contamination levels in Pour Caves will be unknown and no retrospective analysis of contamination levels can be done. When personnel enter the pour cave, contamination on the floor and equipment they mobilize will not be known.	Install the CAM system described in the System Description to allow retrospective analyses to be done for the pour caves.
LPH-PC-1-V013	• Overpacks, and containers within overpacks, will not be able to be remotely handled, limiting LAW Facility throughput if manual handling must be done. • Use of conventional lifting & rigging gear will increase the quantity of potentially contaminated items which must be handled and controlled.	There is currently no equipment supplied to remove a container from the turntable if either the flange is distorted or a buildup of glass interferes with the engagement of the grapple, or if a glass overflow "glues" the container/overpack to the Turntable. A manned entry will have to be made into the pour cave to recover the Pour Cave.	The inability to lift a container from the Turntable will stop operations in that pour cave until the container is cleared and force the opposite spout of the melter into single pour operations. Manual handling will require Pour Cave entries with filled containers present. The amount of contaminated lifting equipment will be increased.	Design and procure a lightweight, high strength, remotely handled, lifting frame to handle overpacks, and containers in overpacks, when lifting them to/from the Pour Cave Turntable is required.
LPH-PC-1-V014	The natural circulation hole in the Container Lower Overpack will increase radiant heating of the Turntable and Turntable base.	The original design of the Container Lower Overpack was a closed bottom overpack with 1" of thermal insulation to prevent overheating the Pour Cave Turntable. The Lower Overpack was modified to promote natural air circulation past the container and allow heat to be transferred via thermal radiation out the bottom of the container. This radiant energy will now heat up the lower Turntable area.	The impact of higher temperatures due to radiant heating must be determined for the Turntable seismic analysis, the turntable bearing, the Turntable heat exchanger, and the concrete below the Turntable.	• Perform a CFD thermal analysis of the pour cave turntable with radiant heating from the modified overpack. Re-perform the turntable seismic analysis if the temperature increase exceeds the bounds of the existing seismic analysis. Install heat shields and thermal insulation on the turntable as required. It is suspected that Pour Cave L-B013C will have the highest temperatures during normal operation. • A new thermal analysis of the Turntable should be done, and if the Turntable metal temperatures increase above the Turntable's seismic analysis temperature assumptions/limits, a new seismic analysis should be done.
LPH-PC-1-V017	Potential equipment damage to Pour Cave Turntable locking actuator.	The Elevator/Turntable Vendor Manual 24590-CM-POA-MJW0-00001-11-00001 page 454 of 989 cautions that jamming the actuator by driving the actuator against an immovable object and thus overloading the actuator severely can damage the actuator. The end of the Turntable locking pin is tapered to engage the turntable,	A slight misalignment or Turntable binding may jam the actuator and damage it.	Ensure a timer in the control system is monitoring the run time of the Turntable locking actuator motor. If the actuator motor exceeds a run time setpoint, the control system stops pour cave equipment operations until Operating/Maintenance

Table A-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

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		slightly move the turntable if required to precisely position the turntable, and then precisely lock it in position (24590-CM-POA-MJW0-00001-03-87, Supplier's Submittal - Turntable Drive Cassette Assembly). Driving the high reduction pinion gear drive backwards will require significant force.		personnel have investigated and corrected the failure of the Turntable locking pin actuator to lock the turntable in position.
LPH-PC-1-V018	Overheating the Turntable bevel gear drive oil, will reduce the life of the bevel gear drive.	The Turntable Vendor recommends Hub City Lubricant GL-90 for ambient temperatures of 15°F to 125°F and for ambient temperatures above 125°F to consult the factory. With the removal of the bottom of the Container Lower Overpack to promote natural convection cooling, the Turntable bevel gear drive (24590-CM-POA-MJW0-00001-03-84, Supplier's Submittal - Elevator Assembly) will be exposed directly to the bottom of hot containers in the cooling position. This will heat up the bevel gear.	Overheating the Turntable bevel gear lubricant will reduce the operating life of the bevel gear. Failure of the bevel gear drive will stop Pour Cave operations.	Use a synthetic oil with a higher rated operating temperature and install a heat shield to protect the Turntable bevel gear drive from the hot container sitting in the Lower Overpack.
LPH-PC-1-V019	Overfill of container will impact facility throughput, require immediate maintenance actions, result in a large contamination cleanup effort, and impose unplanned costs on the facility.	Duratek Vendor Submittal 24590-QL-HC4-W000-00011-03-00256 Section 5.2.1 page 46, discusses the ramifications of container overfill and suggests two methods of recovery. The first method is to lower the container and spill the excess molten glass into the pour cave below. The second is to let the glass cool and solidify and then through mechanical means separate the bellows with the column of glass in it from the melter and lower it into the pour cave and then replace the pour spout components. Both of the suggested Duratek methods of recovery could have very serious operational concerns. In Section 5.2.1.1.1 Duratek states that spilling molten glass has been done on several occasions at the LAW pilot melter and reduced the time required to recover from a container overfill. LPH System Description, Section 7.3.10, page 46, discusses recovery of an over-filled container says an over-filled container is lowered to the turntable and rotated to the cooling position. However, the System Description does not say if the overfilled container will be lowered with the glass still liquid, or if delay is imposed to allow the glass to solidify.	• Allowing the glass to solidify in the melter bellows before lowering the container to the Pour Cave Turntable would cause damage to the melter pour spout and Seal head assemblies. • Spilling the molten glass to the Pour Cave below would coat the Elevator, container, and Turntable with hot glass. • Both paths forward will require extensive repair efforts to recover the melter pour spout and Pour Cave.	Install an overfill spout to direct the molten glass to a safe area. A system similar to the WTP HLW melter installation could be used. The WTP HLW melter has a spill port closed by a disk secured with an aluminum bolt that will melt when exposed to molten glass and spill the molten glass to a safe area in the cave below the canister.
LPH-PC-1-V020	Failure to detect glass build-up in a Melter spout bellows can lead to blockage of the bellows and render the respective Melter pour spout inoperable.	Theoretically, the tip of the melter pour spout is aligned with the container flange hole below the spout so that the glass falls from the melter spout into the container. When Duratek performed the LAW container prototypical pours per 24590-101-TSA-W000-0009-101-00007, RPP Pilot Melter Prototypic LAW Container and HLW Canister Glass Fill Test Results Report, Duratek had a pour spout streams that deposited glass on upper surfaces of test containers LT002 and LT003. This indicates the prototypical pour stream has a variation greater than the radius of the prototype container flange hole. The	• If the glass builds up in the bellows, it can block the pour stream and render that Melter pour spout inoperable. • If the pour is continued through the blocked pour spout, a glass spill will occur. • Failure of the container to fill cannot be detected by the infrared camera when the level is low in the container since the camera cannot see the lower portion of the container.	Install a camera in the Pour Cave to look upward into the bellows when the container is lowered to the Turntable to allow the Operator to determine if any glass is building up on the Melter pour spout bellows.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		prototype containers had the same nominal 16" container flange hole diameter as the LAW Facility production containers will have. However, at the LAW Facility, any wavering glass will not hit the flange of the container. It will hit the bellows piece 4 on detail drawing 24590-QL-HC4-W000-00011-03-00244, Supplier's Submittal – Canister Seal Ring Details. The bellows piece 4 has a 13" diameter hole. Duratek submittal 24590-QL-HC4-W000-00011-03-00256, LAW Glass pour spout final design resolution, sections 5.2.1.2 and 5.2.1.3, pages 47 through 49, discuss the impact of a wavering glass stream and the resulting glass build-up.	• Observation of the weight increase indicated by the Elevator load cell will be problematic since the bellows diameter/area is much smaller than the container diameter/area.	
LPH-PC-1-V021	If the replacement melter Vendor uses original design drawings rather than "as-built" drawings to determine allowable Melter pour spout installation tolerance, the replacement melter may not be able to pour glass into a container.	The WTP Project appears to have used just about all of the available installation tolerances for the melter / turntable / elevator / canister installations to allow a +/- 1" centerline installation tolerance over the original design installation tolerance of +/- 5/16". The computation for the tolerance stack up is done in Field Change Request 24590-WTP-FC-M-12-0350, LAW - LMP-MLTR-00001 & 2 Melter Centerline and not done in an Engineering Calculation.	If all the tolerances for installation of equipment are used by the WTP Project during the initial installation, then the follow on vendors / installers will have to work to tighter installation tolerances.	Create a Melter replacement document that captures all the special places the Melter replacement Vendor must fabricate the replacement Melter with tight dimensions and tolerances which are Not-To-Be-Exceeded in any case.
LPH-PC-1-V022	Installation of an Elevator weigh instrument with a very small or no temperature margin can cause operational and maintenance problems.	• The insulation on the Container Elevator steel is on the outside of Elevators in room L-B012 & L-B-014 and not on the Pour Cave side of the Elevator steel inside the Pour Caves. The load cell is installed below the horizontal shaft bearings in the load path between the Elevator bearings and the LAW Facility embeds. The lower shaft is inside the elevator insulation. Calculation 24590-LAW-M4C-C5V-00001, Figure 36, sheet 107 calculates an Elevator steel temperature of 180°F to 300°F depending on where in the pour cycle the process is and an average temperature at the steel / insulation interface of about 105°F. Per figure 39, sheet 110, when the Serapid chain and elevator lifting arm are supporting the container in the pour position, the Serapid chain and container lifting arm near the top of the pour cave should go to near the calculated steel temperatures and this temperature could be 300°F to 500°F. • When the full container is lowered to the Turntable, the Serapid chain is withdrawn into the chain canister in rooms L-B012 & L-B014 and the lifting arm is near the bottom of the Elevator. The hottest portion of the chain and lifting arm will heat up to the lower elevator metal. The load cell is installed in this area of the elevator (The load cell is tagged with note 12 on drawing 24590-CM-POA-MJW0-00001-03-49,	The Elevator load cell should fail safe and the load cell failure will stop the pour from the respective Melter spout until the load cell is replaced. This will force the LAW Facility into a single pour mode of operation with the Melter's opposite spout. Single pour operations cause higher Pour Cave temperatures and higher container temperatures, which may lead to the early failure of the second load cell monitoring the single pour operation. If the load cell does not stop a pour on high container glass weight, overfill of container will impact facility throughput, require immediate maintenance actions, result in a large contamination cleanup effort, and impose unplanned costs on the facility.	Install an Elevator load cell that is rated for the temperature of the installation area.

Table A-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		Supplier's Submittal - Elevator Lift Table Weldment, section BB). If the Elevator steel starts at a temperature of 105°F the hot lifting arm and Serapid chain will increase this temperature until an empty container is raised to the pour position. The temperature of the load cell will probably be over 95°F since it will be inside the insulation and in contact with the Elevator steel.		
LPH-PC-1-V026	Indeterminate specification of mode of operation for the Model 60 series Container Elevator load cells may cause problems if an improper mode is used.	The Elevator Vendor Manual 24590-CM-POA-MJW0-00001-11-00001, chapters 4, 5, and 6, beginning on page 319, details the various operating modes the Model 60 series load cell controller can perform: Counting Mode, Known Container Weight, Accumulation Mode, Truck-in/Truck-out, and several other operating modes detailed in the vendor manual; it is a versatile instrument. At first glance, the Accumulation Mode given on page 323 appears to be the mode to choose. However, the LAW containers will be continuously filled for a one hour period with a constant stream from the pour nozzle and the Vendor Manual page 323 says if motion is occurring when an accumulation is requested, then a "Mot'n Delay" prompt is displayed until motion ceases. This may make weighing the container problematic when the weight is continually increasing during the pour.	If the "Accumulation Mode" is selected, then a continuous pour will cause continuous motion and when the control system requests an accumulation, a "Mot'n Delay" prompt is displayed until motion ceases.	Specify a proper instrument mode of operation to preclude overfill of a container
LPH-PC-1-V028	It appears the control system will allow a full container to be raised to the pour position. This will increase the risk of overfilling a container.	LPH System Description, Section 7.2.1, page 36, says that each Elevator has a set of load cells to determine the state of the container prior to pouring: whether the container is full, partially full, or empty. The intent is not to raise a full container to the pour position and initiate another pour because it may overfill a container. 24590-LAW-J3-LPH-01014, LAW Container Pour Handling System LPH Elevator Weight LPH-ELEV-00001, 00002, 00003, and 00004, pass signals to drawings 24590-LAW-J3-LMP-00008, LAW Melter 1 Discharge Airlift Instrument Air Valves, and 24590-LAW-J3-LMP-00010, LAW Melter 2 Discharge Airlift Instrument Air Valves, to indicate a full container is present and to override close the respective melter airlift valve.	The J3 drawing 24590-LAW-J3-LPH-01014 does not follow the intent of 24590-LAW-3YD-LPH-00001, System Description for the LAW Container Pour Handling System (LPH), and a partially full or completely full container could be raised to the pour position.	Update the LPH system Description to reflect how the control system will control the system. If the control system will not perform/provide an acceptable control scenario to meet System Description requirements, revise the control system.
LPH-PC-1-V029	During shift turnovers, if a partially filled container is placed on the Turntable for the next shift to complete the filling process, the oncoming Operator may not know a partially filled container is present if turnover is not proper. If the weight of the "empty" container is tared upon lifting it with the	• 24590-LAW-M1-LPH-00001, Mechanical Sequence Diagram (MSD) For LAW Vitrification System LPH, page 36 of 37, step 3.1 has the Operator determining that the pour cycle is complete and that an Empty Container is staged in Import/Export position of Turntable. Determining an empty container is staged in the Import/Export position of the Turntable may be difficult. The operator must do it by reviewing shift	A container can be overfilled if the Conduct of Operations is not strictly adhered to.	Strictly control the topping off of a previously poured container with an Operating Procedure. Install instrumentation (cameras) and lighting to allow the operator to inspect the container internals after moving the container to the Pour Cave Turntable.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	elevator, the container may be overfilled.	or turnover logs. The container is sitting on the Turntable in the Pour Cave with its 16" diameter opening in the top flange of the container about 12 feet in the air. There is no camera in the Pour Cave that can look down through the 16" diameter opening in the top of the container and see the bottom of the container. There will probably not be enough light inside the container for the operator to see anything if a camera was available. It is unclear how the Operator determines the container is empty other than written logs. • Further, during the life of the facility, there is the possibility that a container will be partially filled and the pour will be interrupted due to a problem in the facility. This will result in the situation where a partially full container must be raised to the pour position and filled to 90%. A container that has had glass poured into it undergoes thermal oxidation as a result of the glass pour; a new container is bright stainless steel, and the poured container is discolored. So if a container is 30% or more full, the operator should be able to see it in the camera. However, the container overpack is 29 inches tall; a container could have 20 inches of glass poured in it and the resulting container discoloration that will be hidden by the overpack. The infrared camera will not detect a glass level in a cold container. Overfilling this container may be problematic if the load cell is tared.		
LPH-PC-1-V030	Non-installation of Pour Cave MSMs transfers items to the LAW Facility Operations Contractor. Insufficient equipment complicates recovery operations and increases the risk of the spread of contamination; may impose operational delays.	While the Pour Cave windows have penetrations for MSMs above the windows, no MSMs are called out on the drawings. They are shown on drawings 24590-LAW-P1-P23T-00005, Equipment Location Plan EL. (-) 21'-0"/ Area 4, Note 8, and 24590-LAW-P1-P23T-00006, Note 7, as being shown for space allocation only. LPH System Description, Section, page 32 states the MSMs will be installed or removed as needed. Section 6.2.19, page 32 and 33, describes tasks the MSMs may perform on an as needed basis. The WTP Project has procured spare MSMs and is holding them in the spares inventory for use as needed. The WTP Project is not providing any MSM tools for use in the pour caves and they will have to be developed / designed / imported on an as needed basis.	Pour Cave recovery efforts may be complicated and delayed if the Operators have to move MSMs from another location and work around the inability to easily import MSM tools into the pour caves.	Provide MSMs or other equipment capable of performing Pour Cave recovery operations.
LPH-PC-1-V031	Cracking of the Pour Cave viewing windows may limit viewing.	The Pour Caves viewing windows are overheated by the close proximity of a filled LAW container sitting at the cooling position on the Turntable. 24590-LAW-M4C-C5V-00001, CFD Analysis of LAW Pour Caves (with Additional Cooling) and Finishing Lines, Section 8 and	Pour Cave recovery efforts may be complicated and delayed if the Operators have to work around cracked viewing windows.	Remove the Pour Cave windows, install video monitors at the Pour Caves, and install more replaceable cameras in Pour Cave to replace the viewing window functionality.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		calculation 24590-LAW-M4C-C5V-00005, Conclusions Section 8.3, sheet 29, conclude the Pour Cave viewing window limit of a 2°F per hour heat-up rate is exceeded for the various configurations and thermal shields analyzed. It is unclear what the WTP Project path forward is to prevent overheating the Pour cave shield windows with a cooling container in the turntable cooling position.		
LPH-PC-1-V032	• Contamination on the surface of the Container Lower Overpacks may be physically pressed and imbedded in the lower surface of the container at 8 locations. The indentations will increase complexity of the decontamination process since "indentations" are being decontaminated rather than a smooth cylinder. • Thermal distortion of the Lower Overpack may cause binding of the container and Overpack.	Calculation 24590-LAW-M4C-C5V-00001, Figure 47, sheet 116, reports that during glass pour number 1 the maximum container surface temperature will be on the order of 2,100°F. Calculation figure 46, page 116, says the peak average container temperature is 1,413°F. However, during the first pour, the molten glass fills the lower ¼ of the container and thus the bottom of the container will be closer to glass temperature than the container average temperature. The projected mean coefficient of thermal expansion for 304 stainless steel will be on the order of 12.94 x 10-6 in/in °F in a temperature range of 32°F to 2,100°F. The container diameter will thermally expand and increase from 48" to about 49.26". The relatively cool Lower Overpack has eight, ½" thick, 4 ¼" tall, alignment ribs in the bottom of the Overpack with an inside diameter of 48.600 +/- 0.10". Per Engineering Calculation Change Notice 24590-LAW-M4E-C5V-5, the container overpack will heat up to 450°F to 638°F 2.5 hours after the pour starts. Vendor submittal 24590-CM-POA-MJW0-00001-02-07 shows high temperature vertical stripes on the Overpack where it appears the container is hitting the interior ribs and transferring heat due to direct conduction. Vendor submittal 24590-QL-HC4-W000-00085-T07-02-00001, Structural & Thermal analysis of pour cave elevator/overpack, shows the temperature of the overpack one hour after the pour starts. This thermal analysis also has high temperature vertical stripes in the vicinity of the overpack ribs. The LAW Container will heat up and expand much faster than the Lower Overpack. There appears to be nothing that prevents the container from expanding around the ribs and yielding to form 8 indentations (1/2" wide, 4 ¼" tall", & 1/3" deep) around the lower circumference of the container. These indentations may affect the ability of the LFH System to decontaminate the container and the LFH swabbing system to swab the container.	• Contamination will be pressed into the container due to the differential expansion of the container relative to the Lower Overpack. Further the container will be indented by the Lower Overpack ribs and make decontamination and swabbing more problematic. • Not slotting the upper rim flanges as recommended by the Vendor performing a thermal analysis of the overpack, may lead to thermal distortion of the Lower Overpack rim flanges after repeated thermal cycles to 600+°F over several years of operation. • If a container becomes stuck inside a Lower Overpack, there does not seem to be a way to remotely un-stick the container.	• Remove the Lower Overpack ribs as recommended by the analysis in Vendor submittal 24590-QL-HC4-W000-00085-T07-02-00001. • Cut slots in the Overpack upper rim flanges recommended by the analysis in Vendor submittal 24590-QL-HC4-W000-00085-T07-02-00001.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		Given the above, the overpack will also cool and thermally contract faster than the filled container. Uneven heating / cooling cycles can cause distortion in metal parts. 24590-QL-HC4-W000-00085-T07-02-00001 recommended changes to the Lower Overpack such as cutting notches in the overpack support rings and removing the increase in thickness in the lower overpack alignment webs. These recommended changes were not done by the WTP Project per the rationale given in CCN 226706 WTP Rationale to close LAW Overpack/Elevator Technical issue 2009-000. Without the notches in the overpack support rings, they are susceptible to thermal distortion which will occur every time a container is poured and will build up over years of operation. If the overpack contracts faster than the filled container, the alignment webs can contact the container. It is unclear how an Overpack stuck to a container is removed from the container		
LPH-PC-1-V034	A review of Maintenance, Operating, Emergency, and Abnormal Operating Procedures for Pour Caves could not be done to verify no vulnerabilities exist.	At the present time maintenance, operating, emergency, and abnormal operating procedures have not been completed by the WTP Project. These items could not be reviewed for the Pour Cave Operational Vulnerabilities. Review of the procedures for adequacy and correctness must wait until the procedures are written, validated, and issued by the Project.	There is a delay in determining if operating vulnerabilities exist for the Pour Cave equipment.	Expedite the creation of the maintenance, operating, emergency, and abnormal operating procedures so they can be reviewed for Operational Vulnerabilities.
LPH-IC-1-V003	ICN Screens don't use equipment noun names.	The LPH System Description, the Mechanical Handling Diagrams, the Mechanical Sequence Diagrams and the Computer Software Logic Diagrams all refer to 24590-LAW-MQ-LPH-TRLY-00001/00002/00005/00006 as the Container Transport Bogie. However, in the System Design Document for LAW Container Pour Handling (LPH) System (24590-LAW-PISW-J-08-0023-01), the ICN screens, "Transport Carts", "Transport Carts - Recovery", "Buffer Store Crane - Bridge and Trolley", "Buffer Store Crane - Recovery" and " LAW Container Pour Handling - Maintenance" all refer to the Bogies as Carts.	The inconsistent use of noun names will encourage confusion among different disciplines. A maintenance person trained on Engineering and Operations documents will be confused by the screens. Screen Captures made for reports or troubleshooting or for the Traveler verifying the Waste Acceptance Criteria will not be consistent with other facility documentation. This is not proper from a Conduct of Operations perspective.	Revise the ICN screens to use labels that are consistent with facility documentation. .
LPH-HST-1-V001	LAW Pour Cave Hoist Data Sheet Inconsistencies	LAW Pour Cave Hoist data sheets (24590-LAW-M0D-LPH-00053/54/55/56) do not provide a clear basis for the design. The hoist calculation that is referenced is cancelled, the specification that is inaccurately referenced, and there is no documented basis for the operating requirements (number of lifts per day, moves per day, and operating envelope).	• Inconsistent design basis • Inadequate design margin • Potential for undersized equipment	Provide a detailed analysis of the requirements of the pour cave hoists. Establish a bounding design and document the basis in a formalized document that provides the specific inputs used in the design (provide details for hoist sizing, operating envelope, number of movements, travel speeds, etc.). Review this information against what is procured

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				and define what requirements need to change or what items already procured need to be modified to meet the requirements. This analysis needs to be documented as well.
LPH-HST-1-V003	LAW Pour Cave Hoist High Hook Limit Related to Preliminary Container Recovery Frame Design	The high hook limit of the Pour Cave hoists (LPH-HST-00001/2/3/4) is adequate for container handling into/out of the turntable as well as lifting the proposed container recovery lifting frame during off-normal events. The design of the recovery lifting frame (LPH-RCVY-00003) is preliminary and based on the proposed 24590-LAW-M0-LPH-00024, Rev. 0, Design Proposal Drawing - Container Recovery Lifting Frame, the lifting flange is inadequate to support the load. Any future changes to the lifting frame design must remain within the bounds of the hoist high hook envelope. The current recovery lifting frame DPD does not reference the hoist operating envelope limitation or bound the frame to any specific dimension.	• Inconsistent design basis • Inadequate design margin • Potential for Operational Impacts and Risks to Commissioning Phase	Establish a bounding design envelope for the container recovery lifting frame and complete the design for it. Provide a design that is consistent with the requirements for off-normal events (load limit, flange design that can be grappled, flange design that can support the load limit, etc.).
LPH-BFSTR-1-V002	Additional interlocks needed for transfer corridor shield doors.	24590-LAW-M0D-LPH-00030, Mechanical Handling Data Sheet Shield Door, Transfer Corridor, North, and 24590-LAW-M0D-LPH-00031, Mechanical Handling Data Sheet Shield Door, Transfer Corridor, South and design proposal drawings 24590-LAW-M0-LPH-00012001, Transfer Corridor Shield Door (South), and 24590-LAW-M0-LPH-00013001, Transfer Corridor Shield Door (North), requires a door closed and door open position sensor. These door position sensors are utilized as sequence specific interlocks, per 24590-LAW-M1-LPH-00001 Mechanical sequence diagram for system LPH, to ensure the buffer store bridge crane is prevented from colliding with shield doors during the transition from the buffer storage area to the store maintenance area. However, no such interlocks exist for the buffer store crane bridge device specific interlocks, per 24590-LAW-M1-LPH-00001 Mechanical sequence diagram for system LPH.	Additional risk of a collision between the crane or load with a closed maintenance shield door. This door could be left closed after a maintenance event and the operator will have to totally rely on visual methods to ensure the path is clear.	Add the shield door position sensor inputs as an added interlock for all crane bridge movements. This will lower the risk of a collision due to human error.
LPH-TOOL-1-V001	Inadequate design basis documentation.	Failure to provide accurate design requirements in data sheets, drawings, and test documentation.	Maintenance and operations will spend time researching and establishing the design basis for equipment.	Revise design and fabrication documentation to ensure accurate and as-built information.
LPH-TOOL-2-V001	Inconsistent grapple load rating.	Mechanical Handling Data Sheets - LPH-LAW Product Container Grapples Pour Cave 24590-LAW-M0D-LPH-00009, 24590-LAW-M0D-LPH-00010, 24590-LAW-M0D-LPH-00011, 24590-LAW-M0D-LPH-00012, 24590-LAW-M0D-LPH-00013, 24590-LAW-M0D-LPH-00014, and 24590-LAW-M0D-LPH-00015 LPH-LAW Product Container Grapple Buffer Store, all require the	Confusion with basis of design.	Increase the grapples safe working load design to 25,000 lbs. to handle all container conditions.

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		grapple load capacity to be 10 ton (20,000 lbs.). However, 24590-WTP-3PS-MQL0-T0003, Engineering Specification for Special Grapples and Lifting Devices, section 3.8.2.1 requires a safe working load of 16,500 lbs. The 24590-WTP-ICD-MG-010015 (ICD 15), Interface Control Document for Immobilized Low Activity Waste, allows the mass of each package to not exceed 10,000 kilograms (22,046 lbs.).		
LPH-TOOL-2-V002	LAW production container volume, weight, and center of gravity calculation, 24590-LAW-M0C-LRH-00004, does not include an Overpack condition.	An abnormal condition could occur if the container cannot be decontaminated and over packing is required to be added to the container.	Special container handling devices will be required to handle off-normal conditions	Revise calculation to include the addition of over packing material to the outside of the container. This will provide a basis for future non-conforming container handling designs.
LPH-TOOL-2-V003	Grapple temperature limitations.	24590-QL-POA-FH00-00001-08-00001, Supplier's Submittal - LAW Container Grapple Stress Analysis, indicates that the reserve factor is barley met with a load of 16,500 lbs. and a flange temperature of 600°F. The CFD Analysis of LAW Pour Caves and Finishing Lines, 24590-LAW-M4C-C5V-00001, indicates the surface temperature of the pour container neck and flange vs. time will be much higher than 600°F. The analysis, shown in figure 49, stops after 20 hours but the trend is to be well above 800°F after 28 hours. This temperature range would prevent the container movement under the single pour operating conditions. The alternating pour operating conditions may or may not be an issue based on this data, so the analysis should be redone to include additional time and cooling conditions.	Since the grapple is a common design the temperature limitation is as important as the safe working load limitations. These conditions could lead to unsafe lifting conditions and/or prevent the melter single pour operating condition.	Add grapple markings to clearly identify temperature limitations the same way safe working loads are identified. Consider adding instrumentation to directly measure the container flange temperature, in the pour cave, prior to using the grapple.
LPH-TOOL-2-V004	Grapple excessive load testing.	24590-WTP-3PS-M000-T0002, General Specification for Remote and Mechanical Handling Equipment Design and Manufacture, Section 3.4.3.10, indicate that lifting attachments shall be factory load tested at 125% of rated load in accordance with ASME B30.20-2010, Below - The-Hook Lifting Devices, Safety Standard for Cableways, Cranes, Derricks, Hoists, Hooks, jacks, and Slings. The ASME B30.20, Below the hook lifting devices, section 20-1.3.8.2 indicate that test loads shall not be more than 125% of the rated load unless otherwise recommended by the manufacturer. The testing requirement in 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 6.4.6.c requires the grapple static load test to be performed at 150% of the SWL and held for 15 minutes.	Confusion with basis of design.	Revise BNI procurement process to ensure vendors test equipment according to contractual documentation and that all requirements are consistent between documents.
LPH-TOOL-2-V005	Design requirement not verified in factory acceptance testing.	The design requirement in 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 3.8.2.3 requires the grapple's three fingers to have a combined minimum total contact area of 15 in2. This	Failure to document design requirements.	The requirement should be validated during start-up testing to ensure these critical characteristic are met.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		requirement was not validated in 24590-QL-POA-FH00-00001-13-00003, Factory Acceptance Test Plan for MR36 LAW Grapples and Grapple Stands, and should have been measured as a critical characteristic of the grapple assembly. This requirement is carried into the LAW Production Container Stress Analyses, 24590-LAW-M0C-LRH-00003, which indicates that at hour 20 the container flange temperature is 457°F and can be safely moved without the container flange reaching yield stress limit. However, this analysis container flange temperature does not agree with the CFD analysis, the grapple contact area is less than half the actual grapple contact area, and the container load is assumed to be 16,000 not 16,500 lbs.		
LPH-TOOL-2-V006	Requirements for factory acceptance testing not fully being performed.	• Specification requirements in 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 6.4.7.g indicate the grapple will be tested to ensure it is capable of maintaining its engagement even if the load is laid on its side and the tension on the bail is relieved; the grapple shall then be capable of lifting the load when the hook is raised, all as part of the 20 complete cycles simulating actual operating conditions. The simulated operating conditions test consisting of 20 completed cycles is performed in 24590-QL-POA-FH00-00001-13-00003, factory acceptance test plan for MR36 LAW grapples and grapple stands section 3.A.4, but this step is omitted. • 24590-LAW-3YD-LRH-00002, System Description for the LAW Container Receipt Handling System (LRH), section 4.1.2.1.2, indicates the grapple, in the disengaged position, shall be capable of being inserted into and withdrawn in a vertical direction from a right-circular, cylindrical cavity with a diameter equal to that of the container. This requirement would qualify as a critical dimension and should have been verified during the factory acceptance testing performed and documented in 24590-QL-POA-FH00-00001-13-00003, factory acceptance test plan for MR36 LAW grapples and grapple stands. • The specification for special grapples and lifting devices, 24590-WTP-3PS-MQL0-T0003, section 3.2.2.3 requires the grapple to be capable of being remotely engaged and disengaged from a container that is standing on its base, with the container's centerline within five degrees of vertical. This requirement was not tested or verified in the factory acceptance test plan for MR36 LAW grapples and	Failure to test and document that the design requirements are met.	All required performance design requirement should be performed as part of an additional FAT or demonstrated through analysis.

Table A-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		grapple stands, 24590-QL-POA-FH00-00001-13-00003.		
LPH-BSMF-1-V003	Buffer Store Maintenance Facility Crane (LPH-CRN-00001) issues.	The basis document for the rated capacity of the Buffer Store Maintenance Facility Crane has been cancelled, and the Mechanical Data Sheet has become the "controlling source of the crane capacities". Some dimensional inconsistencies exist between the Mechanical Data Sheet and general arrangement drawings.	Adversely affects ability to confirm design meets requirements and operational envelope	Prepare a document that evaluates potential loads to be lifted by the maintenance crane.
LPH-OR-1-V003	Inconsistencies in the MTBF data for the Buffer Store Crane.	24590-CM-POA-MJKG-00003-15-01, Failure Mode, Effects, Reliability, Maintainability, and Criticality Analysis, which was prepared by the crane manufacturer, states the MTBF is 3,300 hours. However, the MTBF for the crane is listed as 35,040 hours on page 1 of Attachment 9 of CCN068381. The CCN references 24590-CM-POA-MJKG-00003-06-03, Spare Parts List and Cost, LAW Buffer Store Crane, as the basis the 35,040 hours. There is no information in 24590-CM-POA-MJKG-00003-06-03 that justifies the significant increase in the MTBF. To further confuse the issue, Table 75 of 24590-WTP-MDD-PR-01-001, Operations Research (WITNESS) Model Design Document, indicates an MTBF of 730 hours for the Buffer Store Crane. A rationale for which value is the most appropriate could not be located.	Results of the OR Model may be inaccurate because the input data may be inappropriate.	Develop and document a robust logic for the Buffer Store Crane MTBF value to be used in the OR Model and update the OR Model accordingly.
LPH-OR-1-V004	24590-WTP-MDD-PR-01-001, Operations Research (WITNESS) Model Design Document, inconsistencies.	Section 6.6 and Table 71, of 24590-WTP-MDD-PR-01-001, Operations Research (WITNESS) Model Design Document, indicates the number of ILAW containers in the model has been reduced from 18 to 12 storage spaces due to height constraint in the buffer storage area. However, Note 5 of 24590-LAW-J3-LPH-02011001, Sequential Function Chart LPH Filled Container To and From Buffer Storage LPH-CRN-00002, provides the sequencing of how the ILAW containers will be stored in the Buffer Store and Rework Areas and lists 11 storage locations.	Results of the OR Model may be inaccurate because the input data may be inappropriate.	Revise the OR Model to be consistent with the current sequencing and handling strategy.
LPH-CPS-1-V002	Durability of Park/Export Stand thermal insulation material over a 40-year operating life is not documented.	The Vendor's submittal does not provide evidence that the selected insulation material will maintain its insulating properties and protect the floor for over 40 years in the conditions of its application inside the Transfer Corridor L-B025B.	• Inconsistent/inadequate design • Operations concerns • Maintenance concerns	Resume contacts with Pittsburgh Corning Corp and obtain documented evidence of the durability of the selected insulation material over 40 years at 460°F. Modify the existing Park/Export Stands prior to commissioning to provide a way to facilitate the replacement of the insulation material blocks.
LPH-CPS-1-V003	Design of the manufactured Container Park/Export Stands may result in unnecessarily complex maintenance.	Welded retention plates will not make the replacement of the insulation blocks possible (see Note 2) without lengthy hands-on work inside the Transfer Corridor L-B025B.	• Inconsistent/inadequate design • Maintenance concerns • ALARA concerns	Modify the existing Park/Export Stands prior to commissioning to provide a way to facilitate the replacement of the insulation material blocks.

Table A-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LPH-CPS-1-V004	Thermal conductivity of the selected thermal insulating material for the Container Park/Export Stands doesn't meet the WTP thermal conductivity requirement.	Thermal conductivity of the selected insulation material is higher than the thermal conductivity requirement for the material which provides insulation to concrete floor from filled Containers. This material offers less protection than defined by the design requirement.	• Inconsistent/inadequate design • Maintenance concerns	Update calculation 24590-LAW-M4C-C5V-00003 using the actual physical properties of the thermal insulation material and verifies that the 4"-thick blocks are sufficient to meet the 150°F maximum allowable temperature for the concrete floor.
LPH-CPS-1-V006	FAT Test of the Container Park/Export Stands was not conducted in a representative temperature configuration.	The temperatures recorded in the FAT Test Report lead to think that the tests were performed by the Vendor at a much lower "ambient" temperature than the expected average temperature in the Transfer Corridor, and don't actually demonstrate that the concrete floor temperature will remain under the 150°F limit when the Corridor temperature will be 113°F (or higher).	• Inconsistent/inadequate design • Operations concerns • Maintenance concerns	Re-run the heat tests for the Park and Export Stands) in a more representative temperature environment to verify that the concrete floor is not overheated.
LPH-CPS-1-V007	Lack of calculations to support the design and validate the performance of the fabricated Container Park/Export Stands.	There is no documentation (primarily calculations) available that supports the revision of the design of the Stands and validates that the revised final design actually meets the expected performance of preventing damage to the concrete floor from the heat dissipated by the Containers.	• Inconsistent/inadequate design • Operations concerns • Maintenance concerns	Develop documentation (primarily calculations) to validate that the revised final design of the Park/Export Stands actually meets the expected performance of preventing damage to the concrete floor from the heat dissipated by the Containers.
LPH-CTB-1-V005	Performance of IR Transmitters measuring Container surface temperature before export to System LFH is not demonstrated.	Two IR transmitters are used to verify the temperature of the container prior to export to the LFH System. There is no documentation available which describes key features of the transmitters and no evidence that the selected transmitters meet the functional requirements for this essential temperature measurement.	• Inconsistent/inadequate design • Operations concerns	Perform tests of the selected IR Transmitters in a representative environment to demonstrate the performance of these essential Container surface temperature measurement components prior to commissioning.
LPH-CTB-1-V007	Engineering Specification for Transport Bogie design defines a temperature environment not representative of anticipated higher ambient temperatures in the Transfer Corridor.	There are operating conditions and large areas of the Transfer Corridor where the Container Transport Bogies may see ambient temperatures over the maximum specified operating environment of 113°F.	• Inconsistent/inadequate design • Operations concerns • Maintenance concerns	Re-run the Manufacturer's thermal analysis of the Container Transport Bogies for the expected higher ambient temperature range, and verify that the temperatures of the Bogie's most fragile components including the motor and junction boxes remain acceptable.
LPH-CTB-1-V008	Value of the maximum Container weight shown on DPD and in Engineering Specification for Container Transport Bogie is misleading.	DPD and Engineering Specification for the Container Transport Bogie mention a maximum weight of the container at 22,046 lbs. when the maximum filled container mass without lid is 14,902.28 lbs. with a glass density at 2.6 MT/m3 (and 15,422.28 lbs. for the approximate density of glass at 2.7 MT/m3).	Inconsistent design	Revise Note 4 on 24590-LAW-M0-LPH-00026, Design Proposal Drawing Container Transport Bogie, and Section 5.6.2.1.2 of, 24590-WTP-3PS-MQR0-T0003, Engineering Specification for LAW and PTF Bogies, with correct value of product container weight.
LPH-CTB-1-V009	Maximum payload of the Bogie is defined for a service that the Bogie may never be providing during the Facility operating life.	Maximum payload (25,000 lbs.) is defined for the transport of test weights for the overhead hoists located in the Corridor when these test weights should be delivered through a totally different path.	Inconsistent design	Update Engineering Specification 24590-WTP-3PS-MQR0-T0003 and System Description to reflect alternative approach for transporting test weights for the overhead hoists within the Corridor.

Table A-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LPH-BMA-1-V002	Discrepancy in location of Bogie Maintenance Hoist between Vendor's calculation and Structural Steel Drawing.	There is no evidence that the building steel is adequate to allow the Bogie Maintenance Hoist to be used, which may lead to operational administrative controls to limit live floor loads and to increased maintenance efforts.	• Inconsistent/inadequate design • Operations concerns	Re-run 24590-LAW-SSC-S15T-00015, Calculation - Bogie Maintenance Monorail, with the correct location of the monorail and hoist so that the structural resistance of the structural steel in the Bogie Maintenance Area is verified.
LPH-PC-1-V007	Cold commissioning will demonstrate adequacy of container bottom within a modified overpack. This will allow an adequate container to be procured if required.	Informal computations showed the hydrostatic head of the molten glass was sufficient to challenge the proposed LAW container at elevated temperatures and the lower container overpack was modified to promote natural convection cooling and heat transfer radiated from the container. Pours into the container during cold commissioning will demonstrate the falling glass will not heat up a spot on the container bottom and punch a hole in the weakened metal.	If the container will not resist the impact of falling glass on a hot spot, then a glass spill to the pour cave floor will occur. This would require a slightly more robust container to be procured (perhaps with a splash plate on the bottom of the container).	Perform a prototypical pour of the LAW glass, or accept the risk and test the container during cold commissioning. It any case, this item should be resolved prior to hot operations with radioactive materials.
LPH-PC-1-V008	Increased maintenance entries to restore pour cave lighting.	The electrical lighting calculation selected light fixtures reported on Architectural Drawings. The Architectural Drawings were revised to remove the temperature information. A HVAC calculation predicts a varying temperature of between 126°F to 140°F at the light fixture installation location over a 20 hour period as container pour/cooling cycles are performed in the pour cave. It is unknown if the ballasts in the lights are suitable for these temperatures.	Failure of the light fixtures will require maintenance entries into the Pour Cave.	Evaluate the suitability of the electric light fixtures in the pour caves. This item should be done after pour cave temperatures are re-evaluated.
LPH-PC-1-V015	• A motor with an operating surface temperature of 239°F is a personnel hazard. • The Pour Cave Elevator motors are supplied with a 105°C (189°F) temperature rise creating a personnel hazard greater than 140°F. .	• The Vendor supplied Turntable rotation motor has an 80°C (144°F) temperature rise. • Per data sheet 24590-CM-POA-MJW0-00001-06-05, Supplier's Submittal - Turntable Rotary Lock Assembly, the Elevator motor has a 105°C (189°F) temperature rise. If the ambient temperature in the rooms is 95°F, the motor could be at 284°F.	• Operating and Maintenance Personnel in the room could be exposed to high temperature surfaces. • This is a personnel hazard for people working in the immediate area along the Pour Cave walls in rooms L-B012 & L-B014.	Install a removable, expanded metal heat shield around the motor to prevent personnel from contacting the hot surfaces and still enable maintenance to be done.
LPH-PC-1-V016	Missing Vendor documentation needed to support maintenance.	The Elevator/Turntable Vendor Manual 24590-CM-POA-MJW0-00001-11-00001 page 351 of 989 appears to be incorrectly scanned into the file and separated from the remainder of the Vendor information.	If Vendor information is not available when maintenance needs to be done, maintenance will be delayed until the information is obtained.	• Correct the Vendor Manual 24590-CM-POA-MJW0-00001-11-00001. • Perform an extent of conditions review of the WTP PIER data base and determine if this is a unique occurrence. If the review shows there are enough occurrences of lost vendor documents in PADC, take corrective actions as required.
LPH-PC-1-V023	If maintenance must be performed on the modified Pour Cave Elevator Lift Table and it must be lifted from the Elevator, the lift must be planned due the R5/C5 Pour Cave area.	The Pour Cave Elevator Lift Table per 24590-CM-POA-MJW0-00001-03-36 Rev 00D Supplier's Submittal-–Container Overpack Weldment, was modified per Vendor Drawing Change Notice (VDCN) 24590-LAW-VDCN-MH-11-00009, - Modifications to Turntable/Elevator Overpack and WTP Modifications to Elevator Lift Table,	If a lift of the Elevator lifting arm is done using the center-of-gravity located on the drawings, the center-of-gravity will be off and the load will swing upon lift.	Update the 24590-CM-POA-MJW0-00001-03-36 Rev 00D with a VDCN to show the correct weight and center-of-gravity.

Table A-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		to allow natural convection airflow past the container during melter pours. The VDCN removed a 24"x24"x1 ½" piece of material from Piece #4, removed a 24"x66"x1" piece of material from Piece #1, removed a 24"x66"x1 1/2" piece of material from Piece #3, and added a 5.5"x30"x(unspecified thickness) End Plate. Simplistically, the total volume of steel removed from the elevator pour lift table is about 4,701 cubic inches (2.7 cubic feet) and this much steel will weigh about 1,360 pounds. 24590-CM-POA-MJW0-00001-03-36 Rev 00D Note 5 gives the elevator lift table a calculated weight of 2,770 pounds and the drawing gives the XYZ dimensions for the center of gravity for the elevator pour lift table.		
LPH-PC-1-V024	The sides of the Pour Cave Elevators in rooms L-B012 & L-B014 around the location of the door hinges, handles, and lubrication ports may be over 140°F.	While drawing 24590-LAW-DD-S13T-00029, LAW Vitrification Building Main Building Enlarged Pour Cave Plan SS Liner Plate & Insulation @ EL (-) 21'-0", is showing the back of the Elevators insulated with 6" of insulation, nothing appears to be insulating the sides of the Elevator. Per calculation 24590-LAW-M4C-C5V-00001, Figure 36, sheet 107, the Elevator metal temperatures will be a minimum of 150°F.	This is a personnel hazard for people working in the immediate area along the pour cave walls in rooms L-B012 & L-B014.	Provide removable expanded metal barriers to protect personnel from high temperature surfaces.
LPH-PC-1-V025	If improper oil is used in the Container Elevator, the heat will degrade the oil and cause Elevator gear drive problems. If the oils in the gear reducers degrade at the same rate, all four Elevators will experience problems at approximately the same time.	The elevator gear reducers are shipped without oil. The elevator Vendor Manual 24590-CM-POA-MJW0-00001-11-00001 page 278 of 989 gives a table of suitable lubricants versus ambient air temperature. However, the oil selected is not specified.	The Elevator gear reducers will have a shorter service life. If the oils in the gear reducers degrade at the same rate, all four elevators will experience problems at approximately the same time.	Use Elevator gear reducer oil suitable for the temperature service.
LPH-PC-1-V027	LPH System Descriptions which is to be used to document the system should reflect the as-built system and the reason for the design.	System Description 24590-LAW-3YD-LPH-00001, Section 6.2.10, page 25 does not describe the changes done to the Container Lower Overpack to promote natural convection cooling of the container. Figure 6-8, page 27 does not reflect the changes to the Container Elevator done by 24590-LAW-VDCN-MH-11-00009 on 11/15/2011 to promote natural convection cooling of the container. Facility documents such as the System Description which are to be used to document the system should reflect the as-built system and the reason for the design.	Inadequate description of the reason for the system design may cause problems as items are lost due to the failure of tribal knowledge degrading over the years.	Update the LPH System Description to reflect design changes.
LPH-PC-1-V033	• Improper specification of equipment operating in high temperature environments will lead to premature failure of the Pour Cave Shield Doors. • Inadequate specification of the setpoint of thermal switches & motor temperature rises can cause	• Vendor Submittal 24590-CM-POA-ADDH-00005-02-15 is the Operating Manuals / Instructions for Pour Cave Shield Doors LPH-DOOR-00009/00010/00016/00017. The Vendor Manual says that for a proper installation the drive installation site (motors & brake motors) ambient temperatures should be below 104°F. It also says the drive installation site (for gear motors & gear reducers) should be selected	• The Pour Cave Shield Doors will fail early in the service life requiring manned entries into the Container Transfer Corridor and manual recovery of the doors with come-alongs or winches. • The Shield Doors will not operate upon command in high ambient temperature	• Analyze the Pour Cave Shield Door ambient temperatures and supplied door motor/brake/gear motor/ gear reducers and determine if the installation must be upgraded. • Specify and procure replacement motors for the high ambient temperature conditions as required.

Table A-8. Vulnerabilities Identified for Container Pour Handling (LPH). (25 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	motors to trip out when exposed to high ambient temperatures.	to ensure the ambient temperatures are below 104°F. Mechanical Data Sheets - Shield Doors, Pour Cave, 24590-LAW-M0D-LPH-00016/00017/00018/00019 state the maximum operating temperature of the Pour Cave Shield Doors is 175°F. It is unclear whether WTP engineering analysis determined the installation of the Pour Cave Doors was satisfactory from an operating temperature point of view. It is unclear if higher operating temperature greases and oils were specified to replace the vendor supplied greases and oils. • In addition, the Operating Manuals show the motor wiring diagrams for the Pour Cave Shield Doors. In zone B2 for the motor wiring diagrams there appears to be a thermal switch (TS) on terminal #5 with no setpoint indicated.	conditions requiring a manned entry to open/close them.	

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Table A-9. Vulnerabilities Identified for Melter Handling System (LMH). (3 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LMH-F-12-V-01	The current design of the LAW Facility will not support the operation of a 3rd melter without significant facility design revision to accommodate the addition of necessary support equipment such as the UPS system, pour cave heat removal system, LVP and LOP systems, and the buffer storage heat removal system. In addition, the BOF cooling water supply capacity is not sufficient to support 3rd melter operation. There is not sufficient space in the existing LAW Facility to accommodate the necessary equipment to support operation of a 3rd melter.	The basis for this vulnerability is the facility description, the results of this (2014) operational review and existing identified issues. Specifically, the UPS system is undersized, the preliminary results from heat removal capability for the pour cave and canister storage is not sufficient to support the additional heat load from operation of a 3rd melter. In addition, the BOF cannot support the loads associated with operation of a 3rd melter.	The current design of the LAW Facility does not support the addition of a third melter without design changes	• Redesign necessary equipment to support operation of a 3rd melter. The following systems are identified as needing redesign but 3rd melter support is not limited to the systems noted below: - UPS - LVP - LOP - Heat removal in canister store - Heat removal in pour cave - BOF • Consider adding an installed spare melter into the 3rd melter position and keep it isolated from the LAW Facility until it is needed to replace a spent or failed melter.
LMH-S-10-01	The facets of location, human resources, transportation, and parts availability need to be resolved to support fabrication of replacement melters.	Based on a need for replacement melters by 2023 the project needs to start planning for location, parts availability, expertise, and transport for these long lead time components.	Lack of replacement melters available when needed may have significant production ramifications.	Determine a schedule of need, a location for melter assembly, parts availability, and a method of transport for replacement melters. This scope lies with DOE.
LMH-F-15-V-01	• It has not been demonstrated that the 0.1g new melter acceleration limit is adequate to protect the melter systems (refractory). • It has not been demonstrated that the melter winch and rail system will operate within the 0.1g acceleration limit. • It should be established what the correct maximum melter acceleration is and that value should be defined as the criteria for every new melter.	• The torque setting required may be changed by the operator based upon melter condition, ambient temp., age, etc. The basis for these torque settings is not defined. • The Load Limiting feature when activated will slow the winch to a stop based on programmed ramp settings. The basis for these ramps is not defined. • The melter rails are covered with formed metal sheeting to protect the rails from obstructions or minor damage. Requirements for inspection and monitoring are not defined. • No preservation maintenance program has been established for the wheels/rollers and rails or other rotating LMH component to ensure that false brinelling does not occur. • Critical attributes have not been defined and the associated requirements established. • The documented FAT neglected to address numerous critical functions of the winch, pulleys and cable. • No SME was identified that could address the design basis for the items above.	Melter damage could occur and reduced glass production could result from; • Failure to correctly establish and consistently apply acceleration limits requirements for new melters. • Failure to adequately control winch acceleration rate requirements. • Failure to monitor and maintain melter rail conditions. • Failure to test critical winch and rail components against critical attributes and requirements. • Inadequate functional requirements definition may result in negative impacts to new melter operation and throughput.	• Develop and document the basis for the test torque setting ranges and the Load Limiting feature programmed ramp settings including the activities necessary to maintain them. Off-normal conditions should also be considered. • Establish a periodic inspection program and monitor melter rail conditions regularly. Melter rails and wheels/rollers should be inspected and refurbished before each new melter movement. • Definitively establish the acceleration and deceleration limits for new melters and document the basis. Monitor all new melters against the established acceleration criteria. • Develop long term plans that address melter equipment obsolescence, warranties, and replacement or refurbishment for all equipment procured. • Identify and document all critical attributes of equipment and components associated with the winch. Thoroughly test all those components accordingly and document these test.

Table A-9. Vulnerabilities Identified for Melter Handling System (LMH). (3 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		• It has not been determined whether the accelerations imparted to the melter when moved should be monitored only during commissioning or for every melter import.		• Identify a Subject Matter Expert that can assume responsibility for the basis of the design criteria used in the winch and rail design.
LMH-F-05-V-01	The detailed process for containment of the spent/failed LAW melters has not been defined.	• Since this process has not been defined: • A timeline of melter decontamination and removal from the facility is undefined. • All equipment is unspecified, not designed and cannot be purchased. • Resources and funds for the task have not been allocated.	If the melter containment process is left undefined the removal of the melter will impede the new melter moving into operating position causing a delay in production.	Develop a detailed process definition that will allow for procurement of needed equipment and account for allocation of funds during operations.
LMH-S-11-V-01	Alternate vendors for refractory should be identified and plans/schedules for future replacement melter materials defined.	The existing refractory vendor has ceased production. Refractory production for a new melter will require 1 ½ years lead time plus waiting-list time once a new vendor has been selected.	Construction of a replacement melter will be a critical path activity. Failure to adequately plan, procure and execute all of the required activities for replacement melter fabrication will have a negative impact on process throughput and glass production .	Alternate vendors for refractory should be identified and plans/schedules for future replacement melter materials defined.
LMH-S-11-V-02	A consistent philosophy regarding manual and/or remote operations and maintenance should be determined, and the plant design should then be adjusted accordingly.	• System descriptions are inconsistent regarding manual versus remote O&M activities. • This is a configuration management issue.	Inconsistent expectations across systems could lead to incompatible system interactions.	Develop a consistent philosophy regarding manual and/or remote operations and maintenance should be determined, and the plant design should then be adjusted accordingly.
LMH-W-07-V-02	Inadequate melter decontamination approach.	Decontamination of the bottom of the melter is required by SIPD to be performed prior to moving the melter to L-0113; WTP plans to decontaminate bottom of melter in L-0113.	Extended production outage due to delay in melter export to effect alternate method of decontaminating bottom of melter.	Provide systems for decontamination of melter exterior, including the bottom, prior to commissioning to ensure capability to decontaminate is adequate.
LMH-S-16-V-01	There are gaps in the LAW process of designating components to owning systems.	The glass pour seal head, preparation for disposal of the melter, list of components in LMH description and placing the melter on and off of a transporter are examples of the system designator gaps immediate to LMH.	Equipment that is not “owned” by a system will cause inefficiencies when operating and maintaining equipment.	Designate each component to a system to ensure there are no gaps in the operations and maintenance of the equipment.
LMH-F-01-V-01	Melter and facility dimensions should be carefully tracked and controlled to ensure melter ingress/egress access to the LAW Facility. Careful consideration should be given to the installation of any and all additional components in this area, or any modifications to the melter design	• When the melter was moved into place through the rollup door it had the lid and sides installed. The limiting clearance was from the top of the melter lid to the underside of the facility structural beam; which was approximately 3/8 inch. While this 3/8 inch clearance is nominally acceptable, it is dependent upon numerous critical dimensions that must be tracked closely during melter fabrication, (i.e., melter lid warping).	• Melter may not fit into LAW Facility. • Melter ingress and egress could be complicated/precluded by the installation of utilities and equipment.	Melter, utility and equipment dimension stack-up should be carefully tracked to ensure melter ingress/egress access to the LAW Facility is maintained and not impeded.

Table A-9. Vulnerabilities Identified for Melter Handling System (LMH). (3 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	that could impact the nominal clearances available.	• Since the time when the melter frame was moved into place, numerous cable trays, utilities and other equipment have been installed between the melter and the roll-up doors that would impede melter ingress and egress. While the existing equipment could be temporarily relocated to facilitate removal of a spent melter, it could complicate spent melter egress and new melter ingress.		
LMH-F-14-V-01	System LMH does not address the 0.1g acceleration limit for a transport vehicle.(i.e.. sub compartment transporter)	24590-WTP-ICD-MG-01-003 (ICD-03), Interface Control Document for Radioactive Solid Waste, Table 1, item 6 states the WTP contractor shall load RSW onto TOC transport vehicles and provide documentation as requested by TOC to support RSW transportation.	Left unresolved, this issue may reduce throughput of the LAW Facility. If a melter is loaded with refractory at a nearby location, then it will have to be transported to the LAW facility. During transport the melter and/or transport vehicle is limited to an acceleration of 0.1g. If the limit is exceeded an inspection may be necessary. This may cause a delay in startup.	Consider use of submarine compartment transport vehicle in use at Hanford to transport melters including 0.1g acceleration instrumentation.
LMH-CO-13-V-01	The current LMH system excludes the work scope of transferring a melter between the melter rails and a melter transport vehicle.	Current design and exclusions noted in the LMH system excludes the work scope of moving a melter to or from the melter rails	This issue could result in a reduced throughput if left unresolved	Identify a method, system or equipment to transfer a melter from the melter rail system to a transport vehicle.
LMH-W-07-V-01	Inability to drain free liquids from cooling panels in spent melters	In preparation for waste disposal the melter needs to be drained of all free liquids. No plan or process has been identified to remove free liquids (water) from the cooling panels of a spent melter.	Inability to dispose of the spent melter.	Determine a method to drain all free liquids from a spent melter in preparation for waste disposal. Determination should be made prior to loss of access to the cooling panels during fabrication.
LMH-CO-13-V-02	The current LMH system does not include disposal of a spent/failed melter	Current design and exclusions noted in the LMH system description.	This issue could result in a reduced throughput if left unresolved	Identify the final disposal criteria and prepare procedures and align equipment to implement disposal plan.
LMH-S-11-V-03	Section 3.5 of 24590-LAW-3YD-LMP-00001 should be revised to use the correct reference.	Section 3.5 of 24590-LAW-3YD-LMP-00001 references deleted sections and no valid alternate reference has been provided.	No valid alternate reference has been provided.	Section 3.5 of 24590-LAW-3YD-LMP-00001 should be revised to use the correct reference.

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Table A-10. Vulnerabilities Identified for Container Finishing Handling (LFH). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LFH-LID-1-V001	LAW container lid ANSI N14.5-1997 Radioactive Materials – Leakage Tests on Packages for Shipment requirements do not match in the System Description as stated in the ILAW Product Compliance Plan.	24590-LAW-3YD-LFH-00001, System Description for the LAW Container Finishing Handling System (LFH), requires ANSI N14.5 leak tightness and testing but this requirement does not match 24590-WTP-PL-RT-03-001, ILAW Product Compliance Plan, closure and sealing sections. ANSI N14.5 requirements are included in Section 4.4 of the System Description but the ILAW Product Compliance Plan has been revised (Sections 3.2.2.2 and 4.1.12.1) to eliminate the ANSI requirement.	• Confusion in design requirements can lead to inadequate seal design and may require a redesign in the future. • Inadequate Discipline in Design Execution and Control • Transfer of Scope and Risk to the Commissioning Phase	• Define correct package type and seal requirement and update relevant documents. • Establish the correct test method/methodology and update relevant documents.
LFH-LID-1-V002	LAW container leak testing was not implemented correctly.	Leak tests performed by the lidding manufacturer, was not performed to the correct methodology. Leak rates in the tests do not match the specification limits and 1 of 6 lids failed the test. In addition, gasket/seal design may not be adequate to meet the LAW Facility "remote" environment and can cause future seal failures.	• Inadequate testing and non-robust seal design and may require a redesign in the future. • Inadequate Discipline in Design Execution and Control • Transfer of Scope and Risk to the Commissioning Phase	• Establish the correct leak rate limit and update all relevant documents. • Establish the correct test method/methodology and update relevant documents. • Execute valid leak test. • Assess if seal design requires modification (seal/gasket type, threaded vs. welded, etc.).
LFH-LID-1-V003	Lid seal design and method of lid deployment increases chances of seal damage.	The LAW container lid seal is vulnerable to damage as observed in DOE 09-WTP-077 Contract No. De-AC2701RV14136 – the U.S. Department of Energy, Office of River Protection (ORP) Surveillance of the Low-Activity Waste Facility (LAW) Container Lidding Seal Leak Testing S-0-WED-RPPWTP-006. Not only is this type of seal suspect to damage, the seal is pre-attached to the underside of the lid and stacked within a lid holder without any additional protection. The stacking of lids and pre-compression of this type of seal, prior to use, can cause it to be ineffective.	• Inadequate design will lead to ineffective seal • Inadequate Discipline in Design Execution and Control • Transfer of Scope and Risk to the Commissioning Phase Inconsistent design basis • Inadequate Consideration for Conduct of Operations	• Revise lid gasket/seal type that is more robust and not suspect to damage. • Revise underside of lid to provide protection of seal when stacked in lid holder (i.e., standoff integrated into the lid that keeps the seal surface from contacting the next lid it is stacked on).
LFH-LID-1-V007	Lidding Jib Crane FAT Test Deficiencies.	There several requirements of the lidding jib crane specification (24590-WTP-3PS-MJKJ-T0003) that were not tested during FAT and are not covered by a test acceptance criteria in the LFH System Description (24590-LAW-3YD-LFH-00001). The items/functions not tested can impact commissioning or future production when called on to perform. Of the items tested, the FAT does not validate the performance requirements adequately.	• Several features are not fully tested to simulate the bounding conditions and the acceptance of the FAT report places a false sense of security on the adequacy of design. • Inadequate Discipline in Design Execution and Control • Transfer of Scope and Risk to the Commissioning Phase • Inadequate Consideration for Maintenance and Waste Requirements • Inadequate Consideration for Conduct of Operations	• Establish an adequate FAT test plan that meets the requirements of the engineering specification. • Undertake a proof test to ensure the existing jib cranes can adequately meet all the tests required in the plan and document the results.
LFH-LID-1-V008	Finish Line MSMs design temperature conflicts with CFD analysis of finishing line equipment.	Calculation 24590-LAW-M4C-C5V-00003 provides radiant heat data for finishing line equipment. The maximum temperature imparted on the MSMs is calculated at 233°F, while the data sheets for the same	• Incorrect values used to design the equipment may lead to premature failures.	• Provide a detailed analysis of the environmental requirements of the MSMs. • Establish the bounding scenario that provides the basis for temperature values within the finishing line.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		equipment only show a maximum temperature of 175°F. MSM data sheets (24590-LAW-M0D-LFH-00120/121/122/123, North Finishing Line [LFH-Manip-00025/ 00026/ 00027/00028]) do not accurately reflect the correct environmental conditions in which the MSMs will be subjected to and this can lead to premature failure of equipment.	• Inadequate Discipline in Design Execution and Control • Throughput not Adequately Underpinned • Transfer of Scope and Risk to the Commissioning Phase • Inadequate Consideration for Maintenance and Waste Requirements • Inadequate Consideration for Conduct of Operations	• Update data sheets and verify with vendor if changes are required to meet the environment. • Make changes where necessary (different lubricants, localized cooling, higher inspection frequencies, etc.). Review with HVAC if hoist cooling requirements affect HVAC design.
LFH-LID-1-V009	Lid holder decontamination and refilling process has not been determined.	The LFH lid magazine stores lids in a vertical stack. As lids are used by the lid press, the removable lid holder must be moved to Room L-0217C for decontamination and Room L-0217A for refilling. Lids must be manually loaded in the lid holder. The lid holder holds 35 lid-and-seal assemblies, with each lid weighing 45 lbs. The means to load magazines has yet to be determined and is an open issue as documented in Section 6.2.3.2 of the LFH System Description (24590-LAW-3YD-LFH-00001, Rev 2 issued in 2010).	• No current design to execute a safe way to decontaminate and refill lids. • Inadequate Discipline in Design Execution and Control • Throughput not Adequately Underpinned • Inadequate Implementation of ALARA Principles • Transfer of Scope and Risk to the Commissioning Phase • Inadequate Consideration for Industrial Safety • Inadequate Consideration for Conduct of Ops •	• Provide an effective method to safely decontaminate lid holder in L-0217C. • Install fixed lid magazine stand in L-0217A to safely refill lid holder. • Install jib crane with lid lifter dedicated for lid refilling. • Purchase 2 spare lid holders (one for each lidding line) to minimize downtime and keep lids refilled at all times.
LFH-LID-1-V010	Lid Press Tool and Lid Recovery Tool design temperature issues.	The lid press tool and lid recovery tool are specified to engage on a 175°F container flange (Table 3-4 of 24590-LAW-3PS-HCTH-T0001). CFD analysis (Figures 142 and 145 of 24590-LAW-M4C-C5V-00001) shows the flange temperature will range between a low of 335°F to a maximum of 475°F. Pneumatic tubing used in the fabrication of the lidding/rework equipment is not compatible at this temperature and will fail prematurely. The polypropylene tubing manufacturer has a suggested operating limit of 200°F.	• Incorrect values used to design the equipment may lead to premature failures. • Inadequate Discipline in Design Execution and Control • Throughput not Adequately Underpinned • Transfer of Scope and Risk to the Commissioning Phase	• Provide a detailed analysis of the environmental requirements of the tools. • Establish the bounding scenario that provides the basis for temperature values within the finishing line. • Update data sheets and verify with vendor if changes are required to meet the environment. • Make changes where necessary (stainless tubing, additional insulation).
LFH-LID-1-V011	Lid recovery tool operation deficiencies.	• The recovery tool design has not been tested to recover an improperly installed lid. Testing does not validate that the recovery tool is effective for "tilted" lids. • Failed recovery tools that cannot be disengaged from a container, requires MSM use to remotely disengage	• Several features and operational requirements are not fully developed or tested to validate a functional design. • Inadequate Discipline in Design Execution and Control	• Provide a proof of principle test to validate the current design can remove a "tilted" lid, place on park stand, remove lid from stand via MSM and place in disposal bin. • If this cannot be done, revise design to allow for a valid method of lid removal and disposal (this may

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		the recovery tool. The MSM is not designed to remove nuts to release the recovery tool. • Lids that have been removed by the recovery tool are placed on a park stand, prior to disposal. The location of this stand cannot be reached by the MSM in order to remove the lid and place in a disposal bin. MSM may not be able to grasp lid while lid is on park stand. MSM fingers may not be able to hold lid in vertical orientation when attempting to place in disposal bin.	• Throughput not Adequately Underpinned • Transfer of Scope and Risk to the Commissioning Phase • Inadequate Consideration of Maintenance and Waste Management Requirements • Inadequate Consideration for Conduct of Ops	require new equipment be utilized instead of modifying existing designs). • Undertake a new proof of principle test to validate new/revised equipment can effectively meet the functions required in “lid recovery” operations.
LFH-LID-1-V012	Lid disposal bin handling deficiencies	The LFH lid disposal bin (LFH-LID-00033/34) weighs 44 lbs. empty and is significantly heavier when full of lids. The bin is mounted against the finish line wall and is located approximately 10 feet above finished floor elevation. The bin is too heavy to be lifted by MSMs (LFH-MANIP-00026/28) and is out of the reach of the jib cranes (LFH-CRN-00003/4/6/7). With the bins located 10 feet above the floor elevation, it will be extremely difficult to handle manually.	• Several features and operational requirements are not fully developed or tested to validate a functional design. • Inadequate Discipline in Design Execution and Control • Transfer of Scope and Risk to the Commissioning Phase • Inadequate Consideration of Maintenance and Waste Management Requirements • Inadequate Consideration for Industrial Safety • Inadequate Consideration for Conduct of Ops	• Provide a proof of principle test to validate the current design can hold lids without buckling, be removed “manually” in a safe manner. • If this cannot be done, revise design to allow for a valid method of lid disposal (this may require new bin design and new location for remote handling with jib cranes be utilized instead of modifying existing designs). • Undertake a new proof of principle test to validate new/revised equipment can effectively meet the functions required in “lid disposal” operations.
LFH-IC-1-V001	• The design for the LFH system is not in compliance with the requirements flow down as described in the Technical Baseline. • It is not clear how requirements flow from the Mechanical Sequence Diagram or the Mechanical Handling Diagrams (MHD) to the J3 Logic Diagrams, Function Diagrams and Sequential Function Diagrams. • There is no way to verify that interlocks have been passed down to the J3 Logic Diagrams and no way to verify that they are implemented correctly.	• 24590-WTP-ENG-01-001 Technical Baseline Description, Appendix A shows the WTP Design Document Hierarchy. Requirements flow down from upper level document through lower level documents and into the design. • However, it is not possible to know where a higher level MSD or MHD requirement has flowed down to the design or what criteria will be used to test it. For example, an interlock to keep a door from closing on a bogie is device specific; it will always be in effect when the door is asked to close. On the other hand, an interlock to keep the bogie from running into the door if it is already closed is a sequence interlock that will not be in effect when the bogie is run manually and may not be in effect if the sequence is modified or if another sequence is added.	Independent verification that upper level requirements properly flow down to lower level design documents or the implementation will be very difficult. As a result testing will be ineffective.	• Conduct a full review of the J3 Logic diagrams to ensure they meet the requirements of the upper level documents such as the System Description, the Mechanical Sequence Diagrams and the Software Control Narrative. • If the requirements are incorrect, the requirements documents should be updated. • If the implementation is incorrect, it should be corrected. • Add a reference in the MSDs to the J3 Logic Diagrams where the interlock is implemented. • Scrub the logic diagrams to correct the labels and ensure consistency among the off-sheet connectors. • Start-up and commissioning should include exhaustive testing of both success and failure paths and Off-Normal operations to “wring out” errors and identify improvements in operations and operator/control interfaces before operations begin.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LFH-IC-1-V002	Interlocks on the Lidding Bogie listed in the Mechanical Sequence Diagram 24590-LAW-M1-LFH-00001 are not sufficient to protect the equipment from damage.	• There are no device specific interlocks to prevent collisions with: - The Decon Shield Door - The Shard Tray - Load on the Lidding Monorail Hoist - Lidding Bogie Lift - Lidding Jib Crane Arm - Sealing Jib Crane Arm • Device specific interlocks should be complete enough to keep the equipment from damaging itself or other systems, structures or components regardless of whether they are operated locally or remotely; manually or automatically.	An improperly designed or coded sequence, or a sequence modified at a later time, or manual operation, could command an operation that, under the conditions cited, could damage equipment.	• Develop a compliance matrix that identifies where each interlock is implemented, and a criteria matrix that defines how the requirement will be tested. • Conduct a full review of the J3 Logic diagrams to ensure they meet the requirements of the upper level documents such as the System Description, the Mechanical Sequence Diagrams and the Software Control Narrative. • If the requirements are incorrect, the requirements documents should be updated. • If the implementation is incorrect, it should be corrected. • Add a reference in the MSDs to the J3 Logic Diagrams where the interlock is implemented. • Start-up and commissioning should include exhaustive testing of both success and failure paths and Off-Normal operations to “wring out” errors and identify improvements in operations and operator/control interfaces before operations begin.
LFH-IC-1-V003	Interlocks on the Lidding Jib Crane listed in the Mechanical Sequence Diagram 24590-LAW-M1-LFH-00001 are not sufficient to protect the equipment from damage.	The Lidding Jib Crane (LFH-CRN-00003 / 00006) should be interlocked with the Sealing Jib Crane (LFH-CRN-00004 / 00007) to allow movement of the Lidding Crane only if it will not collide with the Sealing Crane. Device specific interlocks should be complete enough to keep the equipment from damaging itself or other systems, structures or components regardless of whether they are operated locally or remotely; manually or automatically.	An improperly designed or coded sequence, or a sequence modified at a later time, or manual operation, could command an operation that, under the conditions cited, could damage equipment.	• Develop a compliance matrix that identifies where each interlock is implemented, and a criteria matrix that defines how the requirement will be tested. • Conduct a full review of the J3 Logic diagrams to ensure they meet the requirements of the upper level documents such as the System Description, the Mechanical Sequence Diagrams and the Software Control Narrative. • If the requirements are incorrect, the requirements documents should be updated. • If the implementation is incorrect, it should be corrected. • Add a reference in the MSDs to the J3 Logic Diagrams where the interlock is implemented. • Start-up and commissioning should include exhaustive testing of both success and failure paths and Off-Normal operations to “wring out” errors and identify improvements in operations and operator/control interfaces before operations begin.
LFH-IC-1-V004	Interlocks on the Sealing Jib Crane listed in the Mechanical Sequence Diagram 24590-LAW-M1-LFH-00001, are not sufficient to prevent the equipment from damage.	• The Sealing Jib Crane (LFH-CRN-00004 / 00007) should be interlocked with the Lidding Jib Crane (LFH-CRN-00003 / 00006) to allow movement of the Sealing Crane only if it will not collide with the Lidding Crane. (Either Lidding Crane NOT at P1; or Lidding Crane at P4 – parking Stand).	An improperly designed or coded sequence, or a sequence modified at a later time, or manual operation, could command an operation that, under the conditions cited, could damage equipment.	• Develop a compliance matrix that identifies where each interlock is implemented, and a criteria matrix that defines how the requirement will be tested. • Conduct a full review of the J3 Logic diagrams to ensure they meet the requirements of the upper level documents such as the System Description, the

Table A-10. Vulnerabilities Identified for Container Finishing Handling (LFH). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		• Device specific interlocks should be complete enough to keep the equipment from damaging itself or other systems, structures or components regardless of whether they are operated locally or remotely; manually or automatically.		Mechanical Sequence Diagrams and the Software Control Narrative. • If the requirements are incorrect, the requirements documents should be updated. • If the implementation is incorrect, it should be corrected. • Add a reference in the MSDs to the J3 Logic Diagrams where the interlock is implemented. • Start-up and commissioning should include exhaustive testing of both success and failure paths and Off-Normal operations to "wring out" errors and identify improvements in operations and operator/control interfaces before operations begin.
LFH-IC-1-V005	Interlocks on the Decon Shield Door listed in the Mechanical Sequence Diagram 24590-LAW-M1-LFH-00001 are not sufficient to protect against HVAC flow disruptions or the spread of contamination.	• The Decon Shield Door (LFH-DOOR-00019 / 00015) should be interlocked to prevent it from opening when the Lidding Trap Door (LFH-DOOR-00010 / 00009) is open. • Device specific interlocks should be complete regardless of whether they are operated locally or remotely; manually or automatically.	An improperly designed or coded sequence, or a sequence modified at a later time, or manual operation, could command an operation that, under the conditions cited, could disrupt air flow and spread contamination.	• Develop a compliance matrix that identifies where each interlock is implemented, and a criteria matrix that defines how the requirement will be tested. • Conduct a full review of the J3 Logic diagrams to ensure they meet the requirements of the upper level documents such as the System Description, the Mechanical Sequence Diagrams and the Software Control Narrative. • If the requirements are incorrect, the requirements documents should be updated. • If the implementation is incorrect, it should be corrected. • Add a reference in the MSDs to the J3 Logic Diagrams where the interlock is implemented. • Start-up and commissioning should include exhaustive testing of both success and failure paths and Off-Normal operations to "wring out" errors and identify improvements in operations and operator/control interfaces before operations begin.
LFH-IC-1-V006	Interlocks on the Decontamination Power Manipulators and the Decontamination Turntable listed in the Mechanical Sequence Diagram 24590-LAW-M1-LFH-00001, are not sufficient to prevent the equipment from damage.	• Since a canister hanging from the crane could collide with any of these components; the Upper Decontamination Power Manipulator (LFH-MANIP-00008 / 00001), the Lower Decontamination Power Manipulator (LFH-MANIP-00012) and the Decontamination Turntable (LFH-TTBL-00002 / 00001) should be interlocked to both the hoist and the trolley of the Decontamination Dual-Rail Hoist(s) (LFH-HST-00005 / 00010). • Also the North Lower Decontamination Power Manipulator (LFH-MANIP-00011) has no interlocks listed.	An improperly designed or coded sequence, or a sequence modified at a later time, or manual operation, could command an operation that, under the conditions cited, could damage equipment.	• Develop a compliance matrix that identifies where each interlock is implemented, and a criteria matrix that defines how the requirement will be tested. • Conduct a full review of the J3 Logic diagrams to ensure they meet the requirements of the upper level documents such as the System Description, the Mechanical Sequence Diagrams and the Software Control Narrative. • If the requirements are incorrect, the requirements documents should be updated. • If the implementation is incorrect, it should be corrected.

Table A-10. Vulnerabilities Identified for Container Finishing Handling (LFH). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		• Device specific interlocks should be complete enough to keep the equipment from damaging itself or other systems, structures or components regardless of whether they are operated locally or remotely; manually or automatically.		• Add a reference in the MSDs to the J3 Logic Diagrams where the interlock is implemented. • Start-up and commissioning should include exhaustive testing of both success and failure paths and Off-Normal operations to "wring out" errors and identify improvements in operations and operator/control interfaces before operations begin.
LFH-IC-1-V007	Interlocks on the Swabbing Bogie (LFH-TRLY-00015 / 00005) listed in the Mechanical Sequence Diagram 24590-LAW-M1-LFH-00001, are not sufficient to prevent the equipment from damage.	• The Swabbing Bogie (LFH-TRLY-00015 / 00005) should be interlocked with the Swabbing Power Manipulator (LFH-MANIP-00009 / 00002) and the Swab Turntable (LFH-TTBL-00006 / 00005) to ensure the Swabbing Bogie doesn't move during Swabbing operations. • Device specific interlocks should be complete enough to keep the equipment from damaging itself or other systems, structures or components regardless of whether they are operated locally or remotely; manually or automatically.	An improperly designed or coded sequence, or a sequence modified at a later time, or manual operation, could command an operation that, under the conditions cited, could damage equipment.	• Develop a compliance matrix that identifies where each interlock is implemented, and a criteria matrix that defines how the requirement will be tested. • Conduct a full review of the J3 Logic diagrams to ensure they meet the requirements of the upper level documents such as the System Description, the Mechanical Sequence Diagrams and the Software Control Narrative. • If the requirements are incorrect, the requirements documents should be updated. • If the implementation is incorrect, it should be corrected. • Add a reference in the MSDs to the J3 Logic Diagrams where the interlock is implemented. • Start-up and commissioning should include exhaustive testing of both success and failure paths and Off-Normal operations to "wring out" errors and identify improvements in operations and operator/control interfaces before operations begin.
LFH-IC-1-V008	• There is no clear flow down of requirements from higher level documents to the Logic Diagrams. • The J3 logic Diagrams attempt to correct this, but that puts them in violation of an upper-level requirement.	• According to the Mechanical Sequence Diagram 24590-LAW-M1-LFH-00001, the Line Transfer Crane Hoist (LFH-HST-00001) is interlocked to prevent it from lowering when the North (LFH-Door-000014) and South (LFH-Door-00011) Line Transfer Trap Doors are not open. However, it should be interlocked when the Crane trolley is at {P2 AND the South Door is NOT open} and when the trolley is at {P3 AND the North Door is NOT open}. • As written both the North and South Line Transfer Trap Doors must be closed before the hoist can be lowered making transfer into either Decon Room impossible. • If the requirement is wrong (it is) then the MSD should be corrected The point is not that the logic won't work; the point is that there is no clear flow down of requirements from higher level documents to the J3 Diagrams.	• This means that the software cannot be tested against the Mechanical Sequence Diagrams, or the Mechanical Handling Diagrams or the System Descriptions. • An improperly designed or coded sequence, or a sequence modified at a later time, or manual operation, could command an operation that, under the conditions cited, could damage equipment.	• Develop a compliance matrix that identifies where each interlock is implemented, and a criteria matrix that defines how the requirement will be tested. • Conduct a full review of the J3 Logic diagrams to ensure they meet the requirements of the upper level documents such as the System Description, the Mechanical Sequence Diagrams and the Software Control Narrative. • If the requirements are incorrect, the requirements documents should be updated. • If the implementation is incorrect, it should be corrected. • Add a reference in the MSDs to the J3 Logic Diagrams where the interlock is implemented. • Start-up and commissioning should include exhaustive testing of both success and failure paths and Off-Normal operations to "wring out" errors and identify improvements in operations and operator/control interfaces before operations begin.

Table A-10. Vulnerabilities Identified for Container Finishing Handling (LFH). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
				• .
LFH-IC-2-V001	The way the carbon dioxide pelletizers, CDG-BLWR-00001/00002/00003/00004 are mounted orients the control panels between the Blasters and the Pelletizers. This provides no room for an operator or maintenance personnel to access the panels.	An operator viewing or working the controls on this piece of equipment will have to reach in from the sides which are partially blocked by the side panels.	Access to E-stop button on the control panel is obstructed. Stretching and reaching to operate controls is poor ergonomics. The operator will have a poor view of his indications. It will make reaching for and operating a control error-prone and will increase the chance of slips and falls.	The carbon dioxide pelletizers, CDG-PLT-00001/00002 must be re-installed with a different orientation that allows proper access.
LFH-IC-2-V002	The bogies (i.e., LFH-TRLY-00006/00007) are variously referred to as Trolleys in the equipment name, Bogies in the System Description; Carriages on the label of the Control Panels LFH-PNL-00002/00011, and as Carts on the HMI Screens.	This is poor engineering practice as it will cause confusion between control room operators and field operators as well as between operations and maintenance.	Every procedure and every work package will have to deal with this inconsistency. If a procedure tells an operator to move a bogie to a position, the operator cannot use a control marked as a cart to accomplish this unless the procedure specifically tells him that the bogie and the cart are the same equipment. Likewise a maintenance technician cannot perform a work package on a trolley by operating a control panel labeled to operate a carriage unless the work package explicitly tells him to. The operator or maintenance technician has no way of knowing whether the procedure is referring to the piece of equipment at hand, or some other piece of equipment elsewhere in the facility. It is a vital part of conduct of operations to verify that one is operating the piece of equipment directed by the procedure. No worker should perform a procedure step on a piece of equipment labeled differently than that called for in the procedure .	Align the design of the facility so that each piece of equipment has one and only one name.
LFH-IC-3-V001	The design provides no method of verifying compliance with Waste Affecting Criteria regarding temperature before the container is exported for transport to the disposal facility.	• The ILAW Product Compliance Plan 24590-WTP-PL-RT-03-001 Section 4.1.13 states, "… This temperature constraint shall assume a shaded, still air environment at an ambient temperature of 38 C…." • Section 4.1.13.1 says the compliance Strategy for the temperature requirement is to hold the filled ILAW containers for sufficient time to cool. "The external temperature of the filled ILAW container will be measured to confirm that the temperature is below the	ICD 15 – Interface control Document for Immobilized Low Activity Waste, Section 1.7 Acceptance Criteria points out that the requirement… "for the PRC to develop waste acceptance criteria for the Integrated Disposal Facility (IDF) may result in exceeding the criteria contained in the WTP contract for the production of ILAW…Also, there are no provisions	Redundant temperature transmitters similar to the ones provided at the end for the Pour Tunnel should be provided at the Monitoring/Export area. These instruments should have an appropriate quality level with pre and post calibrations to verify their operation and accuracy.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		maximum temperature before the ILAW product is picked up for transport to the disposal facility." • However there is no means provided in the design for a still air environment or temperature transmitters to accomplish this. The design provides the only measurement of the container temperature in the Transfer Tunnel. The temperature in the Transfer Tunnel is assumed to be 113°F or 45°C. The assumed air flow in the Transfer Tunnel will be over 5000 scfm. This temperature and air flow make the Transfer Tunnel an unacceptable location to measure the temperature to meet the requirement.	within the WTP contract or its facility permits to retain the ILAW or to accept its return from the TOC once transferred. Consequently, the potential exists that an interface incompatibility may be created wherein the produced ILAW must be transferred from the WTP but the TOC or PRC is unable to accept it."	
LFH-TRLY-1-V001	Bogie thermal shield design differences between the Design Proposal Drawings and the fabricated Lidding and Decontamination Bogies are not documented	No justification is available that documents the WTP Project's acceptance of the Manufacturer's deviation from the initial design that called for the heat barrier to cover the entire top surface of the Lidding Bogie Elevating Tables and Decontamination Bogie Assemblies.	• Inadequate Discipline in Design Execution and Control • Transfer of Scope and Risk to the Commissioning Phase • Inadequate Consideration of Maintenance Requirements	Re-run the Manufacturer's thermal analyses of the Lidding and Decontamination Bogies for the expected higher ambient temperature range, and verify that the temperatures of the Bogie most fragile components including the motor, junction boxes, and cable carrier remain acceptable.
LFH-TRLY-1-V003	Absence of container centering guides on the bogie-mounted Swabbing Turntables may result in challenging container lifting operations and container dropping accidents	The top of the swabbing turntable is a flat circular metal plate. Its edge is only 2.5" wider than the container radius, assuming the container is perfectly centered on the plate. The decontaminated container is lowered onto the swabbing turntable by the Swabbing Dual-Rail Hoist.	• Inadequate Discipline in Design Execution and Control • Inadequate Consideration for Conduct of Ops	Add bolted containers centering wedge assemblies around the top plate of the Swabbing Turntables (similar to the wedges installed on the Decontamination Turntables).
LFH-TRLY-1-V005	Material of flexible electrical conduits to Bogie stand-mounted Power Junction Boxes may not be adequate for temperature conditions in the immediate vicinity of LFH Bogies	Temperature at the side of the ILAW product container may be up to 615°F at the lidding station. Flexible electrical conduits connected to stand-mounted Lidding Bogie power junction boxes have working temperatures of -22°F to 174°F.	• Inadequate Discipline in Design Execution and Control • Transfer of Scope and Risk to the Commissioning Phase • Inadequate Consideration of Maintenance Requirements	Design and add local insulation for the electrical conduits connected to the Bogie Power Junction Boxes (and to any other junction box in the Finishing Lines located in the immediate vicinity of a side of a product container).
LFH-TRLY-1-V009	Configuration of the recessed rails in the Finishing Line will promote the accumulation of contamination	The rails and rail clips at EL 3'-0" are embedded into an 8" thick concrete infill covering the entire floor of the 2 Finishing Lines.	• Inadequate Discipline in Design Execution and Control • ALARA concerns	Develop procedures for frequent periodic decontamination work activities to prevent contamination buildup along the bogie tracks.
LFH-TRLY-1-V010	Maintenance on Bogies in Swabbing and Export Rooms may be problematic due to contamination potentially pulled from Container Lidding Areas	The bogies are all recovered by the Recovery Systems located in the Monitoring/Export Areas. Use of the recovery systems will pull contamination along with the wire rope onto the recovery winch cable drum.	• Inadequate Discipline in Design Execution and Control • ALARA concerns • Inadequate Consideration of Maintenance Requirements	Develop procedures to minimize the spread of contamination into rooms that should stay clean while performing maintenance on the LFH Bogies.
LFH-TRLY-1-V011	Absence of Finishing Line Bogie maintenance hoist may result in problematic bogie maintenance	The Swabbing Hoists or Export Cranes are the only installed lifting options to gain access to the bottom of the bogies.	• Inadequate Discipline in Design Execution and Control • ALARA concerns	Develop maintenance procedures for LFH Bogies that minimize impact to the installed process lifting equipment.

Table A-10. Vulnerabilities Identified for Container Finishing Handling (LFH). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
			• Inadequate Consideration of Maintenance Requirements	
LFH-TRLY-1-V012	Lidding and Decontamination Bogies need to be disconnected from Power Cables and Carrier prior to maintenance which makes their transfer back to their respective process area problematic	Movements of the Lidding Bogies east of Position 4 and movements of Decontamination Bogies eastward to about Column 19 to the maintenance areas are not possible unless energy chains are disconnected.	• Inadequate Discipline in Design Execution and Control • ALARA concerns • Inadequate Consideration of Maintenance Requirements	Define the maintenance areas actually available for maintaining the Lidding and Decontamination Bogies and develop procedures accordingly.
LFH-TRLY-1-V013	Mechanical Handling Data Sheets and Thermal Analysis for the Swabbing Bogie-Mounted Turntables Define Incorrect Container Bottom and Side Temperatures	There are many discrepancies between engineering documents that define the Bogie-mounted Swabbing Turntables with regard to design temperatures which are definitely a critical process parameter for the design of these components of the LFH System.	Inadequate Discipline in Design Execution and Control	Correct the discrepancies in engineering and Vendor's documentation package for the two Bogie-mounted Swabbing Turntables.
LFH-TRLY-1-V014	High Probability of Damaging the Container Present Sensor of Bogie-Mounted Swabbing Turntables When Lowering Container Lower Overpack on Top Plate	The vertical part of the bracket supporting the Container Present Sensor protrudes over the edge of the circular top table and is located at less than 2" from the edge of the 48" diameter table.	• Inadequate Discipline in Design Execution and Control • Inadequate Consideration of Maintenance Requirements	Re-locate the bracket and Container Present Sensor further away from the edge of the top plate after checking that the laser sensor can detect the presence of an object on the turntable from its modified location.
LFH-DS-1-V001	Retrieval of Bogie Doors in Decontamination Rooms L-0109C/-0115C not yet possible.	Retrieval of Bogie Doors in Decontamination Rooms L-0109C/-0115C not yet possible.	If the doors in the decontamination rooms L-0109C or L-0115C are stuck in the open position, a manned entry must be done to recover the stuck door with a come-along	Develop an easy method of door retrieval to minimize the impact of an occurrence of a door fail-to-move situation.
LFH-DS-1-V002	Container decontamination and recovery of a contaminated container may be problematic.	In, DOE 07-WTP-061 Technology Readiness Assessment for the Waste Treatment and Immobilization Plant (WTP) Analytical Laboratory, Balance of Facilities and LAW Waste Vitrification Facilities, the DOE determined on page 2-19 that the LAW Decontamination system was at a Technology Readiness Level of TRL 4.A CO2 decontamination system has not been demonstrated or proven to be effective. The method to deal with a contaminated container has not been established.	Accumulation of non-conforming ILAW containers will fill up the buffer storage area and stop production in the LAW Facility.	• Demonstrate the capability of a CO2 system to decontaminate an ILAW Container. • Develop a method to export a non-conforming ILAW container.
LFH-DS-1-V003	C5 Duct pressurization over C3 room & C2 Corridor pressure	By design, the pressure in the C5V ducting in the CO2 exhaust ducting from the discharge of the C5V-FAN-00009/-00010 fans is positive compared to the C3 room / C2 corridor the ducting is in.	If a leak develops in the C5 fan discharge ducting, contamination can be spread to a C3 area. A leak may be a CO2 gas personnel hazard	• Install a CO2 gas monitor instrument in Room L-217B to detect rising CO2 levels. • Invoke a periodic maintenance surveillance to inspect the CO2 exhaust ducting from the discharge of the C5V-FAN-00009/-00010 fans through the C3 rooms / C2 corridors to the tie-in point on the main C5V duct.
LFH-DS-1-V004	Operation of the Carbon Dioxide (CO2) pelletizer and C5V vacuum pickup system may be problematic.	Operation of the Carbon Dioxide (CO2) pelletizer and C5V vacuum pickup system may be problematic. The shrouds and operation of the upper and lower decontamination power manipulators may be problematic (24590-LAW-MJ-LFH-MANIP-00001 / -00008 / -00011	ILAW Containers may not be able to be decontaminated by the installed CO2 ice pellet system. If a CO2 blaster shroud cannot decontaminate an ILAW container area on the first	• Testing of the CO2 system to optimize container decontamination efficacy should be done before startup. • It would be best to start the testing and development of the integrated CO2 system as soon as possible to

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		/ -00012). The power manipulators, CO2 pelletizer/blaster, C5V vacuum pickup system, and the LAW Facility Integrated Control Network (ICN) have never been tested as an integrated system. The ability of the robot to dodge the alignment lugs on the decontamination turntable and the fingers/alignment arms on the container lifting grapple has not been demonstrated. The lifting grapple contamination capture target box has not been designed or demonstrated to work. Decontamination of the bottom of the grapple will blow air & ice pellets into the cam area of the grapple through the hole in the bottom plate of the grapple. Switching between the upper and lower decontamination power manipulators and between the various power manipulator end effectors will cause the flow through the contamination pickup system to vary. The CO2 C5 FAN-00009/-00010 flow is monitored by a flow instrument and the ICN uses the flow signal to vary the fan speed to attempt to maintain a constant flow through the system. As the decontamination robot cycles through its program, the C5 FAN-00009/-00010 fan speeds will vary to maintain a constant flow through the system. There has been no demonstration of adequate contamination capture velocities and of the ability of the fan speed control system to keep up with the decontamination robot swapping out end effectors and switching between the upper and lower manipulators. The Vendor is recommending that no spare parts be provided for the pelletizer to support startup and commissioning. The actual flow of CO2 ice pellets is not monitored and if the bottom of the blaster feed hopper is frozen, no ice pellets will be fed into the blasting air creating the possibility of attempting to decontaminate the container by just blowing air on it. Old, rotten, CO2 ice pellets can be removed from the CO2 blasting hopper by letting them sublimate over a period of hours, or manually scooping them out. This may be a problem when one finishing line is down for maintenance and all five containers are processed through one line giving the system a 4.8 hour cycle time rather than a 9.6 hour cycle time.	attempt, repeated attempts using the same shroud system should not be expected to have success a second or a third time.	minimize the impact of the possible failure of the CO2 system to decontaminate an ILAW container on the LAW Facility commissioning.
LFH-DS-1-V005	Decontamination system obsolescence and Vendor support.	The WTP has a 40 year operating mission. There is a danger that the Motoman® decontamination robot, and PLC control system will go obsolete before the 40 year life of the WTP Project is over. Further, KTECH, the robot vendor may go out of business or get bought out by another company. In any case, if Vendor support for	ILAW containers may not be able to be decontaminated by the Motoman® decontamination robot and another system must be procured, tested, installed, and commissioned to resume	DOE should begin the process to qualify another decontamination robot or other system, to replace the CO2 decontamination robots. In light of the time it has taken to develop the current Motoman® decontamination system, DOE should start the hunt for a replacement system immediately.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		repair parts, software support, or training is lost, the decontamination robot may become inoperable.	LAW Facility ILAW Container filling operations.	
LFH-DS-1-V006	Daily hoist inspections required by the Vendor with a "SHALL" in the maintenance manual will mean daily personnel entries into a C5 area. Decontamination rooms L-0109C and L-0115C overhead container hoist maintenance, operation, and spare parts may be problematic.	ASME Code, OSHA and Vendor required daily "SHALL" inspections for cranes and hoists may be difficult. Decontamination rooms L-0109C and L-0115C overhead container hoist maintenance, operation, and spare parts may be problematic.	ASME Code, OSHA, and Vendor requirements appear to require daily manned entries into contaminated areas to perform daily crane/hoist inspections given a "SHALL" by the Vendor.	• Apply to the DOE for relief from the ASME 29 CFR 1910.178, "Occupational Safety and Health Administration Standards" Code of Federal Regulations, Subpart "Powered Industrial Trucks", and Vendor Manual requirements in DOE/RL-92-36 Rev 1, Release 73, Hanford Site Hoisting and Rigging Manual, Chapters 12 & 13. • Tailor the ASME B30 Series Code requirements, OSHA 1920.178, and DOE/RL-92-36 Rev 1, Release 73, Hanford Site Hoisting and Rigging Manual Chapters 12 & 13 requirements in the SRD.
LFH-SWAB-1-V003	24590-CM-POA-HDYR-00002-04-00002, Bolted Pedestal and Frame Structures Structural Design Analysis and Calcs, loss of configuration control.	The calculation was changed after it was stamped by a professional engineer with no evidence the professional engineer reviewed the changes, and there are several pages with no evidence the mathematical calculations were reviewed and checked.	Component failure due to over stress or seismic event due to unreviewed changes made in the analysis.	The calculation needs to be completely reviewed and checked by a registered professional engineer and implement any design changes that result.
LFH-SWAB-1-V005	24590-CM-POA-HDYR-00002-21-00002, Swabbing Manipulator Thermal Calculation, cooling air issues.	The analysis indicates air moving over the robot arm to the gripper to create convective cooling is required to maintain temperature sensitive instruments below critical temperatures. The velocity of the air at the surface of the container was not analyzed to determine the potential for spreading contamination and adversely affecting the quality of the swabs. Temperature of the compressed air lines has not been adequately analyzed to determine if the aluminum wrap is effective at maintaining the compressed air lines below critical temperatures.	Contamination spread and release of contaminated ILAW container to LEH. Failure of compressed air line results in failure of robot to operate.	Analyze air velocity at surface of the container and redesign cooling system to ensure temperature sensitive proximity sensors and compressed air tubing below critical temperatures.
LFH-SWAB-1-V006	24590-CM-POA-HDYR-00002-14-00005, Swabbing System Operating Guide for Decontamination and Swabbing Project, missing instructions	The robot is programmed to swab the curved bottom, vertical sides, and tops of the ILAW containers, but no provisions (i.e., alternate swabbing patterns and programs) have been developed to swab a lower container over pack. The inability of the swabbing robot to handle a lower container over pack could cause significant production delays.	ILAW container and over pack will probably need to be returned to the Buffer Storage Area until the swabbing robot can be reprogrammed and tested.	Create and test swabbing programs for the lower container over packs prior to commissioning activities.
LFH-SIFH-1-V003	No adequate container temperature design basis.	Mechanical handling data sheets 24590-LAW-M0D-LFH-00011, MDS North Inert Fill Hopper, and 24590-LAW-M0D-LFH-00070, 24590-LAW-MJ-LFH-Manip-00017 – Tool Tray used to Hold Effluent Shrouds and Other Tools for Decontamination Power Manipulator, indicate the operating environment is 59-113°F with a container temperature maximum of the bottom=400°F, sides=700°F, and top=350°F. Document reviews have been unable to establish this container temperature profile as the correct basis for the equipment design	This could severely restrict operational throughput for the finishing line.	Perform CFD thermal analysis to establish an actual container cooling temperature profile that the finish line equipment can be evaluated for potential impacts (good or bad). Until a believable container temperature design basis is established the finish line systems cannot be evaluated for maximum throughput.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		requirements. The BNI system matter expert was asked to provide the design basis for the container entering the LFH system and no response has been issued. Described in the CFD Analysis of LAW Buffer Storage and Finishing Line calculation, 24590-LAW-M4C-C5V-00003, the intended operation is to transfer the container directly from the pour cave into the finishing line, after 59.27 hours, in an alternating pour mode. There is no direct container temperature results identified in the analysis, so I will assume the container temperature is identical to container temperature profile for the maximum container temperature for alternate pour schedule, figure 25.b. That would mean the finish line import temperature is 460°F. In the single pour mode the container is required to be removed from the pour cave at 29.63 hours and using the container temperature for a single pour schedule, figure 25.a, the container temperature would be 630°F. However, the container cannot be lifted with the current grapple design until it cools to 600°F. A CCN 051255 LAW Container Skin Temp Calculation, was developed to calculate the container skin temperature as it moves from the LAW pour cave through the transfer tunnel and the finishing line to the airlock for export. In section 6.0, results and conclusion, the process describes the container, at hour 28.33, moving to the lidding station. According to figure 3 the maximum container surface temperature is above 600°F. None of the above mentioned CFD container thermal analysis can be used to support the equipment design environmental conditions listed in the mechanical handling data sheets.		
LFH-SIFH-1-V005	Incorrect isolation valve in day tank.	• The day tank upper isolation valve is identified as a Posi-flate butterfly valve series 485. This type of valve will not be able to displace the inert material in order to close the valve. If the inert material is flowing through the rotary feeder and moving past the isolation valve the valve will be able to be closed, but once the rotary feeder is stopped the spool piece and isolation valve will become packed solid with inert material. Once this happens the butterfly valve will not be able to rotate and displace enough material to fully close. This isolation valve should be a slide gate type. The lower isolation valve is acceptable and will be able to perform as designed. • The vendors factory acceptance testing, section 7.4, indicates that functional testing was not required and	The system isolation valves will not operate as designed.	The day tank upper butterfly valve should be replaced with a slide gate valve that can operate with a full pipe of dense inert fill material. Full functional testing should be performed during commissioning.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		that BNI did not specify any functional testing be performed.		
LFH-SSS-1-V002	Limited glass sample capability.	The shard pickup assembly is intended to be maneuvered by the assembly MSM handle located approximately 18 inches from the tip. This means the shard pickup assembly can only be inserted approximately 16 inches below the container flange surface. That would mean that any container with less than 90 percent fill volume would not be capable of taking a glass sample. This does not meet the requirement to be able to take a glass sample as required. The most likely need to take a glass sample would occur if something unexpected occurred during the glass process and/or the pouring schedule is interrupted. If for any reason the container glass level is not within 16 inches of the flange surface a glass sample cannot be taken with provided equipment.	Glass samples will not be able to be taken from all product containers as required.	Redesign the glass shard pickup assembly to meet the glass sample requirement regardless of the glass height in the product container. I believe this is required to meet the contract requirement.
LFH-SSS-1-V003	Insufficient shard pickup design.	• The shard pickup tool is designed to use the MSM to bang the tool against the glass surface to create shards for collection. This is not an acceptable design task for an MSM to perform on a regular basis • A spring reel used to support the shard pickup assembly will increase the resistance force the more the cable is extended. This will make it difficult for the MSM to control the assembly with the cable reel pulling back with a 30 pound force let alone trying to hammer something.	Premature MSM failures will cause increased maintenance costs and decrease equipment overall effectiveness. Containers requiring samples to be taken will have to be stored until repairs are made thus decreasing the facilities ability to manage the container throughput.	Retest the shard pickup assembly using a proto-typical MSM and prove the tool design can be controlled and glass shards can be generated for sample pickup. These tests should be performed on actual solid glass samples not on glass frit to ensure the tool can be used to generate glass shards for pickup.
LFH-SSS-1-V004	The shard table does not prevent material from dropping into the container during MSM operations.	The Specification for shard Sampling System, 24590-LAW-3PS-M000-T0006, section 3.2.3 requires the equipment shall not introduce any foreign substance into the product container. Normally this would be accomplished by providing a catch pan below activities or components that may introduce foreign materials. The current design, for the shard tray, presented in the drawing series for the shard tray assembly beginning with 24590-CM-POA-M000-00006-06-00082, North Shard Pickup Assembly, has no tray or means to prevent foreign material from dropping into the product container. The foreign material would be the sample bottles and lids that are handled by the MSMs. If during the sample bottle handling either the bottle or lid is dropped it is likely to end up in the product container. Procedures could prevent the handling of all glass sample bottles while the product container is present, however that would not satisfy the specification design requirement.	Foreign material dropping into the product container is prohibited and will require additional operations and/or processes to remove the material to allow the product container to be exported from the facility.	Redesign the shard sampling tray to prevent material from dropping into the product container.
LFH-LID-1-V004	Lid seal identification on DPD is incorrect.	24590-LAW-M0-LRH-00004001, LAW Vitrification System LRH Product Container Assembly, identifies the seal as a Garlock Helicoflex with part number E-800164	• The misidentification of the seal may cause confusion in the fabrication of the container and lid	Provide correct seal manufacturer/type/part number on applicable drawings.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		instead of a Technetics E-Flex type. The part number is actually a Technetics drawing number.	• Inadequate Discipline in Design Execution and Control	
LFH-LID-1-V005	Lidding jib crane capacities do not have a documented basis.	The current 3 ton capacity of the LFH Lidding Jib Cranes (LFH-CRN-00003 and 00006) and Sealing/Lid Recovery Jib Cranes (LFH-CRN-00004 and 00007) are not based on any supporting calculation. Data sheets for these cranes (24590-LAW-M0D-LFH-00096 through 00099) do not have an issued calculation to support the 3 ton hoist rating.	• The lack of a documented basis limits the items that can be handled by the LPH hoists and it is unclear if a 3 ton hoist can meet any future lifting requirements of the system. • Inadequate Discipline in Design Execution and Control • Transfer of Scope and Risk to the Commissioning Phase	• Define all the requirements/scenarios (including any off normal events) of the jib cranes. • Document the lifting requirements and provide an established margin for sizing the hoist. Documentation should be in the form of an approved calculation.
LFH-LID-1-V006	Lidding jib crane design temperature conflicts with CFD analysis of finishing line equipment.	The design temperature of the LFH Lidding Jib Cranes (LFH-CRN-00003 and 00006) and Sealing/Lid Recovery Jib Cranes (LFH-CRN-00004 and 00007) are not based on any supporting calculation. Data sheets for these cranes (24590-LAW-M0D-LFH-00096 through 00099, LFH Lidding and Sealing Jib Cranes, North and South Lines) show a max design temperature of 160°F while CFD analysis show co-located MSMs will reach 233°F.	• Incorrect values used to design the equipment may lead to premature failures. • Inadequate Discipline in Design Execution and Control • Transfer of Scope and Risk to the Commissioning Phase • Inadequate Consideration for Conduct of Operations	• Provide a detailed analysis of the environmental requirements of the cranes. • Establish the bounding scenario that provides the basis for temperature values within the finishing line. • Update data sheets and verify with vendor if changes are required to meet the environment. • Make changes where necessary (different lubricants, localized cooling, higher inspection frequencies, etc.). Review with HVAC if hoist cooling requirements affect HVAC design.
LFH-TRLY-1-V002	The ICN does not prevent collision between the Lidding and Decontamination and Bogies when present at and moving to Position P4 in rooms L-0109C and L-0115C	No interlock prevents the operator from driving the Decontamination Bogie into the Lidding Bogie parked at Position P4 "Decon Station", or conversely, from moving the Lidding Bogie forward and colliding with the Decontamination Bogie parked at Position P4.	• Inadequate Discipline in Design Execution and Control • Inadequate Control System Design Requirements • Inadequate Consideration for Conduct of Ops	Update ICN to include interlocks preventing Bogie collisions in the Finishing Line.
LFH-TRLY-1-V004	Potentially insufficient maximum load capacity of bogie-mounted Swabbing Turntables	Engineering Specification and Vendor's Turntable Instruction Manual state that" in no case should the weight on the turntable exceed 20,000 pounds", when there are conditions where the Bogie-mounted Swabbing Turntables will support a weight (20,533 lbs.) higher than the design working load.	• Inadequate Discipline in Design Execution and Control • Inadequate Consideration of Maintenance Requirements • Inadequate Consideration for Conduct of Ops	Verify the acceptable load range for the Bogie-mounted Swabbing Turntables, resume contacts with the Manufacturer, and run a structural analysis of the turntable for the anticipated higher loads.
LFH-TRLY-1-V006	Vendor's calculation for bogie bumper selection is based on incorrect gross weight and bogie speeds	Calculation of the energy acting on one bumper during collision with rigid structure uses the incorrect 6,500 lbs. gross weight value for the bogie when it should use the bounding weight of 10,500lbs which corresponds to the total weight of the swabbing bogie and the bogie-mounted turntable. In addition, the operating speeds used in the calculation are incorrect and not consistent with the values specified in the other engineering documents for the LFH Bogies.	• Inadequate Discipline in Design Execution and Control	Re-run the LFH Bogie Bumper Selection Calculation for the corrected weights and operating speeds to verify that the bumpers mounted on the fabricated and installed bogies are adequate prior to commissioning.

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Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LFH-TRLY-1-V007	Vendor's calculations for bogie container supports and bogie frame analysis are based on an incorrect maximum loading	Bounding payload does not correspond to the weight of the test weights for overhead hoists, and does not include the weight of the lifting table or the swabbing turntable.	Inadequate Discipline in Design Execution and Control	Re-run the structural calculations for the Lidding and Decontamination Bogies using the revised bounding payload to verify the structural resistance of the guides and chassis are adequate prior to commissioning.
LFH-TRLY-1-V008	Length and travel of Container Present Sensor of Lidding and Decontamination Bogies may not be adequate for detecting presence of an Overpack	No evidence is provided that the radial position, length, and travel of the Container Present Sensor mounted on the fabricated/installed Lidding and Decontamination Bogies allows it to actually make contact with the bottom surface of the Overpack and signal the presence of the Overpack to the ICN.	• Inadequate Discipline in Design Execution and Control • Inadequate Control System Design ☐	Verify radial position, length, and travel of the Container Present Sensor mounted on the fabricated/installed Lidding and Decontamination Bogies against the most current design of the Container Lower Overpack.
LFH-DS-1-V007	Maintenance on the LFH-HST-00001 monorail hoist will be difficult.	Per drawing 24590-LAW-P1-P23T-00046 Rev 3, LAW Vitrification Building Equipment Location Plan EL. 28'-0"/Area 9, the ladder to access maintenance platform LP0217A at elevation 37'-6 ¼" is to the east of the LFH-HST-00001 monorail beam on the north wall of Room L-0217. When the LFH-HST-00001, per 24590-CM-POA-MJKH-00001-05-00001 Rev 00D, Drawing - 10 Ton Monorail Electric Wire Rope Hoist General Arrangement, is not present, there is about 6' of clearance between the bottom of the hoist beam and the platform deck. When the LFH-HST-00001 is present, there is about 3' of clearance between the bottom of the hook and the platform deck. Access to the western side of the platform along the southern side of the hoist is blocked by the hoist's power/control festoon. Access to the western side of the platform along the northern side of the hoist is blocked by a 19' fall to the floor below. To gain access to the western side of the crane, the maintenance worker will have to crawl on his belly under the crane along the platform floor and standup on the west side. It will be very difficult to perform some maintenance activities such as replacing the recovery hoist motor.	Worker contamination due to sliding across the floor to gain access to the western side of the LFH-HST-00001.	Install a second access ladder to the LP0217A platform.
LFH-OR-1-V001	24590-LAW-RPT-PO-05-0001, LAW Reliability, Availability, and Maintainability Data Development Report, errors.	The RAM data development report contains errors in the MTTR hours for the Mechanical Handling System, and it erroneously states the Decon Turntables are mounted on bogies.	Results of the OR Model may be inaccurate because the input data may be inappropriate.	Revise the RAM data development report and incorporated into the OR model and other documents.
LFH-OR-1-V002	24590-WTP-MDD-PR-01-001, Operations Research (WITNESS) Model Design Document, errors and inconsistencies.	The OR Model design document erroneously states temporary lids are installed on ILAW containers, contains process steps for the LFH system that is not consistent with 24590-LAW-M1-LFH-00001, Mechanical Sequence Diagram (MSD) for LAW Vitrification System LFH, and contains process time, MTBF, and MTTR information that is not consistent with 24590-WTP-RPT-PT-02-005, Flowsheet Bases, Assumptions, and Requirements.	Erroneous input data in OR Model results in overly optimistic predictions of system and facility availability.	Compare information in the OR model, mechanical sequence diagrams, and the flowsheet, basis, assumptions, and requirements document and revise the documents as necessary for consistency. Rerun the OR model after all of the process steps and correct MTBF and MTTR data have been updated.

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LFH-OR-1-V003	24590-WTP-RPT-PET-07-003, Waste Treatment Plant Reliability Availability Maintainability (RAM) Basis Report, error.	LFH-WELD-00001/00002 are identified on page B-8 as being "In OR Model" with an MTBF of 43,800 hours and an MTTR of 46 hours based on CCN 068376, LAW - Ram Data Collection for OR Model – LFH. However, CCN 068376 states on page 5 of Attachment 1 that the welders have been deleted due to design change. Furthermore, page 8 of Attachment 2 of the CCN states, "Do not include in OR Model Run 2004. The welding equipment has been deleted through 24590-LAW-DCA-M-03-011, Rev 0."	Erroneous input data in OR Model results in overly optimistic predictions of system and facility availability.	Revise the RAM basis report to remove LFH-WELD-00001/00002 and verify the weld equipment has been removed from the OR model.
LFH-SWAB-1-V001	24590-LAW-3YD-LFH-00001, System Description for the LAW Container Finishing Handling System (LFH), issues and inconsistencies.	Section 3.6 states that surface contamination is determined by swabbing "random container patch areas" using an automated power manipulator. However, Sections 6.2.5.1 and 7.2.4 state swabbing will be performed over "pre-programmed" areas or "patches" of the container surface. The document needs to be revised to resolve the internal inconsistency.	Internal inconsistencies could result in operational confusion.	Revise the document to correct internal inconsistencies.
LFH-SWAB-1-V002	24590-LAW-M0D-LFH-00066, Mechanical Handling Data Sheet: North Swabbing Power Manipulator, inconsistencies.	The maximum cycle time is listed as 120 minutes which conflicts with the 210 minute cycle time for the swabbing bogie mounted turntable as indication on 24590-LAW-M0D-LFH-00087, Mechanical Handling Data Sheet - North (South) Swabbing Bogie-mounted Turntable.	Inconsistencies could result in operational confusion.	Revise the documents to correct inconsistencies.
LFH-SWAB-1-V004	24590-CM-POA-HDYR-00002-10-00001, Swabbing Factory Acceptance Test Plan, issue.	The completed data sheets of the test plan are dated prior to the issuance and approval of the work plan and the duration of the endurance tests failed to meet specification requirements.	Functionality of the system not verified prior to installation and commissioning	Complete full endurance test during commissioning activities.
LFH-SIFH-1-V001	Insufficient rotary valve isolation for maintenance.	According to the inert fill hopper general assembly drawings there is no isolation valve between the rotary airlock valve and the inert fill hopper. Installation, operation and maintenance manual indicates that to perform a seal strip replacement the valve should be removed from the installation or gain access to the top and bottom of the feeder. If the rotary valve fails while the hopper is full of material it will be difficult for maintenance repair to be performed without manually draining the hopper contents out through the valve body.	This will not prevent the repair but will significantly increase the maintenance interval and housekeeping afterwards. The day tank directly above the inert fill hopper has the same rotary valve but does incorporate isolation valves both above and below the rotary valve.	Modify the inert fill hopper design to incorporate a manual slide gate for isolation directly above the rotary airlock valve.
LFH-SIFH-1-V002	Failure to record requirements during factory acceptance testing.	24590-LAW-3PS-HCHH-T0002, Engineering Specification for Special Inert Fill Hoppers – Low Activity Waste Vitrification Facility, section 6.3.14.1, requires tests to be conducted using environmental conditions specified in the associated MDSs. The associated MDSs environmental conditions require a temperature range of 59-113°F and a relative humidity range of 5-85 percent. The performed factory acceptance testing failed to record any environmental conditions at	This is a minor omission of specification requirements, however it was thought to be important enough to specifically identify that testing be perform under specific conditions. This also indicates a programmatic failure to verify all identified design and testing requirements identified in equipment procurement.	This testing requirement should be added to commissioning test documentation.

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		the time of the tests, so this specification requirement cannot be confirmed.		
LFH-SIFH-1-V004	Performance requirements not fully met.	The special inert fill hoppers specification 24590-LAW-3PS-HCHH-T0002, section 3.2.1, requires the equipment to be designed to incorporate features to enable remote maintenance. There are no design provisions for remote maintenance and the 24590-CM-POA-HCHH-00001-03-00004 Vendor Low Activity Waste Facility North Inert Fill Hopper Assembly- Installation, Operation and Maintenance Manual, requires chain lubrication and gearbox oil replacement approximately every 6 months. This maintenance frequency would seem to suggest that the design provisions for remote maintenance would be required.	Increased manned entries, for preventive maintenance, will increase personnel risk of contamination exposure and reduce the system availability.	The design requirement for remote maintenance features cannot be readily corrected, nor should they. The frequency for equipment maintenance should be handled during routine maintenance for all equipment in the same area.
LFH-SSS-1-V001	Inadequate materials of construction.	The coil airline, connecting the shard pickup assembly to the facility air, is not high temperature material. The hose material cannot be operated reliably at temperatures above 180-200°F. The air supply hose will only see high temperatures when the shard pickup assembly is at its lowered position and the air supply is turned off. However, this condition will occur often enough to cause premature airline failures.	Premature material failures will cause increased maintenance costs and decrease equipment overall effectiveness.	The coil air supply line should be covered with high temperature sheathing to reduce any high temperature effects.
LFH-SSS-1-V005	The shard pickup assembly cannot be remotely disassembled for cleaning between samples.	Specification for the Shard Sampling System, 24590-LAW-3PS-M000-T0006, section 3.1.4.9 indicates the shard pickup assembly shall be able to be remotely cleaned to minimize cross contamination between samples, by disassembly of pickup and filter parts for change out. The filter assembly is designed for MSM remote replacement, but the pickup assembly is not designed for remote maintenance. The shard pickup tip assembly does have the ability to provide pneumatic back pressure to reverse flow and blow the pickup tip clean. This may meet the intended philosophy for remotely cleaning between glass samples, however it does not meet the specification functional requirement.	If this is required to prevent cross contamination between samples the activity will need to be performed by a manned entry. This additional maintenance activity will increase maintenance costs and decrease the equipment's overall efficiency.	Redesign the shard pickup tip assembly for remote disassembly for cleaning between samples. Demonstrate the remote disassembly capability using a proto-typical MSM.
LFH-TOOL-1-V001	Inadequate design basis documentation	Failure to provide accurate design requirements in data sheets, drawings, and test documentation.	Maintenance and operations will spend time researching and establishing the design basis for equipment.	Revise design and fabrication documentation to ensure accurate and as-built information.
LFH-TOOL-2-V001	Inconsistent grapple load rating	Mechanical Handling Data Sheets all require the grapple load capacity to be 10 ton (20,000 lbs). However, specification for special grapples and lifting devices, 24590-WTP-3PS-MQL0-T0003, section 3.8.2.1 requires a safe working load of 16,500 lbs. The ICD 15, Interface Control Document for Immobilized Low Activity Waste, allows the mass of each package to not exceed 10,000 kilograms (22,046 lbs.).	Confusion with basis of design	Increase the grapples safe working load design to 25,000 lbs. to handle all container conditions.

Table A-10. Vulnerabilities Identified for Container Finishing Handling (LFH). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LFH-TOOL-2-V002	Law Production Container Volume, Weight, And Center Of Gravity Calculation, 24590-LAW-M0C-LRH-00004, does not include an over pack condition.	An abnormal condition could occur if the container cannot be decontaminated and over packing is required to be added to the container.	Special container handling devices will be required to handle off-normal conditions	Revise calculation to include the addition of over packing material to the outside of the container. This will provide a basis for future non-conforming container handling designs.
LFH-TOOL-2-V003	Grapple temperature limitations.	24590-QL-POA-FH00-00001-08-00001, Supplier's Submittal - LAW Container Grapple Stress Analysis, indicates that the reserve factor is barley met with a load of 16,500 lbs and a flange temperature of 600°F. The CFD Analysis of LAW Pour Caves and Finishing Lines, 24590-LAW-M4C-C5V-00001, indicate the surface temperature of the pour container neck and flange vs. time will be much higher than 600°F. The analysis, shown in figure 49, stops after 20 hours but the trend is to be well above 800°F after 28 hours. This temperature range would prevent the container movement under the single pour operating conditions. The alternating pour operating conditions may or may not be an issue based on this data, so the analysis should be redone to include additional time and cooling conditions.	Since the grapple is a common design the temperature limitation is as important as the safe working load limitations. These conditions could lead to unsafe lifting conditions and/or prevent the melter single pour operating condition.	Add grapple markings to clearly identify temperature limitations the same way safe working loads are identified. Consider adding instrumentation to directly measure the container flange temperature, in the pour cave, prior to using the grapple.
LFH-TOOL-2-V004	Grapple excessive load testing.	General specification for remote and mechanical handling equipment design and manufacture, 24590-WTP-3PS-M000-T0002, section 3.4.3.10, indicate that lifting attachments shall be factory load tested at 125% of rated load in accordance with ASME B30.20 (Below the hook lifting devices). The ASME B30.20, Below the hook lifting devices, section 20-1.3.8.2 indicate that test loads shall not be more than 125% of the rated load unless otherwise recommended by the manufacturer. The testing requirement in 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 6.4.6.c requires the grapple static load test to be performed at 150% of the SWL and held for 15 minutes.	Confusion with basis of design	Revise BNI procurement process to ensure vendors test equipment according to contractual documentation and that all requirements are consistent between documents.
LFH-TOOL-2-V005	Design requirement not verified in factory acceptance testing.	The design requirement in 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 3.8.2.3 requires the grapple's three fingers to have a combined minimum total contact area of 15 in2. This requirement was not validated in the factory acceptance test, 24590-QL-POA-FH00-00001-13-00003, and should have been measured as a critical characteristic of the grapple assembly. This requirement is carried into the LAW Production Container Stress Analyses, 24590-LAW-M0C-LRH-00003, which indicates that at hour 20 the container flange temperature is 457°F and can be safely moved without the container flange reaching yield stress limit. However, this analysis container flange temperature does not agree with the CFD analysis, the	Failure to document design requirements.	The requirement should be validated during start-up testing to ensure these critical characteristic are met.

Table A-10. Vulnerabilities Identified for Container Finishing Handling (LFH). (19 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		grapple contact area is less than half the actual grapple contact area, and the container load is assumed to be 16,000 not 16,500 lbs.		
LFH-TOOL-2-V006	Requirements for factory acceptance testing not fully being performed.	• Specification requirements in 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 6.4.7.g indicate the grapple will be tested to ensure it is capable of maintaining its engagement even if the load is laid on its side and the tension on the bail is relieved; the grapple shall then be capable of lifting the load when the hook is raised, all as part of the 20 complete cycles simulating actual operating conditions. The simulated operating conditions test consisting of 20 completed cycles is performed in 24590-QL-POA-FH00-00001-13-00003, factory acceptance test plan for MR36 LAW grapples and grapple stands section 3.A.4, but this step is omitted. • The system description for the LRH, 24590-LAW-3YD-LRH-00002 section 4.1.2.1.2, indicate the grapple, in the disengaged position, shall be capable of being inserted into and withdrawn in a vertical direction from a right-circular, cylindrical cavity with a diameter equal to that of the container. This requirement would qualify as a critical dimension and should have been verified during the factory acceptance testing performed and documented in 24590-QL-POA-FH00-00001-13-00003, factory acceptance test	Failure to test and document the design requirements are met.	All required performance design requirement should be performed as part of an additional FAT or demonstrated through analysis.

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Table A-11. Vulnerabilities Identified for Radioactive Solid Waste Handling (RWH). (4 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LRWH-F-06-V-01	Incomplete design of equipment and systems to implement waste handling and storage functions.	LAW system RWH only provides cranes; the following are not adequately addressed: • Lifting and handling equipment for handling the various waste containers and movement through the facility. • Waste transfer paths within LAW, export location, and waste storage locations not defined. • Size reduction capability required but not provided for caustic scrubber bed and mist eliminator candles. • The expected dose rate and chemical hazard from the waste and the need for shielding/protection is not defined. • The decontamination effectiveness to meet WIR requirements is not defined.	• Increased risks in delaying completion of commissioning and operations interruptions: • Equipment currently not provided. Delaying definition and procurement of equipment may delay commissioning • Lack of defined path and export point may result in interface issues; lack of permitted storage may result in production delays • Size reduction equipment/facilities not provided; adequate packaging without size reduction not identified • Increased dose to workers if adequate shielding during packaging, handling, or storage not provided; delay in production if adequate packaging not available. • If WIR requires higher level of decontamination than provided by dry wipe down methods; aggressive decon methods and facilities will need to be designed into LAW Facility; delaying start of production	• Define, design, and provide lifting and handling equipment for each identified packaging. • Define waste export paths from each point of generation, define export location with consideration of interfacing systems or competing uses, and define and permit waste storage suitable for radioactive and chemical hazards with consideration of waste flow patterns and waste transport schedule. • Define, design, and provide waste size reduction equipment and facilities for caustic scrubber bed and mist eliminator as required to package in designated packaging. • Define radioactive and chemical hazard expected for the various waste streams and define and provide shielding, protective packaging, as required. • Obtain the WIR determination and evaluate ability to decontaminate to WIR requirements using dry wipe decon methods; define, design, and provide additional aggressive decontamination equipment and facilities as required. •
LRWH-F-07-V-01	The RWH process crane does not have an indexing system that defines its safe operating envelope(s).	• The similar LSH process and CCB handler cranes were manufactured and delivered by the same supplier and have utilized laser positioning for convenience but this technology was not utilized for the RWH crane even though the lifts and lift paths would be repetitive and programmable. • Also, there is offgas piping in the room that can be programmed to avoid if engineering controls were in place. •	• Repetitive and frequent jogging of the crane decreases the life of the electrical components and can cause serious wear to the mechanical components of the crane. • Impact with the offgas piping can completely stop production and puts an operator in a dangerous position.	• Utilize laser positioning and develop indexing or auto-indexing features for the RWH process crane. • Program engineering controls into the crane to avoid travel over the offgas piping.
LRWH-M-02-V-01	Sufficient priority, resources and funding have not been allocated to LRWH maintenance work planning to ensure successful plant commissioning, startup and operations.	• Detailed work plans have not been developed for maintenance/repair activities that utilize the LRWH System to ensure adequate space, time and crane availability. • The current WTP OR model is based upon assumed times and rates, even though no detailed work breakdown evaluation has been conducted to support these assumptions.	• Waiting until plant commissioning and startup to determine how maintenance will be conducted is too late to influence gaps in plant design. • Failure of the LRWH System to support critical path activities for	Detail, model and evaluate all critical LRWH System activities and spaces. Factor the results of these evaluations back into the plant and system designs.

Table A-11. Vulnerabilities Identified for Radioactive Solid Waste Handling (RWH). (4 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		• Failure to conduct adequate work planning and OR modelling so that conflicts can be resolved in the plant design, will negatively impact plant commissioning, startup and production.	other systems on schedule during commissioning, startup and operation resulting in a failure to support glass production estimates and to meet throughput expectations.	
LRWH-M-02-V-03	• WTP is not following the DOE Hoisting and Rigging program, and no WTP specific hoisting and rigging program and/or critical lift program for the LRWH System have been defined nor is currently under development. • It is unclear how a WTP LAW hoisting and rigging program or critical lift program will adequately protect critical at-risk Safety equipment.	• Operations will be constrained to the DOE Hoisting and Rigging program, but this is not considered in the current construction contract or plant design. • It is unclear how any hoisting and rigging programs will adequately prevent damage to Safety system piping.	Due to the crane and LRWH area configuration, damage can occur to critical Safety system offgas piping.	Restrictive crane envelopes, and more extensive physical and procedural barriers, should be added to protect critical Safety systems. The specific hoisting and rigging program and/or critical lift program for the LRWH must comply with the DOE Hoisting and Rigging Manual.
LRWH-F-06-V-02	HEPA filters may develop too high a radioactive loading before pressure differential monitoring indicates a heavy particulate loading.	HEPA filters are bagged out using a hands-on method and this change-out is currently assumed to be scheduled before the filters have accumulated excessive radioactive loading; however, how this will be achieved is not defined as most particulate is not expected to be radioactive.	• Inadequate consideration of ALARA principles: • Increased dose to workers, • Ad-hoc procedures and packaging necessary after assumed survey prior to filter extraction, • Disruption of normal activities as off-normal container is conveyed though corridors and freight elevator.	Identify available ports on the HEPA filter assemblies and specify a method to monitor radioactive loading buildup during normal inspections (i.e., rounds).
LRWH-S-09-V-01	Experience performing startup and commissioning the LAW System RWH Process Area Bridge Crane for turnover to construction indicates that not performing these activities as soon as possible will delay all startup and commissioning activities as problems are uncovered late in the schedule when the project will be on the critical path for startup and commissioning.	• Commissioning major pieces of equipment is a difficult and usually lengthy effort. LAW Facility Systems are often complex, with many interacting components. Installed plant equipment that has not been through the commissioning process or otherwise turned over to operations will very likely require rework, delaying the completion of the Facility System startup and commissioning. • Current startup and commissioning plans begin after construction is complete, which will place all component rework on the critical path to startup/commissioning.	Startup and commissioning will be delayed as rework on component equipment and assemblies will occur on the system startup and commissioning critical path. This will delay facility startup and commissioning, which will have mission impact of six months or more.	• Follow a "bottom up" startup and commissioning strategy to reduce upsets on the critical path during plant startup and commissioning: • Isolate an area from construction activities containing installed components, • Bring in plant services or equivalent temporary services, • Startup / commission all components in the isolated area, • As the area can be extended, startup and commission interacting components and assemblies, • When a Facility System is entirely in an isolated area, begin startup and commissioning activities.
LRWH-M-02-V-02	Funding & resources have not been allocated to address:	• Equip. procured early in the project:	• Existing equipment warranties have expired (e.g., plant cranes)	Develop long term funding and plans that address expired warranties,

Table A-11. Vulnerabilities Identified for Radioactive Solid Waste Handling (RWH). (4 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	• Equipment no longer under warranty. • Equipment preservation and degradation	- Is now no longer covered under the manufacturer's warranty (e.g., cranes). - Is experiencing degradation such as corrosion and false brinelling (e.g., cranes). • If plant startup is subsequently delayed, additional inspection, refurbishment and equipment procurements may be required	• Increased costs due to additional procurements of equipment to replace degraded items procured early in the project. • Increased cost and schedule delays due to numerous setbacks in WTP plant startup date projections.	replacement and/or refurbishment of equipment.
LRWH-M-02-V-04	Key LAW documents contradict each other regarding LRWH System scope.	• The scope of the LRWH System is not consistent in key LAW documents. • The LAW Facility Description and RWH System Description are inconsistent regarding the discussion of; "bagging, packaging, decontamination, swabbing, etc." • The LRWH System description specifies that crane decon can be accomplished with CO2, pressurized warm water, steam, etc. However no such capability exists within LRWH and the SME states that no decontamination beyond wet wipes will be done. • The LRWH System description states that crane operations are conducted autonomously from the crane's pendant or its radio transmitter which is a contradiction.	• The lack of consistent understanding regarding key LRWH system functions could lead to deficiencies that delay commissioning and startup. • LRWH crane control will not be correctly designed nor adequately protect Safety System components.	The specific activities included in the scope of the LRWH System and equipment, and all interactions with associated systems should be clarified and documented consistently in WTP documentation.
LRWH-S-04-V-01	Many methods of secondary waste disposition and transfer paths within the facility remain undefined.	• Facility personnel conveyed that HEPA filters "may" fit in 55 gallon drums and a location for agitator blade change out remains undetermined. No specific system addresses this scope. • The agitator and pump will not fit in the waste container identified. A special waste container design and certification will be required.	Inability to disposition waste could significantly impact facility production.	Model all waste disposition streams and determine whether necessary equipment and transfer paths within the facility are adequate. Incorporate results into appropriate system descriptions.
LRWH-F-13-V-1	Transitioning an agitator or pump from a vertical position to a horizontal position is not identified in the current design or operation.	A methodology to export a spent agitator or pump has not been identified. No size reduction is planned. Therefore, a spent agitator or pump must be transitioned between vertical and horizontal at least twice on the export pathway from El. 28 ft. to El. 3 ft.	The LAW Facility design does not currently facilitate exporting and packaging a spent agitator or pump in a vertical only position. Therefore, the spent components must be transitioned between vertical and horizontal positions.	Develop a methodology to export a spent agitator or pump which may require transitioning the spent equipment between a vertical and horizontal position.
LRWH-F-13-V-2	A method to transport an agitator or pump from: a) the process cell charge floor hatch area to the L-0207 floor hatch; and b) El. 3 laydown area to the truck dock has not been identified.	A methodology to transport a spent agitator or pump within the LAW Facility has not been identified	The LAW Facility will be unable to transport a spent or new agitator or pump within the facility.	Develop a methodology to transport a spent agitator or pump.
LRWH-O-03-V-01	Equipment and attachment points are not determined for recovery of the Process Area Bridge Crane to its maintenance position.	The System Description talks to "recovery features" but no specific method or equipment is identified.	In the event of a failure of the Process Area Bridge Crane drive system, a recovery approach and the needed equipment would have to be determined with potential production impacts.	Perform preliminary planning on how the crane would be recovered and what equipment is needed.

Table A-11. Vulnerabilities Identified for Radioactive Solid Waste Handling (RWH). (4 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LRWH-F-13-V-3	Replacement of 14 components (agitators and pumps) from tanks within the process cell may be completed within the 6 month schedule to replace a melter. However, each replacement activity will compete for a finite man-hour resource.	The estimated outage for agitator and pump replacement activities is 168 days using the OR model. The melter replacement effort will compete with agitator and pump replacement and may create a challenge for the LAW man-hour resource.	The melter outage may not be completed within 6 months as currently planned due to competition with agitator and pump replacement for man-power resources.	Perform a man-power loaded melter outage including RP technicians, operators, and maintenance staff and include a simultaneous outage for replacement of 14 agitators and pumps and determine if throughput is reduced without modification such as staff augmentation.

Table A-12. Vulnerabilities Identified for Concentrate Receipt and Melter Feed Preparation (LCP/LFP). (6 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LCP/LFP-01	Potential for GFR component omission to cause premature melter failure	• Waste composition changes to melter feed expected to be gradual over time, but misbatching GFR addition (bounded by a component omission) calculated to cause change to melter inventory composition after one melter feed batch • Some GFR components ensure glass properties are compatible with melter operation • Estimate omission of single GFR for one or two feed batches in succession reduces melter inventory composition by 20 to 50 % relative to goal composition • Unclear if this type of off-normal condition could cause premature melter failure • MFPV sample not designated as hold point, but would be expected to be available to define mitigation under normal conditions • Unclear if laboratory priorities could delay results for samples that are not designated as hold points during time periods where a work flow backup occurs • Could result in processing multiple off-normal feed batches in succession • Waste composition changes to melter feed expected to be gradual over time, but misbatching GFR addition (bounded by a component omission) calculated to cause change to melter inventory composition after one melter feed batch • Some GFR components ensure glass properties are compatible with melter operation • Estimate omission of single GFR for one or two feed batches in succession reduces melter inventory composition by 20 to 50 % relative to goal composition • Unclear if this type of off-normal condition could cause premature melter failure • MFPV sample not designated as hold point, but would be expected to be available to define mitigation under normal conditions • Unclear if laboratory priorities could delay results for samples that are not designated as hold points during time periods where a work flow backup occurs Could result in processing multiple off-normal feed batches in succession	• Undefined potential for premature melter failure resulting in loss of production • Non-conforming glass canister	• Conduct impact assessment that defines the time period associated with omitting each glass forming component that could result in a premature melter failure • Define receipt of MFPV sample analysis results as hold point for initiating the next (or a fixed number of batches) glass former addition to mitigate potential for multiple misbatch additions in a row based on the omission time periods that could result in premature melter failure • Use control system to identify gross changes in batch to batch glass former component additions as method of warning that a potential input error has occurred (i.e., use control system to flag large variances in expected inputs such as glass former weights).
LCP/LFP-03	Design basis temperature of 150°F for CRV, MFPV and MFV vessels may not be adequately conservative under	• Cooling jackets for MFPV and MFV appear adequate under nominal conditions but could exceed temperature design limit if agitation is required over long periods or if temperatures of feed transferred from CRV are elevated.	• Operation of vessels beyond design temperature limits (tanks are built as pressure vessels with code stamp). Vessel appears adequately robust to	• Re-evaluate design basis temperature limits for vessels to increase operating margin and operational flexibility. Vessels appears

Table A-12. Vulnerabilities Identified for Concentrate Receipt and Melter Feed Preparation (LCP/LFP). (6 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	off-normal conditions (extended idle periods).	• Appears 150°F is adequate for CRV under most conditions. However, establishment of vessel design temperature considered agitator operation for 64 hours rather than an equilibrium temperature. Agitation could be required for more than 64 hours. • The current temperature hi-hi alarm is set at 150°F without margin to design limit.	support increasing the design basis temperature. • If tank temperature limits are exceed then development of recovery action plans and associated vessel analysis could impact throughput.	adequately robust to support increasing the design basis temperature to 200°F • Establish operational procedures and protocols to deal with prolonged periods of agitation operation in both CRV and LFP tanks (i.e., add water, temporary termination of agitation, etc.). • Re-analyze LCP/LFP tank equilibrium temperature for the possibility of extended periods for melter idling. Calculate the tank equilibrium temperature using agitator heat input, latent heat of evaporation inside the tank, plant service air flow rate and vessel vent flow rates. • Evaluate the impact that the boric acid exothermic reaction has on the operation of the MFPV tank temperature. • Consider feeding glass formers into the MFPV tank over a longer period of time (5-7 hours) to prevent tank temperature approaching or exceeding the tank design temperature limit.
LCP/LFP-04	Unknown ability of the LAW LFP Feed Prep and Feed Vessels to structurally support the external cooling panel sections.	• Unverified assumptions in the code calculation addendum need to be verified. • Method for attaching the cooling panels to the vessel is different than what was analyzed. • Weight of the panels analyzed was 3,000 lbs. when actual panel weights are 3,556 lbs. with cooling water and hoses. • Actual height of the jackets (unsupported portion) is 7'-11" and the calculation shows 5'-5". • In the WTP calculation, the UBC information utilizes an "R Factor" of 2.2000 and the Vendor calculation utilizes an "R Factor" of 2.9000. The reason for this difference is unclear. • In the WTP calculation, the UBC "Soil Profile" uses "SD" and the Vendor calculation uses a "Soil Profile" of "SC". The reason for this difference is unclear. • The Vendor calculation and the WTP calculation did not take into account the full equipment weight attached to the vessel (1,631 lbs. vs. 18,450 lbs.) • The cooling jackets have been fabricated and delivered without closing out the unverified assumptions in the calculation.	• The LFP vessels may not meet the structural and seismic requirements of ASME Boiler and Pressure Vessel Code. Vessels that do not meet code requirements will result in delays to resolve issues and may not be able to place vessels into service until resolved (e.g., RCRA permit concerns related to code requirements) • May require vessel repairs or replacement if structural integrity cannot be confirmed. • There appears to be sufficient margin in the vessel skirt thickness analysis but cannot confirm acceptability.	• Confirm unverified assumptions in analysis • Update analysis and verify adequacy of vessel design.
LCP/LFP-05	The 40 year design life of the LFP Vessels is in question due to the lack of credible data to	• The basis for the assumption that for the LFP Vessels, the velocity inside the vessels with glass formers will be less than ½ the agitator tip speed is derived from the results of	• Premature failure and leaking of LFP vessels in the C5 Wet Cell.	• Conduct additional CFD analysis with appurtenances modeled per vessel

Table A-12. Vulnerabilities Identified for Concentrate Receipt and Melter Feed Preparation (LCP/LFP). (6 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	accurately predict the erosion wear for SA-240, 316L material.	a Non-NQA-1 Computational Fluid Dynamic (CFD) software performed by the agitator vendor. With this unverified assumption accepted, all that is currently required for verification is to confirm the agitator shaft RPM and blade dimensions during startup testing and commissioning. • The LFP Vessels have welded features attached to the inside lower head (instrument cluster, pumps and pump alignment pins and agitator bump ring) that have not been modeled in the agitator vendor CFD analysis. These internal appurtenance's will disrupt flows and create eddies such that accelerated erosion pockets can form in the bottom head and shell which could exceed the calculated uniform erosion rate. • The 24590-WTP-RPT-M-12-001, WTP Sensitivity Assessment of Erosion Calculation states "All of the models used by the WTP Project have coefficients and exponents with a large degree of uncertainty since they are primarily derived from test data that was not directly applicable to the waste streams that are expected to be treated at WTP and/or did not use the materials of construction at WTP."	• Premature failure of equipment installed in the vessels • Expectation of a 40 year design life without a plan for vessel removal, fabrication and re-installation.	configuration to identify potential areas of accelerated erosion. • Based on the CFD analysis, consider remote vessel wall thickness monitoring (e.g., ultrasonic thickness transducers) permanently mounted to lower head and shell. • Conduct additional prototypic testing with relevant simulant to confirm relationship of agitator speed to fluid velocity at vessel head/walls. • Perform post-commissioning vessel inspections to determine evidence of premature erosion. • If still warranted from above, consider thermal spray hard coating of vessels and internals. • If thermal spray is considered, then also consider increasing the vessel design temperature to eliminate the need for the add-on cooling panels.
LCP/LFP-06	The operating envelope has not been defined to ensure the requirement for mixing homogeneity can be met during normal plant operations	• The information (e.g., agitator performance) required to prove 2% mixing variance is not directly or immediately available to the operator. • VSL testing indicated that radar level instrumentation may be problematic (affected by vortexes, foaming, splashing, etc.)	• Non representative sampling leads to incorrect GFC composition/amounts leading to non-compliant LAW glass. • May require additional waste or glass sampling. • May prolong commissioning efforts to determine 'confirmed' operating envelope for mixing.	• Define operating envelope and how much deviation can be allowed. • Consider alternative level detection such as using existing dip tubes (add transmitter to long leg of specific gravity dip tubes). • Consider adjustable speed drive (ASD) on agitators to allow flexibility to achieve required mixing performance.
LCP/LFP-07	Fixed speed agitators may not provide adequate flexibility to address variations in process conditions or recover after prolonged down time	• Adjustable speed drive was recommended by the vendor. • Testing has shown that variation in feed rheology is not always predictable.	• Increased erosion rates during prolonged melter idling reduce life expectancy of vessel and/or agitator. • Inability to recover from batches that exhibit high viscosity due to 'aging'.	Consider adding ASD to agitators.
LCP/LFP-12	A comprehensive equipment condition monitoring strategy/system is not evident so that process cell entries can be avoided	• Pump and agitator performance parameters (e.g., amperage, earth fault, thermistor) are inherent in the design but not currently identified for display to operators. • Many useful pump performance parameters are available via the ASDs PROFIBUS connection. The ASD design exists for the pumps and could be easily modified to include ASDs on the Agitators to improve flexibility and troubleshooting capabilities	• Incomplete information regarding equipment performance may require process cell entries for troubleshooting that could otherwise be avoided • Premature failure of equipment that otherwise could be avoided • Unaccounted production impacts and potential for increased worker exposure to hazards (e.g., to enter process cells).	Develop a formal comprehensive strategy for equipment performance monitoring. Review current design against the strategy and implement design changes as necessary.

Table A-12. Vulnerabilities Identified for Concentrate Receipt and Melter Feed Preparation (LCP/LFP). (6 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		• Riser for agitator gear box oil provided but no definition on how to use it. • No means evident to monitor/maintain oil pumps included in agitator gear boxes		
LCP/LFP-14	Current approach to ADS pump monitoring/trending may not be adequately indicative of performance	• Monitoring/trending currently considers single point comparisons of time phased pressure drop. This may provide false indication of adequate pump performance if the poppet valve is stuck closed. • Cannot confirm adequacy of ADS pump performance by the visual inspection of the condition of the cold-cap	Inadequate pump performance not identified thereby leading to lack of uniform feed for cold cap which can then lead to melter performance problems such as the creation of hot spots, elevated temperature in the offgas and loss of volatiles normally suppressed by the presence of the cold cap.	Consider using a two or more point comparison of ADS pump air-line pressure as a better indicator of overall performance and as an operator aid, for example the apex of the pump discharge pressure.
LCP/LFP-02	Capability to monitor feed slurry rheology during extended storage in MFPV/MFV is not defined/demonstrated	Test reports indicate that feed slurry apparent viscosity can increase by a factor of 2 due to aging	• Increased apparent viscosity may prevent transfers at desired transfer rate • Inadequate transfer rate may result in line plugging • No tool available to decide if/when MFPV/MFV contents must be recycled to Pretreatment via RLD system when idling melters for an extended time period (glass former recycle has potential to cause Pretreatment and HLW operating upsets)	• Include agitator power trending and/or periodic (or perhaps continuous) pumping of tank contents through MFPV/MFV recirculation lines as part of monitoring scheme when melters placed in idle mode. An ASD is considered to be the best method for agitator control and trending parameters/performance. • Periodic sampling during long outages to test for rheology changes
LCP/LFP-08	Cooling jackets for MFPV and MFV tanks do not include pressure relief.	• Jackets are designed for a maximum pressure of 100 psig. • Maximum demineralized water pressure is 145 psig. • Pressure relief is provided for other cooling jackets (e.g., SBS vessel)	Failure of cooling jacket could impact production and challenge the design temperature limit (150°F) of the vessel	• Evaluate the need for pressure relief for the MFPV and MFV cooling jackets. • Add pressure relief on the demineralized water system downstream of the PCV-2101 to control pressure for SBS as well a LFP cooling jackets.
LCP/LFP-09	Lack of comprehensive engineering strategy for removal of hard to remove solids or significant accumulations of solids in piping and vessels.	• Spool pieces are available to connect flush equipment but interfacing equipment not designed • Necessary design features for flush equipment and strategies for removal of significant solids accumulations not yet defined • Flush equipment necessary to support removal of pipe blockages or introduce alternative flush agent chemicals has not been developed. • Not evident that spray nozzles in vessels are sufficient to remove high shear (up to 2300 Pa) solids from vessels as could result from the loss of agitation for an extended period or collection in tank zones with poor agitation over an extended period (e.g., under center of agitator impeller)	Lack of design and testing of interfacing flush equipment could delay recovery from pipe blockages with attendant production impacts May impede pump and agitator replacements Reduction of vessel working volume	• Develop comprehensive strategy for removal of blockages from piping and high shear solids from vessels. • Define features necessary for pipe and vessel flush equipment to implement solids removal strategy • Design, test and demonstrate ability to deploy flush equipment • Evaluate the need for additional spool pieces/cleanout ports to support pipe flushes • Evaluate alternative flush chemicals • Evaluate need for other slurry handling systems based on lessons learned from other facilities • Consider tank farm lessons learned on removal of high shear solids

Table A-12. Vulnerabilities Identified for Concentrate Receipt and Melter Feed Preparation (LCP/LFP). (6 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LCP/LFP-10	The LCP/LFP bulge drain systems do not appear to have adequate drain capacity when spray rings are turned on.	• It appears that the LCP and LFP bulges can either partially fill with water or completely overflow via the HEPA filter if spray water system is left on for extended periods. • The only equipment for control of the spray water is the manual water spray ring valve and the RLD sump level • Drain blockage can be caused by system leaks which dry up and form crystals that blind strainer. Creeping film across the bulge to the drain is also possible. If the bulge drain line strainer is partially blocked or totally blocked then the bulge could overflow into the C3 area in less time than for a free flowing drain.	• Contaminated water (from C5 area) can overflow to the floor of a C3 area. • The bulge HEPA filter will become wet and have to be replaced.	Consider additional controls for the flush water flow to the bulge spray rings such as: • Install level monitoring in the bulge and change manual valve to a control valve which could be shut off automatically whenever the level in the bulge gets too high. • Install smaller capacity spray nozzles. • Install local liquid level gauge for operator to monitor liquid level. • Install orifice to reduce flow and pressure to spray nozzles. • Automate water spray system to limit time of flush and/or sequence flushes for short flushes followed by time drainage periods in a series of 2-3 cycles.
LCP/LFP-11	Ability to automate using existing design features appears underutilized	• Valve alignments for fluid transfers and flushes currently rely on operator actions and specific permissives. • Functionality is inherent in the design to fully automate transfer and flush sequences to minimize the potential for misrouting or line blockages due to operator error. • Auto-lubrication system for pumps/agitators includes option for remote control & power which has not included in the design (relies on battery power and in-cell indicator lights monitored by a camera)	• Increased probability of human error leading to misrouting transfers of process solutions or inadequate flushing leading to blockages. • Increased frequency of entries to process cells to monitor/maintain lubrication system with attendant throughput impacts.	• Consider fully automating transfer and flush sequences. • Consider adding equipment performance trending/monitoring parameters for display to operators. • Consider adding ASDs for agitator operation. • Incorporate remote monitoring/power option for auto-lubrication system
LCP/LFP-13	Undemonstrated ability to install/replace pumps/agitators and other internal components that require alignment with the vessel base (such as bubbler tubes and thermowells).	• No testing evident that the approach for alignment of pumps and agitators within the vessels can be effectively performed with the vessel in various operational conditions (e.g., full, partially full, minimum heel, etc.). • Effectiveness of the positioning aids to ensure alignment not apparent or demonstrated with anything other than a completely empty tank.	• Extended duration of agitator/pump replacement. • Installation without verification of adequate alignment could result in premature failure of pump/agitator and damage to vessel.	• Confirm the ability to change a pump/agitator under various vessel operating conditions during commissioning or as a mock-up • Consider the viability of incorporating additional alignment aids such as inverted cone to the base of the flange with the stabilizer guide
LCP/LFP-15	Basis/definition of acceptable gear oil leakage rates and process impacts is not evident	• Seals in gear boxes for agitators are not totally leak free, as per operating manual "If oil level has been exceeded, drywell will be filled with oil and oil leakage down output shaft will occur". Therefore, it appears that gear box oil/grease could leak into process vessels unnoticed. • Gear box holds 9.5 gallons of mineral oil. • Normally small amounts of leakage are probable, but no formal analysis demonstrated to determine process impacts, if any.	• Increased wear on agitator gear boxes from loss of oil/lube • Increased generation of Products of Incomplete Combustion (PICs) in the melter • Increased TCO catalyst usage • Exceed VOC limits in the offgas discharge • Operators have to enter Wet Process Cell to refill lubricant as necessary – requires melter(s) to be idled.	• Perform calculations to quantify acceptable limits for leak rates and/or amounts each vessel can tolerate. • Finalize design features for checking and replacing gearbox oil utilizing existing riser piping at the 28" level.

Table A-12. Vulnerabilities Identified for Concentrate Receipt and Melter Feed Preparation (LCP/LFP). (6 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LCP/LFP-16	Adequate mock-up/testing facilities are not available/planned to support high risk contact maintenance activities (such as pump/agitator replacement) and testing/run-in of mechanical equipment	• Lessons learned from nuclear facilities across the DOE complex indicated that the success of high risk maintenance activities depends on the ability to mock-up and practice such activities. • No evidence that a mock-up facility or dedicated mock-up area within the facility is planned or available	• Increased planning and preparation duration • Increased potential for errors (in planning and execution) that cause rework. • Increased risk of worker exposure to hazards • Increased impact to throughput due to prolonged outage durations	• Conduct a formal and systematic analysis of maintenance infrastructure needs • Identify and prepare an existing facility for use as a WTP mock-up/testing facility (e.g., 2101M, MASF at FFTF, etc.) or; • Design and build (e.g., pre-fab building) a testing/mockup facility at WTP. • Consider working with the tank farm contractor to establish a shared/consolidated mock-up facility.

Table A-13. Vulnerabilities Identified for Container Export Handling (LEH). (7 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LEH-IC-1-V001	Requirement Documents Conflict	• The 24590-CM-POA-MJKG-00003-11-00002 Software Document LEH Export Handling Crane, says that the LEH Export Handling Crane LEH-CRN-00003 uses the North position as its "home position" and that forward motion indicates south travel. The first interlock shown on Mechanical Sequence Diagram (MSD) for Law Vitrification System LEH (24590-LAW-M1-LEH-00001) indicates that forward movement is to the North. This makes interpreting the interlock difficult.	• If the interlock fails to operate as intended the crane, the container or the extended shield wall may be damaged. Crane operations over the Export Office would endanger workers. • Even if the interlock operates as intended, the conflicting documentation will make it difficult to over-ride the interlock for off-normal operations or to change the interlock, if necessary for future software revisions.	• Correct the Export Handling Crane LEH-CRN-00003 software documentation for consistency and to agree with the calibration of the Laser Positioner ZT-0147. Verify that the programming matches the updated documentation. • Review requirements documents to verify that requirements have been correctly addressed and implemented in the logic diagrams and programming
LEH-IC-1-V002	Interlock Incorrectly Defined	The interlocks for raising and lowering the Main Hoist on the LEH Export Handling Crane (LEH-CRN-00003) are shown on Mechanical Sequence Diagram (MSD) for Law Vitrification System LEH (24590-LAW-M1-LEH-00001). The state column incorrectly shows the undesirable condition (i.e., Overload instead of Not Overload or Slack Cable instead of Not Slack Cable).	• Reversing the interlocks will cause the crane hoist to not operate. Operation of an overloaded hoist will damage the crane and stop all export operations as there is no redundancy. • The consequence of incorrect documentation is improper programming, and improper programming of software changes.	• Correct the Export Handling Crane LEH-CRN-00003 documentation so the interlock shows the correct state. • Review requirements documents to verify that requirements have been correctly addressed and implemented in the logic diagrams and programming
LEH-IC-1-V003	Missing Interlocks	There are no interlocks shown on the Mechanical Sequence Diagram (MSD) for Law Vitrification System LEH (24590-LAW-M1-LEH-00001) that prevent one of the two roll-up doors to the Export Truck Bay (L0127) from being opened while one or both of the Hatches to the Finishing Lines is open. There are no interlocks at all for the LFH Hatches to the Export Truck Bay shown either on the LEH MSD or 24590-LAW-M1-LFH-00001, Mechanical Sequence Diagram for LAW Vitrification System LFH. Without these interlocks it would be possible to open both hatches at the same time, open a hatch when the roll-up door was already open, or to close the hatches while transporting a container through them.	Opening one of the hatches and roll-up doors at the same time would expose a R5/R3/C2 area (Rooms L-115E or L-109E) to the Outside.	• Add interlocks to the design to: - Allow only one LFH hatch to be open at a time - Prohibit the opening of a roll-up door when a hatch is open - Prohibit the opening of a hatch when a door is open. • Review requirements documents to verify that requirements have been correctly addressed and implemented in the logic diagrams and programming with special attention to interlocks that interface between LFH and LEH systems.
LEH-CRN-1-V001	Jib Crane Data Sheets and Specification Inconsistencies	Documentation related to the design and procurement of the West and East Maintenance Jib Cranes (LEH-CRN-00005/6) on 24590-LAW-M0D-LEH-00036/0037 Mechanical Handling Data Sheets - LEH West Maintenance Jib Crane / LEH East Maintenance Jib Cranes, are not in agreement with modifications to de-rate the crane. Hoist information is not consistent with de-rating changes. No record of de-rating or embed wall limitations are documented on the data sheet, even when data was required to be submitted by vendor under 24590-WTP-3PS-MJKH-T0001, Engineering Specification for	• Inconsistent design basis • Unknown design margin • Potential for exceeding design capacity	Revise all issued documents to reflect the de-rated capacity of the maintenance jib cranes (LEH-CRN-00005/00006).

Table A-13. Vulnerabilities Identified for Container Export Handling (LEH). (7 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		Commercial Quality Monorail Hoists, Jib Cranes, and Under-Running Single Girder Cranes.		
LEH-CRN-1-V002	Structural Analysis of Export Bay Inconsistencies	The FEA Model for the LAW Export Bay (LAW-S0C-S15T-00022, Rev 0, GT Strudl Finite Element Analysis for the LAW Export Bay) and the LAW Export Bay Wall Design calculation (24590-LAW-DBC-S13T-00053, Rev. 0) were both issued in 2005. Both calculations utilized jib crane vendor issued data as input into the analysis, but neither document determined that embeds design and anchorage could not support the vendor reaction forces from the jib crane and 5 ton load.	• Inconsistent design basis • Unknown design margin • Potential for exceeding design capacity	• Provide a full extent of conditions analysis on embeds that support loads on vertical walls of the LAW Export Bay to ensure the embed design meets equipment loads. • This may already be covered under PIER 13-0515, but this PIER was not provided by BNI during the review.
LEH-CRN-1-V003	Maintenance Jib Crane De-rating and Analysis of Embeds Inconsistencies	The de-rating of the LEH maintenance jib cranes (LEH-CRN-00005 and 00006) from 5 tons to 1.75 tons was not well documented or provides a level of assurance that the de-rated value is within the embedment structural limit. There is no evidence to support how the de-rated value of 1.75 tons is calculated or what margin exists if the crane embedments are subjected to that de-rated crane load.	• Inconsistent design basis • Unknown design margin • Potential for exceeding design capacity	• Provide a full extent of conditions analysis on embeds that support loads on vertical walls of the LAW Export Bay to ensure the embed design meets equipment loads (This may already be covered under PIER 13-0515, but this PIER was not provided by BNI during the review). • Revise the embed anchorage calculation to provide the limit of the embed design. The results should show the actual load the embeds can support, including resulting crane capacity that produces that load.
LEH-CRN-1-V004	Maintainability of LAW Export Bay Crane and Jib Crane Capacity	The decision to de-rate the jib cranes (LEH-CRN-00005/6) was partly based on the idea that the new 1.75-ton capacity would cover any item requiring removal from the 10-ton Export Bay crane (LEH-CRN-00003). The main area where maintenance is going to occur on the Export Bay Crane will be the trolley and trolley mounted equipment. The trolley is designed to be lifted as a single unit but neither maintenance jib cranes have the capacity to lift the 7.5 ton trolley. This will force work to be done on the crane itself and individual components will need to be removed while working over 30 feet above the Export Bay operating floor.	• Inconsistent design basis • Maintenance requirements not met • Potential for plant throughput impacts	• Investigate the feasibility of a different lifting system (i.e., single underhung or under-running type) to support the maintenance of the LAW Export Bay Crane designed to work within the limits of the facility and lifting capacity requirements. This might require additional structural support or utilizing other structural steel already in place. • The new lifting system should have the ability to move over the entire range of the intended work zone.
LEH-CRN-1-V005	Maintainability of LAW Export Bay Crane and Jib Crane Reach	Based on the location of the permanent maintenance platform LP0127 for the 10-ton Export Bay crane (LEH-CRN-0003), the 10-ton crane cannot move underneath the de-rated maintenance jib cranes (that are located above the permanent platform). The permanent platform forces the 10-ton crane to "park" farther away from the jib cranes and results in a significant area where the crane trolley cannot be reached by either jib crane. In addition any item to be lowered over the south end of the crane has only a 12 inch clearance past the crane handrail when using	• Inconsistent design basis • Maintenance requirements not met • Potential for plant throughput impacts	• Investigate the feasibility of a different lifting system (i.e., single underhung or under-running type)) to support the maintenance of the LAW Export Bay Crane designed to work within the limits of the facility and lifting capacity requirements. This might require additional structural

Table A-13. Vulnerabilities Identified for Container Export Handling (LEH). (7 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		the West Jib Crane (LEH-CRN-00005), there is only a 1 inch clearance when using the East Jib Crane (LEH-CRN-00006).		support or utilizing other structural steel already in place. • The new lifting system should have the ability to move over the entire range of the intended work zone.
LEH-CNTR-1-V001	Filled ILAW Container export temperature may affect Tank Farm Contractor (TOC) / Integrated Disposal Facility (IDF) operations	The ILAW glass thermal conductivity property, single pour / alternating pour operations, Facility throughput, Buffer Storage area capacity available, and LAW Facility ambient temperatures will all affect how quickly the filled ILAW containers cool. The IDF base mat has thermal limitations. At a LAW Facility production rate of 30 MT/day, the Average surface temperature of an ILAW container holding low conductivity glass will be about 320°F and the temperature of an ILAW container holding high conductivity glass will be about 250°F.	If the filled ILAW containers are thermally hot, the TOC may have to stage the containers for further cooling prior to internment in the IDF.	Either increase the ILAW container cooling capabilities of WTP LAW Facility, or construct ILAW container cooling facilities at either the TOC or IDF facilities.
LEH-RCSH-1-V001	Contamination migration when transferring ILAW product container	When transferring the ILAW product container, Operations lowers the grapple into the System LFH monitoring/export area. The ILAW product container is then raised, and is then lowered into an ILAW transport container. Although this task is planned to be remotely conducted, there is no engineered decontamination or downposting verification process identified to ensure none of the contamination has migrated outside of the C5 boundaries (such as on the grapple equipment).	• Contamination migration and permanent increased contamination posting • Increased operational and maintenance costs	Evaluate the currently defined work processes and ensure an engineered or administratively-defined process is adequate for controlling contamination migration when transferring the ILAW Product Container from System LFH to the Transport Trailer and that confirmation is available, such as continuous air monitor, to ensure personnel are not inadvertently exposed to an airborne radioactivity area.
LEH-RCSH-1-V002	LEH system compliance to design and operational safety and health requirements	Within the system description for the LEH are specific OSHA requirements and other standards that pertain to cranes and hoists and fire protection; however, a significant number of requirements and standards were not identified as part of the system such as (to mention a few) Subpart D, Walking-Working Surfaces, Subpart E, Means of Egress, Occupational Health and Environmental Control, Subpart N, Materials Handling and Storage. In particular, under "Hands-On Maintenance" no standards for heat stress were identified, only radiological control considerations. It should also be noted that within 24590-WTP-RPT-OP-001, Rev. 4, Operations Requirements Document, general plant safety requirements are identified; however, minimal operational requirements are not clearly identified.	• Inadequate design and operational procedures • Not meeting regulatory/contractual requirements	Verify and validate that all required codes and standards have been incorporated into the design of the LEH system and, if not within the design, the requirements and standards are within appropriate procedures for both operations and maintenance work evolutions.
LEH-RCSH-1-V003	Thermal Temperatures on ILAW Transport Container Package	Workers are required to physically secure the ILAW transport container package to the transport vehicle; however, this may not be physically possible depending upon the external temperature of the transport container package. Evaluation of calculations by the Review Team found that the predicted external temperature of the transport container is variable depending upon operational throughput and the ability for	• Inadequate design and operational procedures • Not meeting regulatory/contractual requirements	Define/determine an external temperature (max operational parameter) of the transport container package that is expected to be encountered by personnel and then to verify that appropriate mitigation of the hazard has been defined. In addition, per the system

Table A-13. Vulnerabilities Identified for Container Export Handling (LEH). (7 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		personnel to be able to physically perform this duty may be significantly impacted, if not physically impossible to be performed with a human being.		description the transport vehicle will contain additional containers; therefore, a cumulative effect of the heat being generated from all shipment containers should be analyzed and determined as to what mitigating factors will be needed to ensure protection of personnel from a heat/thermal hazard
LEH-ICD-1-V001	Shielding of the ILAW product container transporter is not defined	Shielding thickness, height, and configuration (number of containers transported per shipment), etc. are key elements of the design of the ILAW containers transporter, which interfaces daily with the LEH System. They remain undefined, which may have an impact onto the loading operations in Export High Bay L-0127.	• Inconsistent/inadequate design • ALARA design inadequacies • Operations concerns	Provide adequate details in ICD 15 for the requirements of the LEH system in regard to source term and shielding. The details should provide enough information for WTP to complete LEH design activities.
LEH-ICD-1-V002	Essential elements of the authorization process for exporting ILAW containers from the LAW Facility and review/approval of the shipping Manifest have not been defined	Lack of definition of the organization/personnel at WTP and TOC who will actually validate for each shipment that the Manifest is acceptable and can be handed out to the transporter driver so that the containers can be exported out of the Export Bay. No definition of the documentation review/approval time. No verification that this time can effectively be compatible with the 5 package/day production rate and the size of the filled containers buffer area.	• Inconsistent/inadequate design • Potential impacts to throughput • Potential impacts to operations or operability	Provide adequate procedures for LEH export activities including ILAW Container shipping inspection and authorization requirements.
LEH-ICD-1-V003	Potential conflict between Contamination limitations in Export High Bay and surface contamination of ILAW product containers	Lack of plan and/or operations procedure to address the more restrictive limiting factor for loose surface contamination in the Export High Bay required by 10CFR 835, Appendix D against the surface contamination levels of the ILAW product containers defined by the WTP Contract and the performance of the Carbon Dioxide decontamination process deployed in the LFH System.	• Inconsistent/inadequate design • ALARA design inadequacies	Align the design basis of the facility to the design implemented in regard to Contamination limitations in Export High Bay and surface contamination of ILAW product containers.
LEH-ICD-1-V006	Open ICD 15 issues and actions may affect the operations in the LEH System	Appendices A and C to ICD 15 list many issues and actions which remain out of the baselines of the 3 Hanford Projects - WTP, TOC, and PRC – or pending, which may impact the design and operations of the LEH System.]	Inconsistent/inadequate design	Provide adequate details in ICD 15 for the requirements of the LEH system and close open issues that may cause significant impact to the project. The details should provide enough information for WTP to complete LEH design activities.
LEH-OR-1-V001	24590-LAW-RPT-PO-05-0001, Rev 0, LAW Reliability, Availability, and Maintainability Data Development Report, inconsistencies and RAM data issues.	The LAW RAM Data Development Report contains information that is inconsistent with other documents, MTTR data that is over optimistic and MTBF data that appears to be wrong. The document describes a sequence of operations for loading ILAW containers on the transportation trailer which is not consistent with 24590-LAW-3YD-LEH-00001, System Description for the LEH LAW Container Export Handling, Rev. 2. The MTTR data for the cameras on LEH-CRN-00003 is overly optimistic if a camera fails while the crane is transferring an ILAW container. The MTBF data provided for	Overly optimistic MTTR data entered into the OR model results in facility availability estimates that are not accurate.	Correct inconsistencies in LAW Reliability, Availability, and Maintainability Data Development Report, re-evaluate sequence of operations when crane camera fails and either allow suspended loads to be landed or increase MTTR for camera replacement, and correct MTBF for LEH-CRN-00003.

Table A-13. Vulnerabilities Identified for Container Export Handling (LEH). (7 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		LEH-CRN-00003 appears to be an error because the MTBF hours are less than the MTBM hours.		
LEH-OR-1-V006	24590-WTP-MDD-PR-01-001, Rev 12, Operations Research (WITNESS) Model Design Document, inconsistency and missing information.	The OR Model Design Document (MDD) and the Flowsheet Bases, Assumptions, and Requirements document do not contain the same process steps and times for the LEH system. The OR MDD does not contain RAM information for the cameras mounted on the LEH-CRN-00003.	Incorrect data input into the OR Model will result in facility availability estimates that are not accurate.	Correct inconsistencies in the Operations Research (WITNESS) Model Design Document, and re-evaluate sequence of operations when a Load-out Bay Crane camera fails and either allow suspended loads to be landed or increase MTTR for camera replacement.
LEH-CRN-2-V001	LEH-CRN-00003 crane capacity may not be sufficient.	If a container cannot be decontaminated then an overpack will have to be added. The added weight of the overpack and lifting device (23,863 lbs) will exceed the 20,000 lbs crane capacity.	LAW container cannot be exported and the facility is at risk of being blocked with non-compliant containers.	Establish method for exporting non-compliant containers and validate LEH-CRN-00003 crane capacity is not exceeded.
LEH-ICD-1-V004	Duration of ILAW product container approval process prior to shipment not defined	Lack of indication of the overall schedule/time necessary to go through the successive steps of the documentation preparation and approval process, and no evidence that the overall process can support shipments of ILAW containers at a production rate of 5 containers a day with a limited buffer capacity in the LFH System.	• Potential impacts to throughput • Potential impacts to operations or operability	Provide adequate procedures for LEH export activities including shipping inspection and authorization requirements.
LEH-ICD-1-V005	Uncertainties in schedule for initial ILAW container production and transport	There is no explanation provided for showing in ICD 15 an over 4-month time period between the planned date to begin hot commissioning of the WTP LAW Facility (and initiate the transfer of the first ILAW product) and the planned date for TOC to pick up the first loaded ILAW transporter. Such a long time doesn't match the facility throughput requirements.	• Inconsistent/inadequate design • Potential impacts to operations or operability	Provide adequate details in ICD 15 for the requirements of the LEH system in regard to the schedule for initial ILAW container production and transport. The details should provide enough information for WTP to complete LEH design activities.
LEH-OR-1-V002	24590-WTP-MCR-PET-11-0058, Rev 0, LAW Mechanical Handling System RAM Update, inconsistencies.	The report contains information that is internally inconsistent and inconsistent with other documents. The process steps in the report do not include information on how long it will take to reposition LEH-CRN-00003 to retrieve an ILAW container after discharging an ILAW container on the transportation trailer. The report also contains inconsistencies on MTBF and MTTR data for the LEH coiling doors and process step durations.	Incorrect MTBF and MTTR data will affect the results of the OR model.	Correct the LAW Mechanical Handling System RAM Update, so the data is consistent.
LEH-OR-1-V003	CCN 068365, LAW LEH System – RAMI – OR, lacks bases for MTTR data.	Item 4 indicates the cameras mounted on the load out bay crane (PTJ-XT-2161, PTJ-XT-2162, and PTJ-XT-2163) have a MTTR of 8 hours but no basis for these numbers is provided. As indicated in Note 1.c. above, the repair time will be significantly higher if the failure occurs when an ILAW container is being transferred. The process steps as currently written state that the crane must be stopped upon failure of any one camera. This will require significantly more time to establish and setup safety measures (i.e., shielding) and access (i.e., scaffolding or scissor lift) so the failed camera can be replaced. [	Overly optimistic MTTR data entered into the OR model results in facility availability estimates that are not accurate.	Re-evaluate sequence of operations when a Load-out Bay Crane camera fails and either allow suspended loads to be landed or increase MTTR for camera replacement.

Table A-13. Vulnerabilities Identified for Container Export Handling (LEH). (7 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LEH-OR-1-V004	24590-WTP-RPT-PT-02-005, Rev 7, Flowsheet Bases, Assumptions, and Requirements, is inconsistent on the number of ILAW containers to put on the transportation trailer.	The last paragraph of Section 3.7.3 and Figure 3.7-1 imply the trailer in the LEH export bay contains one "flask" to hold one ILAW product container. This is inconsistent with item 28 in Table 3.7-1, page 3.7-11, which states to repeat the transfer of an ILAW product container in to a "cask" on the trailer, and is also inconsistent with other documents that indicate the trailer will be loaded with 5 ILAW product containers.	Incorrect process steps and durations will affect the results of the OR model.	Correct the Flowsheet Bases, Assumptions, and Requirements, so the data is consistent.
LEH-OR-1-V005	24590-WTP-RPT-PET-07-003, Rev 1, Waste Treatment Reliability Availability Maintainability (RAM) Basis Report, redundant information.	The table on page B-5 (rows 23 and 24) appears to be redundant to the information provided in rows 27 and 28. The information in rows 23 and 24 should be deleted.	Incorrect data input into the OR Model will result in facility availability estimates that are not accurate.	Correct the Waste Treatment Reliability Availability Maintainability (RAM) Basis Report, so the data is consistent.
LEH-CRN-2-V002	LEH-CRN-00003 crane maintenance/inspection platform not easily accessible.	The crane platform is located on the South side of the bridge and facility platform is located on the North side. Additionally, the North platform will be under the trolley power rail/cable tray.	Climbing on/over elevated equipment, even with fall protection, is a high risk job.	Establish maintenance/inspection access requirements and make design modifications to ensure safe LEH-CRN-00003 crane access.
LEH-CRN-2-V003	Heavy maintenance strategy not defined for LEH-CRN-00003.	There is less than 3' clearance for the hook lifting device/load spreader and for clearance to lift the item over the crane. Further, when the crane is at the northern travel limit, the South side of the crane handrail will prevent maintenance jib crane access to the floor. The maintenance platform is limited to 100 psf which prevents the platform from being used as a component set-down area.	Heavy maintenance evolutions will be very complicated and will increase the facility downtime during these activities.	Establish heavy maintenance activities and detail step-by-step sequences to establish design requirements for crane LEH-CRN-00003. Make design modifications to perform sequences such as doors or hatches in the maintenance platform.
LEH-TOOL-1-V001	Inadequate design basis documentation for container grapple stands	Failure to provide accurate design requirements in data sheets, drawings, and test documentation.	Maintenance and operations will spend time researching and establishing the design basis for equipment.	Revise design and fabrication documentation for container grapple stands to ensure accurate and as-built information.
LEH-TOOL-2-V001	Inconsistent grapple load rating	24590-LAW-M0D-LEH-00022, Mechanical Handling Data Sheet, Grapple, all requires the grapple load capacity to be 10 ton (20,000 lbs). However, specification for special grapples and lifting devices, 24590-WTP-3PS-MQL0-T0003, section 3.8.2.1 requires a safe working load of 16,500 lbs. The ICD 15, Interface Control Document for Immobilized Low Activity Waste, allows the mass of each package to not exceed 10,000 kilograms (22,046 lbs).	Confusion with basis of design	Increase the grapples safe working load to 25,000 lbs to handle all container conditions
LEH-TOOL-2-V002	LAW production container volume, weight, and center of gravity calculation, 24590-LAW-M0C-LRH-00004, does not include overpack condition.	An abnormal condition could occur if the container cannot be decontaminated and overpacking is required to be added to the container.	Special container handling devices will be required to handle off-normal conditions	Revise calculation to include the addition of overpacking material to the outside of the container.
LEH-TOOL-2-V003	Grapple temperature limitations.	The grapple analysis, 24590-QL-POA-FH00-00001-08-00001, indicates that the reserve factor is barley met with a load of 16,500 lbs and a flange temperature of 600°F.	Since the grapple is a common design the temperature limitation is as important as the safe working load limitations. These conditions could lead to unsafe lifting conditions.	Add grapple markings to clearly identify temperature limitations the same way safe working loads are identified.
LEH-TOOL-2-V004	Grapple excessive load testing.	General specification for remote and mechanical handling equipment design and manufacture, 24590-WTP-3PS-M000-	Confusion with basis of design	Revise BNI procurement process to ensure vendors test equipment according

Table A-13. Vulnerabilities Identified for Container Export Handling (LEH). (7 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		T0002, section 3.4.3.10, indicate that lifting attachments shall be factory load tested at 125% of rated load in accordance with ASME B30.20 (Below the hook lifting devices). The ASME B30.20, Below the hook lifting devices, section 20-1.3.8.2 indicate that test loads shall not be more than 125% of the rated load unless otherwise recommended by the manufacturer. The testing requirement in 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 6.4.6.c requires the grapple static load test to be performed at 150% of the SWL and held for 15 minutes.		to contractual documentation and that all requirements are consistent between documents.
LEH-TOOL-2-V005	Design requirement not verified in factory acceptance testing.	The design requirement in 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 3.8.2.3 requires the grapple's three fingers to have a combined minimum total contact area of 15 in2.	Failure to document design requirements.	This requirement should be validated during start-up testing to ensure this critical characteristic is met.
LEH-TOOL-2-V006	Requirements for factory acceptance testing not fully being performed.	Specification requirements in 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 6.4.7.g indicate the grapple will be tested to ensure it is capable of maintaining its engagement even if the load is laid on its side and the tension on the bail is relieved; the grapple shall then be capable of lifting the load when the hook is raised, all as part of the 20 complete cycles simulating actual operating conditions. The simulated operating conditions test consisting of 20 completed cycles is performed in 24590-QL-POA-FH00-00001-13-00003, factory acceptance test plan for MR36 LAW grapples and grapple stands section 3.A.4, but this step is omitted.	Failure to test and document design requirements are met.	This critical design requirement should be performed as part of an additional FAT or demonstrated through analysis.
LEH-TOOL-2-V007	Inconsistent design requirements.	Data sheet 24590-LAW-M0D-LEH-00022 indicates the operating environment temperatures and humidity is 59 – 113°F and uncontrolled humidity. Specification 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 3.6.2 indicate ambient temperature range of 50 – 113°F and humidity range 5 – 100%. Calculation 24590-LAW-M0C-M40T-00001, LAW HVAC Environmental Qualification Conditions Calculation, indicates the building internal unoccupied C3 areas are 59 – 95°F with 10% relative humidity.	Confusion with basis of design	Revise data sheets, specification, and calculation to indicate a consistent and accurate grapple operating environment.
LEH-TOOL-2-V008	Inaccurate model data for LRH process steps.	The operations research model design document, 24590-WTP-MDD-PR-01-001 table 78, lists the process step for transferring a container from the bogie to the transport trailer. The LAW Vitrification Capacity and Availability Study, 24590-LAW-RPT-ENG-01-001, indicate these same process steps, but the process steps do not match.	Inaccurate model output data.	Engineering should perform a complete OR model input verification prior to model output is considered valid.

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Table A-14. Vulnerabilities Identified for Container Receipt Handling (LRH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LRH-IC-1-V003	No Personal Safety Interlock on the Container Receipt Station.	When a container is inspected and approved, it can be advanced to the P2 position ready to be imported to the Container Receipt Area P3. However when the container at P2 is advanced, a container being inspected at P1 will be advanced at the same time because they are on the same Container Receipt Conveyor.	An operator working on a container at the Container Receipt Station could be injured by a moving Container or the operation of the conveyor.	Add an ICN monitored, hard-wired, lock-out buttons to each of the two Clean Container Receipt Station conveyor lines that will be activated prior to manned operations at that station, and will be deactivated by the receipt inspector before the Container Receipt Conveyor can be operated.
LRH-IC-1-V004	Conveyor Alarm Horns do not sound During Local Operation.	When the conveyors are being operated in Local mode, there will be co-located workers near them. This is when an alarm horn is most needed.	Workers could be injured by the unexpected operation of the conveyors or the moving containers.	Wire the incoming container handling conveyors alarm horn to sound as described in the Software Requirements and Control Logic document in both Local and Remote modes to ensure that everyone in the area knows the conveyors are about to operate.
LRH-IC-1-V005	Retractable Stop is not Required to be Extended to Open the Import Hatch.	Although a hard-wired interlock extends the stop when the Import Hatch is not open, the ICN does not stop the hatch from opening if the stop isn't extended.	If the hard-wired interlock (not shown on the Diagrams) fails, the ICN will allow the hatch to open even though a container at P9 could potentially roll off the Transfer Conveyor into the open hatch.	• Add the interlock requirements to the drawings and program the interlock that allows the Retractable Stop to be retracted when the Clean Container Import Hatch (LRH-HTCH-00001/0002) starts opening but requires it to be extended once the 'Closed' switch indicates the hatch is not closed. • Review requirements documents to verify that requirements have been correctly addressed and implemented in the logic diagrams and programming.
LRH-IC-1-V010	The Software Acceptance Procedures do not identify test actions nor provide criteria for acceptance.	The LAW LRH System Software Acceptance Test, 24590-LAW-PISW-J-08-0024-03, section 6.12.3 performs an Input Variable Check. The step provides a table to identify each input, the software parameter name and a record of Pass / Fail. However, there is nothing in the procedure step to identify what the test operator did to test this parameter, nor an indication of what the expected result would be, nor an indication of what result was actually observed. Without this information it is not possible for a reviewer to determine whether the test step correctly tested the parameter, whether the step was performed correctly, or to independently verify that the observed condition did, in fact meet the criteria for passing. [See Section 5 of CNN 089178, the Integrated Control Network Commissioning Strategy White Paper]	It will not be possible to predict whether the software will perform as intended in each case. SAT test documentation is inadequate for replacing field-testing.	Evaluate procedures for preparing Software Acceptance Testing (SAT), evaluate the SAT tests that have been performed and either correct the test procedures and re-perform the SAT tests or, better, perform full field-testing.
LRH-OR-1-V001	24590-LAW-RPT-PO-05-0001, Rev. 0, LAW Reliability, Availability, and Maintainability Data Development Report, inconsistencies and missing information.	The LAW RAM Data Development Report documents the basis, methodology and development of RAM data for the LAW Facility. However, the report, issued in June 2005 makes some assumptions based on availability of information at that time and the assumed minor design changes to the systems and components in facility. The report appears to assume all spare parts are readily available and sufficient numbers of personnel are readily available to handle maintenance and repair issues. Historically, these have been problems at Hanford and should be incorporated in the MTTR data. Additionally, the MTTR data does not take into account the extra time it takes work to be	Overly optimistic MTTR data entered into the OR model results in facility availability estimates that are not accurate.	Correct the inconsistencies in the LAW Reliability, Availability, and Maintainability Data Development Report, and work with TOC to develop new MTTR data based on historical availability of spare parts and personnel. Develop detailed list of spare parts to be maintained on site, and parts that are readily available from local vendors.

Table A-14. Vulnerabilities Identified for Container Receipt Handling (LRH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		accomplished in contaminated areas versus uncontaminated areas.		
LRH-OR-1-V002	24590-WTP-RPT-PT-02-005, Rev. 7, Flowsheet Bases, Assumptions, and Requirements, inconsistent data.	The MTBF and MTTR data in the Flowsheet Bases, Assumptions, and Requirements document are not consistent with data provided in the LAW RAM Data Development Report for the LRH conveyors.	Incorrect MTBF and MTTR data will affect the results of the OR model.	Correct the MTBF and MTTR data in the Flowsheet Bases, Assumptions, and Requirements documents so the data is consistent with data provided in the LAW RAM Data Development Report for the LRH conveyors.
LRH-OR-1-V003	24590-WTP-MDD-PR-01-001, Rev 12, Operations Research (WITNESS) Model Design Document, inconsistencies and missing data.	The Operations Research (WITNESS) Model Design Document contains MTBF and MTTR data that is not consistent with the LAW RAM Data Development Report and the Waste Treatment RAM Basis Report. Additionally, document credits the conveyors as being redundant systems; however, the conveyors share a common airlock which will inhibit maintenance activities on one conveyor line when the other is in operation.	Incorrect MTBF, MTTR, and omitted components will affect the results of the OR model.	Correct Operations Research (WITNESS) Model Design Document so the data is consistent with data provided in the LAW RAM Data Development Report and Waste Treatment RAM Basis Report, and update OR model to include conveyors that are not included in the current model. Verify redundant systems are truly redundant based on sequence of operations and sequence of maintenance.
LRH-CRN-1-V001	Empty LAW container deliveries will affect LSH and RWH operations	A delivery of empty LAW containers will block the truck bay / loading dock until all the containers are removed from the truck. Blockage of the truck bay with a container delivery will affect LSH & RWH operations.	Around the clock, multiple shift operations may be required to allow required shipments of empty LAW containers, LSH Melter consumables, and RWH waste shipments into and out of the LAW Facility.	• Perform a detailed task analysis of all the over-the-road shipping operations performed in the L-0118 truck bay to support LAW Facility operations. Use the task analysis to develop integrated operating procedures across the LRH, LSH, and RWH systems. The integrated procedures should schedule truck bay operations at the facility level. • Provide operator training to quickly improve their proficiency in handling empty LAW containers, removing container shipping hold-down gear, and the removal of container dunnage.
LRH-CRN-1-V002	Empty LAW container handling by the LSH-CRN-00001 crane will have to be done by either moving the containers around each other or by moving the containers in controlled, sequential order.	The LSH-CRN-00001 crane does not have enough lift clearance to lift a LAW container over another container on an over-the-road truck. Due to the length of the procured pendant cable, use of the pendant to control the crane and move canisters from a truck will be difficult.	The over-the-road truck making a delivery of empty LAW containers will block the L-0118 truck bay until the containers are removed from the truck, receipt inspected, and moved into the facility. Double shift operations may be required to clear a shipment of containers.	Develop operating procedures and operator aides to facilitate unloading containers from the over-the-road trucks. Provide operator training to quickly improve their proficiency in handling empty LAW containers with the LSH-CRN-00001 crane.
LRH-CIS-1-V001	Inspection of incoming empty containers required by WTP Contract and ILAW PCP is problematic	There is no inspection procedure available nor description of any toolkit that would be necessary to deal with the detection and removal of any liquid or solid material present inside the 7.5' tall containers: no light, video camera, bore scope, suction and swabbing devices for drainable or adhering liquids, gripping tool for solid debris, etc. have been defined or selected so far.	• Inconsistent/inadequate design • Operations concerns • Secondary waste concerns • Potential safety concerns	A valid inspection procedure and design for removal of foreign material from the incoming container will need to be provided.
LRH-CIS-1-V002	No safe access by personnel to delivery truck trailer	There is no access tool defined that will provide the operators with the safe access to the trailer when they have to untie slings, tie-downs, etc. that may be used to secure the containers during their road transportation to the Import Bay.	• Inconsistent/inadequate design • Secondary waste concerns • Potential safety concerns	A design will need to be provided to give access to transporter trailer from the loading dock. This may require a ramp or platform or redesign of the import bay (increase the size to allow for proper access around the transporter and proper platforming).

Table A-14. Vulnerabilities Identified for Container Receipt Handling (LRH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LRH-CIS-1-V003	No procedure available for removing container wrapping material and shipping cover	The procedure and tools required for safely removing the shrink wrapped heavy-duty plastic film and steel covers are not defined yet. In addition, no project documentation details the disposition path for the shipping material (wrapping film and steel covers).	• Inconsistent/inadequate design • Secondary waste concerns • Potential safety concerns	A valid inspection procedure and design for removal of wrapping material and shipping cover from the incoming container will need to be provided.
LRH-CIS-1-V004	The angle of view doesn't allow the inspector to see inside the incoming 7.5' tall container	The eyes of the inspector standing on top an inspection stepped platform will be at 130" above the floor of the Load Dock when the top of the container will be at 108" above the same floor. This distance doesn't allow any view of the inside of the container through the 15" diameter container opening.	• Inconsistent/inadequate design • Maintenance concerns	Provide an inspection station that can meet the inspection requirements while the containers are located on the receipt conveyors. This may require a permanent platform over the 3 conveyors and is accessed via ladders.
LRH-CIS-1-V005	The inspection platforms cannot be located as close as possible to the empty container being inspected	The access to the container top opening by the inspector is challenged as the platforms will be located between positions P1 and P2 of the Receipt Conveyors which increases the distance between the inspector and the container vertical axis.	• Inconsistent/inadequate design • Maintenance design inadequacy • Potential safety concerns	Provide an inspection station that can meet the inspection requirements while the containers are located on the receipt conveyors. This may require a permanent platform over the 3 conveyors and is accessed via ladders.
LRH-CIS-1-V008	Problematic communication between Inspector in L-0118 and Operators at LOI in Room L-0117 or in Control Room	There is no operating procedure that defines the role and responsibilities of the Inspector and the operators present at the LOI or in the control room and who makes the decision for transferring an inspected acceptable container from the receipt conveyors to the staging conveyors. Operations may be problematic and even induce an industrial safety risk.	• Operations concerns • Potential safety concerns	It may be necessary to provide a local operator interface (for the receipt conveyors only) at the clean container receipt station, instead of the staging area.
LRH-CIS-1-V010	Proper angular orientation of the incoming container on the Receipt Conveyors is required but not defined	The procedure has not been developed (nor the tool defined to facilitate the safe manual rotation) that defines the proper angular orientation of the painted spot for a container standing at Position P1 on the Receipt Conveyors.	• Inconsistent/inadequate design • Operations concerns	A simple solution would be a procedure that requires the container to be in a specific orientation/rotation at the receipt station. Another option would be to provide a new design for container marking/tracking that eliminates the need to provide the proper rotation. This may be as simple as marking the container in each quadrant so it can be viewed at any rotation.
LRH-CNVR-1-V008	Conveyor Impact Loading Calculation Inconsistencies	The 24590-CM-POA-M000-00001-05-00002, Rev. 00A, Vendor Calculation – Conveyor Roller Impact Loading, determines the resulting stress and bearing reactions in the conveyor roller when the conveyor is loaded by the overhead crane. Inputs to the calculation were based on Section 3.3.3 of the conveyor specification and do not account for the grapple weight. When the weight of the grapple is included, the allowable stress in the conveyor design is exceeded.	• Inconsistent design basis • Inadequate design margin • Potential for undersized equipment	Update the vendor calculation to include the weight of the grapple with the correct weight of the container as the bounding scenario for the clean container handling conveyor roller impact loading calculation. Assess the bounding scenario against the current design to understand the adequacy of the installed equipment. The calculation assumption(s) should be validated against actual loading scenarios (spreading load across several rollers vs. one) to see if it is possible to exceed the stress limits.
LRH-CNVR-1-V011	FAT Test Inconsistencies	The factory acceptance testing of the LRH conveyor system does not seem to meet all the requirements of the conveyor specifications. It is unclear from the test report if the five container requirement for mockup testing was met, if the containers met the required weight limit, and/or if the requirement for 24hr run test meant total run time or continuous run time. It is also unclear if the mockup test container(s) met the bottom requirement	• Inadequate design • Unknown operability • Potential for higher MTTF/operational throughput issues	Reassess FAT test requirements in specification for the LRH conveyor system. Perform a valid startup test to meet the requirements and undertake the test using the accepted requirements.

Table A-14. Vulnerabilities Identified for Container Receipt Handling (LRH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LRH-CNVR-1-V012	Structural Floor Design	24590-LAW-SSC-S15T-00009, Rev. 0 Steel Framing Calculation (EL +3'–0"), of the LAW Facility uses incorrect weight values for conveyor/floor loading. It is indeterminate if the steel design meets shear/moment/deflection limits until new values are calculated using bounding scenarios.	• Potential Inadequate design • Unknown margin for future equipment installation (if heavier) • Potential operational throughput/safety issues	Validate loads defined in 24590-LAW-S0C-S15T-00002, Rev. 2. LAW Floor Loading Calculation. Use this information as input to LAW Steel Framing Calculation 24590-LAW-SSC-S15T-00009 to verify if steel framing design is adequate.
LRH-RCSH-1-V001	Contamination migration at the Container Import/Hatch and Conveyor	The container import to the LPH system consists of lowering the container import hoist and engaging the attached container grapple onto the container that is to be transferred (C3 area). Once the container is engaged the hoist raises the container to a predetermined height and the container import hoist lowers the container to the LPH bogie (C5), disengages the grapple, and returns to the transfer height position and is raised clear of the floor opening into the container import/hatch conveyor area. Although this task is planned to be remotely conducted, there is no engineered contamination/decontamination or downposting verification process identified to ensure none of the contamination has migrated outside of the C5 boundaries (such as on the grapple equipment).	• Contamination migration and permanent increased contamination posting • Increased operational and maintenance costs	Evaluate the currently defined work processes and ensure an engineered or administratively-defined process is adequate for controlling contamination migration at the South and North clean container import hatches and conveyors, and that confirmation is available, such as continuous air monitor, to ensure personnel are not inadvertently exposed to an airborne radioactivity area. In addition, the process for how to decontaminate the clean container conveyor system and needed personnel and method for performance should be evaluated to determine feasibility given the location and intricacies of the system itself (and the impact to facility operations given the existing radiological design of the system).
LRH-RCSH-1-V002	LRH System compliance to design and operational safety and health requirements	Within the system description for the LRH are specific OSHA requirements and other standards the system conveyors and monorails were constructed against. However, what is not flowed down through the system design/description are the other OSHA and 10 CFR 851 standards that are required to be met when constructing the container receipt handling system in its entirety.	• Inadequate design and operational procedures • Not meeting regulatory/contractual requirements	Verify and validate that all required codes and standards have been incorporated into the design of the LRH system and, if not within the design, the requirements and standards are within appropriate procedures for both operations and maintenance work evolutions. Examples include installation of a dock ladder to provide route worker access to the truck bay, maintenance of ventilation components, potential heat stress within the LRH, emergency egress areas, etc.
LRH-IC-1-V001	Inadequate Interlocks at LRH Roll Up Doors	Obstruction detection devices stop and reverse the door once it has contacted an object. However they can't prevent a collision before it occurs.	Rolling Door Impact with a moving canister could derail or damage the door before it could retract. This would forbid opening of any other rolling door stopping the import of canisters on both lines.	• The addition of a photo-electric sensor with interlock would allow the detection of an obstruction before a collision has occurred and could interlock the roll-up door associated with an LRH conveyor to keep it from closing. • The rolling doors should be interlocked with the associated conveyors to keep the door from closing while the rollers are operating.
LRH-IC-1-V002	Requirement documents are incomplete.	Several interlocks are not shown on the MSD (24590-LAW-M1-LRH-00001) and the sensors for some interlocks are not shown on the MHDs (24590-LAW-M7-LRH-00001001 through -00001004).	Unexpected operations due to unknown interlocks. Overrides or plant modifications that expose the equipment and personnel to hazards that the interlocks were designed to prevent.	• All interlock sensors/devices should be shown on a Mechanical Handling Diagram (MHD). All interlocks should be identified on the Mechanical Sequence Diagrams (MSD). All interlocks should be described in a text-based document with enough information to allow operations or maintenance to determine when or whether the interlock could be over-ridden or modified.

Table A-14. Vulnerabilities Identified for Container Receipt Handling (LRH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
				• Review requirements documents to verify that requirements have been correctly addressed and implemented in the logic diagrams and programming.
LRH-IC-1-V006	The Maintenance Control Panels are not described in the System Description.	The conveyors can be controlled by the ICN in Remote mode, by the Local Operator Interface (LOI) in Local mode and by the Main Control Panel (MCP) panel in maintenance mode. However, the System Description (24590-LAW-3YD-LRH-00002) makes no mention of the Main Control Panel.	This will result in an incomplete and conflicting understanding of how the plant operates. New operators or maintenance people may not even be aware that the MCP exists or be confused between the MCP and LOI.	The Control Logic document (24590-CM-POA-M000-00001-01-00001, Software Requirements Document and Control Logic Information WTP LAW Container Receipt Conveyors) should be amended to clarify the difference between the LRH conveyors Main Control Panel (MCP) door controls, and the Local Operator Interface (LOI). The MCP should be added to Section 6 of the System Description to describe the equipment and in Section 7 to discuss when and how these controls will be or not be used.
LRH-IC-1-V007	The Configuration Tool Box items for the LRH Hoists and Receipt Conveyors depend on obsolete hardware and software.	Equipment needed to configure the ELDP Laser Distance Meter is obsolete and will be harder to come by as time goes on. Also, it is questionable whether the software required to configure the ASD drives will run on current operating systems or that it will continue to do so as PC operating systems are updated and replaced.	• As newer operating systems and communications networks are developed, the older systems are eventually abandoned. Even if the software is available, it may not run on newer operating systems. • It may be difficult 40 years from now to configure a new device to match the parameters in the existing software. Maintenance will be difficult if cable adapters are not available.	Configuration toolkits for the LRH hoists and conveyors should be reviewed and updated or instruments replace, if necessary, prior to the beginning of commissioning.
LRH-IC-1-V008	No Link between Interlocks and Requirements	It will be difficult to verify whether the interlocks meet their intended function without understanding the functional requirement. Likewise, it will be difficult for operations to know when an interlock can be over-ridden or for engineering / maintenance to know whether an interlock could be modified or removed without a clear understanding of its purpose or why it was created.	Recovery plans and plant modifications will be slower and less certain as Operations, Maintenance and Engineering try to determine the consequences of over-riding or changing interlocks.	• A requirements matrix would identify the source of the interlock requirements. A description of the interlocks in a higher level document such as the System Design Document would allow the interlock function and purpose to be clearly understood by Operations, Maintenance and Engineering. • Review requirements documents to verify that requirements have been correctly addressed and implemented in the logic diagrams and programming
LRH-IC-1-V009	Start-Stop control station in the LRH Clean Canister Receipt Area is not labeled.	During the Walk-down Q&A of the LAW Systems LRH and LEH, a Start/Stop control station was noticed on the North Wall. The station was not labeled and it was not clear from its location what equipment it controlled. Upon questioning it was determined that the station controlled room environmental equipment	Someone will need to control the equipment and not be able to readily locate the control station.	Label all control stations in the LRH Clean Canister Receipt Area. Review equipment with stand-alone controls to verify that the controls are easily associated with the proper equipment and that the controls are properly labeled.
LRH-OR-1-V004	24590-WTP-RPT-PE-12-002, Rev 0, 2012 WTP	Table D-2, page D-32, does not contain downtime information for the container grapple that is used in the Import High Bay	Omitted data for non-redundant component will affect availability of the facility.	Update OR model to include container grapple that is used in the Import High Bay area.

Table A-14. Vulnerabilities Identified for Container Receipt Handling (LRH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
	Operations Research Assessment, data omission.	area. This should be added because it is a non-redundant component.		
LRH-CRN-1-V003	LSH-CRN-00001 Crane usage for the LRH system	From a load lifting perspective, the LSH-CRN-00001 appears to be over-specified as a Class D (Heavy Service) crane for empty container handling. However, from a motor jog/start stop perspective, the crane may require a Class D rating. Excessive numbers of starts, stops, and motion reversals is hard duty for motors, motor starter contacts, and motor brakes and may lead to early failure of the motors, starters, and brakes. Maintenance on the motors and motor brakes will require a scissor lift to be rented and delivered to the site. If the repairs cannot be completed in two or three days, the LAW Facility will have to be shut down due to a lack of empty LAW containers.	Premature failure of the LSH-CRN-00001 crane motors, motor starters, and motor brakes will increase maintenance activities and may lead to a facility shutdown if repairs cannot be completed quickly.	Provide operator training to quickly improve their proficiency in handling empty LAW containers with the LSH-CRN-00001 crane to minimize crane bumps/creeps. Procure, or lease, a scissor lift and have it staged on the WTP site for rapid response to an LSH-CRN-00001 crane maintenance need. (Note: this scissor lift may be used to service other overhead cranes such as the HRH crane in the HLW Facility. There are several cranes on the WTP Project where crane maintenance platforms were not installed since the overhead crane maintenance could be done from a scissor lift).
LRH-CIS-1-V006	Time required to unload the container delivery trailer may negatively impact the throughput of the LSH System	There is no operational procedure that defines how fast the containers will be unloaded from the trailer and transferred to the North and South Receipt Conveyors for inspection. The trailer may be parked for a long time in the Import Bay, which may be problematic as this bay is also used by the LSH System for the delivery/export of components and consumables to the LAW Facility.	• Inconsistent/inadequate design • Throughput concerns • Maintenance design inadequacy	A study of the functional requirements of LRH and LSH processes as they relate to the import bay should be developed. Competing LSH activities may determine that the throughput is affected by the single crane and ineffective layout of the import bay, which may result in a redesign of the area.
LRH-CIS-1-V007	Limited staging area for non-acceptable containers	There is no indication of the location and size of the area available on the Load Dock for staging non-acceptable containers, which may be a challenge in this busy area.	• Inconsistent/inadequate design • Operations concerns	A study of the functional requirements of LRH and LSH processes as they relate to the import bay should be developed. Competing LSH activities may determine that the throughput is affected by the single crane and ineffective layout of the import bay, which may result in a redesign of the area.
LRH-CIS-1-V009	Risk exists that proscribed material enters an inspected container in the Staging Area (Room L-0117)	There is a risk that liquids, tools, or various debris fall accidentally into an open container standing on the conveyors in Room L-0117 (and may remain unnoticed).	• Inconsistent/inadequate design • Operations concerns • Secondary waste concerns	It may be necessary to provide a cover/shield over the staging conveyor area to eliminate the chances of material falling into containers that have already been inspected.
LRH-CNVR-1-V001	Container Weight Inconsistencies	LAW container weight data does not seem to be bounded by any specific document. There are several individual documents that define anticipated weight(s) for the container, but none provide a specific bounding design. Weights range from 920 lbs. to 1,600 lbs.	• Inconsistent design basis • Inadequate design margin • Potential for undersized equipment	Provide a bounding weight for equipment design. This may be as simple as revising the LAW container weight calculation (24590-LAW-M0C-LRH-00004, Rev. 0) by adding a margin to the 1,321 lbs estimated weight. Use the results of the revised calculation as the input for all other equipment (where the container weight is the bounding input source). This includes the container DPD.
LRH-CNVR-1-V002	Receipt Conveyor Design Inconsistencies	Input data used for design/procurement of the South and North Receipt Conveyors (LRH-CNVR-00001/7) is inconsistent. Information (equipment load capacity, equipment floor loading, bounding size/dimension allowed, conveyor weight limit) contained within issued project documents conflict with each other. Vendor submittal data conflict with project limits. In addition, the weight of the grapple was not adequately included in the design.	• Inconsistent design basis • Inadequate design margin • Potential for undersized equipment • Potential for exceeding floor loading limit	A set of bounding inputs for design and procurement should be established and used for consistency. The South and North clean container receipt conveyor design and procurement documents should be revised to include all scenarios of conveyor loading; including the weight of the grapple. Vendor submittals will need to be assessed for impacts to current design limits.

Table A-14. Vulnerabilities Identified for Container Receipt Handling (LRH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LRH-CNVR-1-V003	Staging Conveyor Design Inconsistencies	Input data used for design/procurement of the South and North Receipt Conveyors (LRH-CNVR-00002/8) is inconsistent. Information (equipment load capacity, equipment floor loading, bounding size/dimension allowed, conveyor weight limit) contained within issued project documents conflict with each other. Vendor submittal data conflict with project limits.	• Inconsistent design basis • Inadequate design margin • Potential for undersized equipment • Potential for exceeding floor loading limit	A set of bounding inputs for design and procurement should be established and used for consistency. Vendor submittals will need to be assessed for impacts to current design limits for the South and North clean container staging conveyors.
LRH-CNVR-1-V004	Airlock Conveyor Design Inconsistencies	Input data used for design/procurement of the South and North Airlock Conveyors (LRH-CNVR-00003/5) is inconsistent. Information (equipment load capacity, dimensional/size limits, equipment floor loading) contained within issued project documents conflict with each other. Vendor submittal data conflict with project limits.	• Inconsistent design basis • Inadequate design margin • Potential for undersized equipment • Potential for exceeding floor loading limit	A set of bounding inputs for design and procurement should be established and used for consistency. Vendor submittals will need to be assessed for impacts to current design limits for the South and North clean container airlock conveyors.
LRH-CNVR-1-V005	Transfer Conveyor Design Inconsistencies	Input data used for design/procurement of the South and North Transfer Conveyors (LRH-CNVR-00004/6) is inconsistent. Information (equipment load capacity, dimensional/size limits, equipment floor loading) contained within issued project documents conflict with each other. Vendor submittal data conflict with project limits.	• Inconsistent design basis • Inadequate design margin • Potential for undersized equipment • Potential for exceeding floor loading limit	A set of bounding inputs for design and procurement should be established and used for consistency. Vendor submittals will need to be assessed for impacts to current design limits for the South and North clean container transfer conveyors.
LRH-CNVR-1-V006	Import/Hatch Conveyor Design Inconsistencies	Input data used for design/procurement of the South and North Import/Hatch Conveyors (LRH-HTCH-00001/2) is inconsistent. Information (equipment load capacity, equipment floor loading, bounding size/dimension allowed, conveyor weight limit) contained within issued project documents conflict with each other. Vendor submittal data conflict with project limits. In addition, the weight of the grapple was not adequately included in the design.	• Inconsistent design basis • Inadequate design margin • Potential for undersized equipment • Potential for exceeding floor loading limit	A set of bounding inputs for design and procurement should be established and used for consistency. The South and North import/hatch conveyor design and procurement documents should be revised to include all scenarios of conveyor loading; including the weight of the grapple. Vendor submittals will need to be assessed for impacts to current design limits.
LRH-CNVR-1-V007	Conveyor Specification Inconsistencies	24590-LAW-3PS-M000-T0004, Rev. 1, Engineering Specification for LAW Container Receipt Conveyors, has no reference to the ten data sheets issued for the conveyors. The data sheets have not been cancelled/superseded and were issued for procurement in 2002. There are other inconsistencies in the specification including inadequate load capacity parameters and container weight.	• Inconsistent design basis • Inadequate design margin • Potential for undersized equipment	A set of bounding inputs for design and procurement should be established and used for consistency. The South and North clean container handling conveyor specification should be revised to include accurate requirements, notably the information contained in Sections 1 (Scope), 2 (Applicable Documents) and 3 (Design requirements). Vendor submittals and documents will need to be assessed for impacts to current design limits.
LRH-CNVR-1-V009	Conveyor Drive Motor Sizing Inconsistencies	The 24590-CM-POA-M000-00001-05-00003, Rev. 00B, Vendor Calculation Conveyor Drive Motor Sizing, uses inconsistent BNI specified input to determine the adequacy of the motor and gearbox selection. Although the results show the anticipated factor of safety of design, there is no requirement to meet.	• Inconsistent design basis • Unknown design margin • Potential for undersized equipment	Update the vendor clean container handling conveyor drive motor sizing calculation to include the bounding weight scenario. Assess the bounding scenario against the current design to understand the adequacy of the installed equipment. Provide a project approved factor of safety for design of equipment.
LRH-CNVR-1-V010	Conveyor Stress Analysis Inconsistencies	The 24590-CM-POA-M000-00001-05-00004, Rev. 00A, Vendor Calculation – Conveyor Frame Stress Analysis, uses	• Inconsistent design basis	Update the vendor clean container conveyor frame stress analysis calculation to include the bounding

Table A-14. Vulnerabilities Identified for Container Receipt Handling (LRH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
		incorrect assumptions as the worst loading condition and bounding case. The information and assumptions used are not accurate. Preliminary analysis with assumed bounding data show the design stress is within allowable limits, but the calculation needs to be revised formally.	• Unknown design margin • Potential for undersized equipment	weight scenario. Assess the bounding scenario against the current design to understand the adequacy of the installed equipment.
LRH-TOOL-1-V001	Inadequate design basis documentation for container grapple stand	Failure to provide accurate design requirements in data sheets, drawings, and test documentation.	Maintenance and operations will spend time researching and establishing the design basis for equipment.	Revise design and fabrication documentation for container grapple stand to ensure accurate and as-built information.
LRH-TOOL-2-V001	Inconsistent grapple load rating	Mechanical Handling Data Sheets 24590-LAW-M0D-LRH-00004 and 24590-LAW-M0D-LRH-00005 all require the grapple load capacity to be 10 ton (20,000 lbs). However, specification for special grapples and lifting devices, 24590-WTP-3PS-MQL0-T0003, section 3.8.2.1 requires a safe working load of 16,500 lbs. The ICD 15, Interface Control Document for Immobilized Low Activity Waste, allows the mass of each package to not exceed 10,000 kilograms (22,046 lbs).	Confusion with basis of design	Increase the grapples safe working load design to 25,000 lbs to handle all container conditions.
LRH-TOOL-2-V002	LAW production container volume, weight, and center of gravity calculation, 24590-LAW-M0C-LRH-00004, does not include over pack condition.	An abnormal condition could occur if the container cannot be decontaminated and over packing is required to be added to the container.	Special container handling devices will be required to handle off-normal conditions	Revise calculation to include the addition of over packing material to the outside of the container.
LRH-TOOL-2-V003	Grapple temperature limitations.	The grapple analysis, 24590-QL-POA-FH00-00001-08-00001, indicates that the reserve factor is barley met with a load of 16,500 lbs and a flange temperature of 600°F.	Since the grapple is a common design the temperature limitation is as important as the safe working load limitations. These conditions could lead to unsafe lifting conditions.	Add grapple markings to clearly identify temperature limitations the same way safe working loads are identified.
LRH-TOOL-2-V004	Grapple excessive load testing.	General specification for remote and mechanical handling equipment design and manufacture, 24590-WTP-3PS-M000-T0002, section 3.4.3.10, indicate that lifting attachments shall be factory load tested at 125% of rated load in accordance with ASME B30.20 (Below the hook lifting devices). The ASME B30.20, Below the hook lifting devices, section 20-1.3.8.2 indicate that test loads shall not be more than 125% of the rated load unless otherwise recommended by the manufacturer. The testing requirement in 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 6.4.6.c requires the grapple static load test to be performed at 150% of the SWL and held for 15 minutes.	Confusion with basis of design	Revise BNI procurement process to ensure vendors test equipment according to contractual documentation and that all requirements are consistent between documents.
LRH-TOOL-2-V005	Design requirement not verified in factory acceptance testing.	The design requirement in 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 3.8.2.3 requires the grapple's three fingers to have a combined minimum total contact area of 15 in2.	Failure to document design requirements.	This requirement should be validated during start-up testing to ensure this critical characteristic is met.

Table A-14. Vulnerabilities Identified for Container Receipt Handling (LRH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LRH-TOOL-2-V006	Requirements for factory acceptance testing not fully being performed.	Specification requirements in 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 6.4.7.g indicate the grapple will be tested to ensure it is capable of maintaining its engagement even if the load is laid on its side and the tension on the bail is relieved; the grapple shall then be capable of lifting the load when the hook is raised, all as part of the 20 complete cycles simulating actual operating conditions. The simulated operating conditions test consisting of 20 completed cycles is performed in 24590-QL-POA-FH00-00001-13-00003, factory acceptance test plan for MR36 LAW grapples and grapple stands section 3.A.4, but this step is omitted.	Failure to test and document design requirements are met.	This critical design requirement should be performed as part of an additional FAT or demonstrated through analysis.
LRH-TOOL-2-V007	Inconsistent design requirements.	Data sheets 24590-LAW-M0D-LRH-00004 and 24590-LAW-M0D-LRH-00005 indicate the operating environment temperatures and humidity is 59 – 113°F and uncontrolled humidity. Specification 24590-WTP-3PS-MQL0-T0003, special grapples and lifting devices, section 3.6.2 indicate ambient temperature range of 50 – 113°F and humidity range 5 – 100%. Calculation number 24590-LAW-M0C-M40T-00001 indicates the building internal unoccupied C3 areas are 59 – 95°F with 10% relative humidity.	Confusion with basis of design	Revise data sheets, specification, and calculation to indicate a consistent and accurate grapple operating environment.
LRH-TOOL-2-V008	Inaccurate model data for LRH process steps.	The operations research model design document, 24590-WTP-MDD-PR-01-001 table 72, lists the process step for conveyors to move the container into the facility as 20 minutes. The time includes moving the container into the facility, opening/closing container airlocks, lowering the container import hoist, attaching the container grapple to the container, and opening the container import/hatch conveyor. The LAW Vitrification Capacity and Availability Study, 24590-LAW-RPT-ENG-01-001, indicate these same process steps require 41 minutes to perform.	Inaccurate model output data.	Engineering should perform a complete OR model input verification prior to model output is considered valid.
LRH-HST-1-V001	Inconsistent operating environment requirements.	The data sheets 24590-LAW-M0D-LRH-HST-00016 and 24592-LAW-M0D-LRH-00017 indicate the operating environment temperature to be 59-95°F and the relative humidity to be 30-100 percent. The calculation for LAW HVAC Environmental Qualification Conditions Calculation, 24590-LAW-M0C-M40T-00001, section 2.3.1 indicates the inside design conditions for temperature and relative humidity of internal unoccupied C3 areas to be 59-95°F and 10%.	Confusion with basis of design	Revise design basis documentation to be consistent and perform impact analysis to ensure no impact to equipment life span or performance
LRH-HST-1-V002	Incorrect factory testing requirements.	The data sheets 24590-LAW-M0D-LRH-HST-00016 and 24592-LAW-M0D-LRH-00017 indicate the main hoist maximum operating speed to be 12 ft/min. The factory acceptance test procedure, 24590-CM-POA-MJKH-00001-09-00006, indicates the hoist speed testing was performed and verified to 10 fpm +/- 10%, which would be 9-11 fpm. The testing requirements do not match the specification requirements.	Failure to document design requirements.	Perform an impact analysis for facility overall throughput capacity and verify the OR model assumptions for this hoist activities and process steps. Update all design basis documentation for the current maximum hoist speed.

Table A-14. Vulnerabilities Identified for Container Receipt Handling (LRH). (10 pages)

Vulnerability No.	Description	Basis	Consequences	Opportunities for Improvement
LRH-HST-1-V003	Failure to perform all required factory acceptance tests.	The process monorail hoists specification, 24590-WTP-3PS-MJKH-T0002, section 6.3.8 indicate the factory acceptance test shall include but are not limited to recovery of the trolley drives and hoist units and a bumper test. According to the factory acceptance test procedure, 24590-CM-POA-MJKH-00001-09-00006, these tests were not performed.	Failure to test and document design requirements are met.	Perform testing requirements during the facility startup.
LRH-HST-1-V004	Limited maintenance allowed from maintenance platforms.	The hoists LRH-HST-00001/2 are serviced from platforms per 24590-LAW-S1-S15T-00090. The structural design criteria, section 4.4.1, requires crane and other heavy maintenance area live floor loads to be 250 psf, the platforms are only designed with a loading of 100 psf, per calculation 24590-WTP-S0C-S15T-00012 sections 2.4.1 & 2 and drawings 24590-WTP-S0-S15T-00015 and 24590-WTP-S0-S15T-00050.	Heavy maintenance evolutions will be very complicated and will increase the facility downtime during these activities.	Perform a maintenance requirements analysis for the hoists and available space to perform all material handling and maintenance activities.

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24590-LAW-M0D-LPH-00031 *Mechanical Handling Data Sheet Shield Door, Transfer Corridor, South.*

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APPENDIX B
CROSSWALK OF SYSTEM VULNERABILITIES TO VULNERABILITY CATEGORY

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B.1 INTRODUCTION

The Department of Energy (DOE), Office of River Protection (ORP) reviewed each of the 519 vulnerabilities identified in "Appendix A" of the Waste Treatment and Immobilization Plant Low Activity Waste Facility Design and Operability Review (the D&O Review), as part of an assessment of the Low-Activity Waste Facility (LAW) D&O review results. The purpose of this review was to determine more accurately and completely the status of the LAW Facility design and the true vulnerability that exists in the design. Thus it was important to determine how many of the vulnerabilities were new, how many were known to the LAW project, and the number that would necessitate a Waste Treatment and Immobilization Plant contract change/direction from ORP if determined required.

The vulnerabilities in each of the systems, and cross cutting areas were reviewed and assigned to one of four areas. They are:

1. Newly identified vulnerabilities not previously known to the WTP Project
2. Vulnerabilities previously identified by the LAW project having either: Open Actions, Completed Actions, or Scheduled Work to be completed.
3. Vulnerabilities for which a Contract Change/Direction is required for resolution.
4. Vulnerabilities that require further review to determine their validity.

The table below presents summary data for each of the system areas that categorize the Vulnerabilities. This summary provides a crosswalk between the vulnerability identified in Appendix A and the vulnerability category summarized in Table 3.1 of the D&O Review.

Note: When reconciling the number of vulnerabilities per system, it is important to note that some vulnerabilities form a sub-group within a system. These groups are noted in grey highlight and are counted as one vulnerability for that system.

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Table B-1. Crosswalk of System Vulnerabilities to Vulnerability Category (5 pages)

System	Newly Identified	Previously Identified		Contract Change Required	Validity Requires Further Review	
LAW Primary and Secondary Off-gas/Vessel Vent Process System (LOP/LVP/AMR)	LOP/LVP-12	LOP/LVP-01	LOP/LVP-02	LOP/LVP-09	LOP/LVP-03	
	LOP/LVP-13	LOP/LVP-06	LOP/LVP-17	LOP/LVP-16	LOP/LVP-08	
	LOP/LVP-14	LOP/LVP-18	LOP/LVP-19	LOP/LVP-29	LOP/LVP-10	
		LOP/LVP-21	LOP/LVP-04	LOP/LVP-34	LOP/LVP-11	
		LOP/LVP-24	LOP/LVP-05		LOP/LVP-15	
		LOP/LVP-26	LOP/LVP-07		LOP/LVP-20	
		LOP/LVP-27	LOP/LVP-22		LOP/LVP-23	
		LOP/LVP-28	LOP/LVP-33		LOP/LVP-25	
		LOP/LVP-30	LOP/LVP-37		LOP/LVP-35	
		LOP/LVP-31	LOP/LVP-41		LOP/LVP-38	
		LOP/LVP-32	LOP/LVP-42		LOP/LVP-39	
		LOP/LVP-36	LOP/LVP-43		LOP/LVP-44	
		LOP/LVP-40	LOP/LVP-45		LOP/LVP-46	
Instrumentation and Control (ICN)		IC-S-07-V-01		IC-S-09-V-01	IC-S-06-V-01	IC-CO-01-V-03
					IC-O-02-V-03	IC-O-01-V-01
					IC-S-10-V-01	IC-O-02-V-01
					IC-S-02-V-01	IC-O-02-V-04
					IC-CO-01-V-01	IC-S-01-V-01
					IC-CO-01-V-02	IC-O-02-V-02
Confinement Ventilation System (C1V,C2V,C3V,C5V)	HVAC-01-1	HVAC-12-3		HVAC-43-1	HVAC-02-4	HVAC-21-2, HVAC-21-4, HVAC-21-6
	HVAC-01-2	HVAC-31-1			HVAC-11-4	
		HVAC-31-2, HVAC-31-3			HVAC-12-4, HVAC-31-6	HVAC-21-5
	HVAC-01-4, HVAC-02-5, HVAC-02-6, HVAC-03-1, HVAC-11-5, HVAC-24-1	HVAC-31-4			HVAC-32-2	HVAC-21-8
		HVAC-31-5			HVAC-25-1, HVAC-25-2	HVAC-23-1
	HVAC-02-3	HVAC-31-9			HVAC-31-8	HVAC-25-3
	HVAC-11-2	HVAC-53-2			HVAC-32-1	HVAC-25-4
	HVAC-12-6	HVAC-02-2			HVAC-33-1	HVAC-31-7
	HVAC-21-3	HVAC-12-1			HVAC-44-2	HVAC-35-1
		HVAC-31-10			HVAC-45-1, HVAC-46-1	HVAC-35-3
		HVAC-34-1				HVAC-41-1
		HVAC-03-2			HVAC-51-1	HVAC-41-2
		HVAC-44-1				HVAC-47-1, HVAC-47-2

Table B-1. Crosswalk of System Vulnerabilities to Vulnerability Category (5 pages)

System	Newly Identified	Previously Identified	Contract Change Required	Validity Requires Further Review
		HVAC-42-1 HVAC-48-1 HVAC-56-1 HVAC-02-7 HVAC-11-3 HVAC-12-7		HVAC-53-1, HVAC-53-3 HVAC-54-1 HVAC-55-1 HVAC-55-2 HVAC-01-3 HVAC-02-1 HVAC-35-2 HVAC-11-1 HVAC-12-2 HVAC-12-5 HVAC-21-1 HVAC-51-2 HVAC-51-3 HVAC-51-4 HVAC-21-7 HVAC-22-1, HVAC-22-2 HVAC-23-2 HVAC-42-2 HVAC-44-3 HVAC-49-1
Electrical Distribution System	ROR-ELEC-1: V #3 ROR-ELEC-2: V #5	ROR-ELEC-3: V #2 ROR-ELEC-2: V #3 ROR-ELEC-1: V #7 ROR-ELEC-2 V #6 ROR-ELEC-3: V #3 ROR-ELEC-1: V #4, 5, 6 ROR-ELEC-1: V #8, #9, #18 ROR-ELEC-2: V #1 ROR-ELEC-2: V #2 ROR-ELEC-2: V #4 ROR-ELEC-3: V #4 ROR-ELEC-1: V #10 ROR-ELEC-1: V #11 and V#12 ROR-ELEC-1: V #13 ROR-ELEC-1: V #17 ROR-ELEC-3: V #6	ROR-ELEC-3: V #1 ROR-ELEC-3: V #5 ROR-ELEC-1: V #1 ROR-ELEC-1: V #14 and ROR-ELEC-4, V #7 ROR-ELEC-1: V #15 ROR-ELEC-4: V #2	ROR-ELEC-1: V #16, ROR-ELEC-4 V #8 and #9 ROR-ELEC-4: V #1 ROR-ELEC-1: V #2 ROR-ELEC-4: V #3 ROR-ELEC-4: V #6
Radiological Control and Industrial Safety and Hygiene (RC and SH)		RC-1-V-003 RC-1-V-004 RC-1-V001 RC-1-V-002 SH-1-V-001 SH-1-V-002 SH-1-V-003 SH-1-V-004		
Melter Equipment Support Handling System (LSH)	LSH-M-14-V-15 LSH-M-14-V-12 LSH-M-14-V-07 LSH-W-07-V-01 LSH-M-13-V-04 LSH-F-20-V-02	LSH-F-01-V-01 LSH-M-14-V-02 LSH-M-14-V-04 LSH-F-10-V-01 LSH-S-08-V-01 LSH-M-16-V-01 LSH-M-14-V-16 LSH-M-14-V-08 LSH-F-11-V-05 LSH-F-09-V-01 LSH-F-11-V-01 LSH-F-11-V-02 LSH-F-11-V-03 LSH-F-11-V-04 LSH-F-20-V-03 LSH-F-18-V-02 LSH-M-13-V-03 LSH-F-21-V-01 LSH-M-13-V-07 LSH-M-14-V-13 LSH-S-15-V-01 LSH-F-18-V-03 LSH-M-14-V-03 LSH-F-20-V-05 LSH-W-07-V-02 LSH-M-13-V-01 LSH-F-20-V-01 LSH-F-20-V-04	LSH-W-19-V-01 LSH-W-07-V-03 LSH-M-14-V-01 LSH-M-13-V-02 LSH-S-12-V-01	LSH-F-28-V-01 LSH-F-18-V-04 LSH-W-07-V-05 LSH-M-14-V-09 LSH-M-14-V-05 LSH-M-14-V-10 LSH-F-17-V-02 LSH-F-26-V-01 LSH-F-18-V-01 LSH-CO-24-V-05 LSH-M-13-V-06

Table B-1. Crosswalk of System Vulnerabilities to Vulnerability Category (5 pages)

System	Newly Identified	Previously Identified	Contract Change Required	Validity Requires Further Review
		LSH-M-14-V-11 LSH-F-17-V-01 LSH-F-17-V-04 LSH-F-17-V-03 LSH-W-07-V-04 LSH-M-14-V-14 LSH-CO-24-V-01 LSH-CO-24-V-04 LSH-CO-24-V-03 LSH-S-06-V-01 LSH-CO-24-V-02		
Container Pour Handling System (LPH)	LPH-IC-2-V001 LPH-CTB-1-V003 LPH-PC-1-V016	LPH-IC-1-V001 LPH-HST-1-V002 LPH-HST-1-V003 LPH-HST-1-V007 LPH-BFSTR-1-V003 LPH-CPS-1-V004 LPH-CTB-1-V002 LPH-BMA-1-V002 LPH-PC-1-V010 LPH-PC-1-V011 LPH-PC-1-V013 LPH-PC-1-V014 LPH-IC-2-V002 LPH-HST-1-V006 LPH-BFSTR-1-V002 LPH-BFSTR-1-V006 LPH-TOOL-2-V004 LPH-CPS-1-V006 LPH-CPS-1-V007 LPH-PC-1-V002 LPH-PC-1-V004 LPH-PC-1-V005 LPH-PC-1-V021 LPH-PC-1-V022 LPH-PC-1-V031 LPH-HST-1-V001 LPH-BFSTR-1-V001 LPH-TOOL-2-V001 LPH-OR-1-V002 LPH-OR-1-V003 LPH-OR-1-V004 LPH-CTB-1-V005 LPH-BMA-1-V003 LPH-PC-1-V003 LPH-PC-1-V023 LPH-PC-1-V026 LPH-PC-1-V027 LPH-PC-1-V032 LPH-PC-1-V034	LPH-TOOL-2-V002 LPH-CTB-1-V004	LPH-IC-1-V002 LPH-IC-1-V003 LPH-HST-1-V004 LPH-HST-1-V005 LPH-HST-1-V008 LPH-HST-1-V009 LPH-BFSTR-1-V004 LPH-BFSTR-1-V005 LPH-BFSTR-1-V007 LPH-TOOL-1-V001 LPH-TOOL-2-V003 LPH-TOOL-2-V005 LPH-TOOL-2-V006 LPH-BSMF-1-V001 LPH-BSMF-1-V002 LPH-BSMF-1-V003 LPH-OR-1-V001 LPH-CPS-1-V001 LPH-CPS-1-V002 LPH-CPS-1-V003 LPH-CPS-1-V005 LPH-CTB-1-V006 LPH-CTB-1-V001 LPH-CTB-1-V007 LPH-CTB-1-V008 LPH-CTB-1-V009 LPH-BMA-1-V001 LPH-PC-1-V001 LPH-PC-1-V006 LPH-PC-1-V007 LPH-PC-1-V008 LPH-PC-1-V009 LPH-PC-1-V012 LPH-PC-1-V015 LPH-PC-1-V017 LPH-PC-1-V018 LPH-PC-1-V019 LPH-PC-1-V020 LPH-PC-1-V024 LPH-PC-1-V025 LPH-PC-1-V028 LPH-PC-1-V029 LPH-PC-1-V030 LPH-PC-1-V033
Melter Handling System (LMH)		LMH-S-10-01 LMH-F-15-V-01 LMH-F-05-V-01 LMH-S-11-V-01 LMH-S-11-V-02 LMH-W-07-V-02 LMH-S-16-V-01 LMH-W-07-V-01 LMH-S-11-V-03	LMH-F-12-V-01 LMH-F-14-V-01 LMH-CO-13-V-01 LMH-CO-13-V-02	LMH-F-01-V-01
Container Finishing Handling System (LFH)		LFH-LID-1-V007 LFH-LID-1-V011 LFH-LID-1-V012 LFH-DS-1-V002 LFH-DS-1-V004 LFH-SWAB-1-V005 LFH-LID-1-V001 LFH-IC-3-V001 LFH-TRLY-1-V005 LFH-TRLY-1-V010 LFH-TRLY-1-V011 LFH-TRLY-1-V012 LFH-TRLY-1-V013 LFH-DS-1-V001	LFH-TRLY-1-V008 LFH-SWAB-1-V006 LFH-TOOL-2-V002	LFH-LID-1-V003 LFH-LID-1-V004 LFH-LID-1-V005 LFH-LID-1-V006 LFH-LID-1-V010 LFH-IC-1-V001 LFH-TRLY-1-V001 LFH-SSS-1-V003 LFH-TOOL-1-V001 LFH-TOOL-2-V001 LFH-TOOL-2-V003 LFH-TOOL-2-V004 LFH-TOOL-2-V005 LFH-TOOL-2-V006

Table B-1. Crosswalk of System Vulnerabilities to Vulnerability Category (5 pages)

System	Newly Identified	Previously Identified	Contract Change Required	Validity Requires Further Review
		LFH-LID-1-V002 LFH-IC-2-V001 LFH-SWAB-1-V003 LFH-LID-1-V008 LFH-LID-1-V009 LFH-IC-1-V002 LFH-IC-1-V003 LFH-IC-1-V004 LFH-IC-1-V005 LFH-IC-1-V006 LFH-IC-1-V007 LFH-IC-1-V008 LFH-IC-2-V002 LFH-DS-1-V003 LFH-DS-1-V005 LFH-DS-1-V006 LFH-DS-1-V007 LFH-OR-1-V001 LFH-OR-1-V002 LFH-OR-1-V003 LFH-SWAB-1-V001 LFH-SWAB-1-V002 LFH-SIFH-1-V002 LFH-SIFH-1-V005 LFH-SSS-1-V004 LFH-SSS-1-V005		LFH-TRLY-1-V002 LFH-TRLY-1-V003 LFH-TRLY-1-V004 LFH-TRLY-1-V006 LFH-TRLY-1-V007 LFH-TRLY-1-V009 LFH-TRLY-1-V014 LFH-SWAB-1-V004 LFH-SIFH-1-V001 LFH-SIFH-1-V003 LFH-SIFH-1-V004 LFH-SSS-1-V001 LFH-SSS-1-V002
Radioactive Solid Waste Handling System (LRWH)		LRWH-F-06-V-01 LRWH-M-02-V-01 LRWH-M-02-V-03 LRWH-F-13-V-1 LRWH-F-13-V-2 LRWH-O-03-V-01 LRWH-F-13-V-3 LRWH-F-06-V-02 LRWH-S-09-V-01 LRWH-M-02-V-02 LRWH-M-02-V-04 LRWH-S-04-V-01		LRWH-F-07-V-01
Concentrate Receipt and Melter Feed Preparation System (LCP/LFP)	LCP/LFP-03 LCP/LFP-04	LCP/LFP-01 LCP/LFP-06 LCP/LFP-07 LCP/LFP-08 LCP/LFP-10 LCP/LFP-12 LCP/LFP-13 LCP/LFP-15	LCP/LFP-16	LCP/LFP-02 LCP/LFP-05 LCP/LFP-09 LCP/LFP-11 LCP/LFP-14
LAW Container Export Handling System (LEH)		LEH-RCSH-1-V002 LEH-CRN-2-V002 LEH-IC-1-V001 LEH-IC-1-V002 LEH-CRN-1-V001 LEH-RCSH-1-V003 LEH-ICD-1-V002 LEH-ICD-1-V003 LEH-ICD-1-V004 LEH-ICD-1-V005 LEH-ICD-1-V006 LEH-OR-1-V001 LEH-OR-1-V002 LEH-OR-1-V003 LEH-OR-1-V004 LEH-OR-1-V005 LEH-OR-1-V006 LEH-CRN-2-V003 LEH-TOOL-2-V008	LEH-CNTR-1-V001 LEH-ICD-1-V001 LEH-CRN-2-V001 LEH-TOOL-2-V002	LEH-IC-1-V003 LEH-CRN-1-V002 LEH-CRN-1-V003 LEH-CRN-1-V004 LEH-CRN-1-V005 LEH-RCSH-1-V001 LEH-TOOL-1-V001 LEH-TOOL-2-V001 LEH-TOOL-2-V003 LEH-TOOL-2-V004 LEH-TOOL-2-V005 LEH-TOOL-2-V006 LEH-TOOL-2-V007
LAW Container Receipt Handling System (LRH)	LRH-CNVR-1-V008	LRH-IC-1-V008 LRH-RCSH-1-V002 LRH-IC-1-V002 LRH-IC-1-V005 LRH-IC-1-V006 LRH-IC-1-V007 LRH-CIS-1-V007 LRH-CIS-1-V008 LRH-CIS-1-V009 LRH-CIS-1-V010 LRH-CNVR-1-V001 LRH-CNVR-1-V002	LRH-TOOL-2-V002	LRH-IC-1-V001 LRH-IC-1-V003 LRH-IC-1-V004 LRH-IC-1-V010 LRH-CRN-1-V003 LRH-CNVR-1-V011

Table B-1. Crosswalk of System Vulnerabilities to Vulnerability Category (5 pages)

System	Newly Identified	Previously Identified		Contract Change Required	Validity Requires Further Review
		LRH-IC-1-V009	LRH-CNVR-1-V003		LRH-TOOL-1-V001
		LRH-OR-1-V001	LRH-CNVR-1-V004		LRH-TOOL-2-V001
		LRH-OR-1-V002	LRH-CNVR-1-V005		LRH-TOOL-2-V003
		LRH-OR-1-V003	LRH-CNVR-1-V006		LRH-TOOL-2-V004
		LRH-OR-1-V004	LRH-CNVR-1-V007		LRH-TOOL-2-V005
		LRH-CRN-1-V001	LRH-CNVR-1-V009		LRH-TOOL-2-V006
		LRH-CRN-1-V002	LRH-CNVR-1-V010		LRH-TOOL-2-V007
		LRH-CIS-1-V001	LRH-CNVR-1-V012		LRH-HST-1-V001
		LRH-CIS-1-V002	LRH-RCSH-1-V001		LRH-HST-1-V003
		LRH-CIS-1-V003	LRH-TOOL-2-V008		
		LRH-CIS-1-V004	LRH-HST-1-V002		
		LRH-CIS-1-V005	LRH-HST-1-V004		
		LRH-CIS-1-V006			

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APPENDIX C
PROPOSED BNI ACTION PLAN TO ADDRESS RECOMMENDATIONS 1 THROUGH 10

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RECOMMENDATION 1: DISPOSITION EACH IDENTIFIED VULNERABILITY AS PART OF THE WTP PROCESS TO COMPLETE THE LAW FACILITY DESIGN AND DOCUMENT TIDS DISPOSITION FOR REVIEW BY ORP LAW FEDERAL PROJECT DIRECTOR

Each vulnerability identified in Appendix A should be dispositioned in a manner that is integrated into the work process to complete the LAW Facility design. ORP will review the basis for closure of each vulnerability. This disposition process should include:

- BNI providing a determination of when it expects to disposition each vulnerability within its baseline schedule to complete LAW engineering and communicate this timeline to ORP.
- The disposition should include a description of, and the basis for, any actions taken to resolve each vulnerability.
- BNI should indicate which open actions are related to a given vulnerability and provide documentation of successful closure.
- To the extent BNI believes a responsive action to any vulnerability is not necessary to complete engineering or operational planning, it should justify this position (with specific reference to the vulnerabilities), and submit this justification to ORP for review.
- Disposition of each vulnerability should not be considered complete until the ORP review is completed and/or additional requisite actions are agreed upon and their completion is documented.
- Ensure consistency in LAW Facility design media to support ongoing design activities prior to design completion.
- Vulnerabilities requiring contract action should be identified to ORP for action.
- Due to the safety significance, complexity, and number of vulnerabilities associated with the LOP/LVP system, identified by both BNI and the D&O Review Team, ensure these are comprehensively evaluated.
- Update design documentation consistent with the Systems Engineering Management Plan (24590-WTP-PL-ENG-14-002) requirements.

BNI RESPONSE

There were 529 design and operability comments in the LAW D&O Review Team report. BNI has provided the AMWTP with their feedback on each one as an attachment to their October 16, 2015 letter.

The approach taken to accomplish this was:

- Establish a decision methodology that each vulnerability would be processed through
- Develop a categorization a categorization process based on the decision methodology
- Evaluate each vulnerability and assign it to the appropriate category
- Determine disposition mechanisms for each of the categories

Each comment was assigned to a category based upon its expected disposition as follows:

1. **Credible and newly identified:** BNI will provide PIER or Condition Report (CR) references
2. **Credible, previously identified and to be implemented:** BNI will provide PIER or CR references
3. **Credible, previously identified and implemented:** BNI will provide closure details from PIER/CR or schedule activities
4. **Scope not in contract:** DOE to determine path forward
5. **Not Credible:** Action not warranted, specific reasons described in BNI response
6. **Credible, scope is captured in scheduled work to go:** BNI will provide closure details from PIER/CR or schedule activity IDs

Results from the initial assessment indicate that confidence in the quality of BNI' s design of the LAW Facility should be quite high and that, with a small number of improvements, the LAW Facility will be fully capable of meeting the throughput requirements prescribed in the WTP Contract. New CRs have been generated in the CAMP system to reflect those new items identified by the D&O review team that have been determined to be credible.

The results in terms of percentages (actual numbers in parentheses) that correspond to the categories above are as follows:

- **38%** (197) were categorized as not being credible (Category 5)
- **50%** (259) were previously identified and have been, or planned to be, resolved by executing the currently planned scope (Categories 2, 3, and 6)
- **5%** (26) were categorized as credible and newly identified (Category 1)
- **7%** (39) have contract implication requiring further review by DOE (Category 4)

In addition to the obvious conclusion one could draw from these results, namely that this team did not identify any fundamental challenge to the BNI plan to complete LAW Facility, there were also trends in the data that warrant mention. Specifically, the alleged vulnerabilities that were disputed by BNI fell into five major categories that showed that the D&O review team had:

- No contractual, schedule, or budget constraints
- Incomplete or inaccurate information
- A lack of understanding of document hierarchy; e.g., governing document
- An lack of agreement within the team on the issue
- A difference in opinion from BNI's view

RECOMMENDATION 2: CONDUCT AN ENGINEERING EVALUATION TO DETERMINE THE MOST APPROPRIATE CONFINEMENT VENTILATION SYSTEMS SAFETY CLASSIFICATION

The review identified a number of vulnerabilities related to the LAW Facility confinement ventilation system design. Remedial actions in response to the ventilation system vulnerabilities could be impacted by the final safety classification of the confinement ventilation system, particularly if any of the SSCs are determined to be safety-significant. This determination would normally be expected as an outcome of the ongoing effort to complete the hazard analysis and control selection as part of the effort to realign the LAW safety and design bases. However, the current schedule for this action would not achieve this determination until later in the project schedule. The delay in implementing any requisite remedial measures could result in a potential need for rework, which could have a substantial impact on project cost and schedule. The WTP contractor should therefore determine the safety classification of the confinement ventilation system using standard processes including:

- Reviewing the current hazard/accident analysis and control selection documentation including SSCs previously identified as providing additional protection class functions.
- Assessing the confinement ventilation system likelihood to perform a function that may be considered a major contributor to defense-in-depth in accordance with the criteria set out in DOE-STD-1 189-2008, Integration of Safety into the Design Process, Section D.2, “Criteria for Selecting SS Major Contributors to Defense-in-Depth.”
- Identifying candidate safety-significant functions and the SSCs in the current design, which may be designated safety-significant.
- Based on the results, assessing the impacts on the LAW design and procured and/or installed SSCs and identify remedial measures.

BNI RESPONSE

BNI commenced this effort (reported in CCN 270726, dated January 15, 2015) at the direction of Contracting Officer (CCN 274137). BNI initiated engineering studies and provided the LAW C5 Ventilation Functional Classification Strategy report (CCN 277648) on June 30, 2015 and an integrated LAW Confinement Ventilation Functional Classification Strategy Report (CCN 281387) on September 10, 2015.

The Executive Summary of the integrated report states “The current Safety Significant (SS) Offgas System, coupled with the additional SS structures, systems and components (SSC) and Specific Administrative Controls (SAC) identified in this study are adequate to protect the Public, CLW, and FW.

BNI is awaiting feedback on the reports.

RECOMMENDATION 3: DEVELOP, VALIDATE, AND IMPLEMENT AN AIR-FLOW SIMULATION MODEL FOR FURTHER INVESTIGATION OF HVAC-RELATED VULNERABILITIES

The HVAC system design and the lack of airlocks to support pneumatic isolation of ventilation systems has created issues in maintaining adequate flow across contamination zone confinement boundaries. This has the potential to result in migration of contamination between zones during the performance of normal operations and maintenance activities.

Therefore, the following actions should be taken by BNI:

- Develop a LAW ventilation system simulation model to aid in validation of the confinement ventilation system design.
- Use this model to investigate those aspects of HVAC system vulnerabilities that relate to dynamic air flow, including:
  - Maintenance of minimum flow velocities across confinement boundaries. Sensitivity of differential pressure for normal operating activities.
  - Reassess the adequacy of the design basis in specifying confinement velocities and which contamination zone boundaries require a minimum confinement velocity.
  - Identify aspects of the design that may have difficulty meeting functional requirements for performance and/or control and evaluate possible design measures, which could facilitate compliance with functional requirements.

BNI RESPONSE

The LAW Ventilation System simulation model, known as the “CONTAM model,” is the same as that which was used for the HLW work. The work on the LAW CONTAM model commenced on April 6, 2015 at the WTP Project Engineering office in Reston, VA. As of September 18, 2015, the effort was 60% complete with a projected completion date of March 4, 2016. Weekly updates on progress continue to be provided to the LAW FPD.

RECOMMENDATION 4: REVIEW THE CURRENT SOFTWARE QUALITY CLASSIFICATION AND CONFORMANCE OF THE ICN DESIGN TO INDUSTRY BEST PRACTICES

The software associated with the plant process control system process control system is currently classified as software quality level D with a lower level for the operating system. Although this is compliant with an NQA-1 graded approach, a question has arisen as to whether this classification is consistent with its intended process control functions, which include:

- Non-safety-significant defense-in-depth functions
- Functions credited in ISA-84 analysis
- Environmental permit affecting functions (DOE P 450.4A, Integrated Safety Management Policy and Department of Energy Acquisition Regulation clause related)
- Non-nuclear safety functions (DOE P *450.4A* and Department of Energy Acquisition Regulation clause related)
- Functions supporting required operator responses
- Functions supporting the programmable protection system inappropriate for a non-safety system
- Support for mission critical, non-nuclear safety-significant operations.

The instrument and control (I&C)-related functional requirements do not drive development of logic diagrams and I&C design specifications. It was further determined that the anticipated implementation of system design descriptions might not be sufficient to bring the I&C design process into alignment with current industry best practices. Following these practices is important as a proven method to minimize errors in design, allow for future upgrades commensurate with technology advances, and facilitate turnover to operations. To address these issues:

- BNI should assemble an independent team of I&C design and related software quality assurance experts, who can provide a constructive opinion as to the adequacy of the WTP approach to safety software classification and software quality assurance requirements, to ensure all hazards (nuclear and non-nuclear) are identified, analyzed, and controlled at nuclear facilities, per 10 CFR 830. The team should also review how the current LAW I&C design process compares to current industry best practice, and methods that might be employed to bring this design process into better alignment with these practices.

- Given this feedback, BNI should reassess the basis for current software quality classification and provide justification for either maintaining the same classification or modifying this classification.

- Given this feedback, BNI should assess the potential implementation of recommendations for conformance to industry best practice for design and determine suitable measures to implement those remedial actions.

Note: ORP and BNI co-sponsored an expert panel to review the adequacy of the ICN software quality. The final report was issued April 2015. BNI is committed to developing and maintaining formal project records to memorialize the disposition of all of their recommendations. ORP is already committed to engaging with the subject matter experts to ensure that the dispositions are transparently developed.

BNI RESPONSE

ORP and BNI co-sponsored an expert panel, chartered by 24590-WTP-CH-MGT-14-009 Rev 1.

The panel of I&C design and related software quality assurance experts reviewed the adequacy of the Integrated Control Network software quality. The Panel initiated work in December 2014, with a preliminary review of documents, including relevant contract provisions, project procedures, previous assessment findings, and improvement plans. BNI and ORP determined that the effectiveness of the Panel's review would be enhanced if there was a mutual agreement on specific questions and issues for which the Project was seeking input. Those questions are as follows:

1. Requirements definition and traceability for the ICN:
   - Concern: There is a lack of Functional Requirement basis traceable to upper tier requirements and a lack of a process to ensure upper-tier requirements are satisfied,
   - Concern: Functional Requirement definition provided by simple logic diagrams (CLSD/J3) may be inadequate.
2. Software classification (safety vs. non-safety) of the ICN:
   - Concern: The process to determine if software is Safety Software may be inadequate per DOE O 414.lC, as it does not include necessary evaluations
   - Concern: The Software QA Grading process may be inadequate per DOE O414.lC, as it does not include necessary evaluations (DOE O 414.lC),
   - Concern: Changing interpretations of the DOE orders and software quality standards (e.g., NQA-1) may be driving the focus of software quality away from what is necessary to provide a quality software product.
3. Adequacy and format of control system documentation:
   - Concern: The control system documentation, e.g. format and content, may be inadequate and not useable for maintenance and operations
   - Concern: Use of industry accepted industry standards for control systems documentation is not evident.
4. Software development process inadequacies:
   - Concern: Testing of the control system software may not be adequate,
   - Concern: The software configuration control and change process for plant installed software is not evident and may be inadequate or missing

In addition, the Expert Panel is asked to review the plans BNI has in place to resolve these issues, as defined in the Software Quality Improvement Plan, a key feature of MIP-28.

Current Status:

The expert panel provided its initial draft report for factual accuracy review to the Project on March 16, 2015. Combined ORP and BNI factual accuracy input was provided to the expert panel on March 30, 2015. The final report was issued on April 8, 2015.

The expert panel determined that the ICN software was classified correctly as level D software and that the procedure for grading ICN software was consistent with requirements of DOE 414.lC quality and NQA-1 requirements. The expert panel and ORP-WED agree that WTP's use of Logic Diagrams is an industry best practice.

BNI worked with ORP counterparts on all of the remaining recommendations from the expert panel. Once both parties concurred with the dispositions, the path forward was documented in CCN 276204, and the appropriate CRs were initiated.

RECOMMENDATION 5: ASSESS THE THERMAL ANALYSIS OF THE LAW MELTER POUR CAVE AND TRANSFER TUNNEL AND IDENTIFY ANY REQUIRED DESIGN OR OPERATIONAL CHANGES

A review of thermal design documents indicates inconsistencies in calculations for thermal (nominal and limiting) conditions where human access would be permitted. In addition, these calculations rely on non-prototypic models to determine ambient room temperatures for either routine or emergency worker access. Calculations using these models for concrete, near-surface temperatures, and SSCs in the affected area show that, under some conditions, they are close to established limits for compliance with structural integrity standards and that component temperature limits appear to lack a clear demonstration of design margins. To fully assess the thermal impacts, the thermal conditions in the pour cave and thermal transfer tunnel should be evaluated as part of the 90% design review. The 90% design should include the following activities:

- Confirm the validation of the computational fluids dynamics model and/or calculations performed.
- Analyze steady state and transient thermal conditions for both worker exposure and concrete structural limits
- Determine the best steady state and transient thermal predictions for ambient room temperatures where human access may be possible and near-surface temperatures for all areas where structural integrity compliance is necessary
- Determine whether additional controls might be necessary to comply with established design limits and/or worker safety standards

BNI RESPONSE

Review of the design documentation identified some inconsistencies in thermal calculations that underpin the design of the LAW melter pour cave, transfer tunnel, and container storage areas.

In accordance with WTP Project procedures, these calculations must be revised to a confirmed state. Also, those procedures require that design margin to be addressed in these calculations. It is recognized by ORP that these calculations were performed using very bounding thermal properties; i.e., specific heat and thermal conductivity. ORP has provided more realistic, yet bounding thermal property data that should be considered in underpinning the design margin of these calculations.

Consequently BNI will:

- Identify additional controls (temperature monitoring devices) and alarms, as needed, to monitor those areas, such as container buffer storage, where large thermal gradients could potentially challenge the design basis. These devices will provide process data to alarm/ monitor the thermal conditions of the plant (critical equipment, room temperatures, etc.).
- Review the sizing calculations and design margin of cooling equipment to ensure temperature design limits are satisfied.
- Conduct 90% design review of mechanical handling and HVAC systems to validate closure of LAW input calculations.

RECOMMENDATION 6: DEVELOP COMPREHENSIVE FACILITY WORKER ENVIRONMENTAL, SAFETY, HEALTH, AND RADIOLOGICAL PROTECTION PROGRAMS THAT RECOGNIZE THE NEED FOR A ROBUST CONTAMINATION CONTROL METHODOLOGY AND IMPLEMENTS ALARA PRINCIPLES PRIOR TO FACILITY STARTUP

The review determined that BNI is taking action to evaluate hazards for chemicals stored onsite for industrial use, but compliance planning for other applicable OSHA standards (as per 10 CFR 851, "Worker Safety and Health Program") regarding chemical process systems and RCRA remedial actions requires improvement.

Compliance with OSHA requirements that evaluate LAW Facility as a chemical process facility and/or a RCRA hazardous waste operational facility can impact D&O and should be considered as part of the hazards' analysis process. In fact, these standards require integration of a chemical management plan within the design effort and the inclusion of operations personnel in the development of the plan. The chemical model of feed stored in tank farms contains more than 1,800 chemicals, of which approximately 50 are managed as chemicals of potential concern for hazardous exposure. This chemical array includes hose identified within the Contract Standard 2 data quality objectives document, in addition to other chemicals. The chemical array may potentially become more variable with LAW as feed passes along the process flow.

BNI should:

- Develop a chemical management plan consistent with the LAW Facility process flow design, in compliance with 29 CFR 1910.119 and 29 CFR 1910.120
- Submit this plan to ORP for concurrence regarding adequacy of design and compliance with OSHA standards
- Integrate this concurrence and plan within the engineering work process, as required by these standards
- Provide a backward look regarding EPC work already completed, to determine any conflicts with this plan and potential need for corrective action of the design and/or operational control.

BNI RESPONSE

As confirmed during the LAW D&O review, BNI will develop a comprehensive hazard analysis process to evaluate facility designs and equipment for potential worker safety and health hazards pursuant to the requirements of 10 CFR Part §851, specifically §851.21 and §851.22. While this process is comprehensive in scope in that it covers recognized physical, chemical, biological, and safety hazards with the potential to cause death or serious physical harm to workers, it was not intended to address the requirements of 29 CFR Part §1910.119, *Process Safety Management of Highly-Hazardous Chemicals (PSM)* in its entirety. Understanding this, BNI agrees with ORP from the perspective that greater consideration should be given to planning for and ensuring compliance with the PSM requirements as part of the design process. Despite this need, it should be noted that, while all hazardous substances must be effectively managed under OSHA, anhydrous ammonia is the only hazardous chemical with potential for a catastrophic event above its threshold quantity. Therefore, it represents the only chemical falling within the scope, application, and coverage of the PSM standard. Notwithstanding this limited coverage, it is recognized that the applicable requirements of 29 CFR §1910.120, *Hazardous Waste Operations and Emergency Response* must be met.

The PSM is a complex standard with 14 major elements consisting of: (1) employee participation; (2) process safety information; (3) process hazard analysis; (4) operating procedures; (5) training; (6) contractors; (7) pre-start up safety review; (8) mechanical integrity; hot work permit; (10) management of change; (11) incident investigation; (12) emergency planning and response; (13) compliance audits; and (14) trade secrets. In the case of BNI and the WTP Project, several functional organizations (e.g., ESH, Engineering, Operations, Training, and Quality Assurance) play critical roles in the development and implementation of PSM. In large part, as a result of DOE's extensive and advanced safety requirements (e.g., adoption of federal standards and national consensus standards and the promulgation of DOE standards and directives), BNI has previously developed plans to address various PSM elements (e.g. emergency preparedness, training, hazard analysis, hot work permit), or it has the resources necessary to develop and implement each PSM element to form a comprehensive and compliant chemical management plan.

Currently, activity IDs are not in the Baseline schedule for this effort. A CR will be written for tracking purposes, until such time this activity can be appropriately planned, staffed, and executed.

RECOMMENDATION 7: PERFORM DETAILED TASK ANALYSIS IN SELECT AREAS TO CONFIRM THE VIABILITY OF THE MAINTENANCE METHODS PROPOSED

Develop radiation dose calculations and maintenance assumptions for select areas where personnel are expected to work (e.g., wet process cells, melter gallery, transfer corridor, and finishing line);

- Develop and document management strategies and time commitments for these areas (e.g., de-inventory before entry, flushing requirements, remote tooling etc.).
- Develop or use existing task analysis to estimate the radiation exposure to the work force to establish if dose management is a significant concern, which requires mitigation through design changes. Undertake a critical analysis of the tasks required to be completed in high temperature areas using a conservative assessment of the expected ambient working temperature. This should identify if there are areas where maintenance tasks may be significantly restricted.

Evaluate the viability of maintenance of electrical systems particularly associated with the melter and melter power supplies for feasibility of isolation, access, and the capability to execute the maintenance on a schedule to maintain the melter with power.

BNI RESPONSE

LAW Plant Operations has developed Maintenance work packages and Operations procedures in select areas in which personnel are expected to work (e.g., wet process cells, Melter gallery, transfer corridor, and finishing lines) for representative challenging tasks in those areas. The procedures and work packages were reviewed by Operations, Maintenance, Radiation Protection, and Industrial Safety experts. The Maintenance work packages and Operations procedures were used to document strategies (e.g., de-inventory before entry, flushing requirements, remote tooling, etc.) and expected dose to perform work in the above described areas. The Operations procedures review is documented in CCN 283060 and the maintenance work package review is documented in CCN 283059. Based on these procedures and work packages, it has been demonstrated that the LAW Facility will be operable and maintainable during chemical and radiological operations. The remaining facility operating procedures and maintenance work instructions will be developed prior to system and facility turnovers in accordance with 24590- WTP-GPP-MGT-042, *WTP System Turnover* and 24590-WTP-GPP-MGT-062, *Area Turnovers*.

The Operations Requirement Document has required that breathing air stations with sufficient air supply for vortex cooling suits be provided for work in melter gallery and container processing areas to provide cooling for the workers, if needed. This eliminated any challenges related to temperature related work limitations in these areas.

Re-evaluation of radiation exposures to the work force was previously identified and is being tracked by 24590-WTP-PIER-MGT-13-0824.

Melter Power supplies - 24590-WTP-PIER-MGT-14-0715-D, *LAW Melter Power Supply Operability Review* was written on 7/7/14 addressing this issue.

RECOMMENDATION 8: REASSESS THE CARBON BED FIRE· SAFETY RISK AND ASSOCIATED CONTROL MEASURES

The PDSA (24590-WTP-PSAR-ESH-01-002-03) postulates an accident scenario consisting of a carbon bed fire with attendant release of adsorbed mercury. The unmitigated consequence of this event is calculated to exceed the public exposure thresholds for mercury at the offsite boundary. Therefore, safety-significant controls are required, consisting of fire detection and physical isolation of the bed. Fire extinguishment using water deluge is available but is not a credited safety control strategy.

Documentation reviews and surveys of relevant industry experience indicate there is an historical safety risk concerning detection ability and difficulty of extinguishing fires within large carbon beds. In such large beds, internally localized conditions can remain unnoticed and become difficult to address.

For LAW, the response to a carbon bed fire, or the more likely false positive indication of a fire, can result in activation of a water deluge system with potential for extensive impacts to equipment and personnel safety hazards. Therefore, it is imperative that the approach for detection of a carbon bed fire is robust, reliable, and proven.

Alternative fire detection methods may be available that could enhance detecting such localized events. In addition, the physical location of this bed within the LAW Facility creates some difficulty of a rapid and effective response to a fire. Being already installed, its size and constrained location will cause remedial measures for this carbon bed to become progressively more difficult as the EPC process advances. Therefore, it may be advisable to maintain a more robust fire prevention approach through aggressive early detection methods and to make this determination regarding detection strategy as soon as practicable. Consequently, BNI should confirm that the carbon beds are necessary to comply with regulatory requirements. The evaluation should consider alternatives available to achieve regulatory compliance without the carbon beds and evaluate scenarios that could be implemented to minimize the use of the carbon beds. If the carbon beds are found to be required, BNI should:

- Investigate the feasibility of utilizing alternative fire detection mechanisms and/or a combination of detection methods.
- Investigate and evaluate alternative fire extinguishing methods, mindful of the carbon bed physical location and the impact of extinguishment methods on the remainder of the facility and personnel hazards involved with both extinguishment and recovery from extinguishment.
- Define the conditions indicative of an incipient fire and the processing conditions required to prevent the development of a carbon bed fire (e.g., minimum flow conditions).
- Define the maintenance requirements to ensure reliability of the fire detection instrumentation such that the potential for spurious or false activations are minimized and the appropriate safety integrity level is achieved.
- Use the results of these investigations to analyze the risks and benefits of alternate remedial measures.
- Input the results of this analysis in the safety case and design basis realignment process.

- Maintain the carbon beds as necessary for pollution control, including the evaluation of carbon bed replacement and removal. Consider methods to improve the accessibility and ergonomics associated with filling and particularly emptying the carbon bed media.

BNI RESPONSE

The PDSA for the LAW Facility (24590-WTP-PSAR-ESH-01-002-03, Rev 5h, *Preliminary Documented Safety Analysis (PDSA) to Support Construction Authorization; LAW Facility Specific Information*) postulates an accident scenario consisting of a carbon bed fire with attendant release of adsorbed mercury. The unmitigated consequence of this event is calculated to exceed the public exposure thresholds for mercury at the off-site boundary. Therefore, safety significant controls are required, consisting of a fire detection system and physical isolation of the bed. Fire extinguishment using water deluge is available but is not a credited safety control strategy.

To address the concern regarding adequacy of the selected controls (differential CO and CO_2 monitoring and isolation of the bed) to detect a fire, a calculation (unconfirmed) was recently performed to evaluate the instrument set-points for the CO and CO_2 monitors. Results of the calculation demonstrate the acceptability of using elevated differential CO or CO_2 concentration to provide early detection of a fire. The calculation showed that at a carbon burn rate sufficient to release mercury or sulfur dioxide at their exposure threshold limits, differential CO would be greater than 7000 ppm and/or differential CO_2 would be greater than 3.5%. Normal process conditions (e.g., feed composition variation) result in differential CO of up to ~500 ppm or differential CO_2 of ~0.3%. Even when considerations were made for metrics such as instrument response time, valve response times, normal process variation, and gas residence time, the calculation results show that there is adequate time to detect the presence of elevated differential CO and/or CO_2, and to actuate the isolation interlock prior to the fire reaching a size capable of resulting in a chemical release that could exceed the exposure thresholds for mercury and/or sulfur dioxide. As long as the fire is detected by the time the differential concentration of CO is ~4700 ppm or the CO_2 differential is ~2.3%, then the bed can be isolated prior to the threshold exposure limits being reached. Further, because these absolute limits are significantly higher than the normal process variation (~ 10X greater), the likelihood of false-positive indication is reduced.

Investigation into alternative controls to bed isolation and water addition has been conducted. The only other practical method for extinguishing a carbon bed fire is via inert gas addition. This has been previously considered as an alternative to water addition, but it was not pursued in the design due to the personnel hazards associated with the use of an inerting system. Because it is anticipated that isolation will be adequate to achieve extinguishment of the fire under the vast majority of conditions, water addition is never anticipated to be required, it was judged to be the safest and most appropriate secondary control.

Carbon media testing is planned and is expected to address many of the concerns related to process conditions. The results of this testing will be used to evaluate the current design for impacts from minimum flow and process variation.

As part of transitioning from the PDSA to a Documented Safety Analysis, BNI continues with the Hazard Analysis and Control Selection for finalizing the hazards, and confirming the input calculations and completing engineering studies, which support/underpin the safety controls and operating strategies that mitigate the carbon fire hazard.

BNI has baseline schedules for conducting the DSA, including the technical basis/underpinning of the hazards and selection of mitigated controls that are developed/identified in accordance with requirements of the WTP Contract.

RECOMMENDATION 9: SUPPORT THE DEVELOPMENT OF AN OPERATIONAL RESEARCH MODEL FOR THE DIRECT FEED LAW PROGRAM

BNI should support the development (by the Tank Operations Contractor) of an integrated operations research model for Direct Feed LAW (DFLAW) to enable a combined DFLAW Program throughput analysis to be developed. The support required will be to provide data to enable an accurate representation of the operation of the LAW/BOF/Lab Facilities in the direct feed configuration. This integrated DFLAW Program model will:

- Be used for scenario analysis and as such should not be constrained by the 70 percent availability requirement in the WTP Contract;
- Evaluate the DFLAW integrated throughput capabilities and provide a more detailed understanding of the key interactions between the Tank Farms, the LAW Pretreatment System, the LAW Facility, and the Integrated Disposal Facility as they effect individual facility operations and maintenance strategies;
- Use common industry data for mean time between failures and mean-time to repair values for the DFLAW Program SSCs, where site-specific data are not available. This should be based on standard databases such as the Savannah River Site Generic Database Development (WSRC-TR-93-362);
- Consider the impact of other losses (i.e., performance and quality losses) to enable an overall equipment effectiveness (OEE) assessment of areas of improvement with maximum potential;
- Undertake what if and bottleneck analysis to support an informed decision on the cost benefit of identified improvements;
- Analyze the operation of the LAW Facility in the direct feed configuration only and be integrated with the LAW Pretreatment System Facility, DST Waste Feed Delivery and other DFLAW Program scope models through the One System Organization;
- Compare the results with analogous facilities to assist in model validation.

BNI RESPONSE:

Contract Deliverables 2.5, Operations Research Assessment, and 2.6, WTP Tank Utilization Assessment, have not yet been submitted to the Contracting Officer's Representative for review and comment by ORP. The current WTP Contract does NOT include these as deliverables for DFLAW. BNI is prepared to undertake this work following receipt of contract direction, with the scope defined as DFLAW; i.e., WTP-EMF and LAW facilities. This would include appropriate coordination with the Tank Operations Contractor.

RECOMMENDATION 10: EVALUATE SYSTEM TESTING THAT COULD BE ACCELERATED TO REMOVE RISK FROM THE STARTUP AND COMMISSIONING PHASE

A number of equipment or system testing activities, if completed earlier, could potentially reduce cost and schedule risk in the startup and commissioning phase of the LAW Facility. Examples include the LAW canister decontamination system and lid recovery tool, and integrated control system testing. Consequently BNI should:

- Identify on an equipment and system basis, the equipment that has not been completely or effectively tested as an equipment component or as part of an integrated system test in prototypic and relevant operating conditions.
- Assess the potential benefit, on an equipment and system basis, of advancing the equipment and/or system startup and commissioning schedule for this equipment or system.
- Based on these evaluations present to ORP:
  - Equipment and system testing opportunities including testing objectives and schedule to reduce technical and operating risks.

BNI RESPONSE

Mechanical performance issues regarding the robotic system in the canister finishing line were identified by DOE in 2007. Given that this system has undergone several reviews during DOE surveillances, ORP assessment teams, and BNI engineering/operations teams, the conclusions are similar in that conducting demonstration testing early in the start-up and commissioning phase is a prudent method of mitigating technical and schedule risks. BNI has submitted in the LBL Completion proposal the conduct of demonstration testing of the finishing line equipment (container lidding, decontamination, and swabbing) as early as practical in the start-up/commissioning schedule. That testing will provide confidence that the design will perform its intended functions. BNI is proceeding with the current plain conducting the demonstration testing early in the start-up and commissioning phase, and will provide to ORP the relevant schedule activity IDs once developed.