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# **TP Low-Activity Waste Facility Design and Operability Review and Recommendations**

[ COVER SHEET TO BE PRODUCED LATER ]

Revision 0 DOE/ORP-2014-XX PREDECISIONAL DRAFT  
Revision 0 DOE/ORP-2014-XX PREDECISIONAL DRAFT  
Revision 0

## EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) Office of River Protection (ORP) completed a review of the Low-Activity Waste (LAW) Facility at the Hanford Waste Treatment and Immobilization Plant (WTP). The review was conducted to provide DOE with increased confidence in the design and operability of key LAW Facility mechanical and process systems. The reviews are intended to identify potential vulnerabilities with respect to operability of specified systems and assist in the resolution of any issues identified. Chartered by the Assistant Manager/Federal Project Director for the WTP, the review was led by the subproject Federal Project Director for Special Projects. Washington River Protection Solutions LLC contracted and coordinated the review teams and served as co-lead for the review.

The review was conducted by independent multidisciplinary teams of established engineering experts from 14 companies with extensive experience in nuclear facility design, radiochemical engineering, and radiochemical process operations. Seven review areas with dedicated teams were established according to process or functional area similarity (Figure ES-1).

SYSTEM REVIEWS			
Container Systems	Mechanical Handling Systems	Process Support Systems	Ventilation Systems
<ul style="list-style-type: none"> <li>• Container Export Handling</li> <li>• Container Finishing Handling □</li> <li>Container Pour Handling □</li> <li>Container Receipt Handling</li> </ul>	<ul style="list-style-type: none"> <li>• Melter Handling □</li> <li>• Melter Equipment Handling</li> <li>• Radioactive Solid Waste Handling □</li> <li>• Third Melter Capability</li> </ul>	<ul style="list-style-type: none"> <li>• Primary Off-gas Process</li> <li>• Secondary Offgas/Vessel Vent Process □</li> <li>Concentrate Receipt Process □</li> <li>Melter Feed Process</li> <li>• Ammonia Reagent</li> </ul>	<ul style="list-style-type: none"> <li>• C1V</li> <li>• C2V</li> <li>• C3V</li> <li>• C5V</li> </ul>
FUNCTIONAL REVIEWS			
Electrical Distribution	Instrumentation & Controls	Radiological Control and Industrial Safety & Hygiene	



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<ul style="list-style-type: none"> <li>• Feed to the Low Activity Waste Offgas Process (LOP/LVP) Exhauster fan motors □ Feed to both melter power supplies</li> <li>• Feed to both LAW melters □ Feed to the C2V, C3V, and C5V confinement system (HVAC) exhaust motors</li> </ul>	<p>□ Integrated Control Network □ Programmable Protection System</p>	<p>□ Implementation of Radiological Control by each process system, collective signification, and systemic effects □ Implementation of Safety &amp; Health (Industrial Safety &amp; Industrial Hygiene) by each process system, collective significance, and systemic effects</p>
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Figure E-1. Low-Activity Waste Facility Design and Operability Review Areas.

The review team was independent, but relied on the cooperation of the WTP prime contractor, Bechtel National, Inc. (BNI) for applicable source documentation and to provide confirmation of the factual accuracy of the review. A WTP subject matter expert was assigned for each system to work with the review teams and provide the required documentation, briefings, site tours, presentations and general review support.

This report reflects the technical judgment of the Design and Operability (D&O) review team based on the team's review of information provided by WTP, discussions with numerous WTP subject matter experts and observations made during LAW facility visits.

The review teams identified 362 significant design vulnerabilities that could limit LAW Facility functionality and operability for which mitigation is highly recommended prior to the start of radioactive operations and in many cases prior to the start of commissioning. Unless resolved in a timely manner, these vulnerabilities are expected to result in unacceptable risk to the overall project mission.

Concomitant fundamental weaknesses and breakdowns in the programmatic implementation of design processes were also revealed which may be a contributory cause of many of the identified vulnerabilities. Effective resolution of these deficiencies is required to prevent manifestation of future vulnerabilities similar to those identified. The eight key programmatic deficiencies are as follows:

1. Inadequate Discipline in Design Execution and Control
2. Inadequate and Incomplete Control System Design Requirements
3. Inadequate Analysis or Understanding of Production Capability
4. Inadequate Implementation of As Low As Reasonably Achievable (ALARA) Principles
5. Transfer of Scope and Risk to the Commissioning Phase
6. Inadequate Definition and Implementation of Design Requirements for Waste Management
7. Inadequate Consideration of Industrial Safety and Hygiene Requirements
8. Inadequate Consideration of Success of Operations and Maintenance Activities

If left unresolved, the design vulnerabilities, coupled with the programmatic design process weaknesses, would likely continue to have a compounding impact on the functionality of individual LAW systems and the LAW Facility as a whole to the extent that the facility is unlikely to achieve operational status within the anticipated timescale or achieve an acceptable throughput.

A key element of the review process was the identification of recommended paths forward and opportunities for improvement. In many cases these potential mitigating actions can be implemented in a relatively straightforward manner, others will typically require additional review and analysis and potentially a cost benefit analysis prior to implementation as part of any overall plan to address the vulnerabilities. If these opportunities for improvement are effectively

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implemented, the associated risks (for the reviewed systems) can be more successfully managed.



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## TERMS

AB	Authorization Basis
ADS	Air Displacement Slurry
ALARA	as low as reasonably achievable
AMR	Ammonia Reagent (System)
ASD	adjustable speed drive
BNI	Bechtel National, Inc.
BOF	Balance of Facilities
CD	Critical Decision
CFD	Computational Fluid Dynamics
cfm	cubic feet per minute
CFR	Code of Federal Regulations
cm <sup>2</sup>	centimeters squared
CO <sub>2</sub>	carbon dioxide
COR	Code of Record
CO <sub>x</sub>	carbon monoxide and carbon dioxide

CRV	Condensate Receipt Vessel
CSLD	Control System Logic Diagram
CV	confinement ventilation
D&O	Design and Operability
DBE	Design Basis Event
DCS	distributed control system
DOE	U.S. Department of Energy
DRE	Destruction and Removal Efficiency
DSA	Documented Safety Analysis
DWPF	Defense Waste Processing Facility
EPC	Engineering, Procurement and Construction
FAT	factory acceptance testing
FFTF	Fast Flux Test Facility
FPD	Federal Project Director
GFR	Glass Former Reagent
HEPA	high-efficiency particulate air
HFE	Human Factors Engineering
Hg	Mercury
HMI	Human Machine Interface
HMI	Human Machine Interface
HVAC	heating, ventilation, and air conditioning
I&C	Instrument & control
ICD	Interface Control Document
ICN	Integrated Control Network
IDF	Integrated Disposal Facility
IEEE	Institute of Electrical and Electronics Engineers
IGRIP™	Interactive Graphics Robot Instruction Program
IHLW	immobilized high-level waste
ILAW	immobilized low activity waste
IS&H	Industrial Safety and Hygiene
ITS	Important to Safety
kV	kilo-volt
LAB	Laboratory
LAW	Low-Activity Waste (Facility)
LAWPS	Low Active Waste Pretreatment System
LBL	LAW BOF LAB
LCP	LAW Concentrate Receipt Process (System)
LEH	LAW Container Export Handling (System)

LFH	LAW Container Finishing Handling (System)
LFP	LAW Melter Feed Process (System)
LMH	LAW Melter Handling (System)
LOOP	Loss of Offsite Power
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)
LSM	Locally Shielded Melter
LVP	LAW Secondary Off Gas/Vessel Vent Process (System)
MASF	Maintenance and Storage Facility
MCC	motor control center
MFPV	Melter Feed Preparation Vessel
MFV	Melter Feed Vessel
MT	metric ton
MTTR	Mean Time to Repair (MTTR)
NO <sub>x</sub>	nitrogen oxides
NQA	Nuclear Quality Assurance
OFI	opportunity for improvement
OR	operational research (model)
ORD	Operations Requirements Document
ORP	U.S. Department of Energy, Office of River Protection
ORR	operational readiness review
OSHA	Occupational Safety and Health Administration
P&ID	pipng and instrumentation diagram
PCJ	process control system
PDSA	Preliminary Documented Safety Analysis
PISA	potential inadequacy in the safety analysis
PJV	Pulse-Jet Ventilation (System)
PPE	Personal Protective Equipment
PPJ	Programmable Protection System
PRC	Plateau Remediation Contract
PT	Pretreatment
PVV	Process Vessel Vent Exhaust (System)
RCISH	Radiological Control and Industrial Safety and Hygiene
RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
RLD	Radioactive Liquid Waste Disposal (System)
RSW	radioactive solid waste

RWH	LAW Radioactive Solid Waste Handling (System)
SBS	Submerged Bed Scrubber
SDG	Standby Diesel Generator
SDJ	Stack Discharge Monitoring (System)
SIF	Safety Instrumented Function
SIL	Safety Integrity Level
SIS	Safety Instrumented System
SME	subject matter expert
SO <sub>2</sub>	sulfur dioxide
SSC	structure, system, and component
TOC	Tank Operations Contractor
UK	United Kingdom
UPS	uninterruptible power supply
WTP	Waste Treatment and Immobilization Plant
WVDF	West Valley Demonstration Facility

## 1.0 INTRODUCTION

This report documents the results of an independent design and operability 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 systems. A selected number of key LAW systems were reviewed to provide DOE with increased confidence that the LAW Facility would successfully achieve its Mission Objectives.

The ORP Assistant Manager responsible for the WTP project chartered the review and assigned a senior Federal Project Director to be the ORP Lead. Washington River Protection Solutions LLC (WRPS) contracted and coordinated the review teams and a senior WRPS manager co-led the review. This review represents the first comprehensive, independent review of the LAW.

The review was conducted by independent multidisciplinary teams of established experts from 14 companies with extensive experience in nuclear facility design, radiochemical process engineering, operations and maintenance. Abbreviated review team biographies are included in Appendix A.

This report documents the results of the Design and Operability (D&O) review teams. The review identified a number of issues and concerns (collectively termed vulnerabilities) as well as opportunities for improvement actions to mitigate or resolve vulnerabilities) based on the collective teams' review of information provided to them. The vulnerabilities identified are discussed in summary fashion in this report.

Although the review teams were all independent, the review process was also appropriately collaborative. A WTP Prime Contractor subject matter expert (SME) was assigned for each system to provide relevant design documentation including drawings and specifications. The SMEs also assisted the teams with WTP site facility tours, and presentations. In addition, WTP personnel contributed to and provided insights that supported the development of the vulnerabilities as well as opportunities for improvement (OFI).

The remainder of this report is organized as follows:

- Section 2.0 defines the review objectives.
- Section 3.0 describes the scope include the review process and identifies the specific systems evaluated.
- Section 4.0 describes underlying programmatic factors associated with the design vulnerabilities identified in Section 5.0.
- Section 5.0 provides summary review results organized in order of greatest to least impact to LAW Facility functionality.
- Section 6.0 provides a suggested path forward on the key issues for DOE-ORP.

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## **2.0 OBJECTIVE**

The objective of the review in accordance with the Low-Active Waste Facility Systems Design and Operability Review Plan (56962 Revision 0) is to evaluate the design and operability of

selected LAW facility systems in order to identify potential vulnerabilities with respect to operability and assist in the resolution of any issues identified.

The focused objective of this review is to assess the functional capability of the specified LAW Systems and to answer the fundamental question of “will the as-designed systems perform their design and safety function in accordance with the WTP contract and design basis requirements”?

Specifically, the reviews will:

- Determine if the system and associated components will meet their functional and design requirements.
- Identify design shortcomings and specific issues that would either prevent the specified LAW Systems from operating or impact design throughput.
- Make recommendations to improve or correct the design based upon the issues found during the reviews.





### 3.0 SCOPE

The design and operability review targeted the following 13 of 26 LAW Facility systems, which ORP considered having the highest potential risk to impact the WTP Mission:

- LAW Container Export Handling (LEH) System
- LAW Container Finishing Handling (LFH) System
- LAW Melter Handling (LMH) 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 (C1V, C2V, C3V, and C5V) Systems
- 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 operability design aspects were also reviewed:

- Electrical Distribution Systems
- Instrumentation & Controls
- Radiological Control and Industrial Safety & Hygiene □ Third Melter Capability.

The system review was generally broad based, with a deep dive into detail where more significant issues were indicated. Although the review did not represent a full investigation of extent of conditions of system vulnerabilities, it identified a substantial number of vulnerabilities that if not corrected could adversely impact the LAW Mission.

### 3.1 APPROACH

The review teams were comprised of technical experts in a variety of disciplines and the review was organized by common system areas as shown in Figure 3-1.

SYSTEM REVIEWS			
Container Systems	Mechanical Handling Systems	Process Support Systems	Ventilation Systems
<ul style="list-style-type: none"> <li>• Container Export Handling <input type="checkbox"/></li> </ul> Container Finishing Handling <ul style="list-style-type: none"> <li>• Container Pour Handling <input type="checkbox"/></li> </ul> Container Receipt Handling	<ul style="list-style-type: none"> <li>• Melter Handling <input type="checkbox"/></li> </ul> Melter Equipment Handling <ul style="list-style-type: none"> <li>• Radioactive Solid Waste Handling <input type="checkbox"/></li> </ul> Third Melter Capability	<ul style="list-style-type: none"> <li>• Primary Offgas Process</li> <li>• Secondary Offgas/Vessel Vent Process <input type="checkbox"/></li> <li>• Concentrate Receipt Process</li> <li>• Melter Feed Process</li> <li>• Ammonia Reagent</li> </ul>	<ul style="list-style-type: none"> <li>• C1V</li> <li>• C2V <input type="checkbox"/></li> <li>• C3V</li> <li>• C5V</li> </ul>
FUNCTIONAL REVIEWS			
Electrical Distribution	Instrumentation & Controls	Radiological Control and Industrial Safety & Hygiene	
<ul style="list-style-type: none"> <li>• Feed to the Low Activity Waste Offgas Process (LOP/LVP) Exhauster fan motors <input type="checkbox"/></li> <li>• Feed to both melter power supplies</li> <li>• Feed to both LAW melters</li> <li>• Feed to the C2V, C3V, and C5V confinement system (HVAC) exhaust motors</li> </ul>	<input type="checkbox"/> Integrated Control Network <input type="checkbox"/> Programmable Protection System	<ul style="list-style-type: none"> <li>• Implementation of Radiological Control by each process system, collective signification, and systemic effects</li> <li>• Implementation of Industrial Safety &amp; Industrial Hygiene by each process system, collective significance, and systemic effects</li> </ul>	

Figure 3-1. Low-Activity Waste Facility Design and Operability Review Areas.

The WTP contractor (BNI) identified and assigned the appropriate SMEs and they provided documentation and briefed the review teams on key aspects of the design and operability approach, including technical design basis, control and operating philosophy, and safety basis assumptions. The WTP SMEs also supported several review team visits to the construction site where the teams viewed the physical plant areas and the installed or stored equipment.

The review teams developed and refined their lines of inquiry, identified any additional expertise required to supplement review areas, and ensured an effective and representative evaluation of each system.

The review teams held routine and ad hoc meetings with the WTP SMEs to ask questions, clarify understanding, and informally brief the SMEs on any issues identified. The WTP SMEs reviewed vulnerabilities identified (with associated supporting notes) for factual accuracy. Throughout the review, the teams provided periodic reports of results to a senior review team, as well as presentations to DOE and BNI.

### 3.2 REVIEW PROCESS

The review process was systematic and methodical, with the objective of achieving an insightful outcome that suggests remedies that may mitigate the potential adverse impacts associated with design/operational vulnerabilities. The review teams applied a combination of document reviews, meetings/discussions, and in-field assessments to generate review results. Each review team developed summaries of the identified vulnerabilities, which are included in Appendix B. Initial results underwent clarification and factual accuracy review by WTP SMEs to promote understanding, confirm factual accuracy, and gain additional perspective.

This review suggests a cost benefit to addressing vulnerabilities as early as possible, since deferral until commissioning or beyond would, in many cases, be more complex and time consuming. In addition, many of the BNI design and construction experts would not be available to lend their expertise to implementing the solutions.

It is important to note that the factual accuracy review was not intended as a means to reach agreement on issues or to achieve WTP project approval of the review analysis or results. The goal of the factual accuracy review was to ensure that the most recent approved WTP Project documentation and data were used during the review.

To facilitate future ORP decision making, the review teams ranked the potential impact of identified vulnerabilities, consistent with the review plan approach relying on experience based on judgment regarding the consequences, probability, and overall operational impact using a guideline adapted from Washington River Protection Solutions TFC-PLN-39, *Risk and Opportunity Management Plan*. This guideline is in use at Hanford and was used in the WTP High-Level Waste (HLW) design and operability review conducted last year.

Tables 3-1 and 3-2 are derived from TFC-PLN-39 for ranking consequence and probability. Table 3-3 was used to determine the vulnerability ranking and associated recommendation.

Table 3-1. Guidelines for Ranking Consequences.

Consequence	Threshold Definition
-------------	----------------------

Very Low	May require post-CD-4 changes to operational/maintenance approaches (e.g., procedures, training tools) to enable full system functionality without redesign/upgrade. Minor throughput (<10%) or operational continuity impacts anticipated. Cost impact: < \$1 million Schedule impact: < 1 month
Low	May require post-CD-4 upgrade with attendant change to operational/maintenance approaches to enable full system functionality. Low-risk workaround can be implemented to enable functionality at reduced throughput (10–25% reduction) as bridge to upgrade. Cost impact: \$1–\$10 million Schedule impact: 1–3 months
Medium	May require redesign/reanalysis of portions of systems to enable adequate system functionality to achieve CD-4. Extensive workaround to achieve desired functionality. Design may not be sufficiently complete such that judgment regarding functionality can be determined. Proceeding with current design may result in significant throughput reductions (25–50%) and intermittent functionality. Cost impact: \$10–\$50 million Schedule impact: 3–6 months
High	Design likely requires substantial rework to provide acceptable functionality. Workaround not identified or very high risk. Significant throughput reductions (>50%) likely with intermittent functionality. Cost impact: \$50–\$100 million Schedule impact: 6–12 months
Very High	Design functionality not feasible/operable. New design, operations, or maintenance concepts required. Cost impact: >\$100 million Schedule impact: >12 months

CD-4= Critical Decision 4.

Table 3-2. Guidelines for Ranking Probability.

Probability	Threshold Definition
Very Low	The probability of a specific vulnerability is $\leq 10\%$ .
Low	The probability of a specific vulnerability is $10\% < P \leq 25\%$ .
Medium	The probability of a specific vulnerability is $25\% < P \leq 75\%$ .
High	The probability of a specific vulnerability is $75\% < P \leq 90\%$ .
Very High	The probability of a specific vulnerability is $>90\%$ .

Table 3-3. Guidelines for Ranking Vulnerabilities and the Associated Recommendation.



**Action Recommendation (Pre or Post CD-4)**

<b>Probability</b>	<b>Very High</b>	Medium – Action Pre-CD-4	Medium – Action Pre-CD-4	Medium – Action Pre-CD-4	High – Action Pre-CD-4	High – Action Pre-CD-4
	<b>High</b>	Medium – Action Pre-CD-4	Medium – Action Pre-CD-4	Medium – Action Pre-CD-4	High – Action Pre-CD-4	High – Action Pre-CD-4
	<b>Medium</b>	Medium – Action Pre-CD-4	Medium – Action Pre-CD-4	Medium – Action Pre-CD-4	Medium – Action Pre-CD-4	Medium – Action Pre-CD-4
	<b>Low</b>	Low – Action Post CD-4	Low – Action Post CD-4	Medium – Action Pre-CD-4	Medium – Action Pre-CD-4	Medium – Action Pre-CD-4
	<b>Very Low</b>	Low – Action Post CD-4	Low – Action Post CD-4	Medium – Action Pre-CD-4	Medium – Action Pre-CD-4	Medium – Action Pre-CD-4
		<b>Very Low</b>	<b>Low</b>	<b>Medium</b>	<b>High</b>	<b>Very High</b>
<b>Consequence</b>						

During the course of this review, the teams identified recurring fundamental deficiencies in the approach to design that appeared to be key contributors to the evolution of the vulnerabilities affecting design functionality. These design approach deficiencies are reported in Section 4.0.

Summary descriptions of the vulnerabilities identified in the 13 selected LAW Facility systems that were considered to require remediation before CD-4 completion or requiring significant actions are presented in Section 5.0 of this report. The system-specific issues identified in Section 5.0 are considered in many cases to be a result of the underlying design process issues identified in Section 4.0.



#### 4.0 FUNDAMENTAL PROGRAMMATIC DEFICIENCIES CAUSING DESIGN AND OPERABILITY VULNERABILITIES

The Design and Operability review teams observed recurring fundamental programmatic design process deficiencies that appear to be key contributors to or causes of the system specific design and operability vulnerabilities. The design and operability vulnerabilities in combination with the fundamental programmatic deficiencies are likely to have a compounding impact on the functionality of individual LAW facility systems and the LAW Facility as a whole. The LAW Facility Design and Operability Review was intended to complement and reinforce, not substitute for, project multidiscipline design reviews that typically are performed at a very detailed level. It was not the primary goal of the system specific reviews to focus on recurring process wide vulnerabilities rather the team's recorded evidence of these as the review progressed. Therefore because of the nature of the differing lines of inquiry used these processwide vulnerabilities may not appear as prevalent in some systems as in others. This should not be considered an indication that an extent of condition evaluation should not be performed in relation to these issues. Rather, it is an indication that, for that specific system, the review team considered the available time to be more effectively used in the identification of new issues specifically related to that system. Therefore, the review teams recommend extent of condition assessments for all programmatic issues identified in this report.

The eight key programmatic deficiencies identified for discussion in this section were repeatedly identified during the course of the review. Effective resolution of these deficiencies is required to prevent manifestation of future vulnerabilities similar to those identified in Section 5.0.

A synopsis of the key programmatic deficiencies identified as causing the system specific vulnerabilities are as follows:

1. **Inadequate Discipline in Design Execution and Control:** It was evident for the systems reviewed that requirements for design execution and control were not being met at an acceptable level.

Failure to effectively establish disciplined design processes results in procurement and installation of equipment that does not meet the desired functional requirements and technical specifications. If left unmitigated, there is a potential that the final design cannot be validated and verified. This may result in an inability to effectively declare readiness to operate, pass an operational readiness review (ORR), and achieve operational status.

2. **Inadequate and Incomplete Control System Design Requirements:** The requirements for the equipment and process control systems lack sufficient clarity of definition and documentation to ensure the functionality of the LAW Facility systems.

The quality classification for the control system software does not appear to be consistent with the hazards and functions that the system is intended to control.

Further, the current approach used to document the identified instrument and control system functions results in a very large number of documents, thereby making configuration control of the systems nearly unmanageable. Prior reviews have identified similar concerns.

3. **Inadequate Analysis or Understanding of Production Capability:** The basis for the LAW Facility production capability is incomplete and/or not technically defensible. Therefore, reasonable projections of future plant performance and production are not reliable.
4. **Inadequate Implementation of As Low As Reasonably Achievable (ALARA) Principles:** There are specific regulatory and contractual requirements associated with meeting goals and objectives intended to reduce worker exposures and the potential for spread of radioactive contamination within a nuclear facility to be As Low As Reasonably Achievable (ALARA).  
Due to a lack of task analyses to reasonably estimate worker exposure and models to predict contamination migration patterns, there is insufficient evidence that ALARA goals and objectives will be achieved. Given the nature of complex chemicals that will enter the LAW, this deficiency exists for chemical as well as radiological hazards.
5. **Transfer of Scope and Risk to the Commissioning Phase:** A number of activities were identified in which integrated testing or functional demonstrations of critical system components are deferred to the commissioning phase of the project.  
Therefore, additional cost and schedule risks are likely as a result of postponing functional design validation of some systems to commissioning.
6. **Inadequate Definition and Implementation of Design Requirements for Waste Management:** The design process has not adequately considered or implemented sufficient features necessary to ensure the capability and reliability of waste management systems to support the LAW mission.
7. **Inadequate Consideration of Industrial Safety and Hygiene Requirements:** There are specific safety and health regulatory and contractual requirements that must be met as part of the design and operational process. In addition hazard identification and control are key core functions of an effective ISMS Program. Fundamental weaknesses were identified in the hazard identification and mitigation process used to address chemical and physical hazards.
8. **Inadequate Consideration of Success of Operations and Maintenance Activities:** There was limited evidence that a thorough and systematic assessment of the facility design has been undertaken to ensure that operational and maintenance tasks required for the effective operation of the facility are safely executable, as the current design depends on hands-on operation and maintenance activities. There are questions about the safe and efficient performance of operators and maintenance technicians in environments with elevated temperature, chemical and radiological hazards and challenging ergonomics which are currently incompletely defined and have not been modeled or considered in sufficient detail.

Figure 4-1 illustrates the cause and effect relationships associated with these eight deficiencies. As indicated by Figure 4-1, it is imperative that these programmatic deficiencies be fully addressed, including a detailed extent of condition review. Resolution is essential to remediate current issues and prevent recurrence of design and operability vulnerabilities as the design progresses. Appendix C summarizes these programmatic deficiencies and recommended path forward actions.



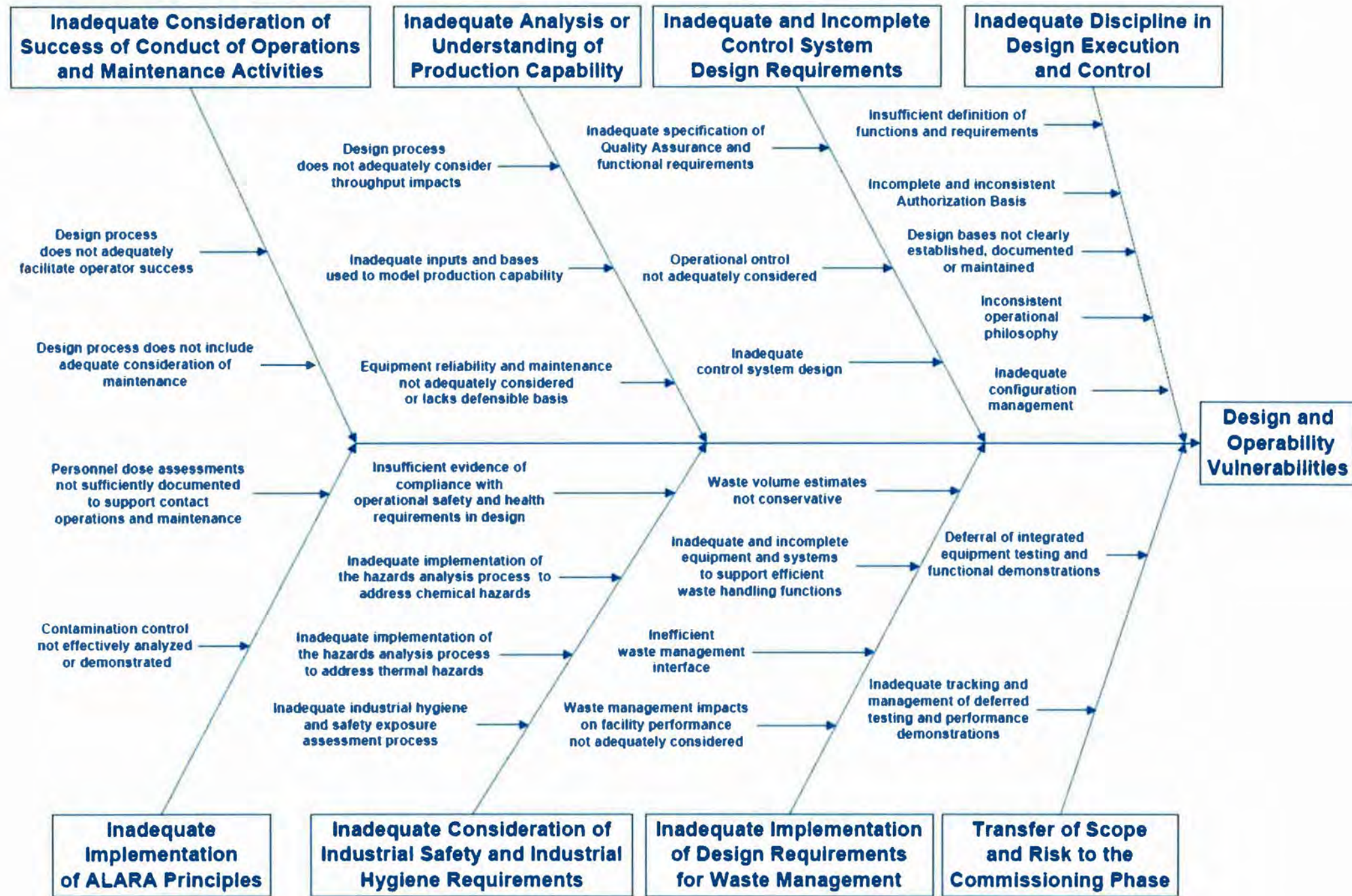


Figure 4-1. Cause and Effects of Fundamental Programmatic Deficiencies

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The following discussion provides representative examples, potential and/or realized consequences, conclusion(s) and recommended path forward for each of the eight deficiencies.

#### 4.1 INADEQUATE DISCIPLINE IN DESIGN AND EXECUTION CONTROL

A comprehensive and rigorous design process should clearly establish the design criteria (design functions and requirements), define a documented basis of design, and apply a configuration management process that manages and maintains the data and information to successfully complete the design development and enable subsequent nuclear operations.

##### 4.1.1 Summary

Throughout the review, it was apparent that a rigorous approach to design execution and control was not evident in the documents reviewed. Design-process issues are the largest cause of all vulnerabilities found during the review and are characterized by the following:

- **Insufficient definition of functions and requirements:** The functions and requirements (design criteria) of each structure, system, and component (SSC) have not been consistently defined or integrated. As a result it cannot be determined if the overall plant design will meet the integrated plant system requirements.
  - **Incomplete and inconsistent Authorization Basis:** Key authorization basis documents such as the Preliminary Documented Safety Analysis (PDSA) and environmental permits are either incomplete, undergoing revision and/or contain inconsistencies such that the design requirements for some equipment and systems are subject to individual interpretation of design intent. This situation results in system designs that may not be in alignment with the fundamental safety and environmental requirements and are likely to require modification in order to achieve a fully functional system.
  - **Inconsistent operational philosophy:** The lack of clear consistent documentation contributed to the lack of common understanding across disciplines within the WTP Project design team of general operational intent. This coupled with a lack of regular multidiscipline reviews led to differences in opinion between project functional groups regarding how some systems should operate. Further, it is unclear that the scope and impact of operations assumptions (e.g., administrative controls and actions) embedded in the design (as a result of calculations, studies, tests, etc.) have been communicated, agreed, and accepted.
- **Design bases are not clearly established, documented or maintained:** The justification for selection of specific design features or the adequacy of how and why the design satisfies the design intent is not clear. As a result, uncertainties are introduced regarding the adequacy of equipment selection, sizing and performance requirements. As a result the information necessary to ensure future modifications can be safely



implemented and are consistent with the design basis requirements may not be available. Additionally, design bases information relied upon to establish readiness to operate and support operations activities and troubleshooting may not be available or difficult to identify.

**Inadequate configuration management:** Design documentation is not adequately maintained or is inconsistent, making design management and configuration control extremely difficult. In addition, use of obsolete and superseded documents along with inconsistent naming conventions was observed. The WTP documentation system appears to be cumbersome and contains historical, redundant and restricted information which makes it difficult to be sure of the documents relevance without recourse to personnel with expert knowledge of the project and the rationale for decisions made. This deficiency can adversely impact the declaration of “Readiness” to operate. There are several examples in the DOE Complex where this deficiency has had significant adverse impacts.

#### 4.1.2 Examples

Following are some representative examples of vulnerabilities that appear to be caused by inadequate discipline in design and execution control:

- The ventilation system failure modes and impacts for normal and off-normal conditions have not been identified. These conditions should include start-up sequencing, reduced production modes, and defined maintenance modes as well as other conditions that are not considered “normal” operations.
- Exhaust fan sizing does not take into account design changes associated with higher incoming air temperatures. Fan performance is reduced with higher air temperatures and the flowrate will be reduced, resulting in potentially inadequate contamination confinement in some rooms.
- Uninterruptible power supplies (UPS) for critical components are undersized and do not meet capacity requirements during a loss of power event. Equipment rooms that house the UPS batteries are too small to accept the additional number of batteries needed to meet the requirements.
- Cooling times used in design analysis of the LAW container do not have a technically defensible basis. The cooling values provided to the review teams used non-prototypic tests as a basis for input to stress calculations to ensure the container integrity under thermal operating conditions. When a container full of molten glass is lifted, there is a chance that the container lifting flange will fail because it has not cooled enough to regain its strength.
- The Submerged Bed Scrubber (SBS) is a main component in the melter offgas system and is relied on to reduce the temperature of melter offgas stream and remove contaminants from the air stream. The design temperature requirement for off-gas

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stream coming directly off the melter was specified to be 1250°F. Therefore, the design of some SBS components, including an O-ring gasket used to seal the vessel, must be compatible with this temperature. However, the O-ring provided by the vendor will likely fail at temperatures above 250°F. This O-ring design was accepted by the WTP Project without evidence of documented analysis or basis.

- Electrical equipment in high temperature areas are not properly designed for the ambient conditions as required. Projected temperatures in several areas of the pour handling system exceed the specified design values of electrical components. This may lead to reduced electrical capacity, overheating of components, signal failure, electrical shorts, and interruption of operation.
- According to the PDSA for the LAW Facility, one of the most significant postulated chemical events involves the release of nitrogen oxides (NO<sub>x</sub>). Current safety analysis indicates that the NO<sub>x</sub> hazard is eliminated two hours after feed to the melter is terminated. At this point, safety significant controls intended to prevent the NO<sub>x</sub> hazard can be relaxed. However, the impacts of process scale-up and waste feed uncertainties on the safety analysis that supports the two-hour based approach to eliminating the NO<sub>x</sub> hazard are unclear. Furthermore, only an indirect approach (i.e., temperature in the melter plenum) is currently available to confirm that the NO<sub>x</sub> hazard has been eliminated after two hours. Confirmation of current estimates that the NO<sub>x</sub> hazard is eliminated after two hours will be necessary during the commissioning phase. There appears to be no analysis on the rate of cold cap burn off following a loss of power event when the melter is cooling. If the two-hour period, which is currently based on trials carried out on the VSL melter (which may not be representative or conservative), is determined to be inadequate, the design of systems required by the Authorization Basis to function for the burn off period will need to be readdressed. The impact to the design and in particular the credited safety significant-SSCs could cause significant delays and cost increases, which could be more significant if not realized until commissioning or even active commissioning when a potential inadequacy in the safety analysis (PISA) could exist.

#### 4.1.3 Conclusions

Failure to effectively establish disciplined design processes, which are relied on to systematically establish and maintain the design bases, results in procurement and installation of items that do not meet the desired functional requirements and technical specifications. There is a risk the final design cannot be validated and verified, resulting in an inability to effectively achieve and demonstrate readiness to operate. Additionally, future design changes may be difficult to implement if these cannot be confirmed to meet the design basis requirements.

#### 4.1.4 Recommended Path Forward

BNI is currently assigned responsibility as both the Design Authority (responsible for specification and confirmation of compliance with design criteria) and the Design Agent (responsible for preparing a design compliant with the specified criteria). Typically the Design Authority is an owner function to ensure that the design policies programs and requirements remain in alignment with the primary goals of the owner. Because in this case the Design Authority and Design Agent are an integral part of the same organization, DOE must ensure adequate oversight at a detailed level to independently ensure that the owner's requirements and intent continues to be the primary focus of the project.

The WTP Project is currently updating the design process as a result of internal reviews. The Project should reintroduce and institutionalize multidisciplinary design reviews and monitor their effectiveness. In conjunction, the following suggested complementary actions should further improve design execution and control and mitigate the identified deficiencies:

- Conduct reviews to ensure that the primary documents relied upon to establish design functions and requirements are accurate and complete. A key objective is to ensure that specific/quantifiable requirements are established.
- Review of the overall WTP documentation system should be undertaken with a view to providing relevant and appropriate documentation to support operations and commissioning and removing all superfluous, obsolete and restricted information to separate archives. This will include the generation of an essential/required documentation list.
- Conduct multi-discipline reviews of the individual system designs and associated documentation for compliance with the functions and requirements established in the primary documents. Confirm that any procured items, those in procurement, or presently installed meet the functions and requirements.
- Implement sizing standards/guides for equipment to provide a standardized documented basis for design. These should include typical design margins to ensure a conservative design is achieved.

## 4.2 INADEQUATE AND INCOMPLETE CONTROL SYSTEM DESIGN SPECIFICATION AND EXECUTION

The control system hardware and software relied upon to safely and reliably control the LAW Facility equipment must meet functional requirements, design and quality standards commensurate with the defined control function. To ensure the required process control functionally, operability, safety, and efficiency required to meet the LAW Facility production mission these requirements and standards must be clearly defined and demonstrably achieved.

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#### 4.2.1 Summary

The WTP Project established two independent control systems to meet the LAW Facility control requirements:

- **The Integrated Control Network (ICN)** is the distributed control system used for nonsafety related routine process control functions. The combination of hardware (instruments and controllers) and software programs for this system must enable the LAW Facility equipment and systems to operate reliably and efficiently to achieve the LAW Facility glass production requirements.
- **The Programmable Protection System (PPJ)** is dedicated to ensuring that the LAW Facility processes and equipment reliably revert to a safe state during postulated events that otherwise could lead to an unsafe condition. The combination of hardware and software for this system must achieve higher levels of reliability than for the ICN and is required to be developed under more rigorous life-cycle requirements commensurate with the safety-related nature of the application.

In order to ensure that the ICN and PPJ are able to perform their required control functions, the functional requirements of both control systems must be specifically defined to provide a clear description of requirements to support design, testing and review. The review identified significant deficiencies regarding the definition and documentation of the ICN and PPJ control system functions and requirements as follows:

- **Control systems lack adequate specification of quality assurance and functional requirements:** During the course of this review, it was observed that the functional requirements of the control systems were not clearly specified and did not include sufficient supporting basis such that the intended control intent could be validated. Further, the D&O team questions whether the quality level of the software is in full compliance with DOE O 414.1C) which may therefore lead to conditions where personnel and the environment are not adequately protected.
- **Design process does not adequately consider operational control:** Review of the design and operational parameters of the LAW Facility found that there was not a clear understanding of how certain components of the ICN will support safe operation of the facility. Consequently, systems may not function as expected under normal and offnormal condition.
- **Inadequate control system design:** The monitoring and control system design for the LAW Facility does not appear to have adequately considered available design input, requirements, or industry standards. This will result in systems not functioning as expected under normal and off-normal condition.



#### 4.2.2 Examples

Following are some representative examples of vulnerabilities that appear to be caused by inadequate and incomplete control system requirements:

- The ICN appears to perform defense in depth functions and to support regulatory reporting criteria for environmental permits. However, the quality level of the software to ensure that the operations and associated data is suitably robust and meets all regulatory, and consensus standard requirements is below the level dictated by DOE O 414.1C.
- The current method for documenting control system requirements is through the use of Control System Logic Diagrams (CSLDs). The review team concluded that the logic diagrams are inadequate for the function because:
  - There is no clear link back to higher level functions and requirements.
  - There is no clear method to document test criteria.
  - Requirements (from upper tier documents) and design features (functionality to make the system operate) are comingled and mutually indistinguishable within the CSLDs.
  - Permit affecting or defense in depth features, providing control system layers of protection within the CSLDs, are indistinguishable from functions with negligible consequence to safe operation of the facility.
  - The methodology is not consistent with the WTP QAM, NQA 1 or ISA84.

Instrument uncertainties are not properly calculated and evaluated, resulting in a control system methodology for the LAW Facility confinement ventilation systems that may not be tenable.

- The control strategy for parallel operation of pumps and fans throughout WTP is not technically defensible and will result in unstable operation.
- No WTP project process currently exists to allow software elements requiring modification during commissioning, startup and operations to be isolated, modified, and regression tested and reintegrated, while maintaining overall configuration control and minimizing the potential for unintended consequences. If the software structure does not support a process to do this the consequences are potentially very significant.
- The current level of automation maximizes manual operation, including many functions that are typically automated, such as subsystem start-up sequences, valve line-ups, ventilation line-ups, shut-down sequences, and repeated mechanical handling steps. This approach is likely to lead to an increased incidence of operator error and decrease the overall performance of the facility.
- The Human Machine Interface (HMI) strategy for the LAW Facility is not compatible with current industry best practice.



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### 4.2.3 Conclusions

The collective evidence indicates that the LAW Facility control systems are lacking in quality assurance, requirements definition, requirements traceability, design processes, design elements, and clear documentation. Further, this lack of requirements definition and traceability to upper-tier requirements prohibited a full assessment of future plant operability, because it is unclear what the control system requirements are, and the basis for those requirements.

Specifically:

- The LAW Facility functional requirements are not adequately defined and lack a basis traceable to upper-tier requirements.
- WTP has applied a questionable and likely inadequate software QA grading and classification process to the LAW Facility control systems (a unique WTP process). The inadequate software QA grading and classification process has resulted in a quality assurance implementation at a level lower than is required to support the ICN functions.
- WTP has not evaluated the hazards associated with the ICN, which monitors and controls the entire WTP. Lack of hazards evaluation has resulted in inadequate software quality assurance, functional requirements, and hazard controls. The hazards (as defined by 10 CFR 830) must be evaluated in order to successfully complete the design and achieve readiness.
- The LAW Facility control system documentation is inadequate, inconsistent, difficult to use, and is not consistent with industry standards (i.e., IEEE). The current LAW control system documentation issues must be corrected in order to successfully complete design and achieve readiness to operate. The current documentation could be replaced with a much simpler set consistent with industry standards.
- Resolution of identified specific control system issues prior to resolution of the underlying control system design processes would not be productive.
- Without the benefit of sound requirements, quality assurance and documentation system to inform and frame the design, the LAW Facility control system is at risk of not being able to meet operational expectations or achieve readiness.

### 4.2.4 Recommended Path Forward

The following suggested actions should be considered to improve the overall control system design:

- Consistently define the ICN boundaries and interfaces commensurate with the functions attributed to the ICN to ensure that functions can be attributed the correct quality level and to allow changes to be safely and effectively executed.
- Evaluate (or reevaluate) the hazards, risk, safety, and permitting compliance controlled or affected by the ICN and its subsystems and ensure the correct quality levels are

consistently applied throughout the software development lifecycle Document the evaluation and basis of software quality determinations for future reference.

- Define (or redefine) the WTP specific functions requirements performed and controlled by the ICN and the PPJ, carefully tracking the flow down of requirements from upper-tier documents. Use these requirements to provide the detailed test criteria when functionality is confirmed during software development or for vendor acceptance criteria.
- Use industry standard documentation sets (e.g., IEEE SE series) for the control system and the functional requirements, making it practical for review without recourse to the control system SME.
- Eliminate the use of commingled design and requirements documents, and the use of logic diagrams as the sole means of defining functional requirements.
- Develop software modification procedures and processes and ensure changes can be effectively isolated and verified with minimal regression testing required.
- Conservatively evaluate the effect of manual controlled operations and the impacts on facility performance. Identify and implement increased automation for those areas where it is assessed that maximum benefit will be achieved.
- Consider implementing current industry best practice in development of facility human machine interfaces.

#### **4.3 INADEQUATE ANALYSIS OR UNDERSTANDING OF PRODUCTION CAPABILITY**

The future performance of the LAW Facility is extremely important as it dictates not only the overall mission length of the facility but also dictates the performance requirements for supporting facilities such as the Low Active Waste Pretreatment System (LAWPS) currently

awaiting CD1 approval of the conceptual design that will provide waste feed from the Hanford Tank Farms.

#### 4.3.1 Summary

The WTP project has developed an operational research (OR) model that includes the LAW Facility, however, there was significant evidence to indicate that the inputs to this model were incomplete or lacking conservatism, resulting in an inaccurate and overly optimistic assessment of LAW Facility production capabilities.

Because the performance of the LAW facility is so important to the overall WTP mission and the future of Hanford, the WTP contract requires that WTP undertake OR assessments using OR modeling to ensure compliance with the contract design and required treatment capacities of 30 MT and 21 MT, respectively, of glass per day or an average production rate of 70% of the stated design capacity. Compare this 70% projection with the West Valley Demonstration Plant (WVDP) which had a design capacity of 300 MT glass per year produced around 250 MT glass in approximately five years or a rate of about 17% of design capacity. The design capacity of the Defense Waste Processing Facility (DWPF) is 2 MT of glass per day. In 2010 (after 14 years operation) had produced 3000 canisters or approximately 3700 Mt of glass. This equates to an average throughput of approximately 36%. This is not to suggest that these figures should be considered low as WVDF was a demonstration facility and DWPF operates at a higher level than many similar facilities in the UK.

Operational Research Models with realistic input data can be a very accurate predictor of facility performance and can provide essential early input into the design process to eliminate bottlenecks and maximize the overall production before much more costly physical plant changes are required to achieve the same result.

Figure 4-2 illustrates the potential collective impacts of incomplete or non-conservative inputs on estimates of LAW facility performance.



## INADEQUATE UNDERSTANDING OF LAW PRODUCTION CAPABILITY

Scales of graph axes are notional for illustration only

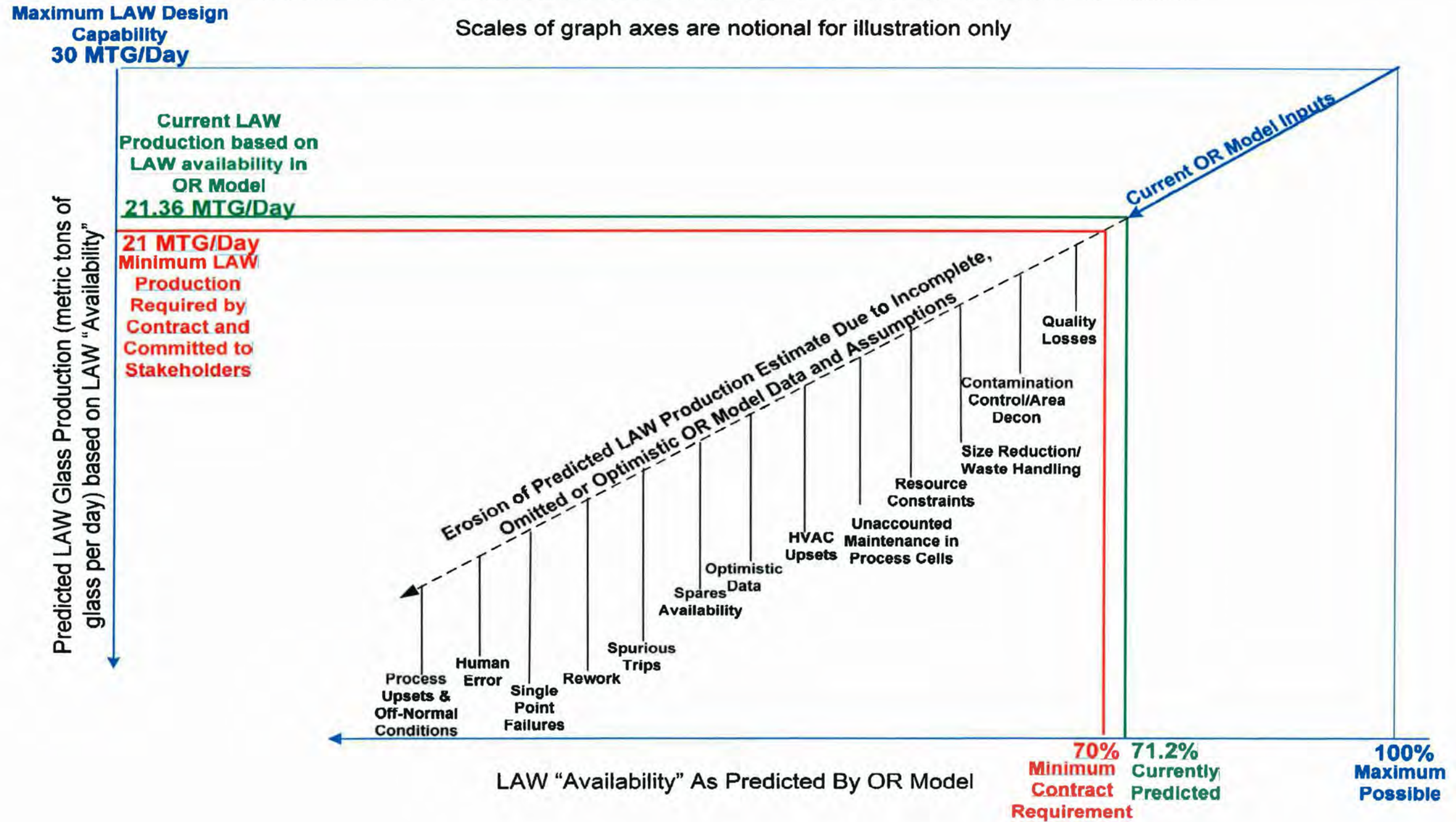


Figure 4-2. Impact of Inadequate Operational Research Model Bases



The production capability of the LAW Facility is unknown but likely significantly less than specified or anticipated to successfully execute the waste treatment mission as evidenced by the following:

- **Equipment reliability and maintenance not adequately considered or lacks a defensible basis:** There were recurring instances where the design did not appear to adequately or completely consider the impacts of equipment reliability and maintenance on the production capabilities of the LAW Facility. The review identified that spurious instrumentation trips on the melter offgas system alone will likely result in a decrease in the LAW Facility production capability to below the required 70%.
- **Inadequate inputs and bases used to model production capability:** The OR model developed and maintained by WTP does not provide a realistic prediction of overall plant performance, on which ongoing design decisions and future predictions of mission and operability can be based because:
  - The current OR model for the LAW Facility uses input assumptions and supporting bases that are not considered to be supportable based on operating experiences from other facilities with analogous equipment and operating constraints.
  - The current OR model does not incorporate all the systems necessary to represent integrated facility operations.
  - The current OR model is not used to evaluate the full range of operating conditions that might reasonably be anticipated during long-term plant operations.
  - The current OR model does not attempt to evaluate losses, other than availability, such as quality and performance losses, which on a minimally automated facility like the LAW facility could be even more significant than the availability losses.
- **Design process does not adequately consider throughput impacts:** The interactions of systems and associated operations within the LAW Facility have not been adequately considered and may result in unanticipated interruptions in melter glass production operations.

#### 4.3.2 Examples

Following are some representative examples of vulnerabilities that provide substantial evidence that the LAW facility production capability is not adequately analyzed or understood:

- The melter offgas treatment system equipment is required to meet environmental requirements prior to discharge to the environment. The off-gas treatment system equipment is complex. This complexity coupled with a lack of component redundancy and numerous safety and permit affecting controls is likely to impact the ability to sustain melter operations and meet production requirements because equipment failures are likely to be more frequent and take longer to repair than currently assumed.



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- Maintenance of some melter primary offgas system equipment requires that a confinement barrier for radioactive material control be disconnected and opened. This will require that both melters temporarily cease production operations so that the system can be placed in a safe condition for maintenance. Further, the review team considers it possible that personnel entry to the melter offgas process cells for any reason could require that glass production from both melters be temporarily ceased and the cell vessels be de-inventoried in order to establish safe conditions for cell entry.
- For electrical safety reasons it is anticipated that the melter power will be disconnected and locked-out during some routine operations (such as replacement of air bubbler tubes used for agitation in the melters, maintenance of redundant power supplies etc.). There is no evidence that the melter safe condition lock-out and subsequent time periods required for melter cool down and reheat have been factored into the facility production capability. These activities could represent a significant production impact for this routine consumable item replacement.
- Hot molten LAW glass produced in the melter is poured into steel containers. These containers must be allowed to cool for a minimum period of time so that the container can be lifted to the next handling station without risk of distorting the container flange. If this container flange were to distort, the container could fall when lifted. The review team concluded that the current time specified for cooling the containers was insufficient and should be extended. If the cooling time for a container is extended consistent with existing WTP data, container production could be significantly reduced.
- Automation of complex facilities is relied upon to ensure consistent control of the facility processes and to minimize time for response to changes and off-normal conditions, thereby increasing efficiency and production capability. However, the current level of automation in the LAW Facility intentionally emphasizes manual operations. As a result, many functions that are typically fully automated, such as start-up sequences, valve lineups, and shut-down sequences rely upon operator interaction for control.
- The impact of the extent of these operator control and response actions on the production capabilities of the LAW Facility do not appear to have been adequately considered. In addition, the WTP contract requires that the operational research model assess activities such as the time required to perform mechanical handling operations, which are generally assumed within the model to be performed instantaneously without consideration of operator response times. These operator response times could significantly impact LAW Facility glass production rates.

### 4.3.3 Conclusions

The evidence observed indicates that the basis for the expected LAW Facility production capability is insupportable. Without the benefit of accurate predictive models to inform the design and the design process that emphasizes production capability as a key consideration, the

LAW Facility glass production capacity presents a significant challenge to the Hanford Tank Farms mission.

#### 4.3.4 Recommended Path Forward

The following suggested actions should be considered to improve the basis and understanding of the LAW Facility production:

- Reconsider the bases and requirements for each system associated with facility performance. Confirm that inter-system interfaces and transitions are considered and integrated.
- Develop detailed work plans for a representative set of critical maintenance and operations activities based upon fully-validated design input data that has been analyzed and accepted through a multi-discipline review process. Use this information to develop and validate an OR model that incorporates a consistent process methodology across all plant systems.
- Model all plant operations and maintenance activities in detail using the updated OR model, scale simulations and mockups to validate throughput, space availability, remotability, accessibility, and availability of interfacing systems and organizations such that the production rate and margin can be accurately estimated at the facility and systems level.
- Establish a formal and systematic design approach to identify and disposition issues that may adversely affect plant operations, maintenance and throughput. Address any redesign effort that may be required to minimize operational work-arounds, and unanalyzed production impacts.
- Include reasonable and justifiable assumptions to predict performance and quality losses in the model basis and assumptions.
- Maintain and utilize models, simulations, and mockups as primary operator training tools.
- Consider incorporating lessons learned and operational feedback from the nuclear industry best practices that includes a specific structured approach to examine system operability and maintainability, using data based on supportable documented operational experience.

#### 4.4 INADEQUATE IMPLEMENTATION OF ALARA PRINCIPLES

The WTP is required to meet specific worker radiological dose exposure and contamination limits imposed by federal regulations (such as 10 CFR 835.202) and to implement design features so that workers are protected and radiological dose is ALARA.

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The LAW Facility design is based upon hands-on operations and maintenance. Consequently, potential radiological conditions must be thoroughly evaluated to ensure radiation exposures and contamination levels are ALARA. Radiological contamination migration, as well as the contamination and dose levels, must be thoroughly modeled and understood. Current assumptions that may later be found to be invalid can substantially impact the operability and maintainability of the facility.

#### 4.4.1 Summary

Throughout the review it was apparent that ALARA principles, incorporated as part of the design process, had not been effectively implemented. Key observations that the LAW Facility design may not effectively achieve ALARA requirements include:

- **Contamination control not effectively analyzed and demonstrated:** There were recurring instances where contamination control methods, defined in the design bases, such as airflow through doorway and hatches, were not sufficiently considered and demonstrated to be effective, challenging the ability of the project to successfully meet ALARA requirements. This is of particular importance for the LAW Facility because the contamination levels expected to be encountered as part of the hands-on maintenance approach are currently unknown and unanalyzed. Additionally, it was not apparent that the design of SSCs has adequately considered the need for periodic decontamination or provided features to facilitate decontamination efforts (such as use of high gloss/nonstick surfaces, or minimization of joints/crevices that can accumulate contamination).
- **Personnel dose assessments are not sufficiently documented to support contact operations and maintenance:** Radiation doses to personnel are undetermined for Operations, Maintenance, and Waste Management activities. Total cumulative radiation dose for a representative or bounding set of operations and maintenance evolution have not yet been determined; therefore, it is not known whether contract ALARA dose requirements can be met with currently planned staffing levels.

#### 4.4.2 Examples

Some representative examples of vulnerabilities associated with inadequate implementation of ALARA principles include:

- The LAW Facility confinement ventilation system is a complex low airflow system. Some rooms require multiple ventilation manipulations to maintain correct air flow direction. Entry and exit from potentially contaminated rooms requires that airflow be manually controlled to prevent reversal of air flows and disruption or shutdown of ventilation systems.
- The storage tanks for incoming waste and the associated rooms are expected to become highly contaminated and the potential exists for personnel to receive significant radiation exposure in the process cells. The anticipated dose levels in the cells have not been assessed and no assumptions identified for the time required for removal of inventory from the cells and flush to attain levels acceptable for personnel entry.
- The transfer of bogies (rail based carts used to transport containers) between rooms may be a problem due to contamination potentially being transferred from rooms with higher contamination to rooms with lower contamination. This issue is exacerbated by the inclusion of design features such as recessed rails and unfinished walls above 7'6" that will trap contamination and make decontamination more difficult.
- The current carbon dioxide (CO<sub>2</sub>) system uses CO<sub>2</sub> blast pellets to decontaminate the glass waste container. The CO<sub>2</sub> system uses pressurized air in the decontamination process and ablated contaminants are contained and removed by the vacuum effluent removal system. Because the CO<sub>2</sub> system has not been tested as an integrated system, it



- is unknown as to how well the vacuum effluent system will capture the ablated contaminants, or whether the contamination will be spread in the general Finishing Line area.

Maintenance in the process cells, upstream of the melter, and within the Pour Cave and Finishing Line may require personnel to be in contact with equipment that exhibits high radiation exposure rates because of the hands-on maintenance design.

- Packaged waste containers that exceed a facility-specified radioactive dose limit, which is often set relatively low to limit cumulative uptake, require special handling and/or shielding so that the waste container can be safely handled and disposed.

#### 4.4.3 Conclusions

There are specific regulatory and contractual requirements associated with meeting ALARA goals and objectives. The review team found that these requirements may not be met, primarily because of uncertainties related to how work will be conducted, a lack of systematic analysis, and modeling to confirm how contamination will migrate.

The effectiveness of a low flow ventilation philosophy has never been demonstrated in this type of facility using a hands-on maintenance approach. The low airflow design may cause contamination to accumulate in some areas or progressively spread in other areas of the facility. There is no model available to evaluate contamination migration paths throughout the facility.

Radiological conditions in the LAW Facility are considered likely to deteriorate over the life of the facility thereby exacerbating difficulties associated with performing contact operations and maintenance. Consideration of design controls to address the radiological dose and contamination hazards over the life of the LAW Facility appears incomplete.

#### 4.4.4 Recommended Path Forward

The following suggested actions should be considered to reduce operational risk in meeting regulatory requirements associated with ALARA implementation:

- Model and evaluate work tasks for each process system, identify potential areas where contamination may migrate, and document any additional engineered (e.g., remotely operated tooling) or administrative controls (e.g., procedures) that will be needed to ensure personnel are appropriately protected.
- Evaluate and document predicted possible airborne radioactivity work locations, given maintenance and operations tasks to be performed, and determine whether existing engineering controls will be effective in mitigating the airborne hazard.
- Apply suitable easy to decontamination surface coatings to the unprotected walls in the facility where radiological contamination could be present and operations or maintenance activities will be performed.



- Accelerate the identification and definition of operation, maintenance, and waste management tasks and revise/update the dose assessment reports to accurately reflect anticipated dose.
- Establish a mockup facility/area to evaluate and practice implementation of approaches to control worker dose and work area contamination prior to in-field execution of tasks expected to be high risk or have high radiological consequences.

#### 4.5 TRANSFER OF SCOPE AND RISK TO THE COMMISSIONING PHASE

Inherent in the commissioning phase of any facility is the resolution of previously unidentified issues. These issues occur despite best efforts to identify and resolve them during the design and construction phases, which can significantly increase the planned duration of the commissioning phase. Therefore, the importance of controlling and minimizing the transfer of known equipment testing and design confirmation activities from the design, procurement, and construction phases to the commissioning phase cannot be overstated.

##### 4.5.1 Summary

A number of equipment testing and functional demonstration activities have been identified on the LAW project that would be best performed prior to installation and commissioning. Delaying the completion of these activities transfers the risk of additional Engineering, Procurement and Construction (EPC) activities to the commissioning phase of the project and will likely extend the commissioning period significantly.

Key observations include:

- **Deferral of integrated equipment testing and functional demonstrations:** A number of cases were identified where integrated testing or functional demonstration of critical components was deferred to the commissioning phase of the project. Many of the deferred activities lack integrated factory acceptance testing, models, simulations or mockups that would help provide assurance that the equipment or system can meet its functional requirements. This would mitigate additional cost and schedule risks associated with postponing functional validation to commissioning.
- **Inadequate tracking and management of deferred testing and performance demonstrations:** There is little evidence to indicate the equipment testing and functional demonstration activities being transferred to the commissioning phase are being sufficiently tracked to support planning and risk management. The commissioning schedule has little or no room (i.e., float) to accommodate scope growth as a result of deferral of activities from the design phase. As the commissioning scope grows, it is vital that the scope is controlled and managed to minimize overall cost and schedule impacts to the commissioning phase.

□

#### 4.5.2 Examples

Examples of vulnerabilities associated with the transfer of scope and risk to the commissioning phase include:

- Filled LAW glass containers are decontaminated by being blasted with CO<sub>2</sub> pellets prior to being removed from the LAW Facility. A previous ORP review of the technical maturity of the selected decontamination technology indicated that additional development and testing were necessary to ensure that the system would perform reliably at the LAW Facility. This technology maturation and demonstration testing were never completed and two identical container decontamination systems are now installed in the

LAW finishing line. Additional testing of the systems is necessary but has been deferred to the commissioning phase. Based on the results of the ORP review, there is significant risk this system will not work as intended and will result in a significant delay in commissioning and costly modifications to either improve or replace the systems.

- If a LAW container is damaged during or following the pouring of glass into the container (e.g., due to over-pouring the glass or distortion of the container flange), a special lifting frame would be needed to recover and relocate the container. A workable lifting frame that could be used to recover damaged containers has not yet been designed and is not currently planned to be procured until the first time a damaged container is encountered. This could occur during the commissioning phase. Delaying the final design and procurement of the frame could adversely impact the ability to complete system commissioning or impact subsequent production operations.
- UPS and associated battery systems are included in the LAW Facility design to ensure power is maintained to selected safety systems in the event of an interruption to the normal power supply. Currently, the WTP Project plans to use manufacturer's calculations and factory capacity tests to demonstrate that battery capacity is adequate rather than performing testing when the UPS and batteries are installed, which takes in account impacts to the battery cell's performance resulting from shipping and installation damage. If batteries are not installed until the 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.
- Integrated Control System testing, including remote I/O, remote operator interfaces, and instruments, is deferred and no integrated simulation process is proposed prior to commissioning.

#### 4.5.3 Conclusions

The deferral of critical integrated equipment tests and functional demonstrations to the commissioning phase has not been adequately anticipated or controlled. The deferral of these activities will increase the duration and cost of LAW Facility commissioning, which will also delay the processing of radioactive waste.

#### 4.5.4 Recommended Path Forward

The following suggested actions should be considered to reduce the risks associated with deferring testing and functional performance demonstrations to commissioning:

- Identify all systems and components that require testing or functional demonstration as part of commissioning. Where feasible, identify off-line testing, modeling, simulations or mockups that may be used to minimize the risk of deferring these tests and functional demonstrations to commissioning

- Develop a system for tracking all testing and functional demonstration activities being deferred to commissioning. Use the tracking system to support the planning and manage the risk caused by the deferral of these activities.

#### 4.6 INADEQUATE IMPLEMENTATION OF DESIGN REQUIREMENTS FOR WASTE MANAGEMENT

The operation of a nuclear facility necessarily generates radioactive solid waste. The majority of this “secondary” solid waste consists of maintenance waste items contaminated with radioactive material (e.g., pumps, agitators, valves, etc.), and consumable items (e.g., bubbler tubes used to mix the melter contents).

The secondary radioactive waste must be packaged and removed from the facility in an efficient manner to meet waste storage and disposal requirements, and to reduce the hazards to workers. The packaging of the secondary radioactive waste may require flushing or other decontamination to reduce hazardous constituents to levels acceptable for disposal and may also require size reduction so that waste items will fit into waste containers.

If the secondary radioactive waste cannot be efficiently handled, packaged, and exported, the waste can accumulate to the point that facility glass production operations are either suspended or slowed so that adequate resources can be applied to manage the waste backlog.

##### 4.6.1 Summary

The review team identified that the design requirements for secondary radioactive waste management were incomplete, and adequate design features were not included to support efficient secondary waste management. The capabilities to perform size reduction, decontamination, storage, and export of secondary radioactive solid waste are considered insufficiently developed to support sustained LAW glass production operations. In addition, the forecasted secondary waste volumes appear to be underestimated based on other analogous facilities and processes.

Retrofitting waste management capabilities into the design during the operating phase may require significant facility modifications or operational compromises that impact LAW glass production objectives.

Observations include:

- **Waste volume estimates not conservative:** The review team observed that estimates of secondary waste volumes are either incomplete or lack appropriate conservatism. Secondary radioactive waste can become a bottleneck, and LAW glass production may be slowed or halted until the waste backlog is processed.
- **Inadequate and incomplete equipment and systems to support efficient waste handling functions:** The review team observed that the LAW facility design did not include expected waste handling design features typically applied to efficient waste handling operations in other nuclear facilities.



- **Inefficient waste management interface:** Currently, radioactive solid waste generated at WTP facilities is planned to be packaged at the facility that generates the waste and then exported to the Tank Operations Contractor (TOC) for size reduction and repackaging for disposal. The TOC currently has no facility to repackage waste. Interface Control Document (ICD-03) for radioactive solid waste management specifies functional requirements and associated responsibilities for contractors involved in the preparations for and disposal of secondary waste. However, the ICD appears to assign requirements and responsibilities or contains requirement gaps that are inconsistent with proven and successful waste management practices on the Hanford site. Per ICD-03, WTP waste packaging and management responsibilities are restricted to characterizing and packaging the radioactive waste for transport rather than for disposal. Further, ICD-03 does not impose specific requirements on WTP for performing waste treatment, such as ensuring waste packages meet void fraction requirements or providing data needed for waste disposal. As a result, these responsibilities are owned by the TOC and/or Plateau Remediation Contractor without the necessary resources/facilities to implement these responsibilities. This situation could lead to difficulties in establishing readiness to operate and attendant delays in starting glass production operations.
- **Waste Management Impacts on Facility Performance Not Adequately Considered:**

Assessments of the throughput capabilities of the radioactive waste handling system do not adequately address the required time and resources for all waste management activities (e.g., size reduction, packaging). Inadequate consideration of all waste management steps will result in a reduction of the overall facility throughput capability.

#### 4.6.2 Examples

Some representative examples of vulnerabilities associated with inadequate implementation of design requirements for secondary radioactive waste management include:

- It is not evident that all necessary lifting and handling equipment (e.g., cranes/hoists, carts, cradles, etc.) has been provided to enable movement of secondary radioactive waste containers from potential packaging locations within the LAW Facility to potential export locations.
- The travel routes for moving waste from the point of generation to packaging areas and export areas are not well defined, except for some known consumable items (e.g. melter bubblers). It is important to understand these waste travel routes to ensure that the wastes can be moved through the facility without a need to implement special administrative controls to minimize hazards to facility workers. Implementation of special administrative controls could result in a need to halt or slow glass production activities.



- Areas for temporary storage of secondary solid waste in compliance with regulatory permit requirements have not been defined or established.
- Size reduction of some large equipment items will be required so that these can be packaged in waste containers. However, a location to perform size reduction activities and the equipment needed to perform the required size reduction is not specified.

#### 4.6.3 Conclusions

The design process has not adequately considered or implemented sufficient features necessary to ensure the effective functionality of waste management systems to support the LAW Facility lifecycle mission needs.

#### 4.6.4 Recommended Path Forward

The following suggested actions should be considered to improve the basis and understanding of facility secondary radioactive waste handling:

- Reassess the adequacy of the functional requirements associated with secondary radioactive waste management to confirm that the full range of wastes anticipated over the life of the LAW Facility is addressed.
- Reassess current secondary waste volumes and waste classifications to derive conservative estimates for design. Provide waste handling process design features to accommodate the forecasted waste volumes and classifications.
- Update the OR model to fully incorporate the waste management processes required to handle the estimated volumes of radioactive wastes generated over the life of the LAW Facility. Develop a range of anticipated scenarios and use the OR model to assess the impacts of waste management activities on overall production. Assess areas that require design changes to ensure that LAW glass production is not impacted to the extent that mission objectives are jeopardized.
- Evaluate the ICD-03 to ensure all roles, responsibilities and impacts to the involved contractors are understood and agreed to ensure the waste treatment packaging and transportation are available to support earliest effective operations of the LAW Facility.
- The DOE must ensure a facility to satisfy the secondary radioactive solid waste size reduction and repackaging requirements of the LAW Facility is available prior to operation.

### 4.7 INADEQUATE CONSIDERATION OF INDUSTRIAL SAFETY AND INDUSTRIAL HYGIENE REQUIREMENTS

The DOE is a self-regulating agency responsible for implementation and oversight of a Worker Safety and Health program that reduces or prevents occupational injuries, illnesses, and accidental losses. The DOE Worker Safety and Health program is regulated under 10 CFR 851

and requires contractors to provide a place of employment that is free from recognized hazards that cause or have the potential to cause death or serious physical harm and ensure work is performed in accordance with regulations and the contractor Worker Safety and Health Program.

The DOE requires contractors to establish procedures to identify existing and potential workplace hazards, and assess the risk of associated workers injury and illness, using recognized exposure assessment and testing methodologies as part of the design process for new facilities. For hazards identified in the facility design, controls must be incorporated into the design or procedure, and hazard controls must be selected based on the following hierarchy:

- Elimination or substitution of the hazards where feasible and appropriate;
- Engineering controls where feasible and appropriate;
- Work practices and administrative controls that limit worker exposures; and □  
Personal protective equipment.

In addition, contractors must address hazards when selecting or purchasing equipment, products, and services.

#### 4.7.1 Summary

Throughout the review process it was apparent that fundamental safety and health principles, incorporated as part of the design process of the LAW Facility, had not been effectively implemented. Key observations indicating inadequate consideration of industrial safety and hygiene requirements include:

- **Insufficient evidence of compliance with operational safety and health requirements in design:** During the course of this review, it was observed that there were recurring instances where safety and health requirements were not effectively incorporated into the design of the LAW Facility.
- **Inadequate implementation of the hazards analysis process for worker safety to address chemical hazards:** The identification of chemicals, other than chemicals associated with the melter offgas system has not been considered as part of the facility design process. In addition, exposure assessments conducted to date were not accurate and did not adequately reflect hazards associated with the LAW Facility.
- **Inadequate implementation of the hazards analysis process for worker safety to address thermal hazards:** There are two worker safety thermal hazards that are expected to be encountered when the facility is operational: 1) the potential for burns due to hot equipment and 2) the potential for heat stress due to elevated room/work environment temperatures and heat. The Review Team found that these hazards had not been appropriately evaluated.

#### 4.7.2 Examples

Some examples of vulnerabilities indicating inadequate consideration of Industrial Safety and Industrial Hygiene requirements include:

- The review team was not able to find any documentation that identified expected chemical compounds in the feed to the LAW Facility from the Pretreatment Facility. The WTP Project maintains a list of anions and cations, along with generic volatile organic compound information; however, no documentation was provided to the Review Team identifying the worst case, or bounding source term, for chemicals present in the waste feed. These compounds and/or list of chemicals need to be compared against worker protection limits to ensure engineering controls are adequate and workers are appropriately protected. In addition, no routine area monitoring for chemicals, other than those associated with the melter offgas system, was found to have been incorporated into the facility design process. This is of particular concern due to the worker protection issues that are associated with the Tank Farms operations and potential exposures to similar chemical vapors at the LAW Facility should incoming waste migrate from the containment piping (e.g., leaking valve, equipment maintenance).
- Ventilation is the primary means for controlling and mitigating exposure of personnel to chemical vapors. It does not appear that chemical dilution (immediate barrier to release), from a worker protection chemical perspective, was considered as part of the ventilation design.
- Breaker bars are required to provide mechanical advantage to open doors against the building depressions allowing personnel to exit a room during emergencies or other offnormal events. Although breaker bars are available for some areas they are not available for other similar areas, this may preclude egress in the event of an off normal or emergency condition. Operation of these devices under abnormal conditions is likely to cause the ventilation system to shutdown, resulting in a potential loss of effective confinement.
- The potential for carbon fines to ignite in the carbon beds during normal operations or during carbon replacement activities has not been thoroughly analyzed as part of the hazards analysis process. Further, replacement of the carbon in the carbon beds involves workers crouching under the beds in a space ~3 feet high. The workers will work in these conditions for an extended period of time since it will require about thirty (30) 55-gallon drums to collect the spent carbon. This design does not adequately implement suitable worker ergonomic features.
- Container lids used in the finishing line must be manually loaded in the lid holder mechanism. Each lid weighs 45 pounds and there are 35 lid-and-seal assemblies. Back injuries are common when routinely lifting heavy equipment. Given the number of lids needed to be loaded, an engineered means to perform this task is warranted.
- Three high voltage (13.8 kV) electrical supply power disconnects are all located in the same power supply compartment on the melter power supplies. This configuration

makes performing zero energy checks to ensure that the system is safe for worker maintenance impossible unless all incoming power to each LAW Facility melter power supply is disconnected. In addition, there is inadequate space for worker access to the power supply cabinet.

- Existing exposure assessments for the LAW Facility were found to be inadequate and in need of revision to accurately address chemical hazards and controls when performing work. In addition, no administrative process exists that ensures results of the exposure assessments are incorporated into the Engineering design process (ensuring engineered solutions to the mitigation of hazards).

#### 4.7.3 Conclusions

There are specific safety and health regulatory and contractual requirements that must be met as part of the design process. The review team found fundamental weaknesses in the hazard identification and mitigation process related to chemical and physical hazards. There is a significant potential that similar worker safety concerns related to chemical vapors in the Tank Farms may be present in the LAW Facility because the incoming feed to the LAW Facility originates from the Tank Farms. Thermal hazards need to be thoroughly addressed to ensure workers are appropriately protected from burns and heat stress. Finally, several examples were identified within the LAW Facility that will require retrofitting of installed equipment to meet 10 CFR 851 requirements.

#### 4.7.4 Recommended Path Forward

The following suggested actions should be considered to ensure regulatory requirements associated with safety and health implementation are met:

- Define and document the chemical source term coming into the LAW Facility. The evaluation should consider historical information previously generated for the Hanford Tank Farms. In addition, identify and incorporate into the design additional area monitoring that may be needed throughout the facility to ensure worker protection (other than areas associated with the offgas system).
- Develop a formal process that ensures safety and health requirements and Industrial Safety and Health personnel are involved in the design process. The process should also list the hierarchy of controls and require a basis to be documented that describes how each control was addressed.
- 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 10 CFR 851 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 (e.g., daily crane inspections in the finishing line).



- Revise exposure assessments to accurately reflect chemical and environmental hazards anticipated during the design phase of the project.

#### 4.8 INADEQUATE CONSIDERATION FOR SUCCESS OF OPERATIONS/MAINTENANCE ACTIVITIES

An important aspect of nuclear facility design is to consider and include conditions that will enable and facilitate the success of operations and maintenance activities. A facility may not be operable or maintainable even though all design requirements have been met. In other words, a compliant facility is not necessarily an operable facility.

The stated intent of the operational philosophy for the LAW Facility, as well as other associated facilities, is to ensure a reliable and operable system that will minimize worker exposure, promote worker safety, successfully complete the ORP tank waste treatment mission, provide cost-effective process operations, maintenance, and minimize life-cycle cost. A primary objective should be to aid the Operator to safely and efficiently process radioactive waste.

##### 4.8.1 Summary

The review team observed that the current LAW Facility design was not consistent with the stated operational intent. Inadequate consideration of operations and maintenance conditions needed to successfully operate and maintain the facility will likely impact the ability to meet production targets, challenge safety and hazard exposure goals, and ultimately extend the LAW Facility mission.

Observations indicating a plan leading to successful operations and maintenance of the facility have not been adequately incorporated into the design include:

- **Design process does not adequately facilitate operator success:** Results of the review indicate the design process does not include consideration for hands-on operation, nor does the design process include a feedback mechanism to revise the design when proposed operational activities identify an obstacle to effective operation. The LAW Facility design inadequately considers the provision of information, methods, and tools to the Operator, as required, to perform some activities safely, efficiently, and in a cost-effective manner.
- **Design process does not include adequate consideration of maintenance performance:** The LAW Facility relies upon hands-on maintenance for equipment repair, calibration and replacement. Implementation of hands-on maintenance may require special precautions to protect workers from chemical hazards, high temperature hazards, and to ensure radiological conditions are controlled to maintain worker safety. The impact of these special precautions on maintenance time durations or glass production do not appear to have been adequately considered.



#### 4.8.2 Examples

Some examples of vulnerabilities indicating inadequate consideration of or conduct of operations/maintenance needs are:

- Plant operating environment (heat, chemical, radiation) within the melter gallery is not defined to date, yet plant design and construction continues to move forward without verification that operators and maintenance personnel can perform anticipated duties within the melter gallery environment during the LAW Facility operations.
- The plant design requires operator action in hazardous environments rather than precluding hands-on operation by implementing engineered controls.
- Maintenance of some equipment requires that a confinement barrier be accessed using hands-on methods. This may require that both melters cease production operations so that the system can be placed in a safe condition for maintenance (e.g., maintenance of some melter off-gas equipment).
- Drawings depicting the conduits (conduit schedules) and electrical cables (wire run lists) are used to identify the location of electrical wiring throughout the facility. The accuracy of these is important to safely troubleshoot or modify plant equipment. However, there are no conduit schedules or wire run lists in the LAW Facility drawing sets; instead WTP Project electrical design uses a proprietary program called SETROUTE to maintain configuration control of conduit runs and wire run data using a database. Currently there are no plans to transfer this proprietary program to the operating contractor. Printouts of the contents of the database are planned to be provided but this database printout will be extremely difficult for maintenance when resolving electrical issues. Additionally, maintaining configuration control/management during future modifications at the facility will prove challenging without having the full capability of SETROUTE software available for use.
- Each LAW melter has two off-gas spray nozzles. Each spray nozzle assembly is a consumable/replaceable item that is removed and replaced annually. The actions to remove and install the spray nozzle are performed in close proximity to the open melter glass pool. Conducting these activities in direct line of sight to the glass pool using the currently proposed methodology is not safe.
- Each LAW melter has 18 bubbler assemblies which are consumable items and have a service life of six months. The current LAW design requires manual actions to remove spent bubblers and replace them with new bubblers. It is anticipated the personnel involved will be required to don Personal Protective Equipment (PPE) including respirators or supplied air masks, as the work includes opening the top of the melter, the hazards do not appear to have been effectively analyzed.

### 4.8.3 Conclusions

The LAW Facility relies upon hands-on maintenance for equipment repair, calibration, and replacement. There is no precedent for this approach for nuclear waste vitrification facilities with similar hazards. As a result, the complexity of implementing a hands-on contact maintenance approach in the LAW Facility and the associated production impacts appears to be underestimated. This is due, in part, to the unknown magnitude of the hazards that are anticipated in the work spaces. There was insufficient information available regarding the magnitude of the hazards associated with temperature, radiation, contamination and chemicals affecting proposed operation and maintenance evolutions. Therefore, accurate assessments of future plant operability and maintainability cannot be made using the limited information that was provided. Specifically:

- The anticipated or calculated radiological, thermal, and chemical environment that operators and maintenance technicians will be exposed to has not been fully defined.
- There appears to be an over reliance on the use of PPE in the performance of routine tasks and evolutions. It is not clear that many of the tasks would be possible in standard PPE.

### 4.8.4 Recommended Path Forward

The following suggested actions should be considered to improve the operability and maintainability at the LAW Facility:

- Complete the hazards analysis for each high-risk anticipated manual operation or maintenance activity, including consumable replacement (e.g., bubbler, film cooler spray nozzle, process agitator and pumps) and consider mitigating the hazards through engineered methods.
- Accelerate the development of detailed task analyses for a representative set of critical maintenance and operations activities based upon currently available designs using a multi-disciplinary review process.
- Develop training simulations and mockups to include hands-on operations and maintenance activities.

## **5.0 SYSTEM REVIEW SUMMARY**

This section provides summary results for each of the thirteen reviewed LAW Facility systems. These summaries start with a brief overview of the system, followed by the key results and consequences, an overall conclusion regarding the functional capability of the system, and a proposed path forward associated with the system. Full descriptions of all vulnerabilities identified during the course of the review are provided in Appendix B.

The review team identified many significant issues that—if left unmitigated—may result in unacceptable risk to the LAW Facility startup and commissioning.

### **5.1 PRIMARY OFFGAS PROCESS (LOP), SECONDARY OFFGAS/VESSEL VENT PROCESS (LVP) AND AMMONIA REAGENT (AMR) SYSTEMS**

The combined function of the LAW LOP, LVP and AMR systems is to safely treat LAW melter and vessel ventilation off gas to protect the public, environment, and operating staff (including co-located workers) from radionuclide and chemical exposure. These systems are also relied upon to confine chemical constituents from treatment of the offgas. Compliance with offgas environmental treatment requirements is achieved prior to release from the LAW Facility stacks for each of the two melters.

There are separate and duplicate LOP trains for each LAW melter. These separate trains are combined into a single LVP train that serves both melters. The primary functions of the LOP trains are to cool the melter off-gas and provide initial removal of radioactive particulates.

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

The AMR system supplies ammonia to the NO<sub>x</sub> abatement equipment within the LVP system.

Although the LOP, LVP, and AMR systems are technically separate systems, they are considered together for purposes of this review due to the high degree of interdependence between these systems.

There were no substantive functionality/operability vulnerabilities identified in the review of the Balance of Facilities component of the AMR system, and this system is considered by the review team to fully meet functionality and operability requirements and is not discussed further. The ammonia skid, which is within the LAW Facility, was reviewed separately as part of the LVP System.



### 5.1.1 LOP/LVP Key Results/Consequences

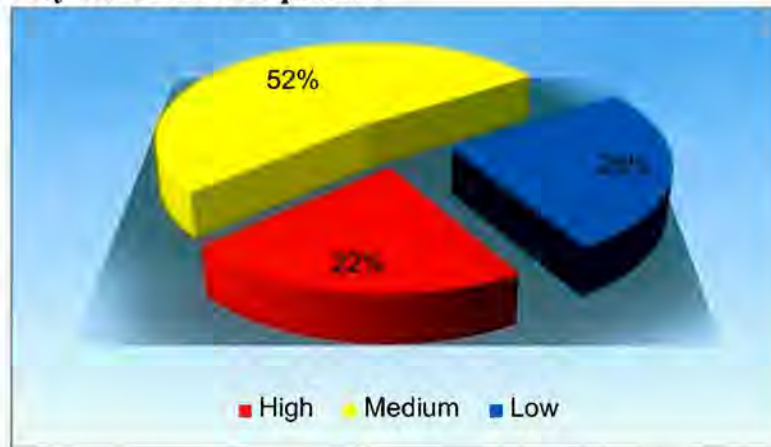


Figure 5-1. Unmitigated Vulnerabilities Identified for the Primary Offgas Process and Secondary Offgas/Vessel Vent Process Systems.

Without mitigating actions, there is collective evidence from this review that the current design of the combined LOP/LVP systems is likely to chronically limit the overall production capability of the LAW Facility.

The summarized principal evidence is as follows:

- There were a total of forty six (46) vulnerabilities identified in these systems. Thirty four (34) of these are considered to require corrective action, including some significant reanalysis/redesign, prior to start-up testing. Figure 5-1 shows the ratio of high-, medium-, and low-impact vulnerabilities identified for the two systems. See Appendix B for a list of vulnerabilities and OFIs.
- A reliable and fully technically defensible strategy for safe operation of the carbon bed adsorber units (under normal and abnormal operating conditions) has not yet been defined or documented as evidenced by the following:
  - A carbon bed fire is a hazard identified in the PDSA; however, the review found no clear definition of this hazard in the design documents. It is not possible to evaluate a detection strategy without a clear definition of the hazard.
  - The design documents provide a limited definition of the operating conditions that minimize the potential for experiencing a carbon bed fire.
  - Monitoring a CO<sub>x</sub> concentration difference across carbon beds as an indication of fire may prove to be difficult to successfully implement based on vendor information and results of pilot scale testing.
  - 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.

- No minimum gas flow rate has been defined for safely operating the carbon beds.
- The complex abatement system design with numerous safety and permit affecting controls is judged likely to impact the ability to sustain operations and meet throughput requirements as evidenced by the following:
  - The adequacy of the design to capably and reliably support control of integrated system equipment/components under startup, shutdown and abnormal operating conditions (such as during low flow or melter surges) was not demonstrated/documentated.
  - There appears to be insufficient redundancy available to avoid single point equipment failures affecting both melters with unaccounted throughput impacts.
  - Single point instrument failures, interlocks, required calibrations and surveillances can result in unaccounted throughput impacts.
  - The collective significance of project self-identified issues from a Requirements Validation Process review previously completed by the WTP Project indicates the overall functionality of LOP/LVP systems is indeterminate.
- The thermal qualification of the SBS is questionable because it is indeterminate that 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 some operating conditions.

### 5.1.2 LOP/LVP Conclusions

The combined LOP/LVP systems are determined by this review to require potentially complex mitigating actions to be capable of fully meeting their intended functions. This is necessary so that some equipment (e.g., carbon bed units) can be safely operated and throughput requirements can be met.

The vulnerabilities stem from one or more of the following issues:

- The complexity of the design,
- Inadequate evidence that the treatment units (either individually or collectively as an integrated system) will meet the intended level of performance,
- Potential consequences of a carbon bed fire (or false positive indication of a fire) and □ Potentially complex maintenance requirements.

Many similar issues have been self-identified within the project; however, they have yet to be completely resolved.

The primary anticipated consequence of the identified vulnerabilities is that failure of this system will cause frequent and persistent outages resulting in significant facility production impacts.



### 5.1.3 LOP/LVP Recommended Path Forward

Further construction, and procurement of the LOP/LVP systems will put the project at risk until actions have been completed such that the identified vulnerabilities have been mitigated and system functionality independently confirmed. Some specific recommended tasks include, but are not limited to, the following:

- Revisit the decision to rely on a CO<sub>x</sub> 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 CO<sub>2</sub> 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 SO<sub>2</sub> concentration difference.
- 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 the beds 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.
- Consider developing and implementing a test program, combined with modeling, where carbon bed fires are actually generated to define the system characteristics expected to be observed during a real fire.

- Develop a system testing approach that avoids passing off-gas through the carbon beds during Destruction and Removal Efficiency (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 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.
- 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.
- Complete analysis to establish reliability requirements of instrumentation based on conservative forecast of Authorization Basis requirements.
- Formally evaluate options to condition the LAW feed to remove mercury such that carbon beds are not required and the risk of a carbon bed fire is eliminated. Engage with regulators to revisit best available control technology to reassess and balance the risk/complexity of the secondary treatment system with the environmental benefit and permitting requirements.
- Consider overall effectiveness of the LOP/LVP systems to remove constituents of concern as opposed to selecting an individual unit operation to address each individual constituent of concern. This approach may justify elimination of some unit operations, thereby simplifying the system without sacrificing overall effectiveness.
- Evaluate the lifetime LOP/LVP systems demonstration requirements for permitting and safety basis compliance testing, and ensure engineered methods are implemented for test fluid introduction, sampling or process measurement points, and other engineering methods.
- Develop an OR model that informs the design and confirms the design will support the mission. The model should be used to investigate a range of normal and anticipated offnormal operating conditions.
- Conduct formal reassessment of the residual commissioning and operations risks associated with previously closed and currently open technical issues. Initiate actions to eliminate or provide appropriate mitigation for residual commissioning / operating risks. Assessment results and resulting actions should be independently confirmed.
- Continue development of “Technical Manuals” as a means to develop and integrate start-up/shut-down sequences and responses to abnormal conditions.

- Specific to the SBS:
  - Consider an alternative high temperature gasket material compatible with existing flange surfaces such as Perfluoroelastomer 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 Metaflex used on the SBS inlet line connections).

## 5.2 INSTRUMENTATION & CONTROL

The WTP Project uses the ICN, comprising several subsystems, to monitor and control the plant equipment and process. The ICN is a large distributed control system (DCS) that controls all five facilities: Pretreatment (PT), LAW, HLW, Balance of Facilities (BOF) and the Laboratory (LAB). While this operability review was only performed on the LAW control systems and their components, the Software Quality Assurance vulnerabilities for the ICN apply to the entire WTP.

The PPJ is the Safety Instrumented System (SIS) for the WTP. This system is required to be developed under rigorous life-cycle requirements commensurate with the safety-related nature of the application.

### 5.2.1 Instrumentation & Control Key Results/Consequences

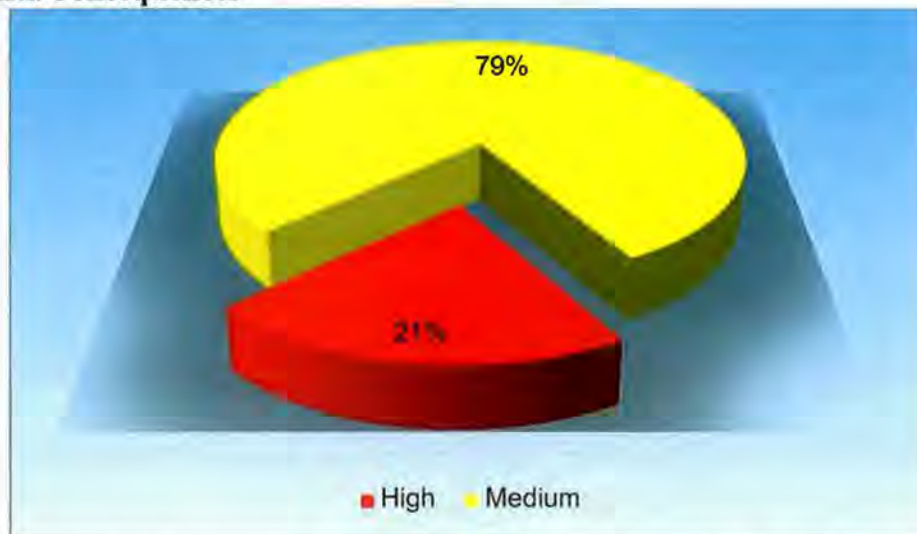


Figure 5-2. Unmitigated Vulnerabilities Identified for the I&C System.



Without mitigating actions, there is collective evidence from this review that the current design of the WTP Instrument & Control (I&C) system is likely to significantly delay startup and commissioning, increase the risk of safety and regulatory noncompliance and limit the throughput capability of the LAW Facility.

The summarized principal evidence is as follows:

- There were a total of fourteen (14) vulnerabilities identified in this system. All are considered to require corrective action, including some significant reanalysis/redesign, prior to start-up testing. Figure 5-2 shows the ratio of high- and medium- impact vulnerabilities identified for the system. See Appendix B for a list of vulnerabilities and OFIs.
- Software Quality Assurance classification of the ICN has been categorized inappropriately at a level below that required by DOE O 414.1C.
  - Only hazards and hazard controls identified in the PDSA, controlled by the PPJ, are used to assign safety software classification and software quality assurance grading level, which inadequately describes all hazards and hazard controls in the plant that involve ICN actions.
  - Layers of protection relied upon to satisfy the Safety Instrumented Function (SIF) and associated Safety Integrity Level (SIL) required by the safety basis are developed to a quality level inappropriate to their safety function
  - The ICN is involved in documenting adherence to permitting requirements, which are imposed to protect the environment, these should be categorized as a minimum quality level C but are currently categorized at the lower level of D or even F for some functions.
  - Software Quality Assurance Level evaluation is insufficient to demonstrate that 10 CFR 830 or DOE O 414.1C requirements have been met.
- Inappropriate use of CSLD/“J3” as requirements:
  - WTP currently plans to procure the custom PPJ from a safety-system vendor by providing only logic diagrams supplemented with input/output and setpoint lists. – The CSLD/J3s do not distinguish between design choices and requirements derived from upper tier bases documents, essentially severing traceability to the Authorization Basis.
  - CSLD/J3 do not adequately communicate the Functional Requirements across disciplines without recourse to the originator/ICN subject matter expert, which is likely to result in erroneous and unintended functionality.
- I&C system does not meet needs for general plant usability:

- Review of the LAW Facility heating, ventilation, and air conditioning (HVAC) System design does not indicate that Human Factors Engineering (HFE) principles have been adequately implemented for HMI control screens or faceplates.
- The level of automation (the degree control functions require operator intervention) is not consistently defined by the design basis documents, with some document sections, e.g., the Operations Requirements Document (ORD), requiring maximum automation, with other document sections specifying minimal automation. This leads to significantly different approaches for different applications and increases the potential for operator error. Consistency throughout the design is one of the primary reasons for developing higher level documents.
- The current level of automation maximizes manual operation including many functions that are typically automated, which is likely to lead to increased operator errors, rework, and suboptimal performance.
- The boundaries and scope of the ICN are not consistently defined, resulting in different interpretations of the ICN functions and therefore misunderstandings regarding the reliance placed on the ICN in support of the Authorization Basis generally and level of importance to the facility mission.

### 5.2.2 I&C Conclusions

The vulnerabilities documented in this review, unless mitigated, will:

- Significantly delay Startup and Commissioning because of extensive redesign due to the potential for reconfiguration of both the ICN and the PPJ to demonstrate readiness.
- Increase the risk of operating permit noncompliance because the software for permit affecting systems has been developed and tested to an inappropriately rigorous quality level.
- Significantly impact LAW Facility production due to:
  - Increased rework and reduced performance as a result of the reliance on manual operations and operator responses.
  - Inappropriate application of software quality standards leading to increased level of software errors.
  - Human Machine Interfaces that require the operator to react rather than providing the tools to proactively identify and correct off normal conditions before they become problems.

### 5.2.3 I&C Recommended Path Forward

Unmitigated consequences found by the review team can be avoided by:



- Define the ICN boundaries and interfaces, consistently and commensurate with the functions attributed to the ICN.
- Evaluate (or reevaluate) the hazards, risk, safety, and permitting compliance controlled or affected by the ICN and its subsystems and develop software to the appropriate quality classification level.
- Define (or redefine) the LAW Facility specific functions requirements performed and controlled by the ICN and the PPJ, carefully tracking the flow down of requirements from upper-tier documents. Use these requirements to provide the detailed test criteria when functionality is confirmed during software development or for vendor acceptance criteria.
- Use an industry standard hierarchy of documents to document requirements rather than distributing them over many CSLDs/J3s, making it practical for review without recourse to the designer or maintainer.

### 5.3 CONFINEMENT VENTILATION SYSTEMS (C1V, C2V, C3V, C5V)

The LAW Facility confinement ventilation (i.e., HVAC) systems are designed to provide confinement of radiological material by maintaining a prescribed differential pressure between confinement zones. They support radioactive contamination control by providing airflow from areas of lesser contamination potential to areas of greater contamination potential in order to provide confinement of contamination at or near the source. Consequently, LAW Facility rooms and corridors (zones) are classified based on their potential for radiological contamination. The contamination classifications zones C1, C2, C3, and C5. Zones classified as C5 are potentially the most contaminated, while zones classified as C1 have the lowest potential for contamination.

#### 5.3.1 Confinement Ventilation Key Results/ Consequences

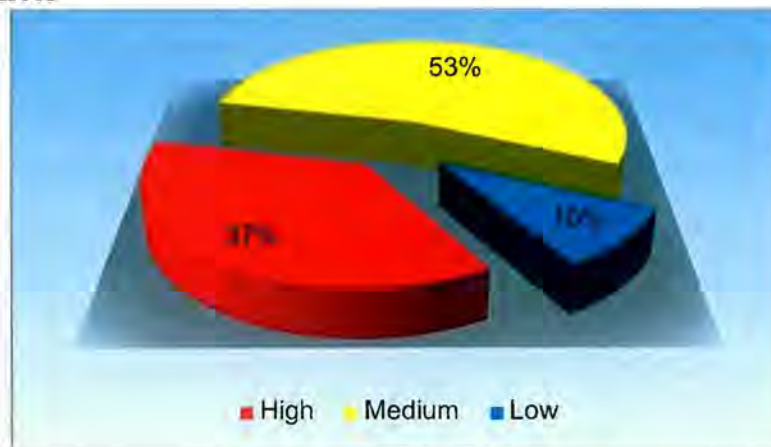


Figure 5-3. Unmitigated Vulnerabilities Identified for the Confinement Ventilation System.

The LAW Facility Confinement Ventilation System has been determined to be incapable of meeting its intended function unless corrective actions are taken. The extent and number of perturbations induced in the ventilation system as a result of routine operations are expected to result in an unstable system. The current ventilation system design may cause delays to facility startup and commissioning and impact facility operation during the life of the facility.

The summarized principal evidence is as follows:

- There were a total of seventy three (73) vulnerabilities identified in this system. Sixty six (66) of these require corrective action, including some significant reanalysis/redesign, prior to start-up testing. Figure 5-3 shows the ratio of high-, medium-, and low-impact vulnerabilities identified for the system. See Appendix B for a list of vulnerabilities and OFIs.
- **LAW Facility HVAC hazard analysis:** A number of hazardous conditions associated with upset and accident scenarios in the LAW off-gas system were identified in the PDSA hazard analysis with high toxicological unmitigated consequences to the facility worker and chemical exposures above threshold limits for the co-located worker. There is a strong potential that currently unidentified HVAC controls will be needed to mitigate the hazards identified in the hazard analysis. A final hazards analysis of the LAW ventilation system needs to be performed. Normal and off-normal operations as well as accident conditions need to be evaluated and all HVAC controls need to be identified.
- **Maintaining confinement:** The LAW Facility confinement strategy relies on carefully controlling dynamic operation within the facility administratively; developing entry/exit sequences instead of isolating ventilation zones. The proposed confinement strategy routinely changes the system configuration, flow balance and thermal loads resulting in a configuration that may not be consistent with operational safety, challenges the life safety requirements, impacts space cooling and reduces air velocities through open doors. A dynamic computer simulation model of the LAW Facility ventilation system is needed to understand the ability for the ventilation system to accommodate dynamic operations including opening of single/multiple doors and hatches, duty/standby fan changeover and activation of differential pressure interlocks.
- **LAW Facility stack sampling and monitoring system operation:** To date a stack sampling and monitoring system has not been identified that will meet the temperature requirements of the LAW Facility ventilation airflow (this is also true of the LAW offgas system). The originally specified stack sampling and monitoring system was not adequate for the anticipated stack temperatures. New stack sampling and monitoring system requirements have been developed. A vendor has been selected and provided the design requirements and is working to provide a system, but the LAW Facility stack temperature is above the standard sampling equipment temperature ratings so there is some risk a new system cannot be developed to meet the LAW Facility requirements.
- **Lack of redundancy:** Several areas in the LAW Facility have been identified where redundant systems that may affect production are lacking. The filled container buffer storage area has only a single commercial grade cooling unit. If this system were to fail

with several recently filled containers stored in this area, the airstream temperature could rise enough to affect the C5V exhaust fan capacity. There are only two C2V exhaust fans and both have to run continuously. These fans will have to be shut down periodically for maintenance, which will impact the entire facility exhaust flow. The C3V fan and filter rooms have only a single cooling unit in each room. If one of these units were to fail, elevated temperatures in the area could impact facility operation and exceed temperature limits for multiple facility SSCs.

- **Thermal analysis / high temperatures:** There is a lack of documentation to indicate a comprehensive understanding of all the thermal issues that exist in a facility, which produces molten glass, especially in the process areas. While calculations have been performed to analyze temperature conditions in some facility areas, there is no single document to provide bounding operating and temperature conditions to confirm the facility will remain within an acceptable operating range. Lack of understanding of temperature conditions will have a significant impact on the ventilation system performance and ability to maintain confinement as well as facility throughput.
- **Off-normal operations:** Several off-normal events, including maintenance configurations and accident conditions, have not been evaluated to ensure facility temperatures and confinement can be maintained within required limits during anticipated off-normal events. Periodic entries will be required into the pour caves and process cells for maintenance activities. During these entries airflow will be adjusted, which could have a significant impact on ventilation capability to maintain confinement and space temperatures.
- **Zone C5V inbleeds:** The C5V inbleeds are engineered flow paths that cascade air from zone C3 to C5. There are twenty-five inbleeds consisting of a filter, a cooling coil, and a volume damper to adjust the flow rate. As the inbleed filter load, the total C5V flow through the inbleeds decreases, which impacts the not only the C5V flow but all other flows cascading into the C5 areas. This will disrupt the overall LAW Facility ventilation flow. The proposed method is to monitor the flow through the inbleeds and make periodic adjustments to the flow rate using the manual volume damper. This is a challenge since many of these dampers are located high above the floor and will require scaffolding or ladders to adjust.
- **Sub-changes/airlocks:** Routine facility maintenance activities require maintenance personnel to access C5 contamination areas through sub-change rooms. These subchange rooms require manual operation of ventilation dampers to adjust the depression within the sub-change to match the depression in the area being accessed. This process is reversed at completion of the entry. The manual adjustment of dampers between rooms of significant differential pressure increases the potential for operator error and changes in C5V ventilation flow, which will likely challenge confinement. Additionally, since the sub-change room depression is set to match the cell area, further access to the sub-change is not allowed during the entry. This prevents entry and exit of



additional personnel and prevents the introduction of tools and equipment that may be needed to support the entry.

- **Failure to follow ventilation codes and guidelines and project design documents:** A number of deficiencies in the following ventilation codes and guidelines have been identified in the LAW Facility. DOE-STD-1066 requires pre-filters and a deluge system to limit soot reaching the HEPA filters during a fire event. These have not been included in the LAW Facility design. DOE guidelines recommend minimum duct velocities to limit the settling out of radionuclides in the duct which could result in high dose rates. In addition, the DOE guidelines recommend filters in the airstream from high contamination areas such as the pour caves and process cells, to limit the potential for dose in the duct. These recommendations were not applied to the LAW Facility.
- **C5V fan size:** The C5V exhaust fans are potentially undersized. Originally the C5V fans were specified with nearly 20% margin. Due to design changes the fan margin has been eroded. There are still other factors that could further reduce C5V fan margin. For example, infiltration through some doors and hatches was not accounted for in the design. Finishing line flows have not been completely defined. C5V flow may need to be increased to provide sufficient flow to maintain confinement across zone boundaries, such as open door and hatches. There are still a number of facility conditions that have yet to be completely evaluated that could challenge the C5V fan flow.
- **Airflow velocity through open doors:** The Basis of Design specifies a minimum flow rate of 100 fpm for a single open door into a C2/C3 area in order to confine contamination within the higher contamination area. These doors, as well as doors between C2 and C3 areas, have been evaluated and several have been identified as having less than 100 fpm flow rate through them. Doors and hatches between C3 and C5 areas have not been evaluated and it is anticipated that many of these doors have well under 100 fpm flow across them. These doors need to be evaluated and adjustments made for adequate flow to maintain confinement.
- **Complex LAW HVAC control system:** The Ventilation control systems for C1V, C2V, C3V and C5V are located within the process control system (PCJ) portion of the DCS. Thirty-two (32) additional process systems are included within the PCJ portion of the DCS, with some of the ventilation I/O points coming through other system controllers. This arrangement could challenge startup and commissioning of the ventilation system since all systems will have to be in place and online prior to ventilation startup. Additionally, changes to the ventilation control system or any of the other control systems has the potential to cause delays in startup and commissioning in order to verify changes to one system does not affect any of the other systems. The control systems should be separated to the extent possible and potential impacts/conflicts between the ventilation controllers and the other PCJ controllers should be thoroughly reviewed and understood prior to commencement of startup and commissioning.

- **Design Basis documents:** In order to safely perform facility start-up testing and system commissioning turnover activities, accurate, complete, and consistent design basis documents need to be completed and placed under configuration control. Functions and Requirements and Alarm and Interlock set-points are not fully defined. System Descriptions, Failure Modes and Effects, and the LAW Documented Safety Analysis (DSA) are not fully developed, consistent, and integrated together. Accurate piping and instrumentation diagrams (P&IDs) are essential to establish system test boundaries, controls and parameters. During this review a number of discrepancies were noted between documents. Equipment numbers do not match, airflow rates and design depression values are not consistent, notes are included in some documents and not in others, and values in calculations were not properly transcribed. The Design Basis documents are essential for training of personnel and preparation of operations, maintenance and testing procedures.
- **HVAC instrument control issues:** Individual instrument and control loop uncertainties were not properly implemented in the development of the control system design. As a result the designs will not function properly and will result in frequent interlock breaches resulting in shutdown of LAW Facility glass production. In addition, a non-standard approach has been incorporated for controlling parallel fans that has the potential to lead to instable operation of the C2V exhaust fans.

### 5.3.2 Confinement Ventilation Conclusions

The number of significant issues identified during the review suggests that the LAW Facility confinement ventilation systems are not capable of achieving required performance, and will result in a high frequency of ventilation shutdowns as currently designed. The review team anticipates that frequently placing the LAW Facility in a limited action status (e.g., idle the melter, cease waste movements) as a result of ventilation perturbations, or to support performance of operability/surveillance requirements, will significantly impact LAW production and result in a spread of contamination outside the primary confinement areas.

### 5.3.3 Confinement Ventilation Recommended Path Forward

Specific recommendations to strengthen the LAW Facility confinement ventilation system design and to mitigate the consequences of the identified system vulnerabilities are provided below:

- Implement integrated multidisciplinary design reviews to evaluate design changes required as a result of the LAW Facility D&O review.
- Identify complete set of baseline documents. Generate those that do not exist (e.g., Code of Record, Functions and Requirements, Failure Mode and Effects, etc.). Update and maintain all baseline documents, including Basis of Design, System Description, PDSA/DSA, etc.



- Perform multi-discipline Hazard Analysis and develop control strategies for mitigation of identified hazards including chemical hazards. Determine if the LAW Facility confinement ventilation system performs a safety significant or defense in depth function.
- Develop a dynamic simulation model of the LAW Facility ventilation system in order to confirm operating parameters, such as zone depressions and flow rates, can be maintained under both normal and off-normal operating conditions.
- Revisit subchange operating strategy based on dynamic simulation model results to identify where airlocks will be required to maintain confinement.
- Identify off-normal operations, including maintenance activities, such as process cell and pour cave entries, and loss of power, and perform an evaluation to determine the impact on the confinement ventilation system.
- Modify ventilation design to ensure airflow through doors and hatches between zones comply with Basis of Design requirements.
- Create and maintain an accurate thermal analysis to ensure a thorough understanding of heat loads within the facility. Update of the thermal models, including CFD analyses, as required to integrate all process related heat loads.
- Evaluate buffer storage cooling, stack sampling and monitoring, and C3 exhaust fan and filter room cooling for redundancy and reliability.
- Evaluate the advantages of a separate and independent ventilation control system both for expediting commissioning and for future modifications and upgrades that will be required as control systems become obsolete.
- Establish control loop parameters and perform instrument loop uncertainty calculations to ensure the control loops will function within the specified parameters.
- Confirm CSV stack sampling and monitoring system meets thermal requirements and has sufficient redundancy to minimize impact to production during routine maintenance and calibration.
- Expedite and complete radial HEPA filter testing and confirm the HEPA filter fits properly and the filter seal can be maintained in the filter housings currently installed in the LAW facility.

#### **5.4 ELECTRICAL DISTRIBUTION SYSTEM**

The LAW Facility obtains electrical utility power from the WTP BOF infrastructure 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 remaining LAW Facility loads obtain power from the BOF switchgear after being transformed from 13.8 kV to 480V via four facility service transformers. Two of these four service transformers are also connected to a

BOF standby diesel generator that can provide 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 systems investigated by the team were carefully selected to provide a thorough review of the backbone of the LAW Facility's electrical distribution system. The electrical distribution components feeding the following systems were selected for review:

- The electrical distribution systems feeding the Low Activity Waste Offgas Process (LOP/LVP) Exhauster fan motors.
- The electrical distribution system feeding power to both LAW melter power supplies.
- The electrical distribution system feeding power to both LAW melters.
- The electrical distribution systems feeding the C2V, C3V, and C5V confinement ventilation system (HVAC) exhaust motors.

The team reviewed these specific systems and their supporting electrical equipment starting at the system loads and backtracking to the facility service transformers. By following this outline the review included: all four facility service transformers, all four facility feeder buses, all four facility switchboards, the two melter power supplies, the melter electrode supply bus, the melter assemblies, and the facility's Important to Safety (ITS) electrical equipment.

#### 5.4.1 Electrical Distribution System Key Results/ Consequences

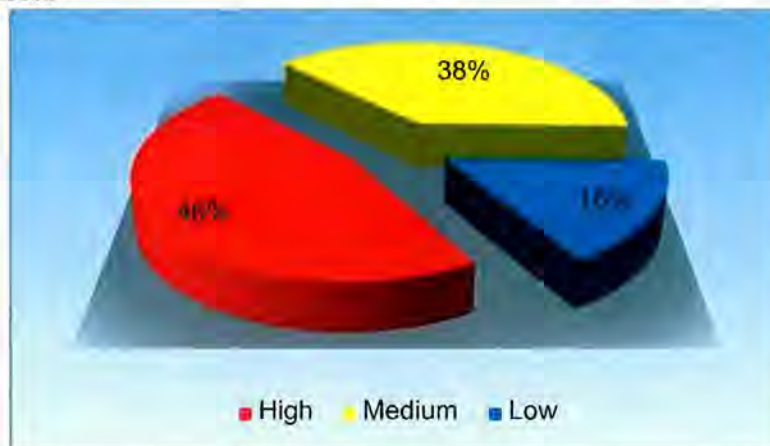


Figure 5-4. Unmitigated Vulnerabilities Identified for the Electrical Distribution System.

The review team found the electrical distribution system at the LAW Facility is capable of supplying the electrical equipment presently connected, with the exception of the facility service transformers, which are loaded at or above design capacity. Although the electrical system is generally sound, a number of significant vulnerabilities were discovered that the review team feels must be addressed prior to startup testing.

It should be noted that many of the vulnerabilities are related, and performing corrective actions on one can resolve multiple vulnerabilities. Many of the vulnerabilities identified in the review had been previously self-identified by BNI and for those issues where evidence is available that resolutions are in process, those issues are not addressed in this report.

The summarized principal evidence is as follows:

- There were a total of thirty seven (37) vulnerabilities identified in this system. Thirty one (31) of these are considered to require corrective action, including some significant reanalysis/redesign, prior to start-up testing. Figure 5-4 shows the ratio of high-, medium-, and low-impact vulnerabilities identified for the system. See Appendix B for a list of vulnerabilities and OFIs.
- The LAW electrical distribution system lacks spare capacity. Three of the four LAW 13.8 kV-480V electrical system service transformers are presently at, or above, design load capacity. The LAW Facility design is not yet complete and should additional power be required to complete the design of the facility, the existing electrical service equipment may not have the capability to support the additional loads. Additionally, it is reasonable to assume that during the 40 year operational life of the facility; additional electrical capacity will be needed for facility modifications and process/program changes.
- The LAW Facility ITS UPS units lack the battery capacity needed to support safety significant design loads, and UPS rated output for the prescribed 2-hour loss of power Design Basis Event (DBE). Additionally the climate-controlled battery rooms, in which the UPS batteries are installed, are too small to accept additional battery system expansion. An associated concern with the UPS batteries is that BNI has no plans to conduct post-installation service testing for the ITS UPS system batteries. Without testing the UPS and the Battery System's combined ability to support the connected load for the design basis run time, there is no assurance that the safety significant UPS units will be able to perform their function during a loss of power DBE.
- LAW melter power supplies cannot be isolated for maintenance activities, while still providing melter idle power. This configuration will negatively affect facility throughput and may pose challenges to maintaining worker safety during maintenance activities and present risk of melter cooling beyond the recovery threshold.
- Spare Power Supply Capacity: The melter power supplies do not have installed spare capacity to carry the production load electrical current in the event of component failure or routine maintenance.
- LAW electrical equipment located in the lidding, decontamination, and finishing line areas lack adequate design consideration for anticipated high ambient temperatures and high radiant process equipment temperatures.
- LAW melter electrode bus electrical ratings may not be adequate for the expected melter loads when operated at potentially higher than anticipated temperatures in the melter gallery. The design margin for amperage on the center electrode bus is only 6.8%; this



design margin can quickly erode if equipment or container temperatures raise the surrounding area above the 95°F ambient temperature basis temperature for the melter gallery. As a result high melter gallery temperatures may cause the area around the center melter electrode bus to exceed the 104°F electrical bus design basis temperature.

- There is not presently any backup power provided to the melter power supplies, and facility power losses of more than three (3) hours may result in significant melter damage and long term impacts to facility throughput. This vulnerability is well known to the WTP project; however, a previous decision to remove melter backup diesel generator power from the design was not well supported. It should also be noted that there does not seem to be any analysis of the safety basis assumption for cold cap burn off during a loss of melter power and if the two hour value incorporates adequate margin in to ensure a cold cap burn off with no power to the melter.
- LAW Facility switchboard feeder circuit breakers and BOF switchgear feeder breakers are equipped with low voltage release mechanisms that 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) and isolating the generator system from the utility. 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 can trip in any low voltage situation including brown outs and/or sags on the electrical grid.
- There are presently no conduit/wire-run drawings in the LAW Facility design documentation, instead the WTP project uses a proprietary program called SETROUTE to maintain configuration control of conduit and wire run information. This software is a good construction tool, 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 maintaining configuration management of the facility when performing future modifications. This vulnerability was self-identified by the WTP project years ago and has been discussed with DOE many times, however, no evidence was provided to the review team to suggest an adequate resolution has ever been reached.
- There is no formal Code of Record (COR) for the WTP project. 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 the code revision that was applicable, as often codes are referenced within documents without mention of the code's revision or issue date.

#### 5.4.2 Electrical Distribution System Conclusions

The LAW Facility electrical distribution system presently lacks the ability to support necessary maintenance activities without affecting throughput, lacks spare design capacity that may be needed for design completion and future facility modifications, lacks adequate design consideration for loss of power events, and lacks adequate design consideration for high process thermal temperatures.

#### 5.4.3 Electrical Distribution System Recommended Path Forward

To address these observations, the design baseline should be strengthened in the following manner:

- Spare capacity may be needed to complete the facility design, and support facility modifications post construction. The review team recommends DOE and the WTP project consider an electrical upgrade to the facility that would provide additional electrical capacity within the facility. DOE and the WTP project should carefully coordinate the electrical equipment upgrade with potential design basis change considerations. For example, should the C2V, C3V, and C5V confinement system fans become credited as safety significant, then the electrical upgrades would need to include installation of redundant safety-significant diesel generators. If adding safety significant generators takes place, the review team recommends changing the backup power philosophy to a “facility level” philosophy (instead of BOF philosophy), which opens the option of eliminating the low voltage release mechanisms on the switchgear and MCCs, preventing unnecessary facility level power loss in the event of sags or brownouts on the electrical grid.
- To address the ITS UPS battery sizing vulnerabilities, the review team recommends that the WTP Project perform battery run/capacity calculations for ITS UPS units to ensure batteries proposed by the UPS vendor have the capacity to meet the run time requirements of a DBE. Additionally, a battery service test must be performed on all ITS UPS batteries, prior to turn over from construction. This test method will ensure batteries were not damaged in shipping or installation and have an appropriate load profile matched to the facility ITS electrical equipment. Complete system acceptability cannot be demonstrated by a manufactures capacity test performed on UPS batteries prior to shipping.
- Install spare inverter sections in the empty (spare) melter power supply cabinets, and install a complete backup inverter to enable a short-duration inverter swap-out shutdown should one of the power supply inverters fail. Additionally, a complete spare melter power supply could be installed in the third melter bay power supply location, in a cold (non-energized) configuration that could be used as a training tool to perform dry runs on maintenance activities, and also serve as a spare parts storage location.



- Procure the SETROUTE software from BNI for use post construction. If SETROUTE is unavailable for purchase, additional conduit/wiring drawings should be produced for the facility.
- Complete a comprehensive thermal analysis of the facility to determine if process equipment thermal radiation poses a risk to degrading/damaging electrical equipment in the facility C5 areas and around the melter galleries.
- Develop and approve a Code of Record for the electrical system design. Review and modify as required, all implementing requirement documents for consistency with the COR.

## 5.5 RADIOLOGICAL CONTROL AND INDUSTRIAL SAFETY AND HYGIENE

The application of Radiological Control and Industrial Safety and Hygiene (RCISH) in the design and operability impacts was evaluated for each process system, but also from a collective significance perspective. Additional emphasis was placed on evaluating whether there were any systematic vulnerabilities that could impact the overall design and facility throughput. This subsection describes those vulnerabilities that could be systemic or of significant importance; additionally, individual Radiological Control and Industrial Safety and Hygiene vulnerabilities are identified within the appropriate system subsection.

### 5.5.1 RCISH Key Results/Consequences

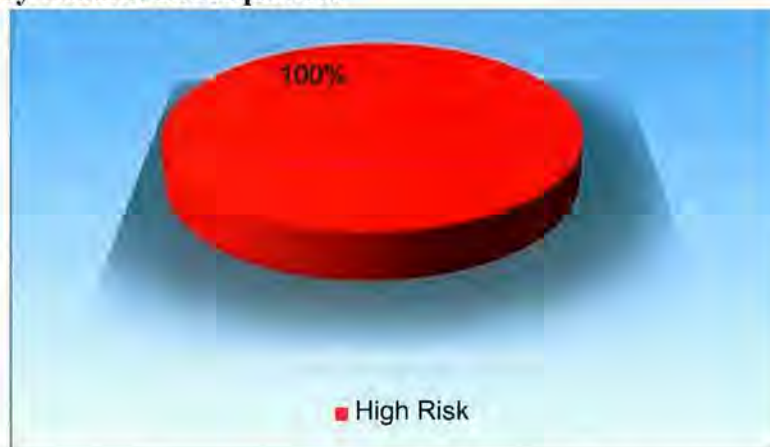


Figure 5-5. Unmitigated Vulnerabilities Identified for Radiological Control and Industrial Safety and Hygiene.

A total of eight (8) vulnerabilities were identified for the radiological control and industrial safety review area. Figure 5-5 shows that the vulnerabilities identified for the system were all considered high impact for which mitigation is recommended prior to cold commissioning and preferably prior to startup testing. See Appendix B for a list of vulnerabilities and OFIs. All

identified vulnerabilities discussed below, if left unmitigated, could impact either the design functionality or, as was more often the case, operating throughput.

#### **5.5.1.1 Radiological Control**

The review team identified specific issues with the radiological control approach all of which will require correction prior to startup testing. Listed below are summarized vulnerabilities:

- The potential for contamination to migrate to adjacent lower classification contamination zones are a key concern of the review team and the design of the low flow ventilation system further compounds this issue. This vulnerability was evident in a majority of the facility systems reviewed and includes examples such as:

- The application of a special protective coating only to the seven and one half feet height level on many of the facility walls, will impact the ability to effectively decontaminate the facility,
- Low flow ventilation increases the quantity of material that settles in the facility rather than being captured on the HEPA filters,
- Potential contamination migration as equipment or material traverse from higher to lower contamination zones, and
- The activity level of the glass suggests that the potential contamination levels will be higher than are currently being assumed in the design (anticipated alpha activity concentration for LAW incoming waste stream is >600,000 dpm/ml and beta activity concentration is >20,000,000 dpm/ml).
- Inability to meet contamination control limits for container release. The container swabbing system smears a container over a 500 cm<sup>2</sup> surface area as opposed to the 100 cm<sup>2</sup> surface area regulatory limit for release to controlled areas. Currently no technical basis exists for the release criteria to meet regulatory requirements or the smear media planned to be used for surveying. A more rigorous swabbing regime is likely to challenge the facility throughput further.
- The project is in the process of developing radiation dose rates for specific areas of the facility but there has been no targeted assessment to understand the ability to effectively perform hands-on maintenance activities for the higher risk tasks. Dose rates have recently been calculated for areas like the melter but these rates have not been applied to a conservative task analysis to understand if there are chronic exposure concerns. Similarly there is no assessment of the implications of manual bagging operations of contaminated bubblers. For areas like the process cells, which are also manually maintained, there may be a more significant dose management challenge. Additionally the effort to de-inventory and decontaminate areas (like the process cells, pour cells, buffer stores etc.) to facilitate maintenance will have an unanalyzed impact on throughput and the radiation levels may restrict some maintenance evolutions even after deinventorying.
- Issues identified in this review were similar to and consistent with those found during the HLW Design and Operability Review that concluded:
  - Administrative controls appear to be favored over engineered controls; and
  - The confinement ventilation system design philosophy drives the need for frequent radiological cleanup to maintain radiological control and confinement, in excess of that normally anticipated at analogous facilities.

### 5.5.1.2 Industrial Safety and Hygiene

For Industrial Safety, the review team also identified four vulnerabilities of high significance that will require correction prior to startup testing. Listed below are summarized vulnerabilities:

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. Examples include: –

- Thermal protection from burns due to potentially hot surfaces, motors, etc.,
  - Inadequate workspace ergonomics and engineered features to enable workers to safely and efficiently fill and empty the carbon bed media,
  - Inadequate access to maintain/operate elevated equipment e.g., ventilation dampers, cranes, etc.
- Inadequate implementation of the hazards analysis process. Examples identified include:
    - Limited or no task analysis of planned hands on maintenance tasks to assess the viability of the existing design to support safe maintenance/operation. Experience on vitrification facilities in the nuclear industry require remote maintenance there is no precedent or relevant experience for the LAW Facility approach so additional conservative analysis is warranted.
    - Lack of a defined chemical source term incoming to the LAW Facility. – Lack of identified chemical area monitoring, throughout the facility, to ensure workers are appropriately protected (greatest risk are 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. This waste is currently causing significant health concerns due to vapors at the Tank Farms and must be considered for WTP.
    - There is no evidence that worker heat stress potential has been considered in the design and there is no task analysis that considers the anticipated temperatures applied to a detailed task analysis.
  - The assessment for replacement of the melter implies Level A PPE will be required, yet Design Engineering has assumed that minimal PPE would be needed. This means that the current design may be incompatible with performance of tasks in this level of PPE.

### 5.5.2 RCISH Conclusions

Several Radiological Control vulnerabilities were identified that are applicable to more than one process system. Primarily the vulnerabilities are related to contamination control and minimizing exposure of personnel to radiation. It is anticipated that frequent decontamination, daily in some cases, will be required to minimize the continued spread of contamination,

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especially ensuring contamination does not migrate during replacement of melter consumables and the transition of personnel and material across confinement zone boundaries. The additional measures required to minimize the potential for contamination spread and to safely accomplish hands on maintenance are anticipated to have a considerable impact on the overall efficiency and throughput of the facility.

All of the IS&H vulnerabilities identified were applicable to more than one process system. The WTP 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 were appropriately considered as part of the design process. The WTP Project needs to have a defined chemical source term incoming to the LAW Facility so that exposures can be appropriately mitigated and monitored. Thermal concerns will always be a significant worker hazard and additional evaluation of the process systems is needed to ensure personnel are adequately protected.

### 5.5.3 RCISH Recommended Path Forward

Specific Radiological Control related tasks include, but are not limited to the following:

- Define and document the chemical source term coming into the LAW Facility. In addition, the Contractor should review the suite of technical documents and chemical vapor controls developed over the past decade for the Hanford Tank Farms. WTP should evaluate the potential for similar organic vapors to be present during operations and maintenance activities at the LAW Facility and the need for mitigation controls.
- Develop a formal process that requires Engineering and Safety and Health organizations to identify and mitigate safety and health/hygiene hazards as part of the design process. This recommendation has been identified as part of an issue related to leakage of ammonia within the LAW Facility offgas equipment rooms; however, at the time of this review the corrective action plan had not yet been approved.
- Revise existing exposure assessments to accurately reflect anticipated environmental conditions and evolutions, and document new exposure assessments for all the process systems. In addition, WTP should develop an administrative process that incorporates the results of qualitative exposure assessments into the Engineering Design Process.
- Perform a LAW Facility thermal analysis study to define and understand both acute (burns) and chronic (heat stress) hazards and any needed required mitigation controls. In addition, it is recommended WTP work with the Occupational Medical Provider and together evaluate industry best practices for applicability to the LAW Facility planned hands-on maintenance activities.
- Develop a LAW Facility contamination control strategy document that evaluates currently defined work processes for each system, identifies potential areas where contamination may buildup and migrate, and defines any needed additional engineering or administrative controls. In addition, the contractor should conservatively postulate

anticipated airborne levels to be encountered in the facility and controls to mitigate them, and evaluate the use of a mock up facility for work evolutions where there is significant potential for contamination and dose.

- Accelerate the identification, definition and analysis of Operation, Maintenance, and Waste Management tasks to better understand anticipated dose. In addition, the Contractor should consider the establishment of a mockup facility to minimize the exposure of workers to radiation for tasks expected to be high risk.

Develop a technical basis that documents the statistical representative sampling to be used to meet the legal release criteria, and the adequacy of the sampling media use for swabbing the container. The approach used for release of the container should be coordinated with other Hanford Contractors who will receive the containers to ensure they understand the release technique. In addition, the contractor should evaluate the potential that the container can be contaminated (from the Finishing Line) from the time when the smear samples were taken to when the sample results are received and the container is ready for export.

- Verify and validate (i.e., walk down) those systems where design is substantially complete and identify equipment that will need to be retrofitted (e.g., work platforms, safe access/egress routes, crane inspections, etc.) to ensure compliance to regulatory requirements prior to commissioning. The WTP project should develop a technical basis, and seek approval from DOE, for those activities whereby an engineered or administrative control cannot be reasonably achieved, e.g. use of ladders for routine access, waving of inspection requirements etc.

## **5.6 MELTER EQUIPMENT SUPPORT HANDLING SYSTEM**

The LAW Melter Equipment Support Handling (LSH) System provides the equipment necessary to complete maintenance tasks on the LAW melters and on other equipment located in the LAW melter gallery. The LSH System provides the mechanical handling equipment to support removal of spent consumables from the melters, packaging of spent consumables, and the installation of new consumables. The LSH System provides equipment for replacement of the off-gas spray nozzle and various thermocouples, removal of start-up heaters, and loading glass frit into the melter during melter start-up. The LSH System equipment includes the truck bay crane, the two melter gallery cranes and their associated maintenance cranes, and the equipment associated with importing, replacing, and exporting melter consumables.

### 5.6.1 LSH Key Results/Consequences

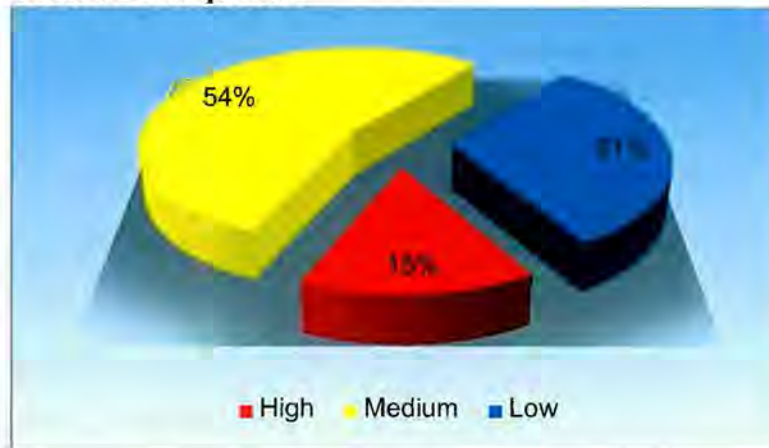


Figure 5-6. Unmitigated Vulnerabilities Identified for the Melter Support Handling System.

The LSH System design may limit the production capability of the LAW Facility for the following reasons:

- The review team identified sixty one (61) vulnerabilities for the LSH System. Forty two (42) require remediation prior to startup testing. Figure 5-6 shows the ratio of high-, medium-, and low-impact vulnerabilities identified for the LSH System. See Appendix B for a list of vulnerabilities and OFIs.
- The ability of the LSH system to provide the support necessary to assure sustained operation of the LAW Facility such that immobilized low activity waste (ILAW) throughput requirements can be met has not been demonstrated. Some examples include:
  - The current equipment availability assessment results and OR models on melter consumable replacement are not supportable based upon WTP assumed melter cooldown and heat-up rates.
  - Reduced efficiency of manual operations due to limited manned entry times when accounting for elevated workspace temperature and increased levels of PPE required due to chemical exposure and contamination considerations.
  - Off-normal and accident recovery scenarios have not been evaluated, nor have mitigation strategies been developed.
- The suitability of designed and delivered equipment for contact maintenance of the melter has not been demonstrated. For example, the spray nozzle changeout box must be redesigned as it does not provide adequate confinement or protection to the worker from thermal and chemical hazards.
- Integrated and interdisciplinary design reviews that incorporate operations, industrial safety, industrial hygiene considerations, and system interfaces have not been documented.



- Configuration management of design documentation was demonstrated to be insufficient, multiple obsolete, cancelled, and superseded documents were provided to the review teams.
- Equipment refurbishment prior to commissioning will be required due to equipment obsolescence and limited preventive maintenance.
- Critical spares have not been defined or provided as required for commissioning and initial operations.

### 5.6.2 LSH Conclusions

The current LSH System design restricts operational flexibility and maintainability to the extent that ILAW glass production operations cannot be sustained and throughput requirements will not be achieved without resolution of identified vulnerabilities.

### 5.6.3 LSH Recommended Path Forward

Specific recommendations to mitigate LSH System vulnerabilities include the following:

- Provide a comprehensive system description such that all project disciplines are uniform in their understanding of the requirements, functions, design, and operational intent.
- Develop detailed work plans for key plant evolutions and identify all critical functions, laydown space requirements, workspace environment hazards, logistics, efficiencies, and other areas.
- Model operations and maintenance activities using detailed work plans that account for manned entry limitations, required PPE, and melter operating constraints to validate design functionality, space availability, accessibility, and throughput.
- Develop an OR model with the goals to:
  - Determine the true availability for key plant equipment and the overall performance capability of the facility independent of any contractually required performance figures.
  - Identify and prioritize potential issues impacting the performance of key equipment and processes. Develop mitigation strategies for each major issue.
  - Inform the design regarding potential bottlenecks, critical spares, and margin on required response and unit operation times.
- Evaluate anticipated off-normal events, and develop corresponding mitigation strategies.

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- Develop a plan for implementing full-scale simulation/mockup/demonstration capability of critical plant components and activities accounting for physical and system interface constraints to ensure design functionality and operability.

## 5.7 CONTAINER POUR HANDLING SYSTEM

The LAW Container Pour Handling (LPH) System supports the vitrification process by accepting empty containers from the LAW Container Receipt Handling (LRH) System, moving empty/filled containers into and out of the pour caves, placing containers under the melter pour spouts to be filled with glass, and allowing for preliminary container cooling prior to transporting filled containers to the LAW Container Finish Handling (LFH) System.

### 5.7.1 LPH Key Results/Consequences

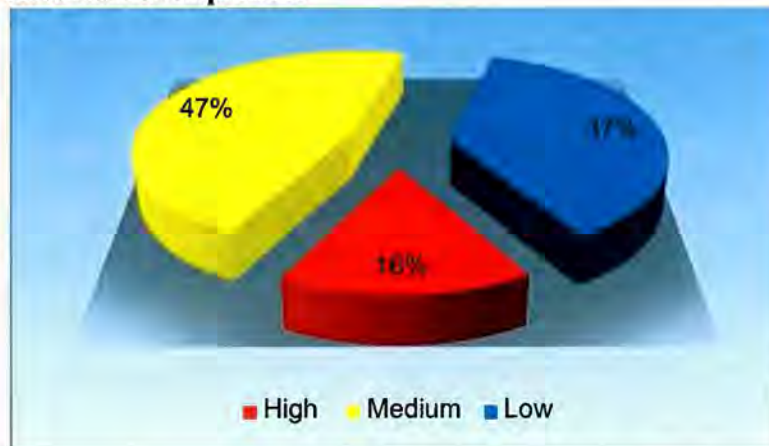


Figure 5-7. Unmitigated Vulnerabilities Identified for the LAW Container Pour Handling System.

The current LPH system design may limit the overall production capability of the LAW Facility based on the following evidence:

- The review team identified 88 vulnerabilities, 55 of which require remediation prior to initiating production operations and preferably before startup testing. Fourteen of the fifty-five vulnerabilities require some level of significant redesign. See Appendix B for a list of vulnerabilities and OFIs. Figure 5-7 shows the ratio of high-, medium-, and low-impact vulnerabilities identified for the LPH System.
- Vulnerabilities attributed to thermal issues include:
  - Lack of adequate and complete thermal analyses within the LPH System, including all buffer storage areas.
  - Use of non-prototypic results from Duratek container glass fill trials as a basis for cooling times and container flange strength values to support safe lifting temperatures.
  - The Lower Container Overpacks do not provide adequate thermal shielding for the LPH turntables and associated equipment
  - Hot containers are routinely positioned near uninsulated concrete walls of the LPH Transfer Corridor.
- Vulnerabilities attributed to container filling operations and overfilling scenarios include:
  - Overfilling a container will impact the overall facility throughput, require immediate maintenance actions, and require a large contamination cleanup effort, resulting in unplanned delays and costs.
  - Failure to detect glass build-up in a melter pour spout bellows can lead to blockage of the bellows and render the pour spout inoperable.
- Vulnerabilities attributed to handling of abnormal product containers include:
  - A workable Container Recovery Lifting Frame has not been designed and will not be procured until it is needed.
  - Moving a non-conforming container from the pour cave to the finishing line will be a lengthy and complex operation as currently designed as no engineered method has been developed.
  - Incomplete Factory Acceptance Testing of pour cave hoists, particularly relating to recovery following hoist failure.
  - There is currently no equipment designed to remove a container from the turntable in the pour cave if the flange is distorted, a buildup of glass interferes with the engagement of the grapple, or if a glass overflow occurs and locks the container or lower overpack to the turntable.

- Vulnerabilities attributed to contamination control issues include:
  - Non-finished surfaces of the LPH Transfer Corridor walls will trap contamination migrating from pour caves.
  - Use of Bogie Recovery Systems will transfer contamination into the Bogie Maintenance Area.

### 5.7.2 LPH Conclusions

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 reanalysis will be needed to define where additional cooling and controls are necessary. If left unchanged, it is anticipated that frequent system intervention and interruption to melter feed operations will be required to achieve a limited level of system operability, thereby leading to significant LAW Facility throughput impacts.

### 5.7.3 LPH Recommended Path Forward

The following recommendations are examples of specific OFIs relative to the vulnerabilities found during the LPH System review. Specific recommendations to mitigate vulnerabilities attributed to thermal issues include:

- Perform a CFD analysis of the Container Transfer Corridor and all four pour caves, at full LAW facility throughput and upset conditions, to assess HVAC system interaction with container operations. Install additional cooling in the LAW Facility and modify the HVAC C5V system as required to preclude excessive temperatures based on the CFD analysis. Convert all the process “delay time” requirements in the container handling HVAC CFD scenarios to actual container temperatures requirements to ensure operations understand all system and equipment thermal limitations. The OR model can then assess any impacts on throughput based on CFD generated data.
- Increase cooling to the filled container flange area to reduce the time it takes for the container flange to cool and regain its structural strength. Install an instrument to measure the temperature of the filled container 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 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). Alternatively, the design basis for the container hold position 15 can be evaluated to mitigate the hold requirements through other control means and completely eliminate the need for the hold position.

- Specific recommendations to mitigate vulnerabilities attributed to container filling operations and overfilling scenarios include:
  - Install an overflow spout to direct the molten glass to a safe accumulation area. A system similar to the WTP HLW melter installation could be used.
  - Install a camera in the Pour Caves 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 internals.
- Specific recommendations to mitigate vulnerabilities attributed to the handling of abnormal product containers include:
  - Identify an alternate storage location for the Container Recovery Lifting Frame that will allow the current conceptual design to be utilized, or redesign the lifting frame so it can be transferred through the Buffer Store Maintenance Facility door.
  - Design a new way to move abnormal containers/overpacks, using a lightweight, high strength, and remotely operated lifting frame to/from the Pour Cave Turntable.
- Specific recommendations to mitigate vulnerabilities attributed to contamination control issues include:
  - Evaluate the need for applying decontamination-resistant coating to the unfinished upper surfaces of the Container Transfer Corridor since the natural convection plume will carry contamination out of the pour caves into the corridor.
  - Develop disposable sleeves and/or maintenance procedures to remove the contamination from the bogie recovery wire ropes before it is dispersed inside the components of the Bogie Recovery Systems located in the Bogie Maintenance Area.

## 5.8 MELTER HANDLING SYSTEM

The dedicated LAW melter handling system (LMH) provides the mechanical handling equipment associated with the import of new Locally Shielded Melters (LSMs) and the export of failed or spent LSMs from the LAW Facility. Key components of the LMH System include the LSM rails and associated winch and pulley block arrangement.



### 5.8.1 LMH Key Results/Consequences

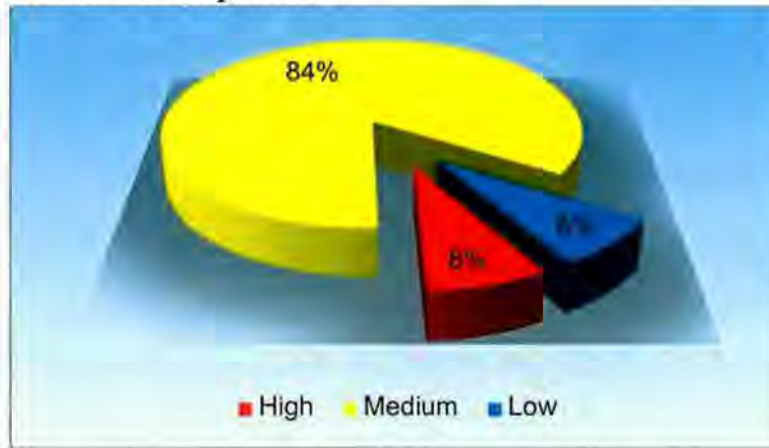


Figure 5-8. Unmitigated Vulnerabilities Identified for the LAW Melter Handling System.

Prolonged LAW Facility outages with attendant impacts to LAW production are anticipated in order to recover from existing shortcomings in LMH System design based on the following:

- The review team identified thirteen (13) vulnerabilities for the LMH System, twelve (12) of which require remediation prior to initiating production operations and preferably before startup testing. Figure 5-8 shows the percentages of high-, medium- and low-impact vulnerabilities identified for the LMH System. See Appendix B for a list of vulnerabilities and OFIs.
- The decision to not develop the capability to replace melter at this stage of the project presents a significant risk to sustainable facility operations.
  - Current melter fabrication and assembly is taking significantly longer than anticipated under less restrictive conditions than will be in place at the time of replacement.
  - It is not clear whether the melter will be assembled local to LAW in which case the assembly building and transportation system must be developed or if assembled remotely the additional complexity of the melter transporter must be considered.
  - Specialist expertise available for melter assembly is limited and subject to attrition. –  
 Draining of melter coolant has not been considered and liquid is incompatible with the Land Disposal regulations.
  - Melter decontamination capabilities have not been adequately considered or addressed.
  - Failure to demonstrate the melter replacement process prior to active operations represents a serious risk in an active and hazardous environment.

### 5.8.2 LMH Conclusions

The failure to plan and design early for replacement of a melter presents a significant risk to continued sustainable operation of the LAW Facility. Undertaking the design and changeout in an active facility without demonstrating key features prior to active operations is likely to reveal significant problems and omissions and take a significant period to effect a change, with attendant losses to production.

Other concerns arise from melter decontamination activities from the perspectives of where it will be done, what medium will be used, etc. In addition there are system gaps in delineating responsibilities for all aspects of spent melter removal and impact on operability of the other melter.

### 5.8.3 LMH Recommended Path Forward

Specific recommendations to mitigate LMH System vulnerabilities include the following:

- Redesign necessary equipment and systems to support operation of a third melter.
- Consider adding an installed spare melter into the third melter position and keep it isolated from the LAW Facility until it is needed to replace a spent or failed melter. Possibly, the pre-staged melter could be operable and brought online relatively quickly, so that throughput could be maintained during the outage necessary to remove the spent or failed melter and build/install the next spare.
- Determine a schedule of need, a location for melter assembly, parts availability, and a method of transport for replacement melters.

## 5.9 CONTAINER FINISHING HANDLING SYSTEM

The LAW LFH System receives filled containers from the LAW LPH System, provides glass sampling functionality, measures container fill level, inert fill addition, installs lid, decontaminates, swabs, and monitors contamination/radiation dose prior to transporting containers to the LAW Container Export Handling (LEH) System.

### 5.9.1 LFH Key Results/Consequences

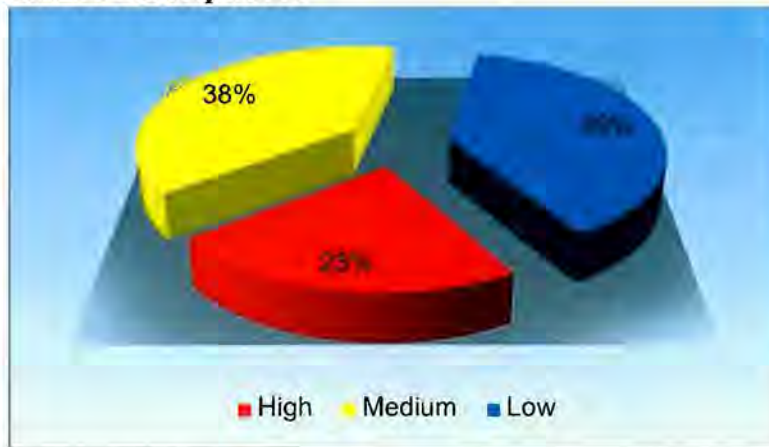


Figure 5-9. Unmitigated Vulnerabilities Identified for the LAW Container Finishing Handling System.

The LFH System cannot meet throughput requirements, unless significant changes are made. Decontamination issues, thermal issues, contamination control and product container handling issues, if unmitigated, will render this system unable to support throughput requirements for the following reasons:

- The review team identified seventy (70) vulnerabilities, forty three (43) of which require remediation before CD-4 and preferably before startup testing. Sixteen of the forty-three vulnerabilities are high impact and require some level of significant redesign. Figure 5-9 shows the percentages of high-, medium-, and low-significance vulnerabilities identified for the LFH System. See Appendix B for a list of vulnerabilities and OFIs.
- Vulnerabilities attributed to CO<sub>2</sub> decontamination ineffectiveness include:
  - Container decontamination may be ineffective based on a low Technology Readiness Assessment Level assignment by DOE, and the integrated system has not been tested and operation may not adequately contain contamination spread.
- Vulnerabilities attributed to thermal issues include:
  - Flexible electrical conduits routed to junction boxes near the LFH lidding area are not correctly specified for the environmental temperature conditions.
  - Inconsistent temperature bases used for LFH equipment air tubing and sampling/inert fill equipment data sheets.
- Vulnerabilities attributed to contamination control issues include:
  - Configuration of the recessed rails in the LFH Finishing Lines will promote the accumulation of contamination.



- Maintenance on Bogies in Swabbing and Export Rooms may be problematic due to contamination potentially pulled from Container Lidding Areas.
- Compressed air required to cool the LFH swabbing robot arm instrumentation may spread contamination on the container surface instead of cooling instruments.
- Vulnerabilities attributed to product container handling issues include:
  - Glass shard sampling is not capable of sampling under-filled containers, and these non-conforming containers are likely to require sampling more frequently.
  - The lid holder magazine decontamination and refilling process still has not been exactly determined or designed.
  - The lid recovery tool has not been proven for all anticipated failure modes. – The LFH swabbing robot is programmed to swab the curved bottom, vertical sides, and tops of the product containers only, not when the container must be exported with the lower container overpack attached to it.
  - Daily crane and hoist inspections required by the Vendor with a “SHALL” in the maintenance manual will mean daily personnel entries into a C5 area.
  - Incorrect type of isolation valve is specified and installed in the inert fill day tank. The day tank upper isolation valve is a butterfly valve. If the inert material is flowing through the rotary feeder and moving past the isolation valve the valve may 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, preventing closure of the isolation butterfly valve as operating instructions indicate.

### 5.9.2 LFH Conclusions

The lack of proven effectiveness of the LFH product container decontamination process poses a significant risk to facility throughput. Surface contamination is expected on the containers and a proven decontamination method is vital to meeting mission goals. Without additional testing and validation of the current system and other mitigating actions, the review team anticipates the LAW Facility will undergo frequent production interruptions and may never achieve the required performance objectives.

### 5.9.3 LFH Recommended Path Forward

The following recommendations are examples of specific OFIs relative to the vulnerabilities found during the LFH review. Specific recommendations to mitigate vulnerabilities attributed to CO<sub>2</sub> decontamination ineffectiveness include:

- Provide fully integrated demonstration tests to prove the capability of the CO<sub>2</sub> container decontamination system to decontaminate containers, grapples, and turntables while



completely capturing the mobilized contamination. Develop a method to decontaminate and export a non-conforming ILAW container.

- Specific recommendations to mitigate vulnerabilities attributed to thermal issues include: – Reassess the environmental temperature (including container proximity to equipment) of the finishing line. Design and provide required insulation or high temperature specific electrical conduits for all junction boxes in the finishing line.
  - Perform CFD thermal analysis to establish valid container cooling temperature profiles through the finishing line and evaluate against the LFH equipment thermal limits.
- Specific recommendations to mitigate vulnerabilities attributed to contamination control issues include:
  - Develop procedures for frequent periodic decontamination work activities to prevent contamination buildup along the bogie tracks and rooms.
  - Analyze air velocity at the surface of the container created by the swabbing robot arm to ensure surface contamination is not disturbed. If required, modify the cooling system to keep temperature sensitive proximity sensors below critical temperatures and eliminate surface contamination spread.
  - Replace the inert fill day tank upper butterfly valve 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.
- Specific recommendations to mitigate vulnerabilities attributed to product container handling issues include:
  - Redesign the glass shard pickup assembly to meet the glass sample requirement regardless of the glass height in the product container.
  - 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.
- Provide an effective method to safely decontaminate the LFH lid holders. Install a fixed lid magazine stand, along with a jib crane dedicated for lid handling to safely refill the lid holder. Purchase two spare lid holders (one for each lidding line) to minimize downtime associated with lid holder decontamination/refilling.
- Provide a proof of principle test to validate the current lid recovery tool design can remove a “mis-installed”/canted lid.
- Create and test swabbing programs for the lower container over packs prior to commissioning activities.

- Apply for relief from crane and hoist ASME Code, OSHA 1910.178, and Vendor Manual requirements in DOE/RL-92-36 and then tailor the crane and hoist “SHALL” requirements in the SRD.

## 5.10 RADIOACTIVE SOLID WASTE HANDLING SYSTEM

The purpose of the Radioactive Solid Waste Handling (RWH) System is to provide the mechanical handling equipment necessary to facilitate handling and packaging of secondary radioactive solid waste (RSW). Examples of RSW include failed equipment, consumable items, and maintenance wastes.

### 5.10.1 RWH Key Results/Consequences

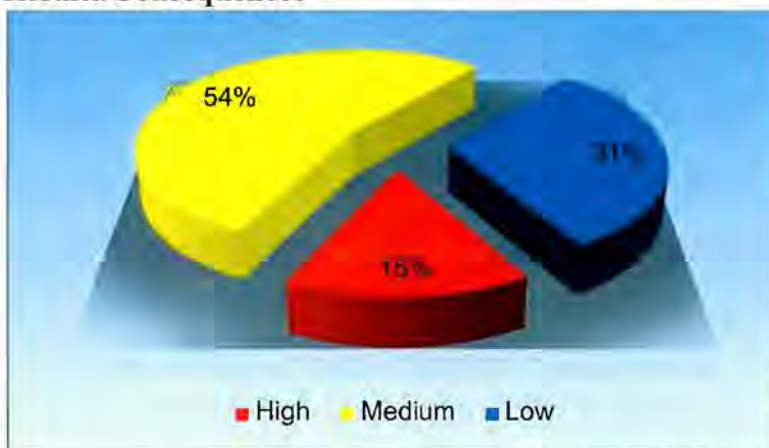


Figure 5-10. Unmitigated Vulnerabilities Identified for the LAW Radioactive Solid Waste Handling System.

The functionality of the RWH system is not adequate to fully support life-cycle operations. Specifically, the RWH System may prevent the LAW Facility from achieving throughput requirements for the following reasons:

- The review team identified thirteen (13) vulnerabilities for the RWH System, nine (9) of which require resolution before startup testing. No high risk vulnerabilities were identified. Figure 5-10 shows the ratio of unmitigated medium- and low-impact vulnerabilities identified for the RWH System. See Appendix B for a list of vulnerabilities and OFIs.
- Design for secondary solid waste management (e.g., decontamination, size reduction, packaging, export and staging) is incomplete and not inclusive of all RSW that will be generated in the LAW Facility (e.g., failed equipment too large to package in a 55-gallon drum, B-25 box or S-0480-1376 box). An inadequate waste management capability will result in a backlog of RSW. This backlog will grow until the RWH System cannot accommodate additional waste generation (i.e., the RWH System reaches a state of gridlock). Resolution of RWH System gridlock situations likely will require frequent

and prolonged interruption to LAW production operations. Some of the identified waste management issues that will contribute to RWH System gridlock include the following: –

The RWH System design includes two cranes that do not adequately support lifting and handling the various waste containers and their movement through the facility;

- HEPA filters may develop too high of a radioactive loading before differential pressure 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 dust loading alone is and not an effective indicator and no monitoring facility is available on the housings to identify radioactive build up.
- 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 RWH System have been defined nor is currently under development.
- Adequate funding and resources do not appear to have been allocated to address equipment preservation and degradation. Equipment is experiencing degradation such as corrosion and false brinelling.
- Key LAW documents contradict each other regarding RWH System scope. Examples of the contradictions are listed below:
  - The LAW Facility Description and RWH System Description are inconsistent regarding the discussion of “bagging, packaging, decontamination, swabbing, etc.” The current contract requires WTP only to package the waste for transportation and not for ultimate disposal. This means that the waste will require unpacking, inspection and repackaging by the Tank Operating Contractor for disposal. This is neither efficient or ALARA compliant.
  - The RWH System Description specifies that crane decontamination can be accomplished with CO<sub>2</sub>, pressurized warm water, steam, etc. However, no such capability exists within RWH and the SME states that no decontamination beyond wet wipes will be done.

### 5.10.2 RWH Conclusions

The RWH System design has not adequately demonstrated the ability to handle projected waste volumes in high maintenance years and does not address export of all secondary waste forms. The RWH System has inadequate functionality for handling, packaging, and exporting the secondary wastes designated to be exported through this system. The lack of adequate system functionality may quickly result in a backlog of secondary RSW. This backlog may grow until the RWH System cannot accommodate additional waste generation (i.e., the RWH System reaches a state of gridlock). Resolution of RWH System gridlock situations may require



frequent and prolonged halts to the LAW Facility production operations to clear out stored waste material.

### 5.10.3 RWH Recommended Path Forward

Specific recommendations to mitigate RWH System vulnerabilities include:

- Perform a conservative and comprehensive assessment of all secondary radiological and hazardous waste volumes and types, and benchmark against other similar facilities, and produce a conservative secondary waste baseline document.
- Develop a waste disposition plan that identifies the export and disposition paths for all secondary wastes, including the levels of decontamination required to meet anticipated disposal requirements, needed size reduction, and appropriate transportation packaging.
- Provide disposition paths for all equipment that is reasonably expected to fail during the operational life of the facility, and document the paths in a comprehensive waste management plan.
- Define the requirements and compliance approach for meeting the transportation and disposal requirements in the plan.
- Develop long term plans that address replacement and/or refurbishment of obsolete or degraded equipment.
- Produce a system capability report, including an OR model, that can be used to describe the design and confirm that all secondary waste peak volumes and waste forms can be exported from the facility with no negative impact to ILAW glass production. Account for the availability of interfacing systems and organizations, and provide a nominal and bounding result based on realistic, documented, and supported inputs.
- Develop a methodology to export spent consumables that supports the requirement to transition the consumable between a vertical and horizontal position which appears to be required to effect export of large items.
- Define, design, and provide lifting and handling equipment for each identified waste package.
- Consider packaging all or some of the secondary waste generated at the LAW Facility for disposal rather than transportation. This will reduce cost and demonstrates an ALARA approach.

## 5.11 CONCENTRATE RECEIPT (LCP) AND MELTER FEED PREPARATION (LFP) SYSTEMS

The overall function of the combined LAW concentrate receipt (LCP) and melter feed preparation (LFP) systems is to receive, prepare and deliver LAW feed to the melters. The specific key functions assigned to the LCP system include:



- Receive LAW concentrate from Pretreatment Facility.
- Store, mix and sample LAW concentrate (sample hold point to determine glass former requirements).
- Transfer LAW concentrate forward to LFP system or back to pretreatment via the radioactive liquid waste disposal (RLD) system.
- Provide flush capability for vessels, piping and in-line components to prevent plugging and provide decontamination.

The specific key functions assigned to the LFP system include:

- Receive LAW concentrate from LCP.
- Receive glass formers and mix to meet product compliance requirements.
- Sample melter feed to verify correct glass former mixture (not a hold point).
- Transfer feed to melters.
- Provide flushing capability to prevent plugging and provide decontamination capability.

There are two independent and duplicate arrays of LCP and LFP components for each melter. There is capability provided to transfer process fluids between various vessels which provides for process flexibility. Although the LCP and LFP systems are technically separate, they are considered together for purposes of this review due to their high degree of interdependence.

#### 5.11.1 LCP/LFP Key Results/Consequences

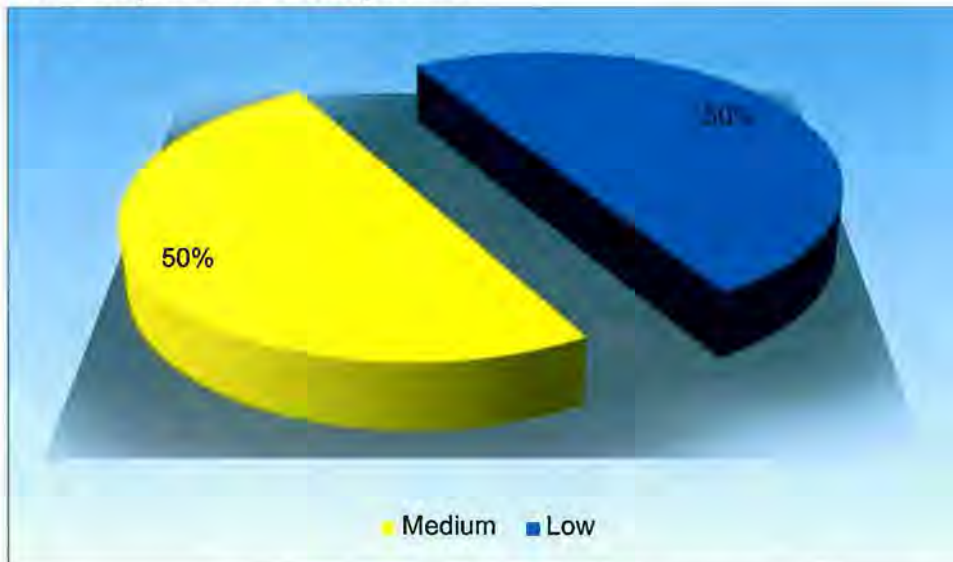


Figure 5-11. Unmitigated Vulnerabilities Identified for the LAW Concentrate Receipt and Melter Feed Preparation Systems.

Some vulnerabilities were identified that may lead to periodic operational interruptions or long term equipment functionality concerns. The summarized principal results are as follows:

- There were sixteen (16) vulnerabilities identified in this system with (8) requiring remediation prior to start-up testing. No major design changes were identified and most if not all of the identified vulnerabilities have uncomplicated mitigation actions available. Figure 5-11 shows the ratio of unmitigated medium- and low-impact vulnerabilities identified for the LCP/LFP System. See Attachment B for a list of vulnerabilities and OFIs.
- It is uncertain that LCP/LFP vessel design can reliably achieve structural integrity requirements over a 40-year design life because:
  - The 40 year design life of the LFP Vessels is in question due to the lack of credible data specific to LFP process conditions to accurately predict the erosion wear for the stainless-steel material used.

- The design basis temperature of 150°F for Condensate Receipt Vessel (CRV), Melter Feed Preparation Vessel (MFPV), and Melter Feed Vessel (MFV) vessels may not be adequately conservative under off-normal conditions (e.g., extended melter idle periods).
- The ability of the LAW LFP Feed Preparation and Feed Vessels to structurally support the external cooling panel sections has not been demonstrated.
- The cooling jackets for MFPV and MFV tanks do not currently include pressure relief.
- The effectiveness of design features to reliably ensure adequate equipment performance and process control under normal and abnormal operating conditions is questionable because:
  - Fixed speed agitators may not provide adequate flexibility to address variations in process conditions or recover after prolonged down time. – The operating envelope has not been defined to ensure the requirement for mixing homogeneity can be met during normal plant operations
  - The current approach to Air Displacement Slurry (ADS) pump monitoring/trending may not be adequately indicative of performance.
  - A comprehensive equipment condition monitoring strategy/system is not evident in the documents provided/reviewed.
  - There is a lack of process control information available to prevent the potential for Glass Former Reagent (GFR) component omission to cause premature melter failure under worst case conditions.
  - The basis/definition of acceptable gear oil leakage rates and process impacts is not evident.
  - The ability to automate using existing design features appears to be underutilized. – The LCP/LFP bulge drain systems do not appear to have adequate drain capacity when spray rings are turned on.
- Contact maintenance approaches for complex/high risk activities have not been developed to the extent necessary to confirm that maintenance can be performed in an efficient manner consistent with the OR model assumptions and that unacceptable production impacts will not result because:
  - The requirement to de-inventory and flush vessels and pipework prior to entry has not been evaluated or included in availability assumptions.

- A comprehensive equipment condition monitoring strategy/system is not evident so that process cell entries can be minimized.
- The ability to install/replace pumps/agitators and other internal components that require alignment with the vessel base (such as bubbler tubes and thermowells) has not been adequately demonstrated.

Adequate mock-up/testing facilities are not available or planned to support high risk contact maintenance activities (such as pump/agitator replacement) and testing/run-in of mechanical equipment so that personnel exposure to in-cell hazards can be minimized.

### 5.11.2 LCP/LFP Conclusions

The combined LCP/LFP Systems are considered to be capable of meeting their intended functions with some limitations:

- Weaknesses associated with undemonstrated equipment availability,
- Restricted process cell access to perform contact maintenance (due to thermal, chemical and radiological conditions), and
- Incomplete use of automation or equipment condition/performance monitoring features that could reduce the potential for process upsets or cell entries to determine/confirm performance.

There were no singular vulnerabilities identified that appear to result in a high impact to facility functionality, but the WTP project should consider the cumulative impacts of the identified vulnerabilities in determining any improvement/risk reduction plan for the system. In the judgment of the review team, most if not all of the identified vulnerabilities have uncomplicated mitigation actions available.

### 5.11.3 LCP/LFP Recommended Path Forward

The identified vulnerabilities and associated forecasted impacts are likely to be realized until mitigation actions have been completed and system functionality independently confirmed. Some specific recommended mitigation options include, but are not limited to, the following:

- For vulnerabilities associated with LCP/LFP vessel design reliably achieving structural integrity requirements over a 40-year design life:
  - Conduct additional CFD analysis with appurtenances modeled per vessel in the actual configurations 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 warranted, 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.

Re-evaluate design basis temperature limits for vessels to increase operating margin and operational flexibility. Vessels appear 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.
- Confirm unverified assumptions in structural analysis for installation of external cooling panel sections for LFP feed preparation and melter feed vessels.
  - Update analysis and verify adequacy of vessel design.
- 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 as LFP cooling jackets.
- For vulnerabilities regarding the effectiveness of design features to reliably ensure adequate equipment performance and process control under normal and abnormal operating conditions:
  - Define the operating envelope for mixing and how much deviation can be allowed. – Consider alternative level detection in vessels that are relied upon to meet mixing

- requirements 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 and to provide additional performance monitoring capability.
- 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, as a single point is not considered an adequate indicator of acceptable performance, e.g. the apex of the pump discharge pressure. – Develop a formal comprehensive strategy for equipment performance monitoring. Optimize the use of available instrumentation etc., and consider using reliability centered maintenance techniques to maximize equipment availability and minimize intrusive or breakdown maintenance requirements.

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 mis-batch 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).
- Perform calculations to quantify acceptable limits for gearbox oil 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-foot level.
- Consider fully automating transfer and flush sequences.
- Incorporate remote monitoring/power option for auto-lubrication system.
- 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 that 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.
- For vulnerabilities associated with contact maintenance approaches:
  - Further develop and implement the out-cell ability to diagnose equipment performance trends using multiple, diverse parameters to reduce the need to enter the process cells and avoid the attendant personnel hazards and facility throughput impacts. Examples may include:
    - Providing equipment performance trending/monitoring parameters that are inherent in current design for display to operators.
    - Providing ASD on agitators will provide additional condition/performance monitoring flexibility and capability.
  - 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 pump/agitator flanges with the stabilizer guide.
  - Conduct a formal and systematic analysis of maintenance infrastructure needs.
 

Identify and prepare an existing Hanford Area facility for use as a WTP mockup/testing facility (e.g., 2101M, MASF at FFTF, etc.) or; design and build (e.g., prefab building) a testing/mockup facility at WTP.
  - Consider working with the tank farm contractor to establish a shared/consolidated mock-up facility.

## 5.12 CONTAINER EXPORT HANDLING SYSTEM

The LAW Container Export Handling (LEH) System provides mechanical handling equipment to remove filled and lidded LAW product containers from the finishing line and place the container on Tank-Farm Contractor-supplied transport vehicles.

### 5.12.1 LEH Key Results/Consequences

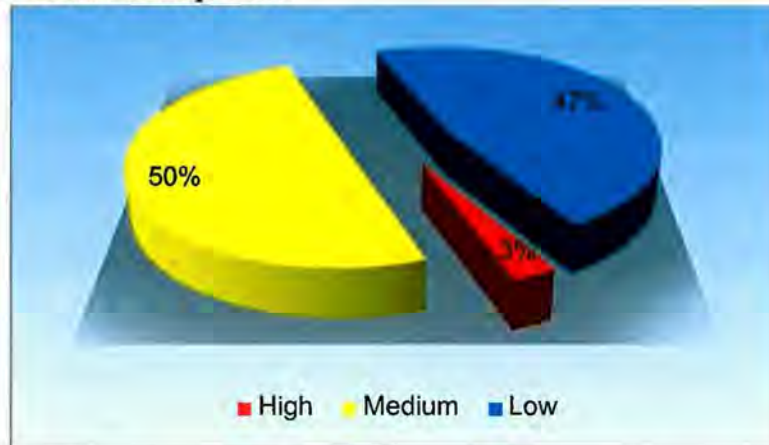


Figure 5-12. Unmitigated Vulnerabilities Identified for the LAW Container Export Handling System.

The current 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 product container handling and contamination control issues.

The summarized principal results are as follows:

- The review team identified 36 vulnerabilities, 19 of which require remediation before initiating production operations and preferably before startup testing. One of the vulnerabilities will likely require significant redesign. Figure 5-12 shows the percentages of high-, medium-, and low-significance vulnerabilities identified for the LEH System.  
See Appendix B for a list of vulnerabilities and OFIs.
- Vulnerabilities attributed to thermal issues include:
  - Filled ILAW Container export temperature may affect container loading, transportation, and/or Tank Farm Contractor (TOC)/Integrated Disposal Facility (IDF) operations.



- Vulnerabilities attributed to product container handling issues include:
  - The structural analysis of the export bay embeds and wall design is inconsistent with LEH jib crane reaction forces.
  - LEH Export Bay Crane maintenance activities may be impacted by de-rating the maintenance jib cranes caused by limited load bearing capability of the embeds. –  
 The reach of the jib cranes is limited and a large portion of the Export Bay Crane cannot be reached by either jib crane. In addition, the permanent maintenance platform blocks the path to lower components from the export bay to the floor below.
  - LEH Export Bay Crane capacity may not be sufficient for cases where a filled ILAW product container cannot be decontaminated to export limits and an overpack must be used.
- Vulnerabilities attributed to contamination control issues include:
  - There are no interlocks that prevent one of the two roll-up doors to the Export Truck Bay from being opened while one or both of the finishing line export hatches are open.
  - The potential for contamination migration exists when transferring ILAW product containers through the export hatches.

### 5.12.2 LEH Conclusions

The LEH System can meet throughput requirements, as long as challenges in exporting and transporting high temperature containers are met. The current site transporter system does not have an effective design to accept high temperature containers (an effective overpack or transporter design does not exist). Although this last vulnerability is not a WTP design issue, it is included in this report because it affects WTP operability and throughput.

### 5.12.3 LEH Recommended Path Forward

The following recommendations are examples of specific OFIs relative to the vulnerabilities found during the LEH System review.

Specific recommendations to mitigate vulnerabilities attributed to thermal issues include:

- Resolve temperature inconsistencies within the Interface Control Document (ICD 15), develop a viable transporter system to handle high temperature containers (including remote features within WTP), resolve temperature inconsistencies within the LPH/LFH process so containers that are exported meet the 200°F expectation for IDF receipt, and/or provide adequate buffer space at either export (WTP) or receipt (IDF) to handle 550°F containers and allow sufficient cooling time.

Specific recommendations to mitigate vulnerabilities attributed to product container handling issues include:

- Revise all issued documents to reflect the de-rated capacity of the maintenance jib cranes. Provide a full extent of condition analysis on embeds that support loads on vertical walls of the LAW Export Bay to ensure the embed design meets equipment loads.
- Investigate the feasibility of a different lifting system to replace the LEH maintenance jib cranes; this could include a 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.
- Define and design a method for exporting non-compliant containers and validate the existing 10-ton Export Bay Crane capacity is not exceeded.

Specific recommendations to mitigate vulnerabilities attributed to contamination control issues include:

- Add interlocks to the design to allow only one LFH export hatch to be open at a time, prohibit the opening of an Export Bay roll-up door when a hatch is open, and prohibit the opening of a hatch when a door is open.
- Evaluate the currently defined work processes and ensure an engineered or administratively-defined process is adequate for controlling and monitoring contamination migration when transferring the ILAW Product Container from the LFH System to the Transport Trailer.

### **5.13 CONTAINER RECEIPT HANDLING**

The LAW LRH System receives empty containers into the LAW Facility and transfers the containers to the LAW Container Pour Handling (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.

### 5.13.1 LRH Key Results/Consequences

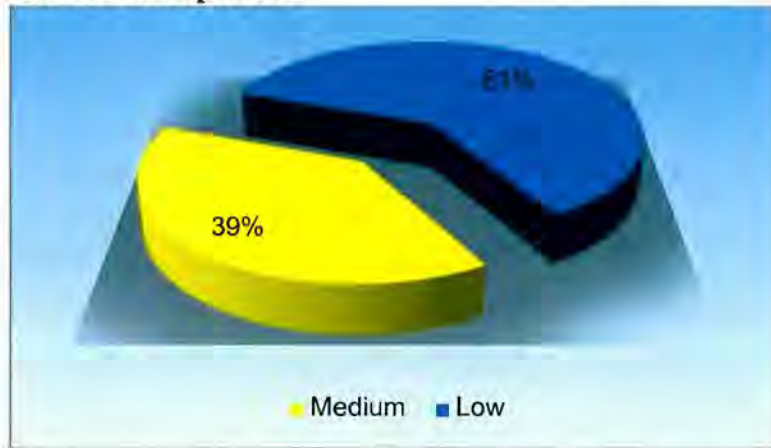


Figure 5-13. Unmitigated Vulnerabilities Identified for the LAW Container Receipt Handling System.

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

The summarized principal results are as follows:

- The review team identified 54 vulnerabilities in this system, 21 of which require remediation before initiating production operations. None of the vulnerabilities resulted in a high impact consequence. Figure 5-13 shows the percentages of medium- and low-significance vulnerabilities identified the LRH System. See Appendix B for a list of vulnerabilities and OFIs.
- Vulnerabilities attributed to empty container handling operations:
  - A delivery of empty LAW containers will block the LAW import bay loading dock until all the containers are removed from the truck. Blockage of the truck bay with a container delivery will affect competing LSH and RWH operations that share the same space (both in loading dock and overhead crane use).
  - The overhead crane in the LAW import bay does not have enough lift clearance to move a LAW container over another container on an over-the-road truck, which will reduce flexibility during the unloading process.
- Vulnerabilities attributed to container receipt inspection operations:
  - The lack of adequate interlocks in the Container Receipt Area allows for the potential of an empty container to be remotely moved while being manually inspected. –  
There is neither an inspection procedure available nor description of any toolkit that would be necessary to deal with the required detection and removal of any liquid



or solid material present inside the 7.5' tall LAW containers. Inspection of empty containers cannot be executed with the current design of the inspection platform.

- There is nothing in the current design that prevents foreign material from entering the containers once they have been unloaded on the import conveyor(s).
- Vulnerabilities attributed to calculations and component testing:
  - The conveyor roller impact loading is exceeded when the weight of the grapple is included in the allowable stress calculation.
  - The factory acceptance testing of the LRH conveyor system was incomplete transferring risk to the commissioning phase.
  - It is indeterminate if the building structural steel design meets shear/moment/deflection limits.

### 5.13.2 LRH Conclusions

The LRH System generally has the ability to import containers into the LAW Facility, but it does not currently have the specific equipment in place to perform all intended functions to meet the design intent. The system will be challenged by the inspection requirements, and in the (offnormal) 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 System LSH and space constraints within the import bay will also challenge operations.

### 5.13.3 LRH Recommended Path Forward

The following recommendations are examples of OFIs relative to the vulnerabilities found during the LRH review.

Specific recommendations to mitigate vulnerabilities attributed to empty container handling operations include:

- Perform a detailed task analysis of all operations performed in the receiving truck bay to support all LAW Facility operations. Use the task analysis to understand operating needs, inform the design regarding any additional features needed and ultimately be used to develop integrated operating procedures across the LRH, LSH, and RWH systems.
- Develop operating processes to facilitate unloading containers from the over-the-road trucks.

Specific recommendations to mitigate vulnerabilities attributed to container receipt inspection operations include:

- Add ICN monitored, hard-wired, interlocks to each of the two Container Receipt Conveyor lines that will be activated prior to manned operations at that station, and must be deactivated by the receipt inspector before the conveyor can be operated.



- Identify a viable inspection process and provide features for removal of foreign material for the incoming containers. Provide an inspection station that can meet all the inspection requirements while the containers are located on the receipt conveyors.
- Provide a cover/shield over the staging conveyor area to eliminate the chances of material falling into containers that have already been inspected.

Specific recommendations to mitigate vulnerabilities attributed to calculations and component testing include:

- Update the vendor calculation to include the weight of the grapple and the correct weight of the container as the bounding scenario for the clean container handling conveyor roller impact loading calculation. Compare the bounding scenario against the current design to assess the adequacy of the installed equipment.
- 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.
- Validate floor loads in the LAW Facility to assess if the structural steel framing is adequate.

**6.0****RECOMMENDED PATH FORWARD DECISIONS  
AND ACTIONS FOR ORP**

The design and operability review teams identified 362 system specific design vulnerabilities that could limit LAW Facility functionality and operability for which mitigation is recommended prior to initiating nuclear operations. Some of these vulnerabilities, as described below are considered essential for achieving approval for hot operations while others are essential for achieving an acceptable level of operational efficiency subsequent to start of hot operations. A larger number of actions have been identified and as potential mitigation for vulnerabilities. In many cases the potential mitigating actions can be implemented in a straight forward manner, others will typically require additional review and analysis and potentially a cost benefit analysis prior to implementation as part of any overall plan to address the vulnerabilities.

A systematic approach, in light of limited resource availability, is needed to develop and implement a plan to address the identified LAW facility vulnerabilities. Further, it is important to note that the overall impact of such a plan is limited to the LAW systems actually reviewed.

The review team recommends that the ORP consider a limited number of decisions and remedial actions are required to support the development of a systematic plan for addressing the results of this review and to provide a foundation for prioritizing and scheduling additional analysis and potential facility design changes and upgrades. These recommended ORP decisions and actions are intended to provide confidence that adequate functionality can be achieved to support safe LAW facility operations without obviating the potential for gradual improvements in facility performance post CD4.

The recommended path forward should consider:

1. The risk to the viability of the LAW facility as a result of the design process deficiencies identified in Section 4 must be systematically assessed and action taken on those areas which have the potential for significantly delaying active commissioning of the facility or present an unacceptable challenge to the overall facility throughput.
  - a. BNI must develop a plan to identify, segregate and validate those documents that will form the design basis and essential document set for operation of the LBL facility. This is essential as the existing document set and storage and retrieval mechanism are currently incapable of supporting an ORR or to provide a demonstrable design basis for operation and maintenance of the facility. This will also provide the structure to ensure that the future design activities will be implementable and demonstrably compliant with the revised WTP procedures.
  - b. DOE must provide significant, critical oversight with appropriate authority to ensure that WTP Design Authority function is effectively and objectively executing the role in the best interests of DOE, the owner.
  - c. The primary Requirements documents must be updated, with an assurance that they define the high level facility requirements consistently and accurately. This is

particularly important for the Authorization Basis documents. If the primary AB documents (Safety Basis and Permit) cannot be updated quickly then conservative assumptions must be made regarding candidate safety and permit affecting systems to allow the design to progress with minimal risk of significant rework.

- d. An extent of condition review must be undertaken by BNI to evaluate the impact of the above actions on the existing constructed and procured systems and a plan developed to bring the facility back into line with the agreed and validated requirements.
2. Multiple independent reviews have questioned the adequacy of the control system software specification, implementation and testing.
    - a. DOE should direct BNI to implement industry best practice in the development of lifecycle documentation, implementation and testing of the control system and the associated Human Machine Interfaces.
    - b. DOE should increase the level of oversight on the WTP control system software development until satisfied that adequate processes are in place to ensure compliant and effective design. DOE should include independent industry and DOE complex contractor expertise in this oversight role.
  3. The anticipated performance of WTP and the basis for the assumptions underpinning the performance has been questioned on multiple occasions.
    - a. DOE should modify/develop the operational research model to objectively assess the true potential throughput/production capacity of the facility as designed and more importantly assess the potential facility bottlenecks that have the most impact on long term production.
    - b. DOE should review the throughput of other nuclear facilities and benchmark the throughput achieved against those facilities. Any significant differences identified as a result of the benchmarking activities should be technically justified.
    - c. DOE may need to consider a reduced throughput target at the start of operations with a detailed strategy and timeline to maximize throughput during the operational phase. This will require a detailed analysis of the changes anticipated during the operational phase and a measured approach to the risk cost and lifecycle schedule impacts introduced due to the higher degree of difficulty introduced in executing change in a radioactive/hazardous environment and the overall ALARA implications of this strategy.
    - d. DOE should undertake a cost benefit analysis based on the cost to remove bottlenecks, the overall improvement to throughput and the impact of deferring the improvement until the operations phase. This should form the basis of planned improvements to the facility prior to and post CD4.

4. A number of potential worker safety issues have been identified. It is not suggested that workers will be placed in harm's way when the facility is operational, rather there is a likelihood that design changes may be identified late and cause schedule delays and/or compromises on throughput and required staffing levels to minimize the risk to workers during operation and maintenance of the facility.
  - a. DOE should direct BNI to undertake detailed ALARA analysis of selected areas and tasks to ensure that the "hands on" versus remote maintenance and operations philosophy is demonstrably supportable. This would involve developing conservative but realistic radiation dose calculations and maintenance assumptions for all areas where personnel are expected to work. Developing and documenting management strategies and time commitments for these areas e.g., de-inventory before entry, flushing requirements, remote tooling etc. Developing 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. The results of this review would inform the Mean Time to Repair (MTTR) durations expected and the potential throughput impacts. Decisions could then be made on if or how these impacts should be mitigated.
  - b. Conservative estimates should be developed by BNI for the facility of the anticipated radiological contamination levels anticipated for the various areas of the facility based on extrapolations from similar high level facilities. There appears to be a prevalent assumption within the project that the contamination levels will be at or near zero with minimal documented justification for this assumption. This assumption appears to be informing important project decisions on relaxation of basis of design assumptions without a clear documented rationale. Based on the anticipated levels the confinement ventilation requirements and operations and maintenance assumptions for the facility should be reevaluated and if necessary adjusted to be compatible with the identified risk.
  - c. Activities in the Tank Farms are significantly challenged as a result of fugitive vapor emissions and the need to protect workers from these emissions. Using the information and source term data available from the Tank Farms BNI should assess the potential impacts for the LAW facility and consider the implications for worker protection undertaking operation and maintenance tasks. This should be used to inform the design regarding the reliance on and significance of the confinement ventilation system and the anticipated PPE requirements for work required to be carried out in various facility areas.
  - d. The challenge of working in high temperature environments is well known and creates challenges to the TOC currently due to the extreme summer temperatures. Similar challenges exist at WTP due to the thermal processes, there are also concerns regarding burn hazards. BNI should 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



it is unreasonable to expect workers to safely perform operational and maintenance tasks or where maintenance tasks may be significantly restricted. This will inform the design regarding the need for additional cooling and/or the potential impact on throughput.

5. The commissioning phase of a project by its very nature is not only always on the critical path but is the point in a project when many unanticipated issues are identified and a flexible and rapid response is required to maintain schedule and cost. As such known issues should wherever possible be resolved prior to the commissioning phase.
  - a. DOE should identify all current activities and risk mitigation actions that are currently deferred to the commissioning phase and develop plans to remove these activities to the extent possible out of the commissioning phase and off the project critical path. Through a cost benefit analysis it may be prudent to allow some issues to remain, these issues should be carefully planned and integrated in the commissioning schedule, with adequate contingency for unanticipated results, in a way that minimizes the impact to the project critical path.
6. The current Computational Fluid Dynamics (CFD) Model and its use along with the applicability of physical non prototypical analysis is particularly significant as it is used to bound many assumptions regarding procurement specifications, civil design, throughput, personnel safety, structural material safety limits etc. This analysis requires further evaluation and justification.
  - a. BNI should be directed to reassess and/or expand the documented validation of the existing thermal model for WTP to ensure the modeling assumptions and analysis is representative of the anticipated operating conditions.
  - b. Based on the validated CFD analysis BNI should reassess the impact if any on the impact of elevated temperatures on Structures Systems and Components within the facility to ensure adequate performance under all anticipated normal, abnormal and accident conditions.
  - c. The container cooling rate should be evaluated by BNI using the same model for representative waste forms and any impacts to throughput should be assessed.
  - d. Where temperatures are outside the SSC specification for acceptable performance or throughput is impacted specific. Cost benefit analysis and specific action plans should be prepared to:
    - i. Improve cooling to maintain the SSC or area within acceptable temperature limits (BNI),
    - ii. Redesign SSCs to tolerate the higher temperatures (BNI),
    - iii. Accept the impact to throughput (DOE).
7. The Melter off gas processes have been driven to be overly complex which has introduced safety and reliability challenges that seem to be disproportionate to the system

hazards. Because the system is driven to meet the Best Available Control Technology as a result of the Melter being designated a thermal treatment unit, the system is unlikely to support the facility throughput demand and may actually result in a system that places the facility worker and potentially the environment at a higher level of risk than if a less complex system were used.

- a. DOE should renegotiate with the state the regulatory designation of the melter to allow a less restrictive and hazardous system to be utilized that minimizes the risk to the public the worker and the environment.
8. The Confinement Ventilation System is an atypical design for DOE facilities in that it utilizes low flow principles developed in the UK as a legacy of the initial facility contractor. As a result the design has evolved into a hybrid system with low air flow but without the low flow design features normally required to ensure a robust and functional confinement system.
    - a. An accurate simulation model must be developed by BNI for the confinement ventilation system to assess if the capacity, mode of operation and control philosophy of the facility is tenable.
    - b. In conjunction with 1c above a critical analysis of the potential for all or parts of the confinement ventilation system to be safety significant should be performed by BNI. If there is any reasonable potential that the system may perform or support a safety significant function for hazardous chemical or radiological confinement, dilution, cooling, etc., BNI should immediately be directed to treat the system as a candidate safety significant system and modify the design accordingly.
    - c. A clear and justifiable basis for ventilation confinement velocities at confinement boundaries (the dominant consideration for a low flow system) should be developed by BNI; see also 4b above. Currently there is no requirement for confinement velocities across C5 boundaries and velocities across C3 boundaries are not consistently achieved and the rationale for lower values are not effectively documented.
    - d. Any conditions where the design fails to meet the designated minimum requirements for confinement or any other function identified by the upper tier requirements documentation should be approved by DOE.
  9. The primary output of the design and operability review process was the system specific vulnerabilities and recommended opportunities for improvement generated. Any path forward must ensure all of the vulnerabilities are considered and a conscious decision be made to either resolve the issue or defer resolution. Figure 6-1 represents a summarized vulnerability and issues management process, with proposed responsibilities.

Proposed Vulnerability and Issues Management Process

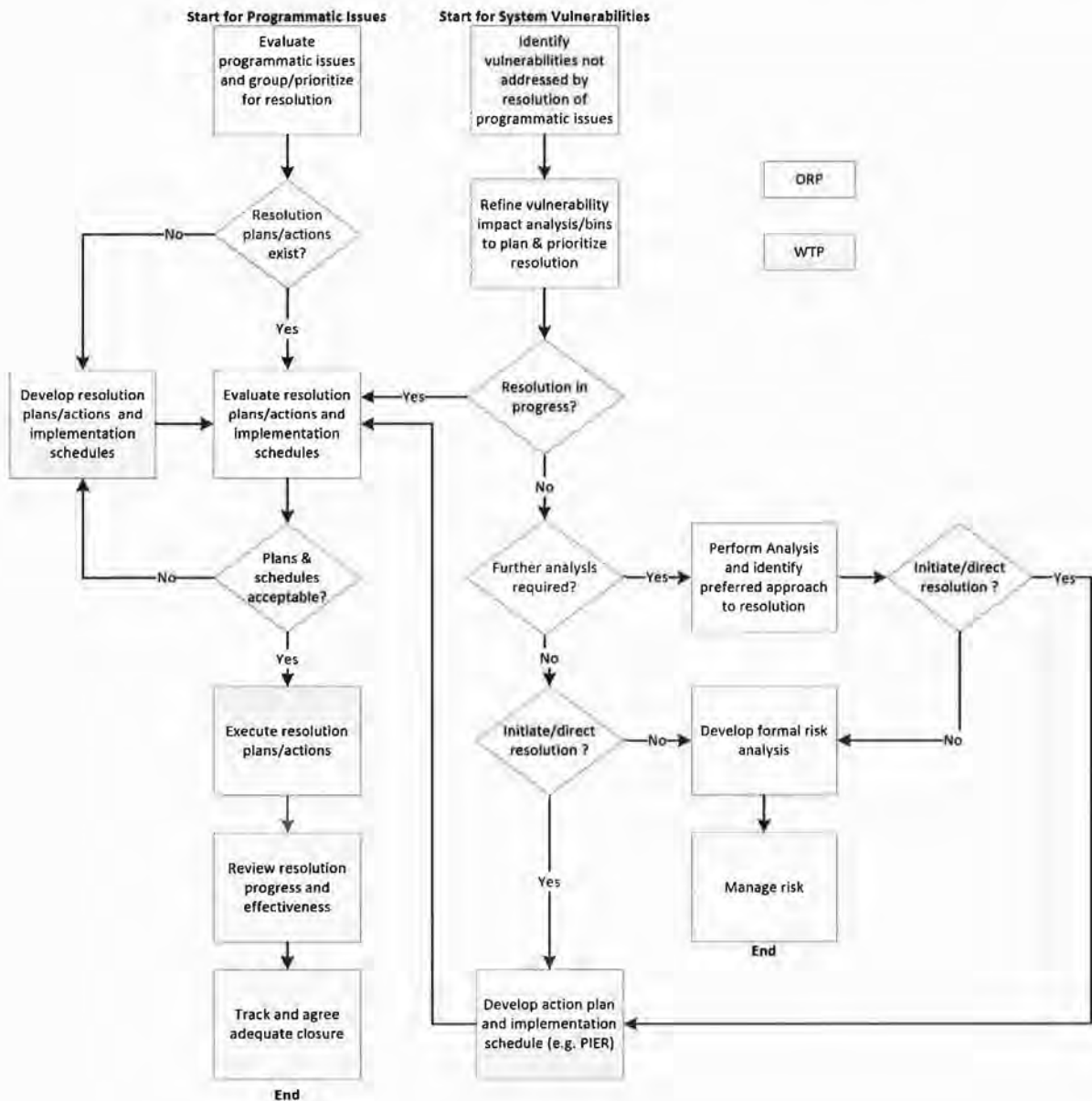


Figure 6-1. Summary Vulnerability and Issues Management Process.

Revision 0

**APPENDIX A**



**LOW-ACTIVITY WASTE FACILITY DESIGN AND OPERABILITY REVIEW  
TEAM BIOGRAPHIES**

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## APPENDIX A LOW-ACTIVITY WASTE FACILITY DESIGN AND OPERABILITY REVIEW TEAM

### Leadership

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#### **Gary Olsen, PMP, PE**

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

Mr. Olsen is the Federal Project Director for Special Projects at the Waste Treatment and Immobilization Plant (WTP) in Richland, Washington. He has more than 25 years of experience in government and private industry, primarily supporting National Priority List environmental cleanup projects. Mr. Olsen previously served as Federal Project Director of the High-Level Waste Facility, and prior to that, the Low-Activity Waste Facility, Balance of Facilities, and Analytical Laboratory at the WTP. Before joining the Office of River Protection, Mr. Olsen worked on commissioning and operating a plant that safely destroyed chemical-agent-filled weapons of mass destruction at the Umatilla Chemical Agent Disposal Facility in Umatilla, Oregon. Mr. Olsen has a Bachelor of Science in Chemical Engineering from the University of Utah, and a Master of Science in Environmental Engineering from the University of Kansas. Mr. Olsen is a certified Project Management Professional and a registered Professional Engineer.

#### **Allan Exley, PMP**

Washington River Protection Solutions LLC

Mr. Exley is the WTP Design and Operability Manager for Washington River Protection Solutions in Richland, Washington. He also serves as EnergySolutions' Project Director.

Mr. Exley has more than 30 years of experience in nuclear facility startup and operations in the United Kingdom and the United States. He previously served as the Client Project Manager and Facility Manager for the Waste Treatment Complex at Sellafield in the United Kingdom, and as Facility Operations Manager for the Advanced Mixed Waste Treatment Project in Idaho Falls, Idaho. Mr. Exley has a Higher National Diploma in Electrical Engineering, and is a certified Project Management Professional.

### Senior Review Team

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#### **Barry Naft, Ph.D., PE**

Environment International, Inc.

Dr. Barry Naft has 47 years of experience in chemical and nuclear engineering. For the past 12 years, Dr. Naft has served as Senior Consultant to the U.S. Department of Energy (DOE) Headquarters, field offices, and prime contractors, providing technical support on engineering, procurement, and construction cost, schedule, and technical issues for tank waste and related nuclear waste management projects. Recent relevant experience includes the supporting the Department in the following capacities:



- Chairman of an independent review committee on the cost, schedule, and technical status of the WTP
- Senior Technical Authority to the Office of River Protection, participating in several dozen external independent reviews for WTP design and construction
- Ex-officio member representing DOE on each of the three “Best and “Brightest” teams chartered by Secretary Bodman
- Member of both the Environmental Management Advisory Board Tank Waste Subcommittee reviews of the WTP and related tank waste activities
- Chairman of the Independent Review Board to assess and certify Tank Operations Contract Line Item Number 3.2.

Dr. Naft previously served as Director of the American Nuclear Society and Chairman of its Waste Management and Fuel Cycle Division; Atomic Energy Commission Fellow; and Professor at the Catholic University Graduate School of Engineering.

Dr. Naft has a Bachelor and Master of Science in Chemical Engineering from Clarkson University and a Ph.D. in Nuclear Engineering from Purdue University. He has completed the Advanced Management Program at Wharton School, and is a registered Professional Engineer in Nuclear Engineering.

### **Len Jones, CE**

DBD Limited

Mr. Jones has over 46 years of unbroken experience in a range of nuclear technologies, which includes technical expertise and project management. This experience has been gained both domestically in the United Kingdom and internationally, and is derived from the management of major projects in the UK, Germany, Brazil, and Japan. He has taken projects from conception to design, to installation and commissioning, and then to full operation.

At Sellafield, he was the Commissioning Director for the High Level Waste Evaporation Plant, the Head of BNFL Engineering, and the Head of Commissioning and Operations for the Low Level Waste Treatment Plants (5 plants). In northern Japan at the JNFL reprocessing plant, he was the General Manager of BNFL Rokkasho KK Japan, leading the HLW and ILW evaporator commissioning team.

During the past four years Mr. Jones has undertaken several lead review roles for the UK Government; these have included extended work for the Ministry of Defense in Whitehall reviewing Nuclear Capabilities in the Middle East and leading a review team of the commissioning and management processes, their implementation and the commissionability for a number of new plants currently under design, and construction at the MoD Atomic Weapons Establishments.

Mr. Jones has a Bachelor’s degree from Liverpool University in Mechanical Engineering, with a specialty in Nuclear Engineering; and he is a Chartered Engineer and a Fellow of the Institution of Mechanical Engineering.

**Anthony (Tony) M. Umek, PE**  
CEO, AKU Enterprises, LLC

Mr. Umek has over 40 years of experience in leading and managing extensive nuclear and chemical processing projects in both the commercial nuclear and the U.S. Department of Energy complex.

As an executive with Fluor Corporation he supported environmental and nuclear projects at DOE's Hanford, Savannah River, Portsmouth, Strategic Petroleum Reserve and Paducah sites; and also supported International government work. He administered the Fluor labor agreement with the National AFL/CIO Building & Construction Trades Council (as part of the Hanford Site Program). He was Project Director of the Hanford Tank Waste Remediation Project for four years, prior to the formation of the DOE Office of River Protection. He has also worked at the DOE Savannah River Site, Idaho National Laboratory and Lawrence Livermore National Laboratory.

He has supported the DOE as a member of the DOE-EM Corporate QA; and as a Chair of the EFCOG Environment, Safety & Health Working Group. He has received formal recognition for his contributions and achievements, including:

- The first DOE Contractor to be an invited (twice) to present at the Washington State Governor's Safety Conference in 2005 and 2006.
- The Energy Secretary's Appreciation Award, 2008, for his leadership in improving electrical safety, DOE Complex wide.
- The DOE VPP Contractor Champion's Award for 2013.

Mr. Umek has a Bachelor of Science in Mechanical Engineering from Carnegie Mellon University and an MBA from the University of Pittsburgh. He leads several Community Non Profit Boards and is a Life Member and PE with the American Society of Mechanical Engineers.

## **Radiological Control and Safety & Health**

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**Emily Millikin, CSP**

URS Professional Solutions

Ms. Millikin has over 29 years of experience in radiation protection, safety and health, environmental, and regulatory experience at U.S. Department of Energy (DOE) and Department of Defense (DOD) chemically- and radiologically-contaminated sites. Ms. Millikin has significant experience in both program and field implementation of both radiological and safety and health disciplines and has served as a subject matter expert on numerous reviews related to Safety and Health, Radiological Control, and Quality. Most recently Ms. Millikin was the Safety, Health, and Quality Director for Washington Closure Hanford and the Safety and Health Manager for the Umatilla Chemical Weapons Disposal Facility. Ms. Millikin holds a Bachelor of Science degree in Environmental Health with double majors in Health Physics and Industrial Hygiene from Purdue University, and is a Certified Safety Professional.

## Electrical Distribution Systems

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### **Mark D. Johnson**

Columbia Energy and Environmental Services

Mr. Johnson is the Electrical Engineering Department Manager for Columbia Energy and Environmental Services, an Engineering and Fabrication Contractor in Richland, Washington, with a business core focus on supporting engineering projects at Department of Energy, Defense Nuclear Facilities. Mr. Johnson has 23 years of experience as an Electrical Engineer, and over 25 years of engineering and technical experience at DOE nuclear facilities, which includes 4 years at the Los Alamos National Laboratory in Los Alamos, New Mexico, 7 years at the Pantex Plant, in Amarillo Texas, and over 16 years of direct and indirect experience at the Hanford Site. Mr. Johnson has performed the roles of: Electrical Distribution System, Control System, and NDE System Design Authorities at the Hanford Waste Receiving and Packaging (WRAP) facility; Systems Engineer and Facilities Engineer at the DOE Pantex Facility; and Electrical Technician at the Los Alamos National Laboratory. Mr. Johnson has a Bachelor of Science degree in Electrical Engineering Technology from New Mexico State University's College of Engineering.

### **Raymond Merriman, PE (Washington)**

AEM Consultants, LLC

Mr. Merriman has over 30 years of experience in electrical power and control Engineering for nuclear, electrical utility, industrial, and commercial facilities. His experience includes electrical system studies, design, operation, maintenance, compliance reviews, and design authority oversight. Past projects include nuclear waste processing facility design, tank farm electrical upgrades, general nuclear site support, and heavy industrial system design and upgrades. DOE sites supported include Los Alamos, Paducah, Fernald, Idaho Falls, and Hanford. Mr. Merriman has a Bachelor of Science in Electrical Engineering and he is a licensed Professional Engineer.

## Instrumentation & Controls

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### **Stephen Wolfe**

Mid-Columbia Engineering MCE

Mr. Wolfe has more than 25 years of experience in process and process control engineering, with expertise in facility and system design, specification, testing, commissioning and start-up. He is an expert on control systems, software quality assurance and testing, having successfully designed, tested, commissioned, and documented dozens of NQA-1 control systems and software packages used by the DOE, DOD, US military, universities and internationally. Mr. Wolfe has conducted control system design, development and testing under nuclear industry rules (10CFR830), quality assurance (NQA-1, 10CFR50, ISO9001), DOE Orders and site-specific requirements. Mr. Wolfe has managed two I&C Engineering groups and two UL508A industrial control panel shops. Mr. Wolfe has successfully commissioned controls systems



through reviews by the DNFSB, NQA-1 Audits, Software Review Boards, ORR and customer acceptance processes. He has led successful acceptance testing, commissioning, MSA, Affidavit Review Boards and ORR efforts at the Hanford Site, and started numerous private sector facilities.

Mr. Wolfe holds numerous U.S. and International Patents. Mr. Wolfe has a Bachelor of Science in Chemical Engineering.

### **John Wootton**

#### **John Wootton Integration**

Mr. Wootton is an Instrumentation and Control Systems Engineer with over 14 years of experience. John has broad-based skills encompassing facility network architecture design, commissioning of software and hardware, facility start-up, and operational project phases. His expertise includes team leadership, staff supervision, design and implementation, training/support, and troubleshooting software and hardware. John has been involved in numerous commissioning efforts on large projects and has been part of facility ORRs on the Idaho National Laboratory (INL) site. Mr. Wootton has a Bachelor of Science (BSc) in Engineering Physics.

### **Container Systems Team**

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#### **Steven Cross, PE**

##### **Canister Systems Team Lead**

*EnergySolutions*

Mr. Cross has 24 years of experience in the pulp and paper, aluminum, semiconductor, chemical, and nuclear industries. His experience includes capital project management, project justification, estimating, value engineering, and return on investment analysis. Mr. Cross' experience includes developing technical and cost basis proposals; providing independent design verification; and developing engineering design guides for flow, pump sizing, vessel sizing, and piping design for the Federal Government. Previous positions include Lead Engineer for the design of chemical and bulk specialty gas systems, and Process Engineer for the design of waste neutralization and industrial water systems. Mr. Cross co-authored the initial High-Level Waste Facility hazard analysis for the Global Nuclear Energy Partnership. Mr. Cross has a Bachelor of Science in Mechanical Engineering and is a registered Professional Engineer.

#### **Gary Buss**

*EnergySolutions*

Mr. Buss has 18 years of facility operations and maintenance, design authority, and project construction experience. He has performed as a design engineer for mechanical equipment on facilities and plant modifications, including risk, design, systems support, construction contractors, startup/testing, and regulatory and code compliance. Mr. Buss has a Bachelor of Science in Engineering.



**Nick Camarata, PE**

HukariAscendent, Inc.

Mr. Camarata has 15 years of experience providing instrumentation and programming expertise for automation process control. He developed the logic control for Hanford's Cold Vacuum Drying Facility, using historical trending to support troubleshooting, trending, and process improvements. During the campaign to dry knockout pot material, he served as a process control engineer. He provided programmable logic controller programming for Hanford's

pump-and-

treat plants. He also designed the instrumentation and control system for the Radioactive Liquid Waste Facility at the Los Alamos National Laboratory. Additional experience includes supporting the National Aeronautics and Space Administration's Arc-Jet Facility, and the U.S. Department of Defense. Mr. Camarata has a Bachelor of Arts in Mass Media and History; a certificate in instrumentation, automation, and process control; and is a registered Professional Engineer.

**Tim Eichhorn, PE (Illinois)**

Polestar Technical Services

Mr. Eichhorn has 40 years of experience in nuclear waste treatment, and nuclear and conventional power plant industries. His experience includes mechanical systems, mechanical handling, process, nuclear, and fire protection engineering. Previous positions include WRPS Senior Engineer performing WTP CLIN 3.2 review work of the WTP Project; Senior Process Engineer at SNC Lavalin Thermal Division (combined cycle power plants); Senior Engineer at Bechtel BNI – WTP project Mechanical Systems group (Design Verifications and compliance); Mechanical Department Head at R. W. Cooper & Associates (Industrial Plants); Senior Technical Staff Engineer at the Braidwood Nuclear Station (Thermal group); and Senior Engineer & SUBSAFE Design Review Piping Flexibility group lead at Puget Sound Naval Shipyard (overhaul of nuclear submarines). Mr. Eichhorn has a Bachelor of Science in Mechanical Engineering and is a registered Professional Engineer.

**Eric Tchemitcheff**

AREVA Federal Services LLC

Mr. Tchemitcheff has 35 years of experience in nuclear engineering, possessing in-depth expertise in all aspects of radioactive waste management (including retrieval, treatment, conditioning, packaging, storage, transport, and disposal activities) and of decontamination and dismantling of nuclear facilities. His management experience includes developing technical strategies, performing project definition, conceptual and detailed design, and supporting nuclear facilities operations. He was a member of the External Flowsheet Review Team, which conducted a comprehensive review of the WTP flowsheet and throughput in 2005/2006. Mr. Tchemitcheff focuses on transferring French technologies to U.S. facilities, applying lessons learned from sites such as La Hague and Marcoule. Mr. Tchemitcheff has a Master of Science in Chemical Engineering.

**Mark VanderZanden, PE (Washington)**

AREVA Federal Services LLC

Mr. VanderZanden is the Director of Engineering for AREVA Federal Services in Richland, Washington. He has more than 26 years of experience in the nuclear industry. He has performed work for the Department of Defense, various operating contractors of the Hanford Nuclear Reservation, Department of Energy national laboratories, and private sector companies (medical isotopes and environmental services). His experience includes the design of new nuclear waste processing facilities and systems, fabrication and testing of nuclear waste processing systems and components, maintenance of existing nuclear equipment and systems, and supervision of nuclear operations. Mr. VanderZanden has a Bachelor of Science in Mechanical Engineering from Gonzaga University and is a registered Professional Engineer.

**Mechanical Systems Team**

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**Steve Doebler, PE****Mechanical Systems Team Lead**

Polestar Technical Services

Mr. Doebler has over 34 years of nuclear industry experience focused on reactor operation and decontamination and decommissioning activities. At the Hanford Site, Mr. Doebler was involved in plant operations, defueling, and decommissioning facilities, including the Fast Flux Test Facility. His experience in decontamination and decommissioning includes facility hazards disposition, waste disposal, demolition, and final site closeout at numerous nuclear fuel processing facilities and associated machine shops. Mr. Doebler served as mentor on the principles of conduct of operations at Hanford facilities and other DOE sites, including the West Valley Demonstration Project in New York, and the Savannah River Site in South Carolina. He prepared a technical watch report on Nuclear Regulatory Commission activities, and was involved in design work for spent nuclear fuel cask disposition. Mr. Doebler holds a Bachelor of Science in Nuclear Engineering and is a registered Professional Engineer.

**Shad Harp,**

ANR Group Inc.

Mr. Harp has two years of experience on the Waste Treatment Plant Project. Mr. Harp is pursuing a Bachelor of Science degree in Mechanical Engineering at Washington State University Tri-Cities.

**Daniel Richey, PMP**

AREVA Federal Services

Mr. Richey has 27 years of experience in project and construction management for government and commercial clients. He has managed all facets of mixed oxide fresh fuel packaging design, procurement, fabrication, and testing, and has directed the development of procedures that focus on a graded approach to project management. Mr. Richey's government experience includes

auxiliary handling equipment, alpha caisson mobile hot cell technology, core sampling, and X-ray systems. Previous commercial experience includes serving as Senior Site Manager of an ethanol biorefinery, Reactor Fuels/Engineering Manager, and Outage Maintenance Coordinator. Mr. Richey holds a Bachelor of Science in Mechanical and Nuclear Engineering.

**Kyle Roberson, Ph.D.**

K Zero LLC

Dr. Roberson has 36 years of private and government sector experience, including 18 years at the Hanford Site. At Hanford, he supported the Tank Farms and WTP Projects, addressing seismic, fluid dynamics, thermal detonation/deflagration and analysis, and melter design. He was the principal investigator for the design and evaluation project under the DOE's Volatile Organic

Compound-Arid Integrated Demonstration Program. He also has experience in food processing and chemical waste industries. Dr. Roberson holds a Bachelor of Science in Maritime Systems Engineering, and a Master of Science and Ph.D. in Mechanical Engineering.

**Robert Sherman, PE, SRO**

HukariAscendent, Inc.

Mr. Sherman has 37 years of nuclear industry experience, comprising commercial nuclear power plants and the government sector. His commercial experience includes Trojan Nuclear Plant, Columbia Generating Station, and Humboldt Bay Power Plant. At Hanford, he supported the Tank Farms, and at both Rocky Flats and Hanford he provided regulatory analysis and enforcement. The majority of his experience is in radiological safety analysis, nuclear safety assessment, licensing, operation, regulatory compliance, and decommissioning. Mr. Sherman holds a Bachelor of Science in Nuclear Engineering and he is a Registered Professional Nuclear Engineer. Mr. Sherman also holds a Senior Reactor Operator certification on a large 4-loop pressurized water reactor.

**Larry Ulbricht, PE**

Columbia Energy and Environmental Services

Mr. Ulbricht has 24 years of nuclear engineering experience ranging from individual components to entire facilities. He has lead project experience for the Portable Evaporation-Wiped Film Evaporator and for a fuel-grade ethanol production facility. He was also the Lead Project Engineer for a Hanford shipping facility study and for an immobilized low-activity waste transportation study. Other Hanford Site experience includes supporting the Accelerated Tank Closure Demonstration, Tank Closure and Fast Flux Test Facility environmental impact statements, the tank farms Mobile Arm Retrieval System component design development, LowActivity Waste Facility mechanical handling construction, and K Basin fuel retrieval. Mr. Ulbricht holds a Bachelor of Science in Mechanical Engineering.

**Ventilation Systems Team**

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**Steven Christensen, PE (Idaho and Washington)  
Ventilation Systems Team Lead**

Lucas Engineering

Mr. Christensen has 25 years of mechanical engineering experience, with 15 years in the nuclear industry. He has experience with Mechanical Design, Structural Analysis, Systems Engineering, and Nuclear Design Analysis. He has performed flow and design verification calculations and system evaluations; designed processing and handling equipment, and lateral force resisting systems; written software programs for inspection equipment and operation and instruction manuals; and specified operating parameters and developed test plans.

He has been the System Engineer and Design Authority for a nuclear confinement ventilation system, ensuring safety basis and code compliance. His DOE experience includes Idaho Falls and Hanford. He has a Bachelor of Science in Mechanical Engineering.

**Robert Bevins**

TradeWind Services LLC

Mr. Bevins has 35 years of design, testing, construction, and startup experience in government and private settings. His experience includes serving as Engineer, Manager, and Startup/Test Engineer for the government's Breeder Reactor Program, nuclear waste processing and storage facilities, and early efforts to design a vitrification plant at Hanford. Private industry experience includes engineering and project management positions in the pulp and paper, food processing, and waste processing industries. Mr. Bevins' expertise includes a working knowledge of ANSI/ISA 84.00 and IEC 61511, and government quality assurance programs such as NQA-1. Mr. Bevins has a Bachelor of Science in Mechanical Engineering and a Bachelor of Science in Electrical Engineering.

**Robert Gregonis**

TradeWind Services LLC

Mr. Gregonis has 30 years of Hanford Site experience. He has been the design authority for mechanical system design, installation, operation, and maintenance for HVAC, steam, compressed gas, fire suppression, process vacuum, and process/sanitary water systems. He has been the technical authority for HVAC, steam, compressed air, breathing air, nitrogen, vacuum sampling pumps, and fire systems. In addition, Mr. Gregonis has prepared conceptual HVAC designs for proposed upgrades and been the Vital Safety System Engineer for hot cell high-efficiency particulate air filters. Mr. Gregonis holds a Bachelor of Science in Mechanical Engineering.

**William M. Harty**

Polestar Technical Services

Mr. Harty has 40 years of nuclear facility experience at the Hanford site. From 1974 to 1994 he has served in numerous management roles; Radiation Monitoring Manager at the Plutonium Finishing Plant, Operations and Engineering Manager at PUREX, and start-up and operations design engineer for the Hanford Waste Vitrification Plant. From 1994 to 2013, Mr. Harty



provided engineering support to the day-to-day operations of the 200 East Area Double-Shell Tank Farms, including since 2007 being the cognizant system engineer for ventilation upgrade projects and operations. Mr. Harty has a Bachelor of Science in Environmental Science and Health Physics from Washington State University.

**Timothy Kot**  
EnergySolutions

Mr. Kot is an experienced engineer, with a background in both government and private settings. He has served as mechanical design engineer and HVAC lead engineer for systems in hospitals, office buildings, and higher education buildings, as well as steam CUP design. Mr. Kot's HVAC

expertise includes analyzing and selecting HVAC system components. He has provided an HVAC Lead Engineer support to the Savannah River Site, Los Alamos National Laboratory, Hanford Site projects, and internationally. This includes performing calculations and developing drawings to ensure an environment with appropriate temperature, humidity, and airflow and air change rate for clean and contaminated areas; providing datasheets and specifications for HVAC equipment; analyzing redundancy, controls, interlocks, and instrumentation for major equipment; and performing studies for cooling and heat transfer. Mr. Kot has a Master of Science in Mechanical Engineering.

**Mahendra Patel, PE (Colorado)**  
URS Corporation

Mr. has more than 40 years of experience in government and private industry, primarily in the HVAC design, procurement, commissioning and start-up of projects. Mr. Patel previously served as Lead HVAC Engineer for the Pit Disassembly and Conversion Facility (PDCF) at Savannah River Site, and prior to that, Lead HVAC Engineer and decommissioning HVAC Engineer of a plant that safely destroyed chemical-agent-filled weapons of mass destruction at the Johnston Atoll. Mr. Patel has a Bachelor of Science in Mechanical Engineering from Gujarat University India, a Master of Science in Mechanical Engineering from the University of Missouri, and Master's degree in Environmental Project Management from the University of Denver. Mr. Patel is a registered Professional Engineer.

**Process Support Systems Team**

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**William Peiffer**  
**Process Support Systems Team Lead**  
Polestar Technical Services

Mr. Peiffer has 34 years of diverse international operations, engineering, and project management experience that includes nuclear facility design, startup, operation, and decommissioning. He has a broad knowledge of nuclear safety, engineering, operations, and

project management standards. Mr. Peiffer's Hanford experience includes evaluating operational readiness plans, optimization startup, analyzing technical risks, and developing remediation strategies for waste burial grounds. He also worked an 18-month assignment at the BNFL Sellafield Site in the United Kingdom, and was selected to participate on an international World Association of Nuclear Operators team to perform a peer review assessment of operations at the Thermal Oxide Reprocessing Plant at Sellafield in the United Kingdom. Mr. Peiffer has a Bachelor of Science in Chemical Engineering.

**Rob Carter**  
EnergySolutions

Mr. Carter is the lead process modeler for EnergySolutions. He has been in the nuclear industry for nearly 25 years, initially in the United Kingdom (U.K.) with BNFL, then transferring to the U.S. in 1990 with EnergySolutions (formally BNFL Inc.). Whilst in the U.K., he worked on the UO<sub>2</sub> fuel manufacturing site in both a plant support role and as a process modeler. He came to the U.S. to support the modeling efforts on WTP and during his time there developed and maintained the WTP Steady-State Flowsheet model. This model leveraged the OLI Systems electrolyte thermodynamics system to predict speciation/precipitation in key areas of the WTP process flowsheet. Later, for EnergySolutions, he developed the steady-state flowsheet model of an integrated used nuclear fuel recycling plant for the GNEP project. Since then, he has worked for WRPS in the capacity of process modeling lead and developed a dynamic flowsheet model of the WTP LAW facility. This model was developed for assessing the operational readiness of the LAW plant and focused on the information available to future operators. During his time with WRPS, Mr. Carter developed the Pitzer Thermodynamic database for incorporation into the System Planning tool HTWOS. Mr. Carter holds a B.Sc. 'Honours' Degree in Chemical Engineering from Salford University and he is currently a member of the U.K. based Institute of Chemical Engineers.

**Paul Fallows**  
AREVA Federal Services LLC

Mr. Fallows has more than 30 years of experience in the design, development, testing, installation, commissioning, and operation of nuclear and non-nuclear facilities and equipment. He has extensive empirical knowledge of fluidic mixers and pumping systems, as well as expertise in research and development. He previously held positions with the UK Atomic Energy Authority, AEA Technology, and NuVision Engineering. Mr. Fallows has supported Hanford Site projects since 2001, including the WTP. Mr. Fallows has a Bachelor of Science degree. He is a Chartered Engineer and a Chartered Scientist, and is a Fellow of the Institution of Chemical Engineers.

**Charles Kelly**  
URS Professional Solutions LLC

Mr. Kelly has more than 40 years of experience in the nuclear and petrochemical industries, functioning in a variety of operations, maintenance, engineering, and project roles. He has 19 years of experience with high-level waste associated with the following facilities at the Savannah River Site: FTF, HTF-W, HTF-E, CIF, BGI, ETF, DWPF, and 299-H. He has also served in assignments at Sellafield in the UK and several DOE sites across the complex as a maintenance subject matter expert. He is experienced in distributive control systems, programmable logic controllers, and instrumentation applications as well as data collection and analysis. Mr. Kelly has a Bachelor of Science in Electrical and Computer Engineering from the University of South Carolina.

**Trevor Kilgannon**

URS

Mr. Kilgannon is a Cognizant System Engineer with URS for the WTP Project. He has 5 years of experience working for government contractors at the Hanford Site. Before joining URS, Mr. Kilgannon worked for Washington River Protection Solutions supporting waste feed delivery projects and studies. He previously worked at the Integrated Waste Treatment Unit in Idaho Falls during final stages of construction and testing. Mr. Kilgannon holds a Bachelor of Science in Chemical Engineering.

**Harold Mashaw**

Aspen Resources Limited, Inc.

Mr. Mashaw is a mechanical engineer with 30 years of experience in project management, engineering, pressure vessel design, and waste handling. He has strong hands-on experience as a project manager and project engineer in NQA-1 shop fabrication, testing/nondestructive examination, and related design processes. Mr. Mashaw's expertise includes mixed wastehandling operations, procedure development, and NQA-1 requirements. His DOE experience includes supporting Hanford Site projects and the Waste Isolation Pilot Plant. Mr. Mashaw holds an Associate in Arts and Sciences in Health Physics, and a Bachelor of Science in Mechanical Engineering.

**Albin Pajunen, PE**

AEM Consulting

Mr. Pajunen is a licensed professional chemical engineer with 35 years of process engineering experience in chemical processing and waste management activities at nuclear facilities. He has a strong background in flowsheet development, including unit operations, kinetics, mass transfer, heat transfer, ion exchange, and drying used in radioactive waste processing, spent nuclear fuel reprocessing, and plutonium processing, and is an expert in model verification and validation. Mr. Pajunen holds a Bachelor of Science in Chemical Engineering and Mathematics, a Master of Science in Chemical Engineering, and is a registered Professional Engineer.

**Gary Tardiff**

AEM Consulting LLC

Mr. Tardiff has 39 years of experience in the chemical and nuclear industries. His experience includes startup and shutdown of the PUREX facility from 1981-1993 working as a shift engineer and Cognizant Engineer, and then transitioning to Tank Farms as a Cognizant and System Engineer for 241-AY, 241-AZ and 241-SY DSTs from 1993-2012. Previous positions include experience in chemical processing plants, process development, and plant startup work for the WR Grace and Dupont companies. Mr. Tardiff has a Bachelor of Science, in Chemical Engineering from the University of New Hampshire.

**Stephen Turner, CEng**

*EnergySolutions*

Mr. Turner is a professionally registered engineer with over 35 years of experience in engineering and project management in the nuclear and chemical industry. He recently led the team that produced an alternatives analysis and conceptual design for waste feed delivery from the tank farms to the WTP. He previously delivered the design, fabrication and testing of the cementation gloveboxes for the Waste Stabilization Building at the Savannah River Site, and supported project design and operations at Sellafield in the United Kingdom. Other experience includes delivering a Global Nuclear Energy Partnership siting study, fluidic components for the WTP, and supporting Hanford's K Basins and fuel sludge treatment and packaging. Mr. Turner has a Bachelor of Engineering in Chemical Engineering and a Master of Business Administration.



Revision 0

**APPENDIX B**

**SUMMARY VULNERABILITY LISTING**

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## APPENDIX B SUMMARY VULNERABILITY LISTING

Table B-1. Summary Vulnerability Listing. (41 pages)

Item No.	Description	Opportunities for Improvement	Rank
<b>LOP and LVP System</b>			
LOP/LVP-01	The collective significance of project self-identified issues indicates overall functionality of LOP/LVP systems is indeterminate	1.1. Complete self-identified actions. 1.2. Implement independent confirmation of effectiveness of issue resolution actions.	High Pre CD-4
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.	2.1 Revisit permit conditions and abatement system requirements to consider: a. 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. b. Costs associated with throughput impacts as part of any associated economic evaluation c. 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 to reducing changeout frequencies of HEPA filters). Equipment such as the WESP would then be operated as non-permit affecting. d. 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. e. Potential to implement alternative regulatory strategies to minimize risks associated with MACT testing.	High Pre CD-4
LOP/LVP-03	There appears to be insufficient redundancy available to avoid single point equipment failures affecting both melters.	3.1 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. 3.2 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.	High Pre CD-4
LOP/LVP-04	Single point instrument failures, interlocks, required calibrations and surveillances can result in unaccounted throughput impacts.	4.1 Confirm, via hazard analysis and discussions with regulators, that all interlocks are required or warranted. 4.2 Verify OR Model considers impacts due to maintenance and calibrations. 4.3 Plan mini-outages for instrument maintenance, loop calibrations, and surveillances (account for these in OR model). 4.4 Consider procedural approach to allow one loop out of service for redundant loops (i.e. designate primary and secondary loops in the DCS).	High Pre CD-4
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 surges, etc) and abnormal operating conditions not demonstrated.	5.1 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. 5.2 Continue development of "Technical Manuals" as a means to develop and integrate start-up/shut-down sequences and responses to abnormal conditions. 5.3 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.	High Pre CD-4
LOP/LVP-06	Lack of functional testing of LOP equipment performance at vendors.	6.1 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. 6.2 Establish performance criteria on individual units and overall system as part of start-up and commissioning planning. 6.3 Develop a dynamic process model as a tool to improve confidence that equipment performance requirements can be achieved.	Medium Pre CD-4
Item No.	Description	Opportunities for Improvement	Rank



Table B-1. Summary Vulnerability Listing. (41 pages)

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 nonintrusive maintenance requiring a process cell entry could also result in idling both melters.	<p>7.1 Add associated maintenance to the OR Model which reflects both melters off-line.</p> <p>7.2 Determine if additional design features are necessary to facilitate maintenance on the LOP system.</p> <p>7.3 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.</p> <p>7.4 Consider relocating the pressure relief devices to another C5 area (3<sup>rd</sup> wet process cell), or pipe 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).</p> <p>7.5 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).</p>	Medium Pre CD-4
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.	<p>8.1 Demonstrate and confirm whether vitreous build-up is a problem or not (rate of accumulation not quantified in testing).</p> <p>8.2 Write procedures to perform inspection of film cooler during annual spray nozzle replacement.</p> <p>8.3 Prepare design for device/procedure to remove build up in film cooler/offgas lines – if required.</p>	Low Post CD-4
LOP/LVP-09	The Melter Film Cooler, Offgas lines (including Wall Penetrations) and the SBS DownComer 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.	<p>9.1 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.</p>	Medium Pre CD-4
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.	<p>10.1 Since these are non-safety devices, consider installing duplicate relief devices that include isolation devices to minimize impacts to production during maintenance.</p> <p>10.2 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.</p>	Medium Pre CD-4
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.	<p>11.1 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 potential add 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.</p> <p>11.2 Convert a spare SBS vessel port to allow periodic camera inspection of the internals.</p>	Medium Pre CD-4
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.	<p>12.1 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.</p> <p>12.2 Evaluate the impact of operating the chillers simultaneously rather than in a duty/standby mode on the plant availability, power demands, control approach, etc.</p> <p>12.3 Evaluate the need for equipment changes and the revised control approach if simultaneous operation of the chillers is an acceptable work around.</p>	Medium Pre CD-4
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.	<p>13.1 Verify design inputs to the Vendor calculation are valid and the Vendor Thermal analysis outputs are accurate and reasonable per project approved procedures.</p>	Low Post CD-4
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.	<p>14.1 Consider alternative high temperature gasket materials compatible with existing flange surfaces such as Perfluoroelastomer (FFKM) or High Temperature Resistant Silicone.</p> <p>14.2 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.</p> <p>14.3 If necessary, reanalyze and remanufacture SBS Top Flat Head flange and mating flange to support high temperature flat gasket (such as Metaflex used on the SBS inlet line connections).</p> <p>14.4 Review hazard analysis for SBS to confirm that potential failure of O-ring has been considered.</p>	High Pre CD-4

Table B-1. Summary Vulnerability Listing. (41 pages)

Item No.	Description	Opportunities for Improvement	Rank
LOP/LVP-15	VSL SBS down-comer testing design changes not carried forward or incorporated into SBS design.	15.1 Evaluate and incorporate proposed VSL design changes to the offgas down-comer (i.e. adding perforations at the bottom of the down-comer).	Medium Pre CD-4
LOP/LVP-16	Documented analysis not evident to discount Ozone as a potential corrosion agent within and downstream of WESP.	16.1 Conduct and document analysis to determine impact of ozone generated in WESP.	Medium Pre CD-4
LOP/LVP-17	Inconsistencies in design documents could lead to design errors that impact the functionality of the equipment or impact future design changes.	17.1 An extent of condition review should be conducted to determine if there are other design media problems.	Medium Pre CD-4
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.	18.1 Evaluate the need for an ammonium nitrate detection and removal system for the preheaters and 1 <sup>st</sup> 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. 18.2 Evaluate means to flush the exhaust stack and associated sampling and monitoring system piping. 18.3 Consider incorporation of periodic inspection of selected systems on an opportunistic basis. 18.4 Evaluate other areas of potential ammonium nitrate accumulation and determine if inspection and/or clean-out capability should be incorporated prior to start-up.	Medium Pre CD-4
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.	19.1 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.	Low Post CD-4
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.	20.1 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.	Low Post CD-4
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.	21.1 Double valve isolation should be required to protect people from the potential gas temperature hazard in all types of operational scenarios. 21.2 Manual valves across the B train HEPA filter banks need to be installed similar to the ones planned for A HEPA filter train. 21.3 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.	Low Post CD-4
LOP/LVP-22	The HEPA filter qualification limits for low flow may be challenged under certain operating conditions thereby impacting filter performance.	22.1 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. 22.2 Below are several other options to be considered for improvement in HEPA filter Operation. a. Switch operations to the backup HEPA B train during periods of low flow (Admin Control). b. Remove one of the HEPA Filter banks in parallel making both the main and backup banks identical (Engineering Control). c. 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. f Option b or c is implemented then the minimum flow rate of ~4600 ACFM could be reduced to ~2800 ACFM at the exhausters.	Medium Pre CD-4
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	23.1 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.	Low Post CD-4
Item No.	Description	Opportunities for Improvement	Rank



Table B-1. Summary Vulnerability Listing, (41 pages)

LOP/LVP-24	Monitoring a COx concentration difference across carbon beds as an indication of fire may prove to be difficult to successfully implement.	<p>24.1 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.</p> <p>24.2 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.</p> <p>24.3 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.</p>	High Pre CD-4
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.	<p>25.1 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:</p> <ol style="list-style-type: none"> <li>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.</li> <li>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.</li> <li>Determine if some type of thermal scan (e.g., infrared) could indicate the presence of localized carbon oxidation reactions.</li> <li>Determine if monitoring for convective gas flow from bed could be used to indicate the presence of localized carbon oxidation reactions.</li> <li>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.</li> </ol>	High Pre CD-4
LOP/LVP-26	No clear definition of a carbon bed fire has been found in the documents reviewed.	<p>26.1 Complete planned set point analysis to define a carbon bed fire.</p> <p>26.2 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.</p>	Medium Pre CD-4
LOP/LVP-27	There is only a limited definition of the operating conditions that minimize the potential for experiencing a carbon bed fire.	<p>27.1 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).</p> <p>27.2 Develop a model of the actual plant equipment for evaluating conditions that could result in a 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. 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:</p> <ol style="list-style-type: none"> <li>Determine a minimum total gas flow rate to avoid the potential for gas mal-distribution.</li> <li>Determine if an actual plant equipment test with high risk gas component compositions is warranted.</li> <li>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.</li> <li>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).</li> </ol> <p>te the risk of fire for the guard bed material ultimately selected.</p>	High Pre CD-4
<b>Item No.</b>	<b>Description</b>	<b>Opportunities for Improvement</b>	<b>Rank</b>

Table B-1. Summary Vulnerability Listing. (41 pages)

LOP/LVP-28	No minimum gas flow rate has been defined for safely operating the carbon beds.	28.1 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). 28.2 Incorporate control logic into the current system that precludes operation of the carbon bed units in a parallel configuration. 28.3 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.	High Pre CD-4
LOP/LVP-29	There are no gas temperature monitoring instruments evident in the piping between adsorber units.	29.1 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).	Medium Pre CD-4
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.	30.1 Based on plant equipment modelling proposed in OFI 27.2, adjust operating procedures as needed to eliminate operating conditions that could initiate a carbon bed fire.	Medium Pre CD-4
LOP/LVP-31	It appears that the current OR model understates the potential impact of carbon bed operation on the calculated plant availability.	31.1 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.	Medium Pre CD-4
LOP/LVP-32	The presence of carbon fines represents a source of ignition has not been thoroughly analyzed.	32.1 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 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). 32.2 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.	Medium Pre CD-4
LOP/LVP-33	Maintaining personnel egress routes during carbon bed replacement activities may be challenging.	33.1 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 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.	Low Post CD-4
LOP/LVP-34	The mercury monitor represents a single point failure.	34.1 Install a duplicate mercury monitor.	Medium Pre CD-4
LOP/LVP-35	There appears to be inadequate isolation of carbon beds upon detection of a potential fire.	35.1 Expand the carbon bed isolation control system to include valves YV-0423A and YV-0423B, or YV-0423C.	Medium Pre CD-4
LOP/LVP-36	Shrinkage of the proposed guard bed particles could occur after loading.	36.1 The significance of this vulnerability should be indicated by the currently defined test program. 36.2 Consider investigating a guard bed material that begins as calcium carbonate.	Medium Pre CD-4
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.	37.1 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: a. 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. b. Periodic monitoring/purging of differential pressure/sample lines and addition of insulation to instrumentation lines prone to collecting condensate. c. Develop a dry air purge of bed discharge ports as part of the bed replacement procedure.	Medium Pre CD-4



Table B-1. Summary Vulnerability Listing. (41 pages)

LOP/LVP-38	No dedicated ports supporting the carbon bed loading bypass test were found.	38.1 Install or identify ports for challenge gas detection equipment installation.	Low Post CD-4
Item No.	Description	Opportunities for Improvement	Rank
LOP/LVP-39	The basis for carbon bed sizing appears to be uncertain.	39.1 Re-evaluate the Hg basis for the LAW facility flowsheet. Consider updating 24590-WTP-RPT-PR-01-011 as a means to reevaluate 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). 39.2 Re-evaluate and confirm the accuracy/adequacy of the sizing basis for the carbon beds.	Medium
LOP/LVP-40	Underestimation of TCO skid thermal cycling.	40.1 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. 40.2 Use the DCS to track thermal cycles of the equipment, if this is determined to be an important parameter for equipment longevity. 40.3 Consider opportunistic based periodic inspection of stress points to confirm that thermal cycling is not affecting equipment.	Low Post CD-4
LOP/LVP-41	Heat-up and cool-down temperature profiles for TCO skid not considered in OR model.	41.1 Consider the ability to invoke operational conditions/controls that would reduce the need to cool down the TCO skid. 41.2 Model the startup sequence of the LVP equipment to see if the 11 hr 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). 41.3 Conduct analysis to determine the maximum flow increase that can be accommodated by the electric heater to remain above the catalyst operating temperature. A new limit on flow rate increase may result.	Medium Pre CD-4
LOP/LVP-42	The viability of the current TCO maintenance approach and associated throughput impacts are indeterminate.	42.1 Complete evaluation of maintenance evolutions so impacts are understood and included in the OR model. 42.2 Determine the disposal paths for removed equipment (e.g. catalysts). 42.3 Generate plans for qualifying replaced or repaired equipment/components.	Medium Pre CD-4
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.	43.1 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. 43.2 Adding mechanical agitation to the vessel would improve mixing and may allow for automatic control in current configuration.	Low Post CD-4
LOP/LVP-44	There is no way apparent to remove an accumulation of insoluble solids, potentially, in LVPTK-00001 (caustic scrubber recirculation vessel).	44.1 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. 44.2 Consider periodic/opportunistic inspections to determine if solids are accumulating.	Low Post CD-4
LOP/LVP-45	The effects from other unit operations on the startup and shutdown of caustic scrubber have not been fully analyzed/determined.	45.1 Consider performing a system wide study/model on the effect of startup/shutdown of individual units has on the whole LOP/LVP system.	Medium Pre CD-4
LOP/LVP-46	There is no direct means evident to monitor the condition of packing or mist eliminators within the caustic scrubber.	46.1 Consider periodic/opportunistic inspections of packing integrity.	Low Post CD-4
I & C			
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.	IC-CO-01-OFI-01.1: Modify HMI objects to include all relevant information for equipment and instruments. Add English worded equipment status to all objects. (Stopped, Running, Failed etc.) IC-CO-01-OFI-01.2: Incorporate process relevant trends on overviews that include process goals and alarm/trip levels. IC-CO-01-OFI-01.3: 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. IC-CO-01-OFI-01.4: Perform assessment of current HMI configuration for all systems and implement NUREG-0700 recommendations for HMIs. Review other industry standards for HMIs including ASM Consortium recommendations for HMIs, OPTO 22 White Paper – Building an HMI that works and ASEE HMI Good Practices.	Medium Pre CD-4

Table B-1. Summary Vulnerability Listing. (41 pages)

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 nonstandard 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.	IC-CO-01-OFI-02.1: Implement single PI controllers logically for all instances of dual controllers for parallel devices into a common header with single process variable feedback. IC-CO-01-OFI-02.2: Remove all dual control faceplates from the HMI screens, CSLDs, CDIs and other related documentation prior to startup and commissioning. IC-CO-01-OFI-02.3: 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 operators to be successful in operating the system.	Medium Pre CD-4
<b>Item No.</b>	<b>Description</b>	<b>Opportunities for Improvement</b>	<b>Rank</b>
IC-CO-01-V-03	CLIN 3.2, Ref RPP-44491 3.8.7, 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.	IC-CO-01-OFI-03.1: 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.	Medium Pre CD-4
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.	IC-O-01-OFI-01: 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.	Medium Pre CD-4
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 of the HVAC system. Furthermore the startup is not sufficiently defined to establish steps for a coherent HVAC system startup.	IC-O-02-OFI-01.1: 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 are required to provide cascaded startup of the system. IC-O-02-OFI-01.2: 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 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.	Medium Pre CD-4
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.	IC-O-02-OFI-02.1: 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. IC-O-02-OFI-02.2: 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.	Medium Pre CD-4
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 and is still present system wide (not restricted to LAW systems).	IC-O-02-OFI-03.1: Eliminate all instances of independent PI control throughout the project (WTP in its entirety) as identified in CLIN 3.2, Table 2-16. IC-O-02-OFI-03.2: Simulate situation conforming to target environmental conditions to provide adequate proof of concept for control of parallel fans into a common header using new control scheme.	Medium Pre CD-4
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.	IC-O-02-OFI-04.1: 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. E.g. 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. IC-O-02-OFI-04.2: Expand error trapping for devices associated with fans to capture failures as soon as possible. E.g. 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.	Medium Pre CD-4
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.	IC-S-01-OFI-01.1: 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. IC-S-01-OFI-01.2: 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. IC-S-01-OFI-01.3: 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.	Medium Pre CD-4



Table B-1. Summary Vulnerability Listing. (41 pages)

IC-S-06-V-01	The 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.	IC-S-06-OFI-01.1: 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. IC-S-06-OFI-01.2: 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. IC-S-06-OFI-01.3: Eliminate the use of CSLDs as requirements for PPJ software development. They do not clearly define the requirements or their delineation from upper tier 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.	High Pre CD-4
<b>Item No.</b>	<b>Description</b>	<b>Opportunities for Improvement</b>	<b>Rank</b>
IC-S-07-V-01	Current life cycle documentation will be cumbersome to maintain and update during startup, commissioning and operations.	IC-S-07-OFI-01.1: 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.	Medium Pre CD-4
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 system software could result in extended implementation of NIST and DOE requirements.	IC-S-09-OFI-01.1: 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 Order 205.1B.	Medium Pre CD-4
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.	IC-S-10-OFI-01.1: 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. IC-S-10-OFI-01.2: Eliminate any ICN functions that are part of an SIS to establish a clear delineation between the safety systems and the plant control system.	High Pre CD-4
IC-S-02-V-01	The Integrated Control Network, the plant system control system, has been developed using an inappropriate quality assurance grading level because the software grade was determined incorrectly by not adequately considering all hazards and hazard controls.	The Opportunities for Improvement related to this vulnerability include: <ul style="list-style-type: none"> <li>IC-S-02-OFI-1.1: Define the ICN boundaries and interfaces, consistently and commiserate with the functions attributed to the ICN.</li> <li>IC-S-02-OFI-1.2: Define (or redefine) the WTP specific functions requirements 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.</li> <li>IC-S-02-OFI-1.3: 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.</li> <li>IC-S-02-OFI-1.4: 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.</li> </ul>	High Pre CD-4
<b>Confinement Ventilation Systems</b>			
HVAC-01-1	Instrument uncertainties are calculated incorrectly challenging instruments ability to work properly.	<input type="checkbox"/> 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 set points.	High Pre CD-4
HVAC-01-2	The C2/C3 DP monitor scheme, as currently designed, will not work.	<input type="checkbox"/> Perform a market search to find instrument with less uncertainty or raise the C2 depressions particularly in the rooms where DP Monitors are located.	High Pre CD-4
HVAC-02-4	Controlling parallel fans with two separate controllers results in unstable fan control.	<input type="checkbox"/> Use one control and split the signal between the two ASDs.	High Pre CD-4

Table B-1. Summary Vulnerability Listing. (41 pages)

HVAC-11-4	Risk of contamination backflow in a Swabbing/Finishing Line.	<input type="checkbox"/> Increase flow from swabbing cells to finishing line, provide airlocks when feasible, increase in-bleed filter capacity.	High Pre CD-4
HVAC-12-3	Zone C2 to C3 doors have less than 100 fpm.	<input type="checkbox"/> Make sure volumetric flow rate into C2/C3 areas is 100 fpm (minimum) through a single open door.	High Pre CD-4
HVAC-12-4 HVAC-31-6	No airflow parameter identified for the open doors between C3 and C5 zones.	<input type="checkbox"/> Provide at least 125 linear fpm through the open C3/C5 door to ensure adequate inflow to prevent the escape of contamination.	High Pre CD-4
HVAC-25-1 HVAC-25-2	C2 supply fan bypass not adequately evaluated and appears it will not work.	<ul style="list-style-type: none"> <li>• Provide a calculation of the BYPASS system to more adequately predict the ventilation parameters for the loss of power event.</li> <li>• Correct the V&amp;ID drawings to depict the anticipated air flow rates and pressure drops.</li> <li>• Reduce infiltration quantity to a minimum.</li> </ul>	High Pre CD-4

Item No.	Description	Opportunities for Improvement	Rank
HVAC-31-1	Lack of engineered controls for cell entries through subchanges.	<ul style="list-style-type: none"> <li>• Convert subchange 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.</li> <li>• Develop a system model to determine the impact of opening subchange doors.</li> <li>• 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.</li> <li>• Add positioning equipment to the cell doors and subchange 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.</li> <li>• Add engineered positioning equipment to the damper to position the damper automatically based on cell door position.</li> </ul>	High Pre CD-4
HVAC-31-2 HVAC-31-3	Life safety and emergency response issues related to subchanges	<ul style="list-style-type: none"> <li>• Convert subchange 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.</li> <li>• Convert subchanges to airlocks to eliminate the need to install breaker bars.</li> <li>• Install breaker bars on subchange doors.</li> </ul>	High Pre CD-4
HVAC-31-4	Subchange rooms too small to accommodate all personnel and equipment associated with typical entries.	<input type="checkbox"/> Convert subchange 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.	High Pre CD-4
HVAC-31-5	Cell entry doors to not have hose pass-throughs.	<input type="checkbox"/> Convert subchange 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.	High Pre CD-4
HVAC-31-8	Adjusting of subchange dampers along with opening and closing doors causes changes in the C5V flow.	<ul style="list-style-type: none"> <li>• Develop a ventilation system model to demonstrate the change in airflow and the impact on depression when adjusting subchange dampers and opening and closing cell entry doors.</li> <li>• Convert subchanges to airlocks where the cells are completely isolated from the corridors.</li> </ul>	High Pre CD-4
HVAC-31-9	Function of transfer duct between L-0108 and L 0109 (and L-0114 and L 0115) is not evaluated.	<ul style="list-style-type: none"> <li>• Develop a model to validate the current system configuration.</li> <li>• Provide evaluation to demonstrate the proper function of the transfer duct between rooms L-0108 and L-0109 (and L-0114 and L-0115).</li> </ul>	High Pre CD-4
HVAC-32-1	Airflow through canister import rollup doors is not included in the design.	<ul style="list-style-type: none"> <li>• 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.</li> <li>• Modify or replace rollup doors to eliminate leakage through the doors.</li> </ul>	High Pre CD-4
HVAC-32-2	Airflow through the canister import hatch has not been evaluated.	<input type="checkbox"/> 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.	High Pre CD-4



Table B-1. Summary Vulnerability Listing. (41 pages)

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.	<ul style="list-style-type: none"> <li>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.</li> <li>Modify or replace rollup doors to eliminate leakage through the doors.</li> </ul>	High Pre CD-4
HVAC-42-1	C5 exhaust fans are not sized based on the latest calculated exhaust temperatures at the exit of Pour Caves.	<ul style="list-style-type: none"> <li>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.</li> <li>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.</li> </ul>	High Pre CD-4
HVAC-44-2	Lack of redundant cooling in Buffer Storage and Canister Rework areas.	<ul style="list-style-type: none"> <li>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.</li> <li>Investigation and validation is required to ensure that ASTM (24590-WTP-DB-ENG-01-001) requirements are complied with for all Buffer Storage ventilation system which may be exposed to temperatures higher than 140<sup>o</sup> 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<sup>o</sup>F where applicable.</li> </ul>	High Pre CD-4

Item No.	Description	Opportunities for Improvement	Rank
HVAC-45-1 HVAC-46-1	Off-normal operations analysis not performed.	<input type="checkbox"/> Identify all possible off-normal conditions. <input type="checkbox"/> Provide evaluation for each off-normal condition to determine impact on facility depression and temperatures. This evaluation may include assessing C5V component capacities. <input type="checkbox"/> Provide facility modifications or work around to ensure facility confinement and temperature limits are satisfied. <input type="checkbox"/> Evaluate the impacts on the balance of plant chilled water system flow, pumps and power requirements. <input type="checkbox"/> Analyze the recovery mode after occurrence of an off-normal event with any control modifications and system hardware modifications if any.	High Pre CD-4
HVAC-48-1	Unverified cooling capacity for safety significant equipment rooms and Non-Safety Battery Rooms.	<input type="checkbox"/> 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. <input type="checkbox"/> Redesign the SS Units as necessary to meet the SS functional requirements.	High Pre CD-4
HVAC-51-1	Radial HEPA filters are not qualified for use.	<input type="checkbox"/> 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.	High Pre CD-4
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.	<input type="checkbox"/> Revise Radioactive Air Emissions Notice of Construction Permit Application for the Hanford Tank Waste Treatment and Immobilization Plant. <input type="checkbox"/> 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. <input type="checkbox"/> Design an enclosure to capture thermally hot hazardous chemical vapors to protect employees during removal of sample probes for inspection. <input type="checkbox"/> Add redundant stack sampling and monitoring systems so that maintenance can be performed while the standby system operates.	High Pre CD-4
HVAC-53-2	C5V air stream temperature exceeds stack monitoring equipment rating.	<input type="checkbox"/> Develop a computer simulation of the facility HVAC System and evaluate thermal loads going to the C5V exhaust system.	High Pre CD-4
HVAC-54-1	Low Flow ventilation design presents multiple inherent vulnerabilities.	<input type="checkbox"/> Develop remote decontamination techniques such as HEPA vacuum cleaners deployed from the overhead crane. <input type="checkbox"/> Prior to hot commissioning operations should perform detailed clean-up and inspect and repair any damage to cell coatings.	High Pre CD-4
HVAC-55-1	LAW C1V, C2V, C3V and C5V Cascade Low Air Flow HVAC System design causes the control system to be complex	<input type="checkbox"/> 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.	High Pre CD-4

Table B-1. Summary Vulnerability Listing. (41 pages)

HVAC-55-2	LAW HVAC control Systems are currently combined with 32 other process control systems.	<input type="checkbox"/> 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.	High Pre CD-4
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, cleanout & flushing and maintenance.	<input type="checkbox"/> 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.	High Pre CD-4
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).	<input type="checkbox"/> Re range the differential pressure transmitters to include a compound range. This would capture the magnitude of differential pressure reversals.	Medium Pre CD-4
HVAC-01-4 HVAC-02-5 HVAC-02-6 HVAC-03-1 HVAC-11-5 HVAC-24-1	Documentation Discrepancies.	<input type="checkbox"/> Review and fix documentation discrepancies.	Medium Pre CD-4
HVAC-02-1	C2V fan control will not work.	<input type="checkbox"/> 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.	Medium Pre CD-4
HVAC-02-2	Lack of safeguards against excessive depression.	<input type="checkbox"/> Add interlocks and or alarms to prevent excessive depression due to loss of control of the fan.	Medium Pre CD-4

Item No.	Description	Opportunities for Improvement	Rank
HVAC-02-3	As currently designed C3V Fan Control Pressure Transmitter (C3V-PDT-2117) will not work to control C3V depression.	<input type="checkbox"/> Place C3V-PDT-2117 in a C3 area or room that is exhausted by C3V.	Medium Pre CD-4
HVAC-02-7	Loss of Power results in C5V at a fixed speed rather than controlling flow or zone differential pressure.	<input type="checkbox"/> Determine the driving factors (heat removal, confinement etc.) for determining the fix speed value and establish the fixed speed value.	Medium Pre CD-4
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, resulting in excessive door opening pressures (life safety concern).	<input type="checkbox"/> 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. <input type="checkbox"/> If it's not feasible install breaker bar for each door exceeding force (above required) to set door in motion.	Medium Pre CD-4
HVAC-11-2	Low duct air velocities will result in deposition of radionuclides in the ductwork.	<input type="checkbox"/> 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.	Medium Pre CD-4
HVAC-11-3	Flow cascades directly from a C2 zone to a C5 zone through an inbleed.	<input type="checkbox"/> 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 inbleed.	Medium Pre CD-4
HVAC-12-1	Combustion and inhalation hazard not considered in establishing ventilation rates.	<input type="checkbox"/> 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.)	Medium Pre CD-4
HVAC-12-2	No HEPA filters on C5V exhaust duct inlet.	<input type="checkbox"/> Provide "Out-bleed" HEPA filtration for the primary confinement areas. Increase velocity in the exhaust ductwork.	Medium Pre CD-4
HVAC-12-5	1. Some areas in the LAW facility have been labeled as C2/C3 and as C3/C5 resulting in inconsistent application of design values.	<input type="checkbox"/> Establish ventilation zones in a three-tiered manner in conjunction with single zoning where the each zone based on the worst case scenario.	Medium Pre CD-4



Table B-1. Summary Vulnerability Listing. (41 pages)

HVAC-12-6	Potential for flow from C3 to C2 areas upon loss of power.	<input type="checkbox"/> 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).	Medium Pre CD-4
HVAC-12-7	C5 exhaust fans/motors could be undersized based on collective vulnerabilities.	<input type="checkbox"/> Evaluate all aspects affecting C5V exhaust fans size and capabilities.	Medium Pre CD-4
HVAC-21-1	Installed inbleed configurations cannot be verified to match pressure drop calculations.	<input type="checkbox"/> Compare "as built" Inbleed design to the original "as calculated design" and evaluate any changes that may affect performance.	Medium Pre CD-4
HVAC-21-2 HVAC-21-4 HVAC-21-6	Flow through inbleeds will decrease as inbleed filters load.	<input type="checkbox"/> 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 electro static precipitator (ESP). <input type="checkbox"/> Change C5 exhaust control from zone depression to zone flow.	Medium Pre CD-4
HVAC-21-3	Fire damper inspection and maintenance will result in bypassing the inbleed and may result in surges in C5 flow.	<input type="checkbox"/> Install "windows" on access doors for visual inspections. <input type="checkbox"/> Enlarge access doors to facilitate fire damper maintenance.	Medium Pre CD-4
HVAC-21-5	Inbleed filter loading affects HEPA filter differential pressure making it difficult to monitor HEPA filter loading.	<input type="checkbox"/> Modify Inbleed for automatic damper control, supply fan to eliminate the effect of filter loading or replace the filter with a electrostatic precipitator (ESP).	Medium Pre CD-4
HVAC-21-8	The INBLEED pressure drop calculation did not include dirty filter loading and additional sub-change damper DP.	<input type="checkbox"/> Consider alternate means of filtration such as ESPs or roll filters to minimize pressure drop through INBLEEDS.	Medium Pre CD-4
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.	<input type="checkbox"/> Strengthen room walls meet increased differential pressure requirements. <input type="checkbox"/> Install relief dampers to connect to outside atmosphere.	Medium Pre CD-4
HVAC-25-3	Zone pressure controls for cascading zone will be unstable.	<input type="checkbox"/> Revisit control strategy by utilizing branch dampers to provide pressure control for C2, C3 and C5 areas. <input type="checkbox"/> Modify INBLEED s for automatic control for filter loading replacing the pressure gauges.	Medium Pre CD-4
HVAC-25-4	LAW C2V Supply System Pressure Drop calculation error.	<input type="checkbox"/> Revise the pressure drop calculation for additional filter differential pressure for the supply fans.	Medium Pre CD-4
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.	<input type="checkbox"/> 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.	Medium Pre CD-4

Item No.	Description	Opportunities for Improvement	Rank
HVAC-31-7	Inbleeds don't function during entries.	<input type="checkbox"/> Convert subchanges to airlocks where the inbleed is located between the corridor and cell entry room. This would allow the inbleed to function continuously.	Medium Pre CD-4
HVAC-34-1	Lack of airlocks between rooms of different differential pressures may result in ventilation upsets.	<input type="checkbox"/> Add an airlock for accessing rooms LCB004 and L-B009. <input type="checkbox"/> Add an airlock for accessing rooms L-0117 from LC0109 and L-0119 from LC0111.	Medium Pre CD-4
HVAC-35-1	Lack of redundancy of C2V exhaust fans.	<input type="checkbox"/> Provide a calculation demonstrating the facility can continue in normal operation with a single operating C2V exhaust fan. <input type="checkbox"/> Install larger fans that have the capacity to provide full C2V exhaust flow with a single fan operating. <input type="checkbox"/> Install a backup fan. <input type="checkbox"/> Construct some sort of protection over the fans to prolong the operating life of the fans and motors.	Medium Pre CD-4
HVAC-35-2	C2 exhaust flow control method will not provide accurate flow control	<input type="checkbox"/> Switch C2 exhaust flow control from maintaining duct pressure to a using flow element	Medium Pre CD-4
HVAC-35-3	Lack of pre-filters to protect HEPA filters.	<input type="checkbox"/> Provide an evaluation to demonstrate why pre-filters are not necessary in the C2V exhaust airstream. <input type="checkbox"/> Modify the C2V exhaust system design to include pre-filters.	Medium Pre CD-4
HVAC-41-1	Lack of Deluge Spray System to protect the C5V HEPA from soot loading.	<input type="checkbox"/> Investigate if deluge spray system can be added to the current design if the HEPA Filter housings. <input type="checkbox"/> Investigate if the current Fire Suppression System reliability can be improved.	Medium Pre CD-4

Table B-1. Summary Vulnerability Listing. (41 pages)

HVAC-41-2	Lack of smoke dampers on inbleeds to protect C5V HEPA filters from soot loading.	<input type="checkbox"/> To make the design consistent with the PT and HLW, add smoke dampers and associated controls for the LAW in-bleed assemblies.	Medium Pre CD-4
HVAC-43-1	Ventilation System Evaluation not performed per the DOE Implementation Plan of DNFSB 2004-2 Recommendation.	<input type="checkbox"/> Recommend that the 2004-2 evaluation be performed for the LAW facility. <input type="checkbox"/> Based on the new 2004-2 evaluation reconcile any gaps which are identified.	Medium Pre CD-4
HVAC-44-1	Inadequate Buffer Storage and Canister Rework area cooling capacity for anticipated heat loads.	<input type="checkbox"/> 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. <input type="checkbox"/> 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.	Medium Pre CD-4
HVAC-47-1 HVAC-47-2	Lack of standby fan coil units in C2 and C3 airspaces.	<input type="checkbox"/> A 100% standby FCU is recommended for L0121 C2V Filter Room, L0317- C3V Fan Room, L0319A- C3V Filter Room, LB029C5V 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. <input type="checkbox"/> Evaluate the possibility of increasing the cascade airflow coming into spaces to offset heat loads during failure of the FCU. <input type="checkbox"/> Investigation and validation is required to ensure that ASTM requirements are complied with for all exhaust system which may be exposed to temperatures higher than 140 <sup>0</sup> F. External surface of Exhaust System components will be provided with adequate insulation to protect the workers from contact with hot surfaces.	Medium Pre CD-4
HVAC-51-2	C5V design may result in non-uniform loading of the multiple filter banks.	<input type="checkbox"/> Evaluate opportunities to install balancing dampers on the C5V exhaust.	Medium Pre CD-4
HVAC-51-3	Contamination traps in HEPA filter housings.	<input type="checkbox"/> Evaluate modifications that can be made to the filter housing to prevent build-up of contamination or cleaning the housing inner floor.	Medium Pre CD-4
HVAC-51-4	C5V design does not include the ability to balance air flow through filter housing.	<input type="checkbox"/> 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.	Medium Pre CD-4
HVAC-52-1	Radiation Source Term values are inconsistent and may require additional evaluation.	<input type="checkbox"/> 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.	Medium Pre CD-4
HVAC-52-2 HVAC-52-3	C5V HEPA Filter Radiation Source Term and filter operating parameters are not integrated for LAW operation.	<input type="checkbox"/> C5V HEPA Filter operating and replacement strategy needs to be developed for LAW Operation	Medium Pre CD-4
HVAC-52-4	Lack of HEPA filter replacement strategy for LAW commissioning.	<input type="checkbox"/> C5V HEPA Filter replacement strategy needs to be developed for LAW commissioning and startup. Ducting needs to be inspected for debris removal before startup testing is performed.	Medium Pre CD-4

Item No.	Description	Opportunities for Improvement	Rank
HVAC-03-2	Temperature Controller does not meet +/-3°F control tolerance required by System Description.	<input type="checkbox"/> Evaluate the design requirements to determine if a broader range of control is acceptable.	Low Post CD-4
HVAC-21-7	Inbleed back draft dampers cannot be checked for leakage.	<input type="checkbox"/> Redesign Inbleed to facilitate back draft damper testing.	Low Post CD-4
HVAC-22-1 HVAC-22-2	C5V fan motor, bearings, and adjustable speed drive may exceed rated temperatures.	<ul style="list-style-type: none"> <li>• Evaluate temperatures and heat transfer effect on fan motor, fan bearings and ASD.</li> <li>• Move ASDs to corridor and away from heat sources.</li> <li>• Provide supplemental cooling to the ASD's and fan motors.</li> <li>• Convert fan bearing lubricant from grease to oil.</li> </ul>	Low Post CD-4
HVAC-23-2	Lack of filters in the C2V bypass duct.	<input type="checkbox"/> Install means of filtration for bypass duct such as an ESP.	Low Post CD-4



Table B-1. Summary Vulnerability Listing. (41 pages)

HVAC-42-2	C5V duct and equipment burn hazards.	<input type="checkbox"/> 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° F. External surface of will be provided with adequate insulation to protect the workers from contact with hot surfaces, where applicable.	Low Post CD-4
HVAC-44-3	Contamination trap in buffer storage cooling ductwork section.	<input type="checkbox"/> Redesign the ducting arrangement for the Buffer Storage Area FCU to avoid accumulation of radiological contamination.	Low Post CD-4
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.	<input type="checkbox"/> Revise the current Code Compliance Matrix to include SS Air Conditioning Units and their compliance in a timely manner for WDOH approval.	Low Post CD-4
<b>Electrical Distribution System</b>			
ROR-ELEC-1: Vulnerability #4, #5, and #6	The ITS UPS units: # UPE-UPS-20301, -20302, and -20303 are undersized for design demand load.	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.	High Pre CD-4
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 <u>full UPS rated</u> output for the required run time as directed by 24590-WTP-DB-ENG-01-001 Section 8.4.11. 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.	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.	High Pre CD-4
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 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.	High Pre CD-4
ROR-ELEC-2: Vulnerability #1	Elevated ambient temperatures negatively impact electrical equipment operation.	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.	High Pre CD-4
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.	Re-evaluate bus amperage rating for identified high risk areas. Provide supplemental cooling if justified.	High Pre CD-4
ROR-ELEC-2: Vulnerability #4	No evidence of final NRTL listing and labeling exists for the melters.	Obtain final NRTL Field Evaluation product mark or procure equipment with the NRTL listing and labeling.	High Pre CD-4
ROR-ELEC-3: Vulnerability #1	No spare melter power supply capacity.	The review team recommends BNI install output inverter and transformer units in each of the spare compartments of each power supply’s lineups.	High Pre CD-4
<b>Item No.</b>	<b>Description</b>	<b>Opportunities for Improvement</b>	<b>Rank</b>
ROR-ELEC-3: Vulnerability #2	Melter power supply component isolation is inadequate.	The review team recommends that BNI evaluate the worker safety requirements for these areas and develop barriers, procedures, or alternate isolation points.	High Pre CD-4
ROR-ELEC-3: Vulnerability #4	No evidence of final NRTL listing and labeling exists for the melter power supplies MVEPSUP-20001 and -20002.	Obtain final NRTL Field Evaluation product mark or procure equipment with the NRTL listing and labeling.	High Pre CD-4

Table B-1. Summary Vulnerability Listing. (41 pages)

ROR-ELEC-3: Vulnerability #5	No Melter Standby Power provided.	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 MVESWGR-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 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.	High Pre CD-4
ROR-ELEC-4: Vulnerability #1	Low Voltage Release.	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.	High Pre CD-4
ROR-ELEC-1: Vulnerability #1	AHJ and NEC inspection Role performed by BNI Design Project personnel.	The review team feels that an independent AHJ and inspection program should be considered by DOE.	Medium Pre CD-4
ROR-ELEC-1: Vulnerability #2	Lack of Conduit Schedules and Wire Run drawings.	The review teams recommend that DOE attempt to negotiate procurement of the SetRoute software from Bechtel.	Medium Pre CD-4
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.	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.	Medium Pre CD-4
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.	See OFI on ROR-ELEC-1 Vulnerability #4 and #5 above.	Medium Pre CD-4
ROR-ELEC-1: Vulnerability #13	UPE-UPS-20301, -20302, and -20303 feeder conductors undersized for UPS full load currents and battery recharge currents.	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.	Medium Pre CD-4
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.	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.	Medium Pre CD-4
ROR-ELEC-1: Vulnerability #15	General Systemization Layout of MCCs.	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.	Medium Pre CD-4
ROR-ELEC-1: Vulnerability #17	ITS UPS units not qualified for DBE flood conditions of 0.92 ft. of water.	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.	Medium Pre CD-4
ROR-ELEC-2: Vulnerability #3	Single phase AC Bus passes thru ferrous metal enclosure, creating magnetic heating.	The review team recommends BNI perform a review of all single phase conductors for inappropriately placed magnetic material.	Medium Pre CD-4
ROR-ELEC-3: Vulnerability #6	Melter Power Supply Grounding.	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.	Medium Pre CD-4
ROR-ELEC-4: Vulnerability #3	There is not currently a formal "Code of Record" for the Waste Treatment Plant.	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.	Medium Pre CD-4
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.	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.	Medium Pre CD-4
ROR-ELEC-1: Vulnerability #3	General Drawing Discrepancies.	The review team recommends correction of drawing errors.	Low Post CD-4

Item No.	Description	Opportunities for Improvement	Rank
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Table B-1. Summary Vulnerability Listing. (41 pages)

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.	The design review team recommends finalizing hydrogen ventilation calculations to ensure VRLA potential off gassing is alleviated or add hydrogen monitoring if required.	Low Post CD-4
ROR-ELEC-2: Vulnerability #5	Grounding & Isolation of electrical equipment around melter glass pool not adequately demonstrated or documented.	The review team recommends BNI perform grounding inspection and testing prior to operation to correct any discrepancies.	Low Post CD-4
ROR-ELEC-2: Vulnerability #6	Project Documentation may not be accurate, or may be obsolete and not marked as canceled or superseded.	Eliminate documentation errors to improve system performance.	Low Post CD-4
ROR-ELEC-3: Vulnerability #3	Current Transformers (CT1s) do not support individual electrode current control in present configuration.	The review team recommends BNI evaluate the recent CT installation configuration to determine if it is complete and incorporated into the control system.	Low Post CD-4
ROR-ELEC-4: Vulnerability #2	Facility Power Study Input Files not in Hanford standard software.	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.	Low Post CD-4
<b>Radiological Control and Industrial Safety</b>			
RC-1-V001	Potential for Contamination to Migrate Due to Adjacent Contamination Zones and Low Flow Ventilation Design.	<ul style="list-style-type: none"> <li>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.</li> <li>The Project should define anticipated airborne levels to be anticipated in the facility and mitigating controls.</li> <li>The Project should evaluate the use of a mock up facility for work evolutions where potential for significant dose can result.</li> </ul>	High Pre CD-4
RC-1-V-002	Inability to Meet Contamination Control Limits for Container Release.	<ul style="list-style-type: none"> <li>Develop a technical basis that documents statistical representative sampling and equivalency of surveying at 500 cm<sup>2</sup> vs. 100 cm<sup>2</sup> (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.</li> <li>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.</li> </ul>	High Pre CD-4
RC-1-V-003	Radiation Doses to Personnel are Undetermined for Operations, Maintenance and Waste Management Activities	<ul style="list-style-type: none"> <li>Accelerate the identification and definition of Operation, Maintenance, and Waste Management tasks and then revise the dose assessment report to accurately reflect anticipated dose.</li> <li>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.</li> <li>Reconsider whether the contract limit of 500 mR/hr for the container will allow for contact-handled work (for both Operations and Maintenance).</li> </ul>	High Pre CD-4
RC-1-V-004	Inability to Effectively Perform Hands-On Maintenance Activities.	<ul style="list-style-type: none"> <li>Accelerate the evaluation of Maintenance and Operational evolutions to understand hazards, mitigation techniques, and ability to perform required tasks.</li> <li>Evaluate the ability to remotely perform Maintenance tasks (such as spray nozzle replacement). If not possible, identify alternative methods for maintenance.</li> <li>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.</li> </ul>	High Pre CD-4

Table B-1. Summary Vulnerability Listing, (41 pages)

SH-1-V-001	Insufficient Evidence of Compliance with Operational Safety and Health Requirements in Design.	<ul style="list-style-type: none"> <li>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.</li> <li>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).</li> </ul>	High Pre CD-4
<b>Item No.</b>	<b>Description</b>	<b>Opportunities for Improvement</b>	<b>Rank</b>
SH-1-V-002	Inadequate Implementation of the Hazards Analysis Process.	<ul style="list-style-type: none"> <li>BNI should define and document the chemical source term coming into the LAW and document for current and future use.</li> <li>As part of 24590-WTP-PIER-MGT-13-0964 the Project has drafted a CAP that includes a corrective action to develop a formal process that requires engineering and ES&amp;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).</li> <li>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).</li> <li>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.</li> </ul>	High Pre CD-4
SH-1-V-003	Deficient Exposure Assessments for Operational and Maintenance Activities.	<ul style="list-style-type: none"> <li>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.</li> <li>It is recommended the Project identify key Operational and Maintenance Activities and incorporate into qualitative exposure assessments.</li> <li>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.</li> </ul>	High Pre CD-4
SH-1-V-004	Potential Weakness in the Systematic Analysis of Thermal Stress/Heat Hazards to Personnel.	<p>□ 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 (i.e. biological monitoring, medical determination of fitness, hydration requirements, etc.).</p>	High Pre CD-4
<b>LSH System</b>			
LSH-F-28-V-01	Configuration Management is inadequate.	<p>LSH-F-28-OFI-01.1: 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.</p> <p>LSH-F-28-OFI-01.2: Revise configuration management system to ensure that:</p> <ul style="list-style-type: none"> <li>only current revisions of documents are retrievable (with exception for historical reviews)</li> <li>controlling documents are identified and maintained current</li> <li>applicable documentation is associated to and retrievable by the system designation and/or the equipment number.</li> </ul>	High Pre CD-4



Table B-1. Summary Vulnerability Listing. (41 pages)

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.	LSH-M-14-OFI-15.1: Develop a secure method to stabilize the spray nozzle CCB on the melter surface. LSH-M-14-OFI-15.2: Design and utilize a gamma-gate and closed changeout box that is compatible with the spray nozzle. LSH-M-14-OFI-15.3: Develop a methods and additional equipment to maximize efficiency and minimize personnel hazards. LSH-M-14-OFI-15.4: Modify spray nozzle CCB and lift method to maintain containment during spray nozzle changeout. LSH-M-14-OFI-15.5: Design and procure a ladder or platform to access the spray nozzle support plate and lid assembly.	High Pre CD-4
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.	LSH-M-14-OFI-16: 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.	Medium Pre CD-4
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.	LSH-F-18-OFI-04: Complete an independent external integrated design review of all LAW systems.	High Pre CD-4

Item No.	Description	Opportunities for Improvement	Rank
LSH-S-08-V-01	PIER process is inadequate for tracking issues found in earlier reviews.	LSH-S-08-OFI-01: 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.	Medium Pre CD-4
LSH-W-07-V-05	Inadequate Lift Capability in Consumables Import/Export Area.	LSH-W-07-OFI-05: Revise design to add a swing jib crane and specified laydown space for the spent consumable transport boxes.	Medium Pre CD-4
LSH-M-14-V-09	Temperature limitations of the bubbler neoprene rubber air supply port gasket and Super OLube silicone grease are incompatible for expected bubbler port environment.	LSH-M-14-OFI-09: Determine anticipated temperatures in the vicinity and resulting temperatures of the bubbler air supply port gasket and utilize appropriate materials.	Medium Pre CD-4
LSH-M-14-V-08	No criteria or specs have been found for: <ul style="list-style-type: none"> <li>• Inspection of the bubbler air supply ports during changeout,</li> <li>• Application of the Super O-Lube silicone grease,</li> <li>• Installation of the neoprene gasket,</li> <li>• Verification of proper operation of the bubbler air supply.</li> </ul>	LSH-M-14-OFI-08.1: Define specifications for application of Super O-Lube lubricant and installation of the neoprene gasket on the bubbler air supply port. LSH-M-14-OFI-08.2: Develop means to verify proper operation of new bubblers after installation.	Medium Pre CD-4
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.	LSH-F-11-OFI-05.1: Time maintenance accordingly with delivery of consumables. LSH-F-11-OFI-05.2: Evaluate different methods of importing and exporting consumables to allow access to the hatch during maintenance of LSH process crane.	Low Post CD-4
LSH-F-09-V-01	Lack of info on the operation and failure modes of the Component Carrier (grapple for consumables).	LSH-F-09-OFI-01: Attain more information and operational understanding of the Component Carrier.	Low Post CD-4
LSH-F-01-V-01	Issues found by the review of DOE-HBK-1132-99 are issues that should be resolved by using this or a similar best practices handbook.	LSH-F-01-OFI-01: It is recommended that a best practices handbook be established and followed to limit amount of design errors.	Medium Pre CD-4
LSH-F-11-V-01	The current bubbler crate width (12') will not fit through the entrance door into the truck bay (12').	LSH-F-11-OFI-01.1: Unpack bubblers at a different location and design a custom bubbler carrier to transfer consumables for delivery to System LSH. LSH-F-11-OFI-01.2: 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.	Low Post CD-4

Table B-1. Summary Vulnerability Listing. (41 pages)

LSH-F-11-V-02	Truck bay crane capacity (10 ton) will not be able to lift current bubbler crate (13.5 ton).	LSH-F-11-OFI-02.1: Unpack bubblers at a different location and design a custom bubbler carrier to transfer consumables for delivery to System LSH. LSH-F-11-OFI-02.2: 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.	Low Post CD-4
LSH-F-11-V-03	The current bubbler crate width (12') may or may not fit onto the width of the unloading platform (~12').	LSH-F-11-OFI-03.1: Unpack bubblers at a different location and design a custom bubbler carrier to transfer consumables for delivery to System LSH. LSH-F-11-OFI-03.2: 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.	Low Post CD-4
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).	LSH-F-11-OFI-04.1: Unpack bubblers at a different location and design a custom bubbler carrier to transfer consumables for delivery to System LSH. LSH-F-11-OFI-04.2: 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.	Low Post CD-4
LSH-M-14-V-12	One gamma gate per two melter will not be sufficient to support anticipated plant operations.	LSH-M-14-OFI-12: Re-evaluate gamma gate usage and consider a second gamma gate for active use or as a spare.	Low Post CD-4
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.	LSH-M-14-OFI-11: Define criteria for gamma gate engineered air gap and determine impact of turbulent air flow on the spread of contamination.	Medium Pre CD-4
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.	LSH-M-14-OFI-05.1: Define critical attributes and requirements for all equipment. LSH-M-14-OFI-05.2: Conduct equivalency analyses for all substitute equipment.	Medium Pre CD-4
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.	LSH-M-14-OFI-10: Define criteria for Kevlar strap and document on a Mechanical Data Sheet.	Medium Pre CD-4

Item No.	Description	Opportunities for Improvement	Rank
LSH-F-17-V-01	Normal System LSH maintenance evolutions will significantly impact production.	LSH-F-17-OFI-01.1: Establish a detailed task analysis that addresses industrial safety, radcon, operational, and staffing issues to evaluate impact on production. LSH-F-17-OFI-01.2: 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.	High Pre CD-4
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.	LSH-F-17-OFI-04: 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.	Medium Pre CD-4
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.	LSH-F-17-OFI-03: 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.	Medium Pre CD-4
LSH-F-17-V-02	Serious contamination releases will result in significant production interruptions.	LSH-F-17-OFI-02: Develop a remotely operated method to change melter consumables while maintaining confinement to the C5V annulus.	Medium Pre CD-4
LSH-F-26-V-01	Melter containment has not been demonstrated during melter maintenance evolutions.	LSH-F-26-OFI-01.1: 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. LSH-F-26-OFI-01.2: 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.	High Pre CD-4
LSH-W-07-V-04	Hazard Analyses and ALARA Reviews are inadequately addressed for spent consumable handling.	LSH-W-07-OFI-04: Perform hazards analyses and ALARA Reviews; redesign system LSH as required to mitigate industrial and radiological hazards.	Medium Pre CD-4
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, CCB lid/interior, gamma gate or bagging station surfaces. Methods and equipment for decontaminating the interior of the CCB have not been provided.	LSH-M-14-OFI-07.1: Develop tools and processes for removing glass from melter and equipment surfaces including subsequent decontamination and inspection. LSH-M-14-OFI-07.2: Evaluate the radiological issues associated with the CCB and provide capability to decontaminate the interior of the CCB if necessary.	Medium Pre CD-4



Table B-1. Summary Vulnerability Listing. (41 pages)

LSH-M-14-V-14	Sufficient details regarding bagging station operations are not available, and the disposition of radioactive bagging station waste not defined.	LSH-M-14-OFI-14: Develop processes and procedures for bagging station operations and radioactive waste disposition. A thermal sealing method should be considered.	Medium Pre CD-4
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.	LSH-F-20-OFI-03.1: Designate storage areas for tools and equipment. LSH-F-20-OFI-03.2: Provide controlled designated storage space for contaminated equipment	Low Post CD-4
LSH-M-14-V-02	There are insufficient funds & resources allocated to address; <ul style="list-style-type: none"> <li>• Equipment obsolescence</li> <li>• Equipment preservation and degradation</li> <li>• Equipment re-inspection, refurbishment and/or replacement effort that will be required (9) months prior to startup.</li> </ul>	LSH-M-14-OFI-02: Develop long term funding and plans that address obsolescence, warranties, and replacement or refurbishment for all equipment procured.	High Pre CD-4
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.	LSH-M-14-OFI-04: Develop schedules for periodic maintenance activities and procure critical spare parts and consumables to be held in-stock to support commissioning and startup activities.	High Pre CD-4
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.	LSH-F-18-OFI-02: Align procedure completion date, including validation and approval, with the date needed for training purposes.	Medium Pre CD-4
LSH-M-13-V-03	Equipment and methods for replacement of "life of melter" components have not been provided.	LSH-M-13-OFI-03.1: Develop engineered tools, equipment, and procedures for replacement of "life of melter" components. LSH-M-13-OFI-03.2: Procure and maintain "life of melter" components in spares inventory, and equipment necessary for changeout.	Medium Pre CD-4
LSH-F-21-V-01	System LSH will need defined interfaces with other systems, which are not documented in the system description.	LSH-F-21-OFI-01: 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.	Medium Pre CD-4

Item No.	Description	Opportunities for Improvement	Rank
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.	LSH-M-16-OFI-01: Identify maintenance equipment failure modes and accidents prior to plant operation.	Medium Pre CD-4
LSH-M-13-V-07	Equipment testing needs to be done in applicable thermal environment.	LSH-M-13-OFI-07: Test equipment in expected environmental conditions with range of exposure times to verify equipment operation and to establish constraints on operations, as applicable.	Medium Pre CD-4
LSH-W-19-V-01	Failed or spent LAW melter may not meet the requirements of the Hanford Dangerous Waste Permit.	LSH-W-19-OFI-01: Clarify the conditions to satisfy for successful LAW melter disposal when transitioning from construction permit to the start-up/commissioning/operating permit.	Low Post CD-4
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.	LSH-M-14-OFI-13: Design, procure and install thread protector inserts/caps on all unused alignment holes in the melter surface.	Low Post CD-4
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.	LSH-F-10-OFI-01.1: All LSH area environmental conditions should be clearly defined and documented.	Medium Pre CD-4
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.	LSH-W-07-OFI-01: 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.	Medium Pre CD-4

Table B-1. Summary Vulnerability Listing. (41 pages)

LSH-W-07-V-03	Spent melter consumables and other secondary wastes are packaged for transportation but not for disposal.	LSH-W-07-OFI-03: 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.	Medium Pre CD-4
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.	LSH-S-15-OFI-01: Incorporate maintenance best practices into procedures and processes early and incorporate the conclusions into the design.	Medium Pre CD-4
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 expectations for glass production rates have not been established. Previously captured in CLIN 3.2 (see RPP-50775) and not yet resolved.	LSH-F-18-OFI-03: Develop realistic expectations for glass production rates, using detailed task breakdowns.	Medium Pre CD-4
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.	LSH-M-14-OFI-03: Realistically model and evaluate anticipated O&M activities. Non-routine ops should be modeled and evaluated as well.	Medium Pre CD-4
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.	LSH-M-14-OFI-01: Develop long term preservation maintenance requirements and plans for all equipment in storage and upon receipt of new equipment.	Medium Pre CD-4
LSH-F-20-V-05	Inadequate permitted waste storage area.	LSH-F-20-OFI-05: 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.	Medium Pre CD-4
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.	LSH-W-07-OFI-02.1: 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. LSH-W-07-OFI-02.2: Delete on-board air supply system from the bubbler design.	Low Post CD-4
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.	LSH-M-13-OFI-02: 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.	Low Post CD-4
LSH-M-13-V-04	Capability to move equipment from the melter gallery to the contaminated equipment (C3) maintenance room has not been provided.	LSH-M-13-OFI-04: Provide monorail or other means of lifting equipment from the melter gallery operating deck (19' el) to the 28' el.	Low Post CD-4
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.	LSH-M-13-OFI-01: 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.	Low Post CD-4

Item No.	Description	Opportunities for Improvement	Rank
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.	LSH-F-20-OFI-02.1: Provide conduit to import and export stations for the CCB, with junction and short umbilical jumpers for the CCB near the gate. LSH-F-20-OFI-02.2: Provide umbilicals on swing booms or similar to the CCB and gamma gate when installed on the melter.	Low Post CD-4
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.	LSH-F-20-OFI-01.1: Provide platforms at the import and export stations. LSH-F-20-OFI-01.2: Provide rolling/moving platform for use on the melter.	Low Post CD-4
LSH-F-20-V-04	The design of the consumables cart requires use of fall protection.	LSH-F-20-OFI-04: Verify required operations are consistent with provisions provided.	Low Post CD-4
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.	LSH-CO-24-OFI-01: Define workspace environment and include in operations and maintenance procedures.	High Pre CD-4
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.	LSH-F-18-OFI-01: 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.	High Pre CD-4



Table B-1. Summary Vulnerability Listing. (41 pages)

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 telecon with VSL. Failure of all bubblers within a single melter will result in loss of temperature control in respective melter.	LSH-CO-24-OFI-04.1: Revisit the 30 minute response assumption for operators regarding restoration of ISA or electrical service for reasonableness and validate the assumption by test. LSH-CO-24-OFI-04.2: Develop procedures and training regarding loss of ISA. LSH-CO-24-OFI-04.3: Identify the supply of back-up air. Identify proper air fittings and hardware to accommodate the supply of back- up air. LSH-CO-24-OFI-04.4: Identify the connection to the ISA for the back-up air supply.	High Pre CD-4
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 CCBs).	LSH-CO-24-OFI-03: Take necessary steps to incorporate key principles of industry best practice to ensure operator response to normal evolutions.	Medium Pre CD-4
LSH-S-06-V-01	Conduct of Operations Principles have not been adequately factored into the facility.	LSH-S-06-OFI-01 Greater attention needs to be paid to incorporating Conduct of Operations principles into the design and logistics of the facility. A simulation/mockup facility would aid in alleviating some of the concern. (see LSH-S-12-OFI-01)	Medium Pre CD-4
LSH-S-12-V-01	Lack of a simulation, mockup, training facility increases the risk of error in performing new and/or complicated evolutions.	LSH-S-12-OFI-01: Identify or construct a facility that can be used to simulate, mockup, and train on evolutions to be performed.	Medium Pre CD-4
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, spread of contamination and radiation exposure.	LSH-CO-24-OFI-05: Review the design philosophy for this and other omissions in the LAW design and modify design as necessary.	Medium Pre CD-4
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.	LSH-CO-24-OFI-02: Identify rotational requirements. Make appropriate modifications/markings on equipment that require rotational orientation.	Low Post CD-4
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.	LSH-M-13-OFI-06: Provide crane indexing capability; preferably auto-indexing capability.	Low Post CD-4

Item No.	Description	Opportunities for Improvement	Rank
<b>LPH System</b>			
LPH-IC-1-V001	There are many inconsistencies between the requirements documents such as the Mechanical Sequence Diagram 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.	LPH-IC-1-OFI001: □ 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.	Medium Pre CD-4

Table B-1. Summary Vulnerability Listing. (41 pages)

LPH-IC-1-V002	Alarms and Interlocks for Elevator position mis-match not described on the Mechanical Handling Diagram can lead to loss of configuration control.	LPH-IC-1-OFI002: □ 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.	Medium Pre CD-4
LPH-IC-1-V003	ICN Screens don't use equipment noun names.	LPH-IC-1-OFI003: Revise the ICN screens to use labels that are consistent with facility documentation.	Low Post CD-4
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.	LPH-IC-2-OFI001: 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.	Medium Pre CD-4
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-LPH02016002/02017002/02018002/02019002. These changes were not made.	LPH-IC-2-OFI002: 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.	Medium Pre CD-4
LPH-HST-1-V001	LAW Pour Cave Hoist Data Sheet Inconsistencies.	LPH-HST-1-OFI001: 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 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.	Low Post CD-4
LPH-HST-1-V002	LAW Pour Cave Hoist Capacity Inadequacy.	LPH-HST-1-OFI002: 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.	Medium Pre CD-4
LPH-HST-1-V003	LAW Pour Cave Hoist High Hook Limit Related to Preliminary Container Recovery Frame Design.	LPH-HST-1-OFI003: 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.).	Low Post CD-4
LPH-HST-1-V004	LAW Pour Cave Hoist Design Temperature Inconsistencies.	LPH-HST-1-OFI004: 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.	Medium Pre CD-4
LPH-HST-1-V005	Hoist Specification Requirement Deficiencies.	LPH-HST-1-OFI005: 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.	Medium Pre CD-4
LPH-HST-1-V006	LAW Pour Cave Trolley Recovery Design Inadequacies.	LPH-HST-1-OFI006: 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.	Medium Pre CD-4
LPH-HST-1-V007	LAW Pour Cave Hoist Recovery Design Inadequacies.	LPH-HST-1-OFI007: 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.	Medium Pre CD-4

Item No.	Description	Opportunities for Improvement	Rank
LPH-HST-1-V008	LAW Pour Cave Hoist FAT Test Deficiencies.	LPH-HST-1-OFI008: 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.	High Pre CD-4
LPH-HST-1-V009	Monorail Hoist Maintenance Platform Inadequacies.	LPH-HST-1-OFI009: 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.	Medium Pre CD-4



Table B-1. Summary Vulnerability Listing. (41 pages)

LPH-BFSTR-1-V001	Insufficient shield door design basis.	LPH-BFSTR-1-OFI001: 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.	Medium Pre CD-4
LPH-BFSTR-1-V002	Additional interlocks needed for transfer corridor shield doors.	LPH-BFSTR-1-OFI002: 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.	Low Post CD-4
LPH-BFSTR-1-V003	Additional cameras needed in container export area.	LPH-BFSTR-1-OFI003: Install two additional cameras, located in the container transfer corridor, to provide an elevation view of the container export position.	Medium Pre CD-4
LPH-BFSTR-1-V004	Incorrect buffer storage and finishing line container import temperature.	LPH-BFSTR-1-OFI004: 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 out puts should be used to refine operating limitations, insulation configurations, and HVAC cooling air profiles.	High Pre CD-4
LPH-BFSTR-1-V005	Insufficient Buffer Storage CFD analysis.	LPH-BFSTR-1-OFI005: Clearly define the container temperature profile, for all operating modes, prior to containers entering temporary storage. Update CFD model 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.	High Pre CD-4
LPH-BFSTR-1-V006	Excessive buffer crane operating temperature.	LPH-BFSTR-1-OFI006: 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.	Medium Pre CD-4
LPH-BFSTR-1-V007	Insufficient Buffer Storage Capacity.	LPH-BFSTR-1-OFI007: Expand the container buffer storage area by one of the following; <ul style="list-style-type: none"> <li>• Increase buffer storage by facility design modifications to expand area designated for container storage both long and short term.</li> <li>• 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.</li> <li>• 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.</li> </ul>	Medium Pre CD-4
LPH-TOOL-1-V001	Inadequate design basis documentation.	LPH-TOOL-1-OFI001: Revise design and fabrication documentation to ensure accurate and as-built information.	Low Post CD-4
LPH-TOOL-2-V001	Inconsistent grapple load rating.	LPH-TOOL-2-OFI001: Increase the grapples safe working load design to 25,000 lbs. to handle all container conditions.	Low Post CD-4
LPH-TOOL-2-V002	LAW production container volume, weight, and center of gravity calculation, 24590-LAWM0C-LRH-00004, does not include an Overpack condition.	LPH-TOOL-2-OFI002: 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.	Low Post CD-4
LPH-TOOL-2-V003	Grapple temperature limitations.	LPH-TOOL-2-OFI003: 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.	Low Post CD-4
LPH-TOOL-2-V004	Grapple excessive load testing.	LPH-TOOL-2-OFI004: Revise BNI procurement process to ensure vendors test equipment according to contractual documentation and that all requirements are consistent between documents.	Low Post CD-4
LPH-TOOL-2-V005	Design requirement not verified in factory acceptance testing.	LPH-TOOL-2-OFI005: The requirement should be validated during start-up testing to ensure these critical characteristic are met.	Low Post CD-4
LPH-TOOL-2-V006	Requirements for factory acceptance testing not fully being performed.	LPH-TOOL-2-OFI006: All required performance design requirement should be performed as part of an additional FAT or demonstrated through analysis.	Low Post CD-4

Item No.	Description	Opportunities for Improvement	Rank
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Table B-1. Summary Vulnerability Listing. (41 pages)

LPH-BSMF-1-V001	Container Recovery Lifting Frame issues.	LPH-BSMF-1-OFI001: 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.	High Pre CD-4
LPH-BSMF-1-V002	Transfer of ILAW container and Lower Overpack from the Container Transfer Corridor to LFH issue.	LPH-BSMF-1-OFI002: 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.	High Pre CD-4
LPH-BSMF-1-V003	Buffer Store Maintenance Facility Crane (LPH-CRN-00001) issues.	LPH-BSMF-1-OFI003: Prepare a document that evaluates potential loads to be lifted by the maintenance crane.	Low Post CD-4
LPH-OR-1-V001	CCN 068381, LAW Facility LPH System - RAM Assessment and Basis, recovery logic inconsistent with equipment operability.	LPH-OR-1-OFI001: 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.	Medium Pre CD-4
LPH-OR-1-V002	24590-CM-POA-MJG-00003-15-01, Failure Mode, Effects, Reliability, Maintainability, and Criticality Analysis, inconsistencies.	LPH-OR-1-OFI002: 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.	Medium Pre CD-4
LPH-OR-1-V003	Inconsistencies in the MTBF data for the Buffer Store Crane.	LPH-OR-1-OFI003: 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.	Low Post CD-4
LPH-OR-1-V004	24590-WTP-MDD-PR-01-001, Operations Research (WITNESS) Model Design Document, inconsistencies.	LPH-OR-1-OFI004: Revise the OR Model to be consistent with the current sequencing and handling strategy.	Low Post CD-4
LPH-CPS-1-V001	Potentially insufficient design margin for working load capacity of Container Park/Export Stands.	LPH-CPS-1-OFI001: 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 simulated Container bottom for the possible higher working load.	Medium Pre CD-4
LPH-CPS-1-V002	Durability of Park/Export Stand thermal insulation material over a 40-year operating life is not documented.	LPH-CPS-1-OFI002: 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.	Low Post CD-4
LPH-CPS-1-V003	Design of the manufactured Container Park/Export Stands may result in unnecessarily complex maintenance.	LPH-CPS-1-OFI003: Modify the existing Park/Export Stands prior to commissioning to provide a way to facilitate the replacement of the insulation material blocks.	Low Post CD-4
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.	LPH-CPS-1-OFI004: 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.	Low Post CD-4
LPH-CPS-1-V005	The truncated Container Export Stands will provide an insufficient thermal protection of the concrete floor below.	LPH-CPS-1-OFI005: 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.	Medium Pre CD-4
LPH-CPS-1-V006	FAT Test of the Container Park/Export Stands was not conducted in a representative temperature configuration.	LPH-CPS-1-OFI006: 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.	Low Post CD-4
LPH-CPS-1-V007	Lack of calculations to support the design and validate the performance of the fabricated Container Park/Export Stands.	LPH-CPS-1-OFI007: 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.	Low Post CD-4
LPH-CTB-1-V001	Bogie thermal shield design differences between the Design Proposal Drawing and the fabricated Bogies are not documented.	LPH-CTB-1-OFI001: 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.	Medium Pre CD-4
LPH-CTB-1-V002	No I&C Component prevents a Bogie from colliding with a filled Container standing on an Export Stand.	LPH-CTB-1-OFI002: 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.	Medium Pre CD-4
LPH-CTB-1-V003	Wall of the Corridor at Column Line 12.5 is not protected from radiant heat dissipated by a filled Container on a Bogie parked at Position 15.	LPH-CTB-1-OFI003: 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).	High Pre CD-4
LPH-CTB-1-V004	Non-finished surfaces of the Corridor walls will trap volatile contamination migrating from Pour Caves resulting in challenging cleanup work.	LPH-CTB-1-OFI004: 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.	High Pre CD-4



Table B-1. Summary Vulnerability Listing. (41 pages)

Item No.	Description	Opportunities for Improvement	Rank
LPH-CTB-1-V005	Performance of IR Transmitters measuring Container surface temperature before export to System LFH is not demonstrated.	LPH-CTB-1-OFI005: 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.	Low Post CD-4
LPH-CTB-1-V006	Maximum temperature requirement for Conductor Bar design is significantly lower than anticipated temperatures near filled Container.	LPH-CTB-1-OFI006: Verify the acceptable temperature range for the cover material of the installed conductor bars, resume contacts with the Manufacturer, and evaluate the option of replacing the conductor bars by a product with an alternative cover material resisting to higher temperatures if the durability of the installed material cannot be demonstrated in the expected temperature conditions.	Medium Pre CD-4
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.	LPH-CTB-1-OFI007: 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.	Low Post CD-4
LPH-CTB-1-V008	Value of the maximum Container weight shown on DPD and in Engineering Specification for Container Transport Bogie is misleading.	LPH-CTB-1-OFI008: Revise Note 4 on DPD 24590-LAW-M0-LPH-00026 and Section 5.6.2.1.2 of Engineering Specification 24590WTP-3PS-MQR0-T0003 with correct value of product container weight.	Low Post CD-4
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.	LPH-CTB-1-OFI009: 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.	Low Post CD-4
LPH-BMA-1-V001	Bogie Maintenance Hoist not adequate to lift the Container Transport Bogies to access the underside of the Bogies.	LPH-BMA-1-OFI001: Develop detailed maintenance/repair procedures for the Container Transport Bogies that minimize the need for a lengthy disassembly of bogie parts prior to lift the failed bogie from the rails	Medium Pre CD-4
LPH-BMA-1-V002	Discrepancy in location of Bogie Maintenance Hoist between Vendor's calculation and Structural Steel Drawing.	LPH-BMA-1-OFI002: Re-run Calculation 24590-LAW-SSC-S15T-00015 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.	Low Post CD-4
LPH-BMA-1-V003	Use of Bogie Recovery Systems will pull contamination inside the Bogie Maintenance Area.	LPH-BMA-1-OFI003: 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	Medium Pre CD-4
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.	LPH-PC-1-OFI001: 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.	High Pre CD-4
LPH-PC-1-V002	Pour Cave shielded windows are overheated.	LPH-PC-1-OFI002: Design a thermal barrier to prevent radiant heating of the pour cave windows by hot containers in the turntable cooling position.	Medium Pre CD-4
LPH-PC-1-V003	Filled containers which cannot be promptly exported from the pour cave will require LAW Facility production to be reduced.	LPH-PC-1-OFI003: 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.	Medium Pre CD-4
LPH-PC-1-V004	If the Seal head cameras overheat and fail, pour operations through the respective melter spout must be stopped until the camera is replaced.	LPH-PC-1-OFI004: Increase the cooling to the Seal head camera areas.	Medium Pre CD-4
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.	LPH-PC-1-OFI005: Perform a B31.3 piping stress analysis on the Seal head cooling water pipe.	Medium Pre CD-4
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.	LPH-PC-1-OFI006: 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.	Medium Pre CD-4
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.	LPH-PC-1-OFI007: Perform a prototypical pour of the LAW glass, or accept the risk and test the container during cold commissioning. In any case, this item should be resolved prior to hot operations with radioactive materials.	Low Post CD-4
LPH-PC-1-V008	Increased maintenance entries to restore pour cave lighting.	LPH-PC-1-OFI008: Evaluate the suitability of the electric light fixtures in the pour caves. This item should be done after pour cave temperatures are re-evaluated.	Low Post CD-4
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.	LPH-PC-1-OFI009: 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.	High Pre CD-4



Table B-1. Summary Vulnerability Listing. (41 pages)

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.	LPH-PC-1-OFI010: Design and procure a Grapple that can be remotely disengaged.	Medium Pre CD-4
LPH-PC-1-V011	After cutting the pour cave hoist cable, recovery of the pour cave will involve a manned entry with containers in the pour cave.	LPH-PC-1-OFI011: Install a hoist with redundant drives for the trolley wheels, and hoist to allow independent recovery without cutting the hoist cable.	Medium Pre CD-4
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.	LPH-PC-1-OFI012: Install the CAM system described in the System Description to allow retrospective analyses to be done for the pour caves.	Medium Pre CD-4

Item No.	Description	Opportunities for Improvement	Rank
LPH-PC-1-V013	Overpacks, and containers within overpacks, will not be able to be remotely handled while in overpacks 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.	LPH-PC-1-OFI013: 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.	High Pre CD-4
LPH-PC-1-V014	The natural circulation hole in the Container Lower Overpack will increase radiant heating of the Turntable and Turntable base.	LPH-PC-1-OFI014: Perform a CFD thermal analysis of the pour cave turntable with radiant heating from the modified overpack. Reperform 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.	High Pre CD-4
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.	LPH-PC-1-OFI015: 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.	Low Post CD-4
LPH-PC-1-V016	Missing Vendor documentation needed to support maintenance.	LPH-PC-1-OFI016: 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.	Low Post CD-4
LPH-PC-1-V017	Potential equipment damage to Pour Cave Turntable locking actuator.	LPH-PC-1-OFI017: 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 personnel have investigated and corrected the failure of the Turntable locking pin actuator to lock the turntable in position.	Medium Pre CD-4
LPH-PC-1-V018	Overheating the Turntable bevel gear drive oil, will reduce the life of the bevel gear drive.	LPH-PC-1-OFI018: 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.	Medium Pre CD-4
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.	LPH-PC-1-OFI019: 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.	High Pre CD-4
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.	LPH-PC-1-OFI020: 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.	High Pre CD-4
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.	LPH-PC-1-OFI021: 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.	Medium Pre CD-4
LPH-PC-1-V022	Installation of an Elevator weigh instrument with a very small or no temperature margin can cause operational and maintenance problems.	LPH-PC-1-OFI022: Install an Elevator load cell that is rated for the temperature of the installation area.	Medium Pre CD-4
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.	LPH-PC-1-OFI023: Update the 24590-CM-POA-MJW0-00001-03-36 Rev 00D with a VDCN to show the correct weight and centerof-gravity.	Low Post CD-4
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.	LPH-PC-1-OFI024: Provide removable expanded metal barriers to protect personnel from high temperature surfaces.	Low Post CD-4

Table B-1. Summary Vulnerability Listing. (41 pages)

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 approximately the same time.	LPH-PC-1-OFI025: Use Elevator gear reducer oil suitable for the temperature service.	Low Post CD-4
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.	LPH-PC-1-OFI026: Specify a proper instrument mode of operation to preclude overfill of a container.	Medium Pre CD-4
LPH-PC-1-V027	LPH System Descriptions which is to be used to document the system should reflect the asbuilt system and the reason for the design.	LPH-PC-1-OFI027: Update the LPH System Description to reflect design changes.	Low Post CD-4
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-PC-1-OFI028: 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.	Medium Pre CD-4
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 elevator, the container may be overfilled.	LPH-PC-1-OFI029: 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.	Medium Pre CD-4

Item No.	Description	Opportunities for Improvement	Rank
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.	LPH-PC-1-OFI030: Provide MSMs or other equipment capable of performing Pour Cave recovery operations.	Medium Pre CD-4
LPH-PC-1-V031	Cracking of the Pour Cave viewing windows may limit viewing.	LPH-PC-1-OFI031: 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.	Medium Pre CD-4
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.	LPH-PC-1-OFI032: Remove the Lower Overpack ribs as recommended by the analysis in Vendor submittal 24590-QL-HC4-W0000085-T07-02-00001. Cut slots in the Overpack upper rim flanges recommended by the analysis in Vendor submittal 24590-QL-HC4W000-00085-T07-02-00001.	High Pre CD-4
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 motors to trip out when exposed to high ambient temperatures.	LPH-PC-1-OFI033: 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.	Low Post CD-4
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.	LPH-PC-1-OFI034: Expedite the creation of the maintenance, operating, emergency, and abnormal operating procedures so they can be reviewed for Operational Vulnerabilities.	Medium Pre CD-4
<b>LMH System</b>			
LMH-S-10-01	The facets of location, human resources, transportation, and parts availability need to be resolved to support fabrication of replacement melters.	LMH-S-10-OFI-1: 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.	High Pre CD-4



Table B-1. Summary Vulnerability Listing. (41 pages)

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.	LMH-F-15-OFI-01.1: 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. LMH-F-15-OFI-01.2: 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. LMH-F-15-OFI-01.3: Definitively establish the acceleration and deceleration limits for new melters and document the basis. Monitor all new melters against the established acceleration criteria. LMH-F-15-OFI-01.4: Develop long term plans that address melter equipment obsolescence, warranties, and replacement or refurbishment for all equipment procured. LMH-F-15-OFI-01.5: Identify and document all critical attributes of equipment and components associated with the winch. Thoroughly test all those components accordingly and document these test. LMH-F-15-OFI-01.6: Identify a Subject Matter Expert that can assume responsibility for the basis of the design criteria used in the winch and rail design.	Medium Pre CD-4
LMH-F-05-V-01	The detailed process for containment of the spent/failed LAW melters has not been defined.	LMH-F-05-OFI-01: Develop a detailed process definition that will allow for procurement of needed equipment and account for allocation of funds during operations.	Medium Pre CD-4
LMH-S-11-V-01	Alternate vendors for refractory should be identified and plans/schedules for future replacement melter materials defined.	LMH-S-11-OFI-01: Alternate vendors for refractory should be identified and plans/schedules for future replacement melter materials defined.	Medium Pre CD-4
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.	LMH-S-11-OFI-02: Develop a consistent philosophy regarding manual and/or remote operations and maintenance should be determined, and the plant design should then be adjusted accordingly.	Medium Pre CD-4
LMH-W-07-V-02	Inadequate melter decontamination approach.	LMH-W-07-OFI-02: Provide systems for decontamination of melter exterior, including the bottom, prior to commissioning to ensure capability to decontaminate is adequate.	Medium Pre CD-4
LMH-S-16-V-01	There are gaps in the LAW process of designating components to owning systems.	LMH-S-16-OFI-01: Designate each component to a system to ensure there are no gaps in the operations and maintenance of the equipment.	Medium Pre CD-4
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 that could impact the nominal clearances available.	LMH-F-01-OFI-01: 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.	Medium Pre CD-4
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.	LMH-CO-13-OFI-01: Identify a method, system or equipment to transfer a melter from the melter rail system to a transport vehicle.	Medium Pre CD-4

Item No.	Description	Opportunities for Improvement	Rank
LMH-W-07-V-01	Inability to drain free liquids from cooling panels in spent melters.	LMH-S-04-OFI-1: 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.	Medium Pre CD-4
LMH-CO-13-V-02	The current LMH system does not include disposal of a spent/failed melter	LMH-CO-13-OFI-02: Identify the final disposal criteria and prepare procedures and align equipment to implement disposal plan.	Medium Pre CD-4
LMH-F-14-V-01	System LMH does not address the 0.1g acceleration limit for a transport vehicle. (i.e., sub compartment transporter).	LMH-F-14-OFI-01: Consider use of submarine compartment transport vehicle in use at Hanford to transport melters including 0.1g acceleration instrumentation.	Medium Pre CD-4
LMH-S-11-V-03	Section 3.5 of 24590-LAW-3YD-LMP-00001 should be revised to use the correct reference.	LMH-S-11-OFI-03: Section 3.5 of 24590-LAW-3YD-LMP-00001 should be revised to use the correct reference.	Low Post CD-4
<b>LFH System</b>			
LFH-LID-1-V001	LAW container lid ANSI N14.5 leak tightness and testing requirements do not match in the System Description as stated in the ILAW Product Compliance Plan.	LFH-LID-1-OFI001: <ul style="list-style-type: none"> <li>• Define correct package type and seal requirement and update relevant documents.</li> <li>• Establish the correct test method/methodology and update relevant documents.</li> </ul>	Medium Pre CD-4

Table B-1. Summary Vulnerability Listing. (41 pages)

LFH-LID-1-V002	LAW container leak testing was not implemented correctly.	LFH-LID-1-OFI002: <ul style="list-style-type: none"> <li>Establish the correct leak rate limit and update all relevant documents.</li> <li>Establish the correct test method/methodology and update relevant documents.</li> <li>Execute valid leak test.</li> <li>Assess if seal design requires modification (seal/gasket type, threaded vs. welded, etc.).</li> </ul>	Medium Pre CD-4
LFH-LID-1-V003	Lid seal design and method of lid deployment increases chances of seal damage.	LFH-LID-1-OFI003: <ul style="list-style-type: none"> <li>Revise lid gasket/seal type that is more robust and not suspect to damage.</li> <li>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).</li> </ul>	Medium Pre CD-4
LFH-LID-1-V004	Lid seal identification on DPD is incorrect.	LFH-LID-1-OFI004: Provide correct seal manufacturer/type/part number on applicable drawings.	Low Post CD-4
LFH-LID-1-V005	Lidding jib crane capacities do not have a documented basis.	LFH-LID-1-OFI005: <ul style="list-style-type: none"> <li>Define all the requirements/scenarios (including any off normal events) of the jib cranes.</li> <li>Document the lifting requirements and provide an established margin for sizing the hoist. Documentation should be in the form of an approved calculation.</li> </ul>	Low Post CD-4
LFH-LID-1-V006	Lidding jib crane design temperature conflicts with CFD analysis of finishing line equipment.	LFH-LID-1-OFI006: <ul style="list-style-type: none"> <li>Provide a detailed analysis of the environmental requirements of the cranes.</li> <li>Establish the bounding scenario that provides the basis for temperature values within the finishing line.</li> <li>Update data sheets and verify with vendor if changes are required to meet the environment.</li> <li>Make changes where necessary (different lubricants, localized cooling, higher inspection frequencies, etc.). Review with HVAC if hoist cooling requirements affect HVAC design.</li> </ul>	Low Post CD-4
LFH-LID-1-V007	Lidding Jib Crane FAT Test Deficiencies.	LFH-LID-1-OFI007: <ul style="list-style-type: none"> <li>Establish an adequate FAT test plan that meets the requirements of the engineering specification.</li> <li>Undertake a proof test to ensure the existing jib cranes can adequately meet all the tests required in the plan and document the results.</li> </ul>	Medium Pre CD-4
LFH-LID-1-V008	Finish Line MSMs design temperature conflicts with CFD analysis of finishing line equipment.	LFH-LID-1-OFI008: <ul style="list-style-type: none"> <li>Provide a detailed analysis of the environmental requirements of the MSMs.</li> <li>Establish the bounding scenario that provides the basis for temperature values within the finishing line.</li> <li>Update data sheets and verify with vendor if changes are required to meet the environment.</li> <li>Make changes where necessary (different lubricants, localized cooling, higher inspection frequencies, etc.). Review with HVAC if hoist cooling requirements affect HVAC design.</li> </ul>	Medium Pre CD-4
<b>Item No.</b>	<b>Description</b>	<b>Opportunities for Improvement</b>	<b>Rank</b>
LFH-LID-1-V009	Lid holder decontamination and refilling process has not been determined.	LFH-LID-1-OFI009: <ul style="list-style-type: none"> <li>Provide an effective method to safely decontaminate lid holder in L-0217C.</li> <li>Install fixed lid magazine stand in L-0217A to safely refill lid holder.</li> <li>Install jib crane with lid lifter dedicated for lid refilling.</li> <li>Purchase 2 spare lid holders (one for each lidding line) to minimize downtime and keep lids refilled at all times.</li> </ul>	High Pre CD-4



Table B-1. Summary Vulnerability Listing. (41 pages)

LFH-LID-1-V010	Lid Press Tool and Lid Recovery Tool design temperature issues.	LFH-LID-1-OFI010: <ul style="list-style-type: none"> <li>• Provide a detailed analysis of the environmental requirements of the tools.</li> <li>• Establish the bounding scenario that provides the basis for temperature values within the finishing line.</li> <li>• Update data sheets and verify with vendor if changes are required to meet the environment.</li> <li>• Make changes where necessary (stainless tubing, additional insulation).</li> </ul>	Medium Pre CD-4
LFH-LID-1-V011	Lid recovery tool operation deficiencies.	LFH-LID-1-OFI011: <ul style="list-style-type: none"> <li>• 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.</li> <li>• If this cannot be done, revise design to allow for a valid method of lid removal and disposal (this may require new equipment be utilized instead of modifying existing designs).</li> <li>• Undertake a new proof of principle test to validate new/revised equipment can effectively meet the functions required in “lid recovery” operations.</li> </ul>	High Pre CD-4
LFH-LID-1-V012	Lid disposal bin handling deficiencies.	LFH-LID-1-OFI012: <ul style="list-style-type: none"> <li>• Provide a proof of principle test to validate the current design can hold lids without buckling, be removed “manually” in a safe manner.</li> <li>• 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).</li> <li>• Undertake a new proof of principle test to validate new/revised equipment can effectively meet the functions required in “lid disposal” operations.</li> </ul>	Medium Pre CD-4
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 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.	LFH-IC-1-OFI001: □ 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. <ul style="list-style-type: none"> <li>• If the requirements are incorrect, the requirements documents should be updated.</li> <li>• If the implementation is incorrect, it should be corrected.</li> <li>• Add a reference in the MSDs to the J3 Logic Diagrams where the interlock is implemented.</li> <li>• 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.</li> </ul>	Medium Pre CD-4
LFH-IC-1-V002	Interlocks on the Lidding Bogie listed in the Mechanical Sequence Diagram 24590-LAWM1-LFH-00001 are not sufficient to protect the equipment from damage.	LFH-IC-1-OFI002: <ul style="list-style-type: none"> <li>• Develop a compliance matrix that identifies where each interlock is implemented, and a criteria matrix that defines how the requirement will be tested.</li> <li>• 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.</li> <li>• If the requirements are incorrect, the requirements documents should be updated.</li> <li>• If the implementation is incorrect, it should be corrected.</li> <li>• Add a reference in the MSDs to the J3 Logic Diagrams where the interlock is implemented.</li> </ul> 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.	Medium Pre CD-4
<b>Item No.</b>	<b>Description</b>	<b>Opportunities for Improvement</b>	<b>Rank</b>



Table B-1. Summary Vulnerability Listing. (41 pages)

LFH-IC-1-V003	Interlocks on the Lidding Jib Crane listed in the Mechanical Sequence Diagram 24590-LAWMI-LFH-00001 are not sufficient to protect the equipment from damage.	<p>LFH-IC-1-OFI003:</p> <ul style="list-style-type: none"> <li>• Develop a compliance matrix that identifies where each interlock is implemented, and a criteria matrix that defines how the requirement will be tested.</li> <li>• 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.</li> <li>• If the requirements are incorrect, the requirements documents should be updated.</li> <li>• 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.</li> </ul> <p>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.</p>	Medium Pre CD-4
LFH-IC-1-V004	Interlocks on the Sealing Jib Crane listed in the Mechanical Sequence Diagram 24590-LAWMI-LFH-00001, are not sufficient to prevent the equipment from damage.	<p>LFH-IC-1-OFI004:</p> <ul style="list-style-type: none"> <li>• Develop a compliance matrix that identifies where each interlock is implemented, and a criteria matrix that defines how the requirement will be tested.</li> <li>• 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.</li> <li>• If the requirements are incorrect, the requirements documents should be updated.</li> <li>• 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.</li> </ul> <p>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.</p>	Medium Pre CD-4
LFH-IC-1-V005	Interlocks on the Decon Shield Door listed in the Mechanical Sequence Diagram 24590LAW-M1-LFH-00001 are not sufficient to protect against HVAC flow disruptions or the spread of contamination.	<p>LFH-IC-1-OFI005:</p> <ul style="list-style-type: none"> <li>• Develop a compliance matrix that identifies where each interlock is implemented, and a criteria matrix that defines how the requirement will be tested.</li> <li>• 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.</li> <li>• If the requirements are incorrect, the requirements documents should be updated.</li> <li>• 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.</li> </ul> <p>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.</p>	Medium Pre CD-4
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.	<p>LFH-IC-1-OFI006:</p> <ul style="list-style-type: none"> <li>• Develop a compliance matrix that identifies where each interlock is implemented, and a criteria matrix that defines how the requirement will be tested.</li> <li>• 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.</li> <li>• If the requirements are incorrect, the requirements documents should be updated.</li> <li>• If the implementation is incorrect, it should be corrected.</li> <li>• Add a reference in the MSDs to the J3 Logic Diagrams where the interlock is implemented.</li> </ul> <p>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.</p>	Medium Pre CD-4

Table B-1. Summary Vulnerability Listing. (41 pages)

Item No.	Description	Opportunities for Improvement	Rank
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.	<p>LFH-IC1-OFI007:</p> <ul style="list-style-type: none"> <li>Develop a compliance matrix that identifies where each interlock is implemented, and a criteria matrix that defines how the requirement will be tested.</li> <li>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.</li> <li>If the requirements are incorrect, the requirements documents should be updated.</li> <li>If the implementation is incorrect, it should be corrected.</li> <li>Add a reference in the MSDs to the J3 Logic Diagrams where the interlock is implemented.</li> </ul> <p>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.</p>	Medium Pre CD-4
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.	<p>LFH-IC-1-OFI008:</p> <ul style="list-style-type: none"> <li>Develop a compliance matrix that identifies where each interlock is implemented, and a criteria matrix that defines how the requirement will be tested.</li> <li>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.</li> <li>If the requirements are incorrect, the requirements documents should be updated.</li> <li>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.</li> </ul> <p>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.</p>	Medium Pre CD-4
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.	LFH-IC-2-OFI001: The carbon dioxide pelletizers, CDG-PLT-00001/00002 must be re-installed with a different orientation that allows proper access.	High Pre CD-4
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.	LFH-IC-2-OFI002: Align the design of the facility so that each piece of equipment has one and only one name.	High Pre CD-4
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.	LFH-IC-3-OFI001: 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.	Medium Pre CD-4
LFH-TRLY-1-V001	Bogie thermal shield design differences between the Design Proposal Drawings and the fabricated Lidding and Decontamination Bogies are not documented.	LFH-TRLY-1-OFI001: 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.	Medium Pre CD-4
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.	LFH-TRLY-1-OFI002: Update ICN to include interlocks preventing Bogie collisions in the Finishing Line.	Low Post CD-4
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.	LFH-TRLY-1-OFI003: Add bolted containers centering wedge assemblies around the top plate of the Swabbing Turntables (similar to the wedges installed on the Decontamination Turntables).	Medium Pre CD-4
LFH-TRLY-1-V004	Potentially insufficient maximum load capacity of bogie-mounted Swabbing Turntables.	LFH-TRLY-1-OFI004: 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.	Low Post CD-4
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.	LFH-TRLY-1-OFI005: 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).	High Pre CD-4
LFH-TRLY-1-V006	Vendor’s calculation for bogie bumper selection is based on incorrect gross weight and bogie speeds.	LFH-TRLY-1-OFI-006: 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.	Low Post CD-4



Table B-1. Summary Vulnerability Listing. (41 pages)

Item No.	Description	Opportunities for Improvement	Rank
LFH-TRLY-1-V007	Vendor's calculations for bogie container supports and bogie frame analysis are based on an incorrect maximum loading.	LFH-TRLY-1-OFI007: 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.	Low Post CD-4
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.	LFH-TRLY-1-OFI008: 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.	Low Post CD-4
LFH-TRLY-1-V009	Configuration of the recessed rails in the Finishing Line will promote the accumulation of contamination.	LFH-TRLY-1-OFI009: Develop procedures for frequent periodic decontamination work activities to prevent contamination buildup along the bogie tracks.	High Pre CD-4
LFH-TRLY-1-V010	Maintenance on Bogies in Swabbing and Export Rooms may be problematic due to contamination potentially pulled from Container Lidding Areas.	LFH-TRLY-1-OFI010: Develop procedures to minimize the spread of contamination into rooms that should stay clean while performing maintenance on the LFH Bogies.	High Pre CD-4
LFH-TRLY-1-V011	Absence of Finishing Line Bogie maintenance hoist may result in problematic bogie maintenance.	LFH-TRLY-1-OFI011: Develop maintenance procedures for LFH Bogies that minimize impact to the installed process lifting equipment.	Medium Pre CD-4
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.	LFH-TRLY-1-OFI012: Define the maintenance areas actually available for maintaining the Lidding and Decontamination Bogies and develop procedures accordingly.	Medium Pre CD-4
LFH-TRLY-1-V013	Mechanical Handling Data Sheets and Thermal Analysis for the Swabbing Bogie-Mounted Turntables Define Incorrect Container Bottom and Side Temperatures.	LFH-TRLY-1-OFI013: Correct the discrepancies in engineering and Vendor's documentation package for the two Bogie-mounted Swabbing Turntables.	Medium Pre CD-4
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.	LFH-TRLY-1-OFI014: 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.	Medium Pre CD-4
LFH-DS-1-V001	Retrieval of Bogie Doors in Decontamination Rooms L-0109C/-0115C not yet possible.	LFH-DS-1-OFI001: Develop an easy method of door retrieval to minimize the impact of an occurrence of a door fail-to-move situation.	Medium Pre CD-4
LFH-DS-1-V002	Container decontamination and recovery of a contaminated container may be problematic.	LFH-DS-1-OFI002: <ul style="list-style-type: none"> <li>Demonstrate the capability of a CO2 system to decontaminate an ILAW Container.</li> <li>Develop a method to export a non-conforming ILAW container.</li> </ul>	High Pre CD-4
LFH-DS-1-V003	C5 Duct pressurization over C3 room & C2 Corridor pressure.	LFH-DS-1-OFI003: <ul style="list-style-type: none"> <li>Install a CO2 gas monitor instrument in Room L-217B to detect rising CO2 levels.</li> <li>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.</li> </ul>	Medium Pre CD-4
LFH-DS-1-V004	Operation of the Carbon Dioxide (CO2) pelletizer and C5V vacuum pickup system may be problematic.	LFH-DS-1-OFI004: <ul style="list-style-type: none"> <li>Testing of the CO2 system to optimize container decontamination efficacy should be done before startup.</li> <li>It would be best to start the testing and development of the integrated CO2 system as soon as possible to minimize the impact of the possible failure of the CO2 system to decontaminate an ILAW container on the LAW Facility commissioning.</li> </ul>	High Pre CD-4
LFH-DS-1-V005	Decontamination system obsolescence and Vendor support.	LFH-DS-1-OFI005: 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.	Medium Pre CD-4
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 L0115C overhead container hoist maintenance, operation, and spare parts may be problematic.	LFH-DS-1-OFI006: Apply to the DOE for relief from the ASME Code, OSHA 1910.178, 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.	High Pre CD-4
LFH-DS-1-V007	Maintenance on the LFH-HST-00001 monorail hoist will be difficult.	LFH-DS-1-OFI007: Install a second access ladder to the LP0217A platform.	Low Post CD-4
LFH-OR-1-V001	24590-LAW-RPT-PO-05-0001, <i>LAW Reliability, Availability, and Maintainability Data Development Report</i> , errors.	LFH-OR-1-OFI001: Revise the RAM data development report and incorporated into the OR model and other documents.	Low Post CD-4



Table B-1. Summary Vulnerability Listing. (41 pages)

LFH-OR-1-V002	24590-WTP-MDD-PR-01-001, <i>Operations Research (WITNESS) Model Design Document</i> , errors and inconsistencies.	LFH-OR-1-OFI002: 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 MTR data have been updated.	Low Post CD-4
LFH-OR-1-V003	24590-WTP-RPT-PET-07-003, <i>Waste Treatment Plant Reliability Availability Maintainability (RAM) Basis Report</i> , error.	LFH-OR-1-OFI003: Revise the RAM basis report to remove LFH-WELD-00001/00002 and verify the weld equipment has been removed from the OR model.	Low Post CD-4
LFH-SWAB-1-V001	24590-LAW-3YD-LFH-00001, <i>System Description for the LAW Container Finishing Handling System (LFH)</i> , issues and inconsistencies.	LFH-SWAB-1-OFI001: Revise the document to correct internal inconsistencies.	Low Post CD-4
LFH-SWAB-1-V002	24590-LAW-M0D-LFH-00066, <i>Mechanical Handling Data Sheet: North Swabbing Power Manipulator</i> , inconsistencies.	LFH-SWAB-1-OFI002: Revise the documents to correct inconsistencies.	Low Post CD-4

Item No.	Description	Opportunities for Improvement	Rank
LFH-SWAB-1-V003	24590-CM-POA-HDYR-00002-04-00002, <i>Bolted Pedestal and Frame Structures Structural Design Analysis and Calcs</i> , loss of configuration control.	LFH-SWAB-1-OFI003: The calculation needs to be completely reviewed and checked by a registered professional engineer and implement any design changes that result.	Medium Pre CD-4
LFH-SWAB-1-V004	24590-CM-POA-HDYR-00002-10-00001, <i>Swabbing Factory Acceptance Test Plan</i> , issue.	LFH-SWAB-1-OFI004: Complete full endurance test during commissioning activities.	Low Post CD-4
LFH-SWAB-1-V005	24590-CM-POA-HDYR-00002-21-00002, <i>Swabbing Manipulator Thermal Calculation</i> , cooling air issues.	LFH-SWAB-1-OFI005: 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.	High Pre CD-4
LFH-SWAB-1-V006	24590-CM-POA-HDYR-00002-14-00005, <i>Swabbing System Operating Guide for Decontamination and Swabbing Project</i> , missing instructions	LFH-SWAB-1-OFI006: Create and test swabbing programs for the lower container over packs prior to commissioning activities.	High Pre CD-4
LFH-SIFH-1-V001	Insufficient rotary valve isolation for maintenance.	LFH-SIFH-OFI001: Modify the inert fill hopper design to incorporate a manual slide gate for isolation directly above the rotary airlock valve.	Low Post CD-4
LFH-SIFH-1-V002	Failure to record requirements during factory acceptance testing.	LFH-SIFH-OFI002: This testing requirement should be added to commissioning test documentation.	Low Post CD-4
LFH-SIFH-1-V003	No adequate container temperature design basis.	LFH-SIFH-OFI003: 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.	High Pre CD-4
LFH-SIFH-1-V004	Performance requirements not fully met.	LFH-SIFH-OFI004: 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.	Low Post CD-4
LFH-SIFH-1-V005	Incorrect isolation valve in day tank.	LFH-SIFH-OFI005: 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.	High Pre CD-4
LFH-SSS-1-V001	Inadequate materials of construction.	LFH-SSS-1-OFI001: The coil air supply line should be covered with high temperature sheathing to reduce any high temperature effects.	Low Post CD-4
LFH-SSS-1-V002	Limited glass sample capability.	LFH-SSS-1-OFI002: 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.	High Pre CD-4
LFH-SSS-1-V003	Insufficient shard pickup design.	LFH-SSS-1-OFI003: 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.	High Pre CD-4
LFH-SSS-1-V004	The shard table does not prevent material from dropping into the container during MSM operations.	LFH-SSS-1-OFI004: Redesign the shard sampling tray to prevent material from dropping into the product container.	Medium Pre CD-4
LFH-SSS-1-V005	The shard pickup assembly cannot be remotely disassembled for cleaning between samples.	LFH-SSS-1-OFI005: Redesign the shard pickup tip assembly for remote disassembly for cleaning between samples. Demonstrate the remote disassembly capability using a proto-typical MSM.	Low Post CD-4
LFH-TOOL-1-V001	Inadequate design basis documentation.	LFH-TOOL-1-OFI001: Revise design and fabrication documentation to ensure accurate and as-built information.	Low Post CD-4

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LFH-TOOL-2-V001	Inconsistent grapple load rating.	LFH-TOOL-2-OFI001: Increase the grapples safe working load design to 25,000 lbs. to handle all container conditions.	Low Post CD-4
LFH-TOOL-2-V002	LAW production container volume, weight, and center of gravity calculation, 24590-LAWM0C-LRH-00004, does not include an over pack condition.	LFH-TOOL-2-OFI002: 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.	Low Post CD-4
LFH-TOOL-2-V003	Grapple temperature limitations.	LFH-TOOL-2-OFI003: 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.	Low Post CD-4
LFH-TOOL-2-V004	Grapple excessive load testing.	LFH-TOOL-2-OFI004: Revise BNI procurement process to ensure vendors test equipment according to contractual documentation and that all requirements are consistent between documents.	Low Post CD-4
LFH-TOOL-2-V005	Design requirement not verified in factory acceptance testing.	LFH-TOOL-2-OFI005: The requirement should be validated during start-up testing to ensure these critical characteristic are met.	Low Post CD-4
LFH-TOOL-2-V006	Requirements for factory acceptance testing not fully being performed.	LFH-TOOL-2-OFI006: All required performance design requirement should be performed as part of an additional FAT or demonstrated through analysis.	Low Post CD-4
<b>RWH System</b>			

Item No.	Description	Opportunities for Improvement	Rank
LRWH-F-06-V-01	Incomplete design of equipment and systems to implement waste handling and storage functions.	LRWH-F-06-OFI-01.1: Define, design, and provide lifting and handling equipment for each identified packaging. LRWH-F-06-OFI-01.2: 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. LRWH-F-06-OFI-01.3: Define, design, and provide waste size reduction equipment and facilities for caustic scrubber bed and mist eliminator as required to package in designated packaging. LRWH-F-06-OFI-01.4: Define radioactive and chemical hazard expected for the various waste streams and define and provide shielding, protective packaging, as required. LRWH-F-06-OFI-01.5: 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.	High Pre CD-4
LRWH-F-07-V-01	The RWH process crane does not have an indexing system that defines its safe operating envelope(s).	LRWH-F-07-OFI-01.1: Utilize laser positioning and develop indexing or auto-indexing features for the RWH process crane. LRWH-F-07-OFI-01.2: Program engineering controls into the crane to avoid travel over the offgas piping.	Medium Pre CD-4
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.	LRWH-M-02-OFI-01: Detail, model and evaluate all critical LRWH System activities and spaces. Factor the results of these evaluations back into the plant and system designs.	Medium Pre CD-4
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.	LRWH-M-02-OFI-03: 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.	Medium Pre CD-4
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.	LRWH-F-13-OFI-1: Develop a methodology to export a spent agitator or pump which may require transitioning the spent equipment between a vertical and horizontal position.	Low Post CD-4
LRWH-F-13-V-1	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) from El. 3 laydown area to the truck dock has not been identified.	LRWH-F-13-OFI-2: Develop a methodology to transport a spent agitator or pump.	Low Post CD-4
LRWH-O-03-V-01	Equipment and attachment points are not determined for recovery of the Process Area Bridge Crane to its maintenance position.	LRWH-O-03-OFI-1: Perform preliminary planning on how the crane would be recovered and what equipment is needed.	Low Post CD-4
LRWH-F-13-V-2	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.	LRWH-F-13-OFI-3: 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.	Low Post CD-4



Table B-1. Summary Vulnerability Listing. (41 pages)

LRWH-F-06-V-02	HEPA filters may develop too high a radioactive loading before pressure differential monitoring indicates a heavy particulate loading.	LRWH-F-06-OFI-02: Identify available ports on the HEPA filter assemblies and specify a method to monitor radioactive loading buildup during normal inspections (i.e. rounds).	Medium Pre CD-4
LAW-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.	LAW-S-09-OFI-01: Follow a "bottom up" startup and commissioning strategy to reduce upsets on the critical path during plant startup and commissioning; <ul style="list-style-type: none"> <li>Isolate an area from construction activities containing installed components,</li> <li>Bring in plant services or equivalent temporary services, □ Startup / commission all components in the isolated area,</li> <li>As the area can be extended, startup and commission interacting components and assemblies,</li> <li>When a Facility System is entirely in an isolated area, begin startup and commissioning activities.</li> </ul>	High Pre CD-4
LRWH-M-02-V-02	Funding & resources have not been allocated to address: <ul style="list-style-type: none"> <li>Equipment no longer under warranty.</li> <li>Equipment preservation and degradation</li> </ul>	LRWH-M-02-OFI-02: Develop long term funding and plans that address expired warranties, replacement and/or refurbishment of equipment.	Medium Pre CD-4
LRWH-M-02-V-04	Key LAW documents contradict each other regarding LRWH System scope.	LRWH-M-02-OFI-04: 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.	Medium Pre CD-4
LRWH-S-04-V-01	Many methods of secondary waste disposition and transfer paths within the facility remain undefined.	LRWH-S-04-OFI-01: Model all waste disposition streams and determine whether necessary equipment and transfer paths within the facility are adequate. Incorporate results into appropriate system descriptions.	Medium Pre CD-4
<b>LCP and LFP Systems</b>			

Item No.	Description	Opportunities for Improvement	Rank
LCP/LFP-01	Potential for GFR component omission to cause premature melter failure.	<ol style="list-style-type: none"> <li>Conduct impact assessment that defines the time period associated with omitting each glass forming component that could result in a premature melter failure</li> <li>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 mis-batch additions in a row based on the omission time periods that could result in premature melter failure</li> <li>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)</li> </ol>	Medium Pre CD-4
LCP/LFP-02	Capability to monitor feed slurry rheology during extended storage in MFPV/MFV is not defined/demonstrated.	<ol style="list-style-type: none"> <li>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.</li> <li>Periodic sampling during long outages to test for rheology changes.</li> </ol>	Low Post CD-4
LCP/LFP-03	Design basis temperature of 150°F for CRV, MFPV and MFV vessels may not be adequately conservative under off-normal conditions (extended idle periods).	<ol style="list-style-type: none"> <li>Re-evaluate design basis temperature limits for vessels to increase operating margin and operational flexibility. Vessels appears adequately robust to support increasing the design basis temperature to 200°F.</li> <li>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).</li> <li>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.</li> <li>Evaluate the impact that the boric acid exothermic reaction has on the operation of the MFPV tank temperature.</li> <li>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.</li> </ol>	Medium Pre CD-4
LCP/LFP-04	Unknown ability of the LAW LFP Feed Prep and Feed Vessels to structurally support the external cooling panel sections.	<ol style="list-style-type: none"> <li>Confirm unverified assumptions in analysis.</li> <li>Update analysis and verify adequacy of vessel design.</li> </ol>	Medium Pre CD-4



Table B-1. Summary Vulnerability Listing. (41 pages)

LCP/LFP-05	The 40 year design life of the LFP Vessels is in question due to the lack of credible data to accurately predict the erosion wear for SA-240, 316L material.	<p>5.1 Conduct additional CFD analysis with appurtenances modeled per vessel configuration to identify potential areas of accelerated erosion.</p> <p>5.2 Based on the CFD analysis, consider remote vessel wall thickness monitoring (e.g. ultrasonic thickness transducers) permanently mounted to lower head and shell.</p> <p>5.3 Conduct additional prototypic testing with relevant simulant to confirm relationship of agitator speed to fluid velocity at vessel head/walls.</p> <p>5.4 Perform post-commissioning vessel inspections to determine evidence of premature erosion.</p> <p>5.5 If still warranted from above, consider thermal spray hard coating of vessels and internals.</p> <p>- If thermal spray is considered, then also consider increasing the vessel design temperature to eliminate the need for the add-on cooling panels.</p>	Medium Pre CD-4
LCP/LFP-06	The operating envelope has not been defined to ensure the requirement for mixing homogeneity can be met during normal plant operations.	<p>6.1 Define operating envelope and how much deviation can be allowed.</p> <p>6.2 Consider alternative level detection such as using existing dip tubes (add transmitter to long leg of specific gravity dip tubes).</p> <p>6.3 Consider adjustable speed drive (ASD) on agitators to allow flexibility to achieve required mixing performance.</p>	Medium Pre CD-4
LCP/LFP-07	Fixed speed agitators may not provide adequate flexibility to address variations in process conditions or recover after prolonged down time.	7.1 Consider adding ASD to agitators.	Medium Pre CD-4
LCP/LFP-08	Cooling jackets for MFPV and MFV tanks do not include pressure relief.	<p>8.1 Evaluate the need for pressure relief for the MFPV and MFV cooling jackets.</p> <p>8.2 Add pressure relief on the demineralized water system downstream of the PCV-2101 to control pressure for SBS as well a LFP cooling jackets.</p>	Low Post CD-4

Item No.	Description	Opportunities for Improvement	Rank
LCP/LFP-09	Lack of comprehensive engineering strategy for removal of hard to remove solids or significant accumulations of solids in piping and vessels.	<p>9.1 Develop comprehensive strategy for removal of blockages from piping and high shear solids from vessels.</p> <p>9.2 Define features necessary for pipe and vessel flush equipment to implement solids removal strategy.</p> <p>9.3 Design, test and demonstrate ability to deploy flush equipment.</p> <p>9.4 Evaluate the need for additional spool pieces/cleanout ports to support pipe flushes.</p> <p>9.5 Evaluate alternative flush chemicals.</p> <p>9.6 Evaluate need for other slurry handling systems based on lessons learned from other facilities.</p> <p>9.7 Consider tank farm lessons learned on removal of high shear solids.</p>	Low Post CD-4
LCP/LFP-10	The LCP/LFP bulge drain systems do not appear to have adequate drain capacity when spray rings are turned on.	10.1 Consider additional controls for the flush water flow to the bulge spray rings such as: <ul style="list-style-type: none"> <li>a. 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.</li> <li>b. Install smaller capacity spray nozzles.</li> <li>c. Install local liquid level gauge for operator to monitor liquid level.</li> <li>d. Install orifice to reduce flow and pressure to spray nozzles.</li> <li>e. 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.</li> </ul>	Low Post CD-4
LCP/LFP-11	Ability to automate using existing design features appears underutilized.	<p>11.1 Consider fully automating transfer and flush sequences.</p> <p>11.2 Consider adding equipment performance trending/monitoring parameters for display to operators.</p> <p>11.3 Consider adding ASDs for agitator operation.</p> <p>11.4 Incorporate remote monitoring/power option for auto-lubrication system</p>	Low Post CD-4
LCP/LFP-12	A comprehensive equipment condition monitoring strategy/system is not evident so that process cell entries can be avoided.	12.1 Develop a formal comprehensive strategy for equipment performance monitoring. Review current design against the strategy and implement design changes as necessary.	Medium Pre CD-4

Table B-1. Summary Vulnerability Listing. (41 pages)

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).	13.1 Confirm the ability to change a pump/agitator under various vessel operating conditions during commissioning or as a mock-up 13.2 Consider the viability of incorporating additional alignment aids such as inverted cone to the base of the flange with the stabilizer guide.	Low Post CD-4
LCP/LFP-14	Current approach to ADS pump monitoring/trending may not be adequately indicative of performance.	14.1 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 e.g. the apex of the pump discharge pressure.	Medium Pre CD-4
LCP/LFP-15	Basis/definition of acceptable gear oil leakage rates and process impacts is not evident.	15.1 Perform calculations to quantify acceptable limits for leak rates and/or amounts each vessel can tolerate. 15.2 Finalize design features for checking and replacing gearbox oil utilizing existing riser piping at the 28" level.	Low Post CD-4
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	16.1 Conduct a formal and systematic analysis of maintenance infrastructure needs. 16.2 Identify and prepare an existing facility for use as a WTP mock-up/testing facility (e.g. 2101M, MASF at FFTF, etc.) or; 16.3 Design and build (e.g. pre-fab building) a testing/mockup facility at WTP. 16.4 Consider working with the tank farm contractor to establish a shared/consolidated mock-up facility.	Low Post CD-4
<b>LEH System</b>			
LEH-IC-1-V001	Requirement Documents Conflict.	LEH-IC-1-OFI001: 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.	Medium Pre CD-4
LEH-IC-1-V002	Interlock Incorrectly Defined.	LEH-IC-1-OFI002: 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.	Medium Pre CD-4

Item No.	Description	Opportunities for Improvement	Rank
LEH-IC-1-V003	Missing Interlocks.	LEH-IC-1-OFI003: Add interlocks to the design to; <input type="checkbox"/> allow only one LFH hatch to be open at a time, <input type="checkbox"/> prohibit the opening of a roll-up door when a hatch is open and, <input type="checkbox"/> 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.	Medium Pre CD-4
LEH-CRN-1-V001	Jib Crane Data Sheets and Specification Inconsistencies.	LEH-CRN-1-OFI001: Revise all issued documents to reflect the de-rated capacity of the maintenance jib cranes (LEH-CRN00005/00006).	Medium Pre CD-4
LEH-CRN-1-V002	Structural Analysis of Export Bay Inconsistencies.	LEH-CRN-1-OFI002: 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.)	Medium Pre CD-4
LEH-CRN-1-V003	Maintenance Jib Crane De-rating and Analysis of Embeds Inconsistencies.	LEH-CRN-1-OFI003: 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.	Medium Pre CD-4
LEH-CRN-1-V004	Maintainability of LAW Export Bay Crane and Jib Crane Capacity.	LEH-CRN-1-OFI004: 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.	Medium Pre CD-4



Table B-1. Summary Vulnerability Listing. (41 pages)

LEH-CRN-1-V005	Maintainability of LAW Export Bay Crane and Jib Crane Reach.	LEH-CRN-1-OFI005: 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.	Medium Pre CD-4
LEH-CNTR-1-V001	Filled ILAW Container export temperature may affect Tank Farm Contractor (TOC) / Integrated Disposal Facility (IDF) operations.	LEH-CNTR-1-OFI001: Either increase the ILAW container cooling capabilities of WTP LAW facility, or construct ILAW container cooling facilities at either the TOC or IDF facilities.	High Pre CD-4
LEH-RCSH-1-V001	Contamination migration when transferring ILAW product container.	LEH-RCSH-1-OFI001: 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.	Medium Pre CD-4
LEH-RCSH-1-V002	LEH system compliance to design and operational safety and health requirements.	LEH-RCSH-1-OFI002: 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.	Medium Pre CD-4
LEH-RCSH-1-V003	Thermal Temperatures on ILAW Transport Container Package.	LEH-RCSH-1-OFI003: 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 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.	Medium Pre CD-4
LEH-ICD-1-V001	Shielding of the ILAW product container transporter is not defined.	LEH-ICD-1-OFI001: 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.	Medium Pre CD-4
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.	LEH-ICD-1-OFI002: Provide adequate procedures for LEH export activities including ILAW Container shipping inspection and authorization requirements.	Medium Pre CD-4
LEH-ICD-1-V003	Potential conflict between Contamination limitations in Export High Bay and surface contamination of ILAW product containers.	LEH-ICD-1-OFI003: 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.	Medium Pre CD-4
LEH-ICD-1-V004	Duration of ILAW product container approval process prior to shipment not defined.	LEH-ICD-1-OFI004: Provide adequate procedures for LEH export activities including shipping inspection and authorization requirements.	Low Post CD-4
LEH-ICD-1-V005	Uncertainties in schedule for initial ILAW container production and transport.	LEH-ICD-1-OFI005: 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.	Low Post CD-4

Item No.	Description	Opportunities for Improvement	Rank
LEH-ICD-1-V006	Open ICD 15 issues and actions may affect the operations in the LEH System.	LEH-ICD-1-OFI006: 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.	Medium Pre CD-4
LEH-OR-1-V001	24590-LAW-RPT-PO-05-0001, Rev 0, <i>LAW Reliability, Availability, and Maintainability Data Development Report</i> , inconsistencies and RAM data issues.	LEH-OR-1-OFI001: Correct inconsistencies in <i>LAW Reliability, Availability, and Maintainability Data Development Report</i> , reevaluate 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.	Medium Pre CD-4
LEH-OR-1-V002	24590-WTP-MCR-PET-11-0058, Rev 0, <i>LAW Mechanical Handling System RAM Update</i> , inconsistencies.	LEH-OR-1-OFI002: Correct the <i>LAW Mechanical Handling System RAM Update</i> , so the data is consistent.	Low Post CD-4
LEH-OR-1-V003	CCN 068365, <i>LAW LEH System – RAMI – OR</i> , lacks bases for MTTR data.	LEH-OR-1-OFI003: 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.	Low Post CD-4
LEH-OR-1-V004	24590-WTP-RPT-PT-02-005, Rev 7, <i>Flowsheet Bases, Assumptions, and Requirements</i> , is inconsistent on the number of ILAW containers to put on the transportation trailer.	LEH-OR-1-OFI004: Correct the <i>Flowsheet Bases, Assumptions, and Requirements</i> , so the data is consistent.	Low Post CD-4
LEH-OR-1-V005	24590-WTP-RPT-PET-07-003, Rev 1, <i>Waste Treatment Reliability Availability Maintainability (RAM) Basis Report</i> , redundant information.	LEH-OR-1-OFI005: Correct the <i>Waste Treatment Reliability Availability Maintainability (RAM) Basis Report</i> , so the data is consistent.	Low Post CD-4



Table B-1. Summary Vulnerability Listing. (41 pages)

LEH-OR-1-V006	24590-WTP-MDD-PR-01-001, Rev 12, <i>Operations Research (WITNESS) Model Design Document</i> , inconsistency and missing information.	LEH-OR-1-OFI006: Correct inconsistencies in the <i>Operations Research (WITNESS) Model Design Document</i> , 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.	Medium Pre CD-4
LEH-CRN-2-V001	LEH-CRN-00003 crane capacity may not be sufficient.	LEH-CRN-2-OFI001: Establish method for exporting non-compliant containers and validate LEH-CRN-00003 crane capacity is not exceeded.	Medium Pre CD-4
LEH-CRN-2-V002	LEH-CRN-00003 crane maintenance/inspection platform not easily accessible.	LEH-CRN-2-OFI002: Establish maintenance/inspection access requirements and make design modifications to ensure safe LEHCRN-00003 crane access.	Low Post CD-4
LEH-CRN-2-V003	Heavy maintenance strategy not defined for LEH-CRN-00003.	LEH-CRN-2-OFI003: 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.	Low Post CD-4
LEH-TOOL-1-V001	Inadequate design basis documentation for container grapple stands.	LEH-TOOL-1-OFI001: Revise design and fabrication documentation for container grapple stands to ensure accurate and as-built information.	Low Post CD-4
LEH-TOOL-2-V001	Inconsistent grapple load rating.	LEH-TOOL-2-OFI001: Increase the grapples safe working load to 25,000 lbs to handle all container conditions.	Low Post CD-4
LEH-TOOL-2-V002	LAW production container volume, weight, and center of gravity calculation, 24590-LAWM0C-LRH-00004, does not include overpack condition.	LEH-TOOL-2-OFI002: Revise calculation to include the addition of overpacking material to the outside of the container.	Low Post CD-4
LEH-TOOL-2-V003	Grapple temperature limitations.	LEH-TOOL-2-OFI003: Add grapple markings to clearly identify temperature limitations the same way safe working loads are identified.	Low Post CD-4
LEH-TOOL-2-V004	Grapple excessive load testing.	LEH-TOOL-2-OFI004: Revise BNI procurement process to ensure vendors test equipment according to contractual documentation and that all requirements are consistent between documents.	Low Post CD-4
LEH-TOOL-2-V005	Design requirement not verified in factory acceptance testing.	LEH-TOOL-2-OFI005: This requirement should be validated during start-up testing to ensure this critical characteristic is met.	Low Post CD-4
LEH-TOOL-2-V006	Requirements for factory acceptance testing not fully being performed.	LEH-TOOL-2-OFI006: This critical design requirement should be performed as part of an additional FAT or demonstrated through analysis.	Low Post CD-4
LEH-TOOL-2-V007	Inconsistent design requirements.	LEH-TOOL-2-OFI007: Revise data sheets, specification, and calculation to indicate a consistent and accurate grapple operating environment.	Low Post CD-4
LEH-TOOL-2-V008	Inaccurate model data for LRH process steps.	LEH-TOOL-2-OFI008: Engineering should perform a complete OR model input verification prior to model output is considered valid.	Low Post CD-4
<b>LRH System</b>			
LRH-IC-1-V001	Inadequate Interlocks at LRH Roll Up Doors.	LRH-IC-1-OFI001: 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 a 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.	Low Post CD-4
<b>Item No.</b>	<b>Description</b>	<b>Opportunities for Improvement</b>	<b>Rank</b>
LRH-IC-1-V002	Requirement documents are incomplete.	LRH-IC-1-OFI002: 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. Review requirements documents to verify that requirements have been correctly addressed and implemented in the logic diagrams and programming.	Low Post CD-4
LRH-IC-1-V003	No Personal Safety Interlock on the Container Receipt Station.	LRH-IC-1-OFI003: 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.	Medium Pre CD-4

Table B-1. Summary Vulnerability Listing. (41 pages)

LRH-IC-1-V004	Conveyor Alarm Horns do not sound During Local Operation.	LRH-IC-1-OFI004: 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.	Medium Pre CD-4
LRH-IC-1-V005	Retractable Stop is not Required to be Extended to Open the Import Hatch.	LRH-IC-1-OFI005: 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.	Medium Pre CD-4
LRH-IC-1-V006	The Maintenance Control Panels are not described in the System Description.	LRH-IC-1-OFI006: The Control Logic document (24590-CM-POA-M000-00001-01-00001) 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.	Low Post CD-4
LRH-IC-1-V007	The Configuration Tool Box items for the LRH Hoists and Receipt Conveyors depend on obsolete hardware and software.	LRH-IC-1-OFI007: Configuration toolkits for the LRH hoists and conveyors should be reviewed and updated or instruments replace, if necessary, prior to the beginning of commissioning.	Low Post CD-4
LRH-IC-1-V008	No Link between Interlocks and Requirements.	LRH-IC-1-OFI008: 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.	Low Post CD-4
LRH-IC-1-V009	Start-Stop control station in the LRH Clean Canister Receipt Area is not labeled.	LRH-IC-1-OFI009: 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.	Low Post CD-4
LRH-IC-1-V010	The Software Acceptance Procedures do not identify test actions nor provide criteria for acceptance.	LRH-IC-1-OFI010: 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.	Medium Pre CD-4
LRH-OR-1-V001	24590-LAW-RPT-PO-05-0001, Rev. 0, <i>LAW Reliability, Availability, and Maintainability Data Development Report</i> , inconsistencies and missing information.	LRH-OR-1-OFI001: Correct the inconsistencies in the <i>LAW Reliability, Availability, and Maintainability Data Development Report</i> , 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.	Medium Pre CD-4
LRH-OR-1-V002	24590-WTP-RPT-PT-02-005, Rev. 7, <i>Flowsheet Bases, Assumptions, and Requirements</i> , inconsistent data.	LRH-OR-1-OFI002: Correct the MTBF and MTTR data in the Flowsheet Bases, Assumptions, and Requirements documents so the data is consistent with data provided in the <i>LAW RAM Data Development Report</i> for the LRH conveyors.	Medium Pre CD-4
LRH-OR-1-V003	24590-WTP-MDD-PR-01-001, Rev 12, <i>Operations Research (WITNESS) Model Design Document</i> , inconsistencies and missing data.	LRH-OR-1-OFI003: orrect Operations Research (WITNESS) Model Design Document so the data is consistent with data provided in the <i>LAW RAM Data Development Report</i> and <i>Waste Treatment RAM Basis Report</i> , 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.	Medium Pre CD-4
LRH-OR-1-V004	24590-WTP-RPT-PE-12-002, Rev 0, <i>2012 WTP Operations Research Assessment</i> , data omission.	LRH-OR-1-OFI004: Update OR model to include container grapple that is used in the Import High Bay area.	Low Post CD-4
LRH-CRN-1-V001	Empty LAW container deliveries will affect LSH and RWH operations.	LRH-CRN-1-OFI001: 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.	Medium Pre CD-4
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.	LRH-CRN-1-OFI002: 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.	Medium Pre CD-4

Item No.	Description	Opportunities for Improvement	Rank
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Table B-1. Summary Vulnerability Listing. (41 pages)

LRH-CRN-1-V003	LSH-CRN-00001 Crane usage for the LRH system.	LRH-CRN-1-OFI003: 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).	Low Post CD-4
LRH-CIS-1-V001	Inspection of incoming empty containers required by WTP Contract and ILAW PCP is problematic.	LRH-CIS-1-OFI001: A valid inspection procedure and design for removal of foreign material from the incoming container will need to be provided.	Medium Pre CD-4
LRH-CIS-1-V002	No safe access by personnel to delivery truck trailer.	LRH-CIS-1-OFI002: 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).	Medium Pre CD-4
LRH-CIS-1-V003	No procedure available for removing container wrapping material and shipping cover.	LRH-CIS-1-OFI003: A valid inspection procedure and design for removal of wrapping material and shipping cover from the incoming container will need to be provided.	Medium Pre CD-4
LRH-CIS-1-V004	The angle of view doesn't allow the inspector to see inside the incoming 7.5' tall container.	LRH-CIS-1-OFI004: 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.	Medium Pre CD-4
LRH-CIS-1-V005	The inspection platforms cannot be located the closest possible to the empty container being inspected.	LRH-CIS-1-OFI005: 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.	Medium Pre CD-4
LRH-CIS-1-V006	Time required to unload the container delivery trailer may negatively impact the throughput of the LSH System.	LRH-CIS-1-OFI006: 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.	Low Post CD-4
LRH-CIS-1-V007	Limited staging area for non-acceptable containers.	LRH-CIS-1-OFI007: 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.	Low Post CD-4
LRH-CIS-1-V008	Problematic communication between Inspector in L-0118 and Operators at LOI in Room L0117 or in Control Room.	LRH-CIS-1-OFI008: 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.	Medium Pre CD-4
LRH-CIS-1-V009	Risk exists that proscribed material enters an inspected container in the Staging Area (Room L-0117).	LRH-CIS-1-OFI009: 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.	Low Post CD-4
LRH-CIS-1-V010	Proper angular orientation of the incoming container on the Receipt Conveyors is required but not defined.	LRH-CIS-1-OFI010: 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.	Medium Pre CD-4
LRH-CNVR-1-V001	Container Weight Inconsistencies.	LRH-CNVR-1-OFI001: 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.	Low Post CD-4
LRH-CNVR-1-V002	Receipt Conveyor Design Inconsistencies.	LRH-CNVR-1-OFI002: 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.	Low Post CD-4
LRH-CNVR-1-V003	Staging Conveyor Design Inconsistencies.	LRH-CNVR-1-OFI003: 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.	Low Post CD-4
LRH-CNVR-1-V004	Airlock Conveyor Design Inconsistencies.	LRH-CNVR-1-OFI004: 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.	Low Post CD-4
LRH-CNVR-1-V005	Transfer Conveyor Design Inconsistencies.	LRH-CNVR-1-OFI005: 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.	Low Post CD-4
LRH-CNVR-1-V006	Import/Hatch Conveyor Design Inconsistencies.	LRH-CNVR-1-OFI006: 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.	Low Post CD-4



Table B-1. Summary Vulnerability Listing. (41 pages)

Item No.	Description	Opportunities for Improvement	Rank
LRH-CNVR-1-V007	Conveyor Specification Inconsistencies.	LRH-CNVR-1-OFI007: 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.	Low Post CD-4
LRH-CNVR-1-V008	Conveyor Impact Loading Calculation Inconsistencies.	LRH-CNVR-1-OFI008: 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.	Medium Pre CD-4
LRH-CNVR-1-V009	Conveyor Drive Motor Sizing Inconsistencies.	LRH-CNVR-1-OFI009: 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.	Low Post CD-4
LRH-CNVR-1-V010	Conveyor Stress Analysis Inconsistencies.	LRH-CNVR-1-OFI010: Update the vendor clean container conveyor frame stress analysis calculation to include the bounding weight scenario. Assess the bounding scenario against the current design to understand the adequacy of the installed equipment.	Low Post CD-4
LRH-CNVR-1-V011	FAT Test Inconsistencies.	LRH-CNVR-1-OFI011: 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.	Medium Pre CD-4
LRH-CNVR-1-V012	Structural Floor Design.	LRH-CNVR-1-OFI012: Validate loads defined in LAW Floor Loading Calculation 24590-LAW-S0C-S15T-00002, Rev. 2. Use this information to as input to LAW Steel Framing Calculation 24590-LAW-SSC-S15T-00009 to verify if steel framing design is adequate.	Medium Pre CD-4
LRH-RCSH-1-V001	Contamination migration at the Container Import/Hatch and Conveyor.	LRH-RCSH-1-OFI001: 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).	Medium Pre CD-4
LRH-RCSH-1-V002	LRH System compliance to design and operational safety and health requirements.	LRH-RCSH-1-OFI002: 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.	Medium Pre CD-4
LRH-TOOL-1-V001	Inadequate design basis documentation for container grapple stand.	LRH-TOOL-1-OFI001: Revise design and fabrication documentation for container grapple stand to ensure accurate and as-built information.	Low Post CD-4
LRH-TOOL-2-V001	Inconsistent grapple load rating.	LRH-TOOL-2-OFI001: Increase the grapples safe working load design to 25,000 lbs to handle all container conditions.	Low Post CD-4
LRH-TOOL-2-V002	LAW production container volume, weight, and center of gravity calculation, 24590-LAWM0C-LRH-00004, does not include over pack condition.	LRH-TOOL-2-OFI002: Revise calculation to include the addition of over packing material to the outside of the container.	Low Post CD-4
LRH-TOOL-2-V003	Grapple temperature limitations.	LRH-TOOL-2-OFI003: Add grapple markings to clearly identify temperature limitations the same way safe working loads are identified.	Low Post CD-4
LRH-TOOL-2-V004	Grapple excessive load testing.	LRH-TOOL-2-OFI004: Revise BNI procurement process to ensure vendors test equipment according to contractual documentation and that all requirements are consistent between documents.	Low Post CD-4
LRH-TOOL-2-V005	Design requirement not verified in factory acceptance testing.	LRH-TOOL-2-OFI005: This requirement should be validated during start-up testing to ensure this critical characteristic is met.	Low Post CD-4
LRH-TOOL-2-V006	Requirements for factory acceptance testing not fully being performed.	LRH-TOOL-2-OFI006: This critical design requirement should be performed as part of an additional FAT or demonstrated through analysis.	Low Post CD-4
LRH-TOOL-2-V007	Inconsistent design requirements.	LRH-TOOL-2-OFI007: Revise data sheets, specification, and calculation to indicate a consistent and accurate grapple operating environment.	Low Post CD-4

Table B-1. Summary Vulnerability Listing. (41 pages)

LRH-TOOL-2-V008	Inaccurate model data for LRH process steps.	LRH-TOOL-2-OFI008: Engineering should perform a complete OR model input verification prior to model output is considered valid.	Low Post CD-4
LRH-HST-1-V001	Inconsistent operating environment requirements.	LRH-HST-1-OFI001: Revise design basis documentation to be consistent and perform impact analysis to ensure no impact to equipment life span or performance.	Low Post CD-4
<b>Item No.</b>	<b>Description</b>	<b>Opportunities for Improvement</b>	<b>Rank</b>
LRH-HST-1-V002	Incorrect factory testing requirements.	LRH-HST-1-OFI002: 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.	Low Post CD-4
LRH-HST-1-V003	Failure to perform all required factory acceptance tests.	LRH-HST-1-OFI003: Perform testing requirements during the facility startup.	Low Post CD-4
LRH-HST-1-V004	Limited maintenance allowed from maintenance platforms.	LRH-HST-1-OFI004: Perform a maintenance requirements analysis for the hoists and available space to perform all material handling and maintenance activities.	Low Post CD-4

**APPENDIX C**



# **PATH FORWARD TO CORRECT PROGRAMMATIC DEFICIENCIES**

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**APPENDIX C PATH FORWARD TO CORRECT PROGRAMMATIC DEFICIENCIES**

Table C-1. Path Forward To Correct Programmatic Deficiencies (3 pages)

<b>Action</b>
<b>Inadequate Discipline in Design and Execution Control</b>
Conduct reviews to ensure that the primary documents relied upon to establish design functions and requirements are accurate and complete. A key objective is to ensure that specific/quantifiable requirements are established.
Reintroduce and institutionalize multidisciplinary design reviews and monitor their effectiveness.
Conduct multi-discipline reviews of the individual system designs and associated documentation for compliance with the functions and requirements established in the primary documents. Confirm that any procured items, those in procurement, or presently installed meet the functions and requirements.
Implement sizing standards/guides for equipment to provide a standardized documented basis for design. These should include typical design margins to ensure a conservative design is achieved.
Provide project-approved design input for procurement documents; replace or supplement datasheet level information with technical bases.
<b>Inadequate and Incomplete Control System Design Specification and Execution</b>
Consistently define the ICN boundaries and interfaces commensurate with the functions attributed to the ICN.
Evaluate (or reevaluate) the hazards, risk, safety, and permitting compliance controlled or affected by the ICN and its subsystems.
Define (or redefine) the WTP specific functions requirements performed and controlled by the ICN and the PPJ, carefully tracking the flow down of requirements from upper-tier documents. Use these requirements to provide the detailed test criteria when functionality is confirmed during software development or for vendor acceptance criteria.
Use industry standard documentation sets (e.g. IEEE SE series) for the control system and the functional requirements, making it practical for review without recourse to the designer or maintainer
Eliminate the use of commingled design and requirements documents, and the use of logic diagrams as the sole means of defining functional requirements.
Develop software modification procedures and processes and ensure changes can be effectively isolated and verified with minimal regression testing required.
Conservatively evaluate the effect of manual controlled operations and the impacts on facility performance. Identify and implement increased automation for those areas where it is assessed that maximum benefit will be achieved.
Consider implementing current industry best practice in development of facility human machine interfaces.
<b>Inadequate Analysis or Understanding of Production Capability</b>
Realistic throughput for the facility.
Reconsider the bases and requirements for each system associated with facility performance. Confirm that intersystem interfaces and transitions are considered and integrated.



Develop detailed work plans for a representative set of critical maintenance and operations activities based upon fully-validated design input data that has been analyzed and accepted through a multi-discipline review process. Use this information to develop and validate an OR Model that incorporates a consistent process methodology across all plant systems.

Table C-1. Path Forward To Correct Programmatic Deficiencies (3 pages)

<b>Action</b>
Model all plant operations and maintenance activities in detail using the updated OR Model, scale simulations and mockups to validate throughput, space availability, remotability, accessibility, and availability of interfacing systems and organizations such that the production rate and margin can be accurately estimated at the facility and systems level.
Establish a formal and systematic design approach to identify and disposition issues that may adversely affect plant operations, maintenance and throughput. Address any redesign effort that may be required to minimize operational work-arounds, and unanalyzed production impacts.
Include reasonable and justifiable assumptions to predict performance and quality losses in the model basis and assumptions.
Maintain and utilize models, simulations, and mockups as primary operator training tools.
Consider incorporating lessons learned and operational feedback from the nuclear industry best practices that includes a specific structured approach to examine system operability and maintainability, using data based on years of operations.
<b>Inadequate Implementation of ALARA Principles</b>
Model and evaluate work tasks for each process system, identify potential areas where contamination may migrate, and document any additional engineering (i.e. remotely operated HEPA vacuum cleaners) or administrative controls (i.e. procedures) that will be needed to ensure personnel are appropriately protected.
Evaluate and document predicted possible airborne radioactivity work locations, given maintenance and operations tasks to be performed, and determine whether existing engineering controls will be effective in mitigating the airborne hazard.
Apply epoxy coating to the unprotected walls in the facility where radiological contamination could be present and operations or maintenance activities will be performed.
Accelerate the identification and definition of operation, maintenance, and waste management tasks and then revise dose assessment reports to accurately reflect anticipated dose.
Establish a mockup facility/area to evaluate and practice implementation of approaches to control worker dose and work area contamination prior to in-field execution of tasks expected to be high risk or have high radiological consequences.
<b>Transfer of Scope and Risk to the Commissioning Phase</b>
Identify all systems and components that require testing or functional demonstration as part of commissioning. Where feasible, identify off-line testing, modeling, simulations or mockups that may be used to minimize the risk of deferring these testing and functional demonstrations to commissioning
Develop a system for tracking all testing and functional demonstration activities being deferred to commissioning. Use the tracking system to support the planning and manage the risk of these activities.
<b>Inadequate Implementation of Design Requirements for Waste Management</b>

Reassess the adequacy of the functional requirements associated with secondary radioactive waste management to confirm that the full range of wastes anticipated over the life of the LAW Facility is addressed.

Reassess current secondary waste volumes and waste classifications to derive conservative estimates for design. Provide waste handling process design features to accommodate the forecasted waste volumes and classifications.

Table C-1. Path Forward To Correct Programmatic Deficiencies (3 pages)

<b>Action</b>
Update the OR Model to fully incorporate the waste management processes required to handle the estimated volumes of radioactive wastes generated over the life of the LAW Facility. Develop a range of anticipated scenarios and use the OR Model to assess the impacts of waste management activities on overall production. Assess areas that require design changes to ensure that LAW glass production is not impacted to the extent that mission objectives are jeopardized.
Evaluate the ICD-03 to ensure all roles, responsibilities and impacts to the involved contractors are understood and agreed so that operational control of WTP waste handling operations is established and maintained.
The DOE must ensure a facility to satisfy the secondary waste size reduction and repackaging requirements of the LAW facility is available prior to operation.
<b>Inadequate Consideration of Industrial Safety and Industrial Hygiene Requirements</b>
Define and document the chemical source term coming into the LAW Facility. The evaluation should consider historical information previously generated for the Hanford Tank Farms, and should also recommend routine area monitoring that may be warranted to ensure workers are appropriately protected. In addition, identify and incorporate into the design additional area monitoring that may be needed throughout the facility to ensure worker protection (other than areas associated with the offgas system).
Develop a formal process that ensures safety and health requirements and Industrial Safety and Health personnel are involved in the design process. The process should also list the hierarchy of controls and require a basis to be documented that describes how each control was addressed.
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 10 CFR 851 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).
Revise exposure assessments to accurately reflect chemical and environmental hazards anticipated during the design phase of the project.
<b>Inadequate Consideration for Success of Operations/Maintenance Activities</b>
Complete the hazards analysis for each (or a representative set of) anticipated manual operation or maintenance activity, including consumable replacement (e.g., bubbler, agitator, and pump) and consider mitigating the hazards through engineered methods.
Accelerate the development of detailed task analyses for a representative set of critical maintenance and operations activities based upon currently available designs using a multi-disciplinary review process.
Develop training simulations and mockups to include hands-on operations and maintenance activities.