Independent Follow-up Assessment of Fire Protection at the Lawrence Livermore National Laboratory

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Office of Enterprise Assessments
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Table of Contents

Acronyms

AWWA	American Water Works Association
CFR	Code of Federal Regulations
COVID-19	Coronavirus Disease of 2019
DiD	Defense-in-Depth
DOE	U.S. Department of Energy
DSA	Documented Safety Analysis
EA	Office of Enterprise Assessments
FHA	Fire Hazard Analysis
FLEP	Facility Level Emergency Plan
FPP	Fire Protection Program
FPPM	Fire Protection Program Manual
FSS	Fire Suppression System
gpm/ft^2	gallons per minute per square foot
HEAF	High Explosives Applications Facility
HEPA	High Efficiency Particulate Air
ITM	Inspection, Testing, and Maintenance
ITS	Integrated Tracking System
LFO	National Nuclear Security Administration Livermore Field Office
LLNL	Lawrence Livermore National Laboratory
LLNS	Lawrence Livermore National Security, LLC
NFPA	National Fire Protection Association
NNSA	National Nuclear Security Administration
OAR	Operational Awareness Record
OFI	Opportunity for Improvement
psig	pounds per square inch gauge
SC	Safety Class
SR	Surveillance Requirement
SS	Safety Significant
TFW	Water Supply Tank
TSR	Technical Safety Requirement

Independent Follow-up Assessment of Fire Protection at the Lawrence Livermore National Laboratory

Summary

Scope

This assessment was conducted to follow up on three previous fire protection assessments conducted by the Office of Enterprise Assessments (EA) at the Lawrence Livermore National Laboratory (LLNL). LLNL is operated and managed by Lawrence Livermore National Security, LLC (LLNS) for the National Nuclear Security Administration. The assessment focused on the Plutonium Facility (referred to as Building 332) fire water tank modification project, which was completed in 2015, and the effectiveness of corrective actions taken to address previous EA (and predecessor organization) findings associated with the LLNS fire protection program. All assessment activities were conducted remotely due to COVID-19 pandemic-related travel constraints.

Significant Results for Key Areas of Interest

Overall, the Building 332 fire water tank modification project resulted in a simplified design and more reliable safety-related fire suppression system (FSS), and an improved ability to conduct maintenance on the fire suppression components associated with the modification. LLNS also generally addressed the weaknesses identified in previous EA findings. However, this assessment identified one weakness associated with maintenance of water supply system isolation valves that was related to a previous finding as well as additional weaknesses with several aspects of the fire water tank modification project in areas not scrutinized by the 2015 assessment because they had not been finalized at the time.

Design and Engineering of the Fire Water Tank Modification

The design and engineering aspects of the fire water tank modification project adequately implemented most of the applicable requirements. However, the assessment team identified several weaknesses associated with hydraulic modeling inputs, design methodologies used in the hydraulic calculations, and the identification of system boundaries. These weaknesses introduce uncertainties regarding the capabilities of the FSS in meeting established safety performance requirements.

FSS Operability, Inspection, and Testing

The operability, inspection, and testing processes for the Building 332 FSS associated with the fire water tank modification project are generally adequate. However, the assessment team identified some specific areas of weakness in the procurement of replacement parts and with the conduct of required testing as well as the surveillance of the fire water tank pressure. These weaknesses represent additional uncertainties in the performance capabilities of the FSS.

Follow-up on Previous Findings

Three previous findings from the 2013 assessment, as well as related issues from a 2016 follow-up assessment, have been satisfactorily addressed through completed corrective actions. However, this current assessment identified that the application of maintenance standards for water system isolation valves was not conducted in accordance with applicable requirements. Additionally, the assessment team identified one instance in which the repair of a fire hydrant was not adequately documented and tracked.

Best Practices and Findings

There were no best practices identified as part of this assessment.

The assessment team identified one new finding associated with the fire water tank modification project, namely that LLNS did not ensure that a safety significant component (fusible plug) was listed with an approved organization as suitable for the intended purpose.

Follow-up Action

A future EA fire protection program assessment will be conducted for LLNL which will include a walkdown of facilities as well as follow up on the new issues documented in this report. A future EA issues management program assessment will also be conducted to follow up on identified weaknesses pertaining to the documentation and tracking of issues.

Independent Follow-up Assessment of Fire Protection at the Lawrence Livermore National Laboratory

1.0 INTRODUCTION

The U.S. Department of Energy (DOE) Office of Nuclear Safety and Environmental Assessments, within the independent Office of Enterprise Assessments (EA), conducted a follow-up assessment of the fire protection program (FPP) at the Lawrence Livermore National Laboratory (LLNL) in March 2021. LLNL is managed by Lawrence Livermore National Security, LLC (LLNS) for the National Nuclear Security Administration (NNSA). The assessment focused on the Plutonium Facility (referred to as Building 332) fire water tank modification project, and the effectiveness of corrective actions taken to address previous EA (and predecessor organization) findings associated with the LLNS FPP.

EA conducted an assessment from August 2014 to May 2015 (hereafter referred to as the 2015 assessment) of the Building 332 fire water tank modification project. Those assessment results and items for follow-up were documented in a field note, EA-LLNL-2015-08-31, *Building 332 Safety Class Fire Water Tank Modification Design Review*. The current assessment followed up on the 2015 assessment results and focused on the final design and supporting analyses; the approved Building 332 documented safety analysis (DSA) and technical safety requirements (TSRs) changes; surveillance test procedures; normal, abnormal, and emergency operating procedures; and preventive maintenance procedures.

Additionally, this assessment followed up on three of four previous EA findings originally identified in the report, *Independent Oversight Review of the Fire Protection Program at Lawrence Livermore National Laboratory – September 2013* (hereafter referred to as the 2013 assessment). The 2013 assessment focused on the LLNS FPP at Building 332, which is a hazard category 2 facility, and the High Explosives Applications Facility (HEAF). In August 2016, EA performed a follow-up assessment of LLNS's response to the four findings identified in the 2013 assessment. The results of that assessment were documented in the Operational Awareness Record, OAR-EA-LLNL-2016-08-15, *Follow-up Assessment of the LLNL Fire Protection Program as Implemented for the Plutonium Facility and the High Explosives Applications Facility* (hereafter referred to as the 2016 assessment). The 2016 assessment concluded that LLNS had resolved Finding F-1, but not the other three findings (F-2, F-3, and F-4). The 2016 assessment also identified additional fire protection concerns related to the three unresolved findings.

This assessment was conducted remotely during March 2021 due to the COVID-19 pandemic.

2.0 METHODOLOGY

The DOE independent oversight program is described in and governed by DOE Order 227.1A, *Independent Oversight Program*, which is implemented through a comprehensive set of internal protocols, operating practices, assessment guides, and process guides. This report uses the terms "best practices, deficiencies, findings, and opportunities for improvement (OFIs)" as defined in DOE Order 227.1A.

The assessment team used selected objectives and criteria from EA criteria and review approach document (CRAD) 31-12, *Fire Protection Program*, Revision 2, and Objective CAS.3 of EA CRAD 30-01, *Contractor Assurance System*, Revision 1. Industry standard citations in this assessment report are based on the current editions.

The assessment team examined key documents, such as the DSA and TSRs, fire hazard analyses (FHAs), design calculations, hydraulic models, program documents, work packages, procedures, and issue tracking system entries. The assessment team also conducted an interview of key personnel responsible for maintaining the site water supply at LLNL.

The members of the assessment team, the Quality Review Board, and management responsible for this assessment are listed in Appendix A. The specific findings and issues identified for follow-up from previous independent assessments are addressed in this report.

3.0 RESULTS

Subsections 3.1 and 3.2 focus on items identified for follow-up in the 2015 assessment of the fire water tank modification project in areas that had not been finalized at the time. Subsection 3.3 focuses on the effectiveness of the LLNS corrective actions for the findings and deficiencies identified in the 2013 and 2016 assessments of the LLNS FPP.

3.1 Design and Engineering of the Fire Water Tank Modification

The objective of this portion of the assessment was to assess whether the engineered design features and associated analyses of the Building 332 fire water tank modification project are technically adequate and implement the requirements of DOE Order 420.1C, *Facility Safety*, such that adequate protection of the public, the workers, and the environment from fires and other hazards is demonstrated.

Overview

The Building 332 fire water tank modification project included disconnecting the safety class (SC) water spray system piping from a water supply tank (TFW-1), rerouting piping to a preexisting water supply tank (TFW-2), abandoning tank TFW-1 in-place, and installing a new pressurized air supply for tank TWF-2. This project resulted in a simplified fire suppression system (FSS) design with improved reliability of the safety-related water spray system, and eliminated a complex air supply system, pressure balancing system, and backup air supply system.

Hydraulic Modeling and Calculations

LLNS performed hydraulic calculations, using commercially available software, to validate the water flow rate and duration to the Building 332 FSS using the methodology of National Fire Protection Association (NFPA) 13, *Standard for the Installation of Sprinkler Systems*. This software models fire systems that are designed in accordance with NFPA 13 and NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, and LLNS's software quality assurance organization has accepted this software for fire systems hydraulic calculations.

The *LLNL Fire Protection Program Criteria*, Policy 1.2, identifies the NFPA Fire Codes as mandatory standards, and the *Building 332 System Design Description for the Fire Suppression System*, Section 3.1.2.1, requires that upgrades or modifications to the automatic sprinklers shall meet the requirements of NFPA 13. NFPA 13 provides detailed steps for designing suppression systems as well as procedures for conducting hydraulic modeling calculations. The design process for the Building 332 FSS generally followed this process with a few exceptions noted below. This process necessitated the identification of the most hydraulically remote area(s) of the building, one of which was appropriately identified as Building 332 Room 1009. Following this step, the calculations referenced above were used to verify that the FSS meets the minimum design requirements of the code, thereby qualifying the entire building

because similarly designed areas that are less hydraulically remote will meet or exceed the design requirements.

The assessment team identified several issues with the inputs and design methodologies used in the hydraulic calculations, with general areas of concern summarized below. The assessment team provided more detailed descriptions and examples, as well as annotated drawings or hydraulic calculation data sheets, to LLNS and NNSA Livermore Field Office (LFO) representatives. The concerns identified below were based on a limited sample of hydraulic information reviewed by the assessment team. As a result of the assessment team's feedback, LLNS initiated further evaluations and in-field measurements, which are still ongoing at the time of writing this report, regarding meeting NFPA requirements such as average sprinkler density, maximum area of coverage, and pipe length modeling. EA will follow up on these issues in a future assessment.

- Pipe fittings were not associated with the correct pipes to accurately reflect the method for calculating friction loss using the Hazen-Williams formula, as delineated in NFPA 13, Subsection 27.2.4.8. The assessment team, in its review of the FSS calculations, identified that pipe fittings had been assumed to be located on the pipe segment upstream of the fittings, rather than on the downstream piping segment as actually installed/applied. Subsequent to the assessment team's review, LLNS performed additional calculations for the safety significant (SS) portion of the FSS and determined that the consequences of these specific identified errors were insignificant. Importantly, this issue also applies to controlling a design basis fire as applied to the defense-in-depth (DiD) portions of the FSS. Because this issue could impact calculated flow to nozzles or sprinklers, the accuracy of the analysis to determine sufficient flow could correspondingly be impacted.

- Based on dimensions in piping layout drawings that the assessment team reviewed, Room 1009 does not meet the minimum design requirements of NFPA 13, as demonstrated by the items below. Therefore, it is indeterminate whether other areas of the building are code compliant, which could result in the inability of the sprinkler system to control a design basis fire.

    - The calculations used an average sprinkler density (amount of water in gallons per minute per square foot (gpm/ft^2)) to determine the required water demand, rather than verifying that each operating sprinkler is flowing at least the minimum density on a per-sprinkler basis, as required by NFPA 13, Subsection 27.2.4.7.1. The DSA specifies a minimum density of 0.15 gpm/ft^2; however, the assessment team determined that this criterion would be met for only 12 out of 21 sprinklers in Room 1009.

    - NFPA 13 specifies the maximum area of coverage for ordinary hazard occupancies for standard upright or pendant sprinklers as 130 ft^2 per NFPA 13, Table 10.2.4.1.2(b). The NFPA 13 required maximum area of coverage was met for only 13 out of 21 sprinklers in Room 1009.

- The assessment team identified discrepancies in pipe lengths for the DiD portions of the system in calculation AB-B332-15-014, *Flow Analysis: Capability of the Domestic Water System at 58 psi to supply SC FSS*. These discrepancies can also result in inaccurate fire water flow information and could result in inadequate sprinkler coverage during a design basis fire.

Further, on sheet 1 of calculation AB-B332-14-003, *Volume and Flow Analysis of B332 7500 Gallon Fire Water Tank, TFW-2*, the checkbox for "Preliminary" was checked even though all required signatures for independent review were complete. The LLNS staff indicated that the preliminary checkbox was checked through an administrative error.

System Boundaries

The 2015 assessment noted that the fire water tank modification project planned to provide redundant check valves at the interface between the facility non-safety-related compressed air system and the SC (now SS) tank pressure system, which provides the motive force to actuate water flow through the water spray nozzles. Drawing AA15-504106-AB, *VSS-Fire Suppression System Bsmt, 1ST Fl, Rm 1200, & Yard Fire Water P&ID*, identifies the interface of the SS boundary of the FSS with the DiD air pressure monitoring sensors located in the motive gas control manifold panel. The function of the sensors is to provide high- and low-pressure alarm signals to the operations room.

This drawing and the description in DSA Section 4.4.5.2 show that the SS boundary of the FSS extends only up to the air pressure monitoring sensors inlet connections. However, LLNS has no air pressure monitoring sensor design information (e.g., manufacturer's design drawing or specifications) for the internal configuration of these sensors beyond these connections. Therefore, the actual SS boundary could be internal to the sensors, not at the inlet. Because the internal design information of the sensors was not known, the potential failure modes were not identified where the SS portion of the FSS could lose the ability to perform its required safety function (of maintaining the pressure boundary), as required by DOE Order 420.1C, Attachment 3, Section 3.a.(4). Also, understanding system boundaries and potential failure modes is necessary to ensure that required inspections, testing, and maintenance can be adequately conducted. (See **Deficiency D-LLNS-1**.) Additionally, the assessment team noted that drawing AA15-504106-AB is not listed in DSA Section 4.4.5.2.3 as a referenced FSS drawing.

DSA and FHA Integration for Fire Water Tank Modification

Overall, the DSA and FHA are mutually consistent with one exception. DOE Order 420.1C, Attachment 2, Chapter II, paragraph 3.f.(1)(d)3a requires the FHA to be revised upon changes to the safety basis. The current DSA (UCRL-AR-119434-12) dated May 2017 classifies the water spray system protecting the HEPA filtration system as SS, having been downgraded from SC in the May 2016 DSA revision. However, Section 2.5.8 of the current FHA (Revision 13, dated July 30, 2020) still identifies the water spray systems that protect the HEPA filtration system as SC. (See **Deficiency D-LLNS-2**.) When informed by the assessment team, the LLNS fire protection personnel acknowledged this issue and noted the needed change in their informal future FHA change list.

Design and Engineering of the Fire Water Tank Modification Conclusions

In general, the fire water tank modification project resulted in a simplified FSS design with improved reliability of the SS water spray system. However, the assessment team identified weaknesses associated with the modeling inputs and design methodology used in the fire water system calculations that could have adversely impacted the ability of the FSS to control a design basis fire. In response to these issues, LLNS performed additional calculations that demonstrated an insignificant impact on the SS portions of the FSS. Additionally, LLNS has no pressure monitoring sensor design information to identify potential failure modes, which is needed to ensure that the FSS can be adequately inspected, tested, and maintained, and thus perform its intended safety function. Lastly, the DSA and FHA are not consistent regarding classification of water spray systems that protect the HEPA filtration system.

3.2 FSS Operability, Inspection, and Testing

The objective of this portion of the assessment was to assess the implementation of controls and procedures associated with the Building 332 fire water tank modification project to ensure fire protection systems operability.

Overview

The LLNS Fire Protection Program Manual (FPPM) and TSR surveillances, for the most part, adequately implement all relevant inspection and testing activities that ensure fire protection systems can reliably perform their intended safety functions when required.

Suitability of Components to Maintain Operability

DSA Section 4.4.5.2 describes the SS water spray system protecting the associated HEPA filtration system from excessive heat as a deluge subsystem consisting of a deluge valve, fusible plug, spray nozzles, interconnecting piping, and demisters. The purpose of the fusible plug is to activate (melt) at elevated temperatures, which allows water to flow through the deluge valve to the water spray nozzles. The DSA performance criteria for the fusible plugs states, "plenum fusible plugs shall be capable of activating the deluge valves in fire conditions."

The LLNS system design description, *Building 332 System Design Description for the Fire Suppression System*, paragraph 3.1.2.2 states that upgrades or modifications to the SS water spray system protecting the HEPA filtration system are performed in accordance with NFPA 15, *Standard for Water Spray Systems for Fire Protection*. Automatic sprinklers are typically used in this application; fusible plugs are not specifically described in NFPA 15. Further, NFPA 15 requires all FSS components to be listed for their intended purpose by an approved organization (e.g., Underwriters Laboratories, FM Approvals).

A fusible plug replacement was required in 2016 for a deficient one found during a required inspection by LLNS technicians. LLNS fire protection personnel developed replacement component purchase documentation but did not specify the requirement for the fusible plug to be listed for the intended purpose by an approved organization. The manufacturer's data on the installed fusible plug indicated that the fusible plug is listed by Underwriters Laboratories for refrigerant service, but not for fire service. This data was confirmed by the assessment team in discussions with the manufacturer's representatives. The available information does not provide reasonable assurance that NFPA 15 requirements were met, or that the fusible plug installed in the SS water spray system protecting the HEPA filtration system can meet the safety functions, functional requirements, and performance criteria established in the DSA. This issue is contrary to 10 CFR 830.122 Criterion 7 that requires procured items to meet established requirements and perform as specified. (See **Finding F-LLNS-1**.)

FSS Inspection and Testing

The LLNS FPPM appropriately implements NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*. NFPA 25 includes a requirement for annual testing of the nozzle discharge patterns for water spray systems to ensure adequate coverage. Where the nature of the protected property is such that water cannot be discharged, NFPA 25 specifies that "nozzles shall be inspected for proper orientation and the system tested with air to ensure that the nozzles are not obstructed." This approach was adopted at LLNL in a 1995 equivalency request (approved by DOE) that allows testing of the nozzles using air and requires that discharge nozzles be visually inspected for blockage when feasible.

Surveillance procedure ELM-U No. 1000859395, *Semiannually, FDAS Input Switch Appliance Alarm Verification, SR 4.16.2 Annually, Increment 1 GBES Spray Plenum Deluge Valves, SR 4.10.1.g*, satisfies the NFPA 25 annual alternative test requirement by flowing nitrogen through the piping into the nozzles. However, surveillance requirement (SR) 4.16.2 only requires verifying nitrogen flows for a short period into the piping and does not verify that nitrogen is flowing from all nozzles, indicating that they are free of internal obstructions or blockage as required by NFPA 25 and the approved equivalency. LLNS staff

stated that spray nozzle testing and inspection to ensure that there is no obstruction for each individual nozzle must weigh the potential radioactive contamination and additional dose considerations for this work as the spray nozzles are on the upstream side of the HEPA filters in the Room Ventilation and Glovebox Exhaust Systems. However, the assessment team noted no attempt to use radiological surveys to determine actual conditions to establish whether the required inspections would be feasible. Although the surveillance procedure requires a visual inspection of the nozzles for external corrosion and/or degradation through a distant view port and nitrogen flow test, this inspection does not individually verify that each spray nozzle is free of internal obstruction. (See **Deficiency D-LLNS-3**.) Additionally, LLNS could not provide historical evidence that all nozzles have been inspected and tested to ensure that nozzles are not obstructed and to verify the proper flow pattern, per NFPA 25. Fully or partially obstructed nozzles impede the ability to satisfy the DSA safety-related performance criteria.

Further, during the annual nitrogen test, the water supply piping that feeds the nozzles is open to the environment due to the physical removal of a section of piping when attaching the nitrogen connections. This exposure could allow opportunities for contaminants to enter the piping that could obstruct nozzles. (See **OFI-LLNS-1**.)

Pressure Measurement

Surveillance requirements for the FSS are established in the DSA and TSRs to ensure that the system will perform its intended safety function as designed under accident conditions. DSA Section 4.4.5.4 specifies that the fire water tank pressure shall be between 60 pounds per square inch gauge (psig) and 100psig. DSA Section 4.4.5.5 requires the fire water tank pressure blanket to be verified weekly. This criterion is flowed down to TSR SR 4.10.1.b, which requires a weekly verification that the fire water tank pressure blanket is between 60psig and 100psig. TSR Surveillance Procedure LLNL-MI-818361, *Weekly, TFW-2 Level and Pressure Checks, SR 4.10.1.a,b*, incorporates this requirement. However, the assessment team noted that LLNL-MI-818361 does not account for variations in gauge accuracy as a potential source of error; consequently, gauge readings at the TSR limit extremes (60psig and 100psig) could exceed the TSR limits. These potential measurement uncertainties were not considered in the establishment of the DSA and TSR limits, and as such, this surveillance procedure did not provide the criteria for measurement inspection as required by DOE Order 420.1C. When informed of this issue by the assessment team, LLNS revised the surveillance procedure to reflect the pressure acceptance criteria of 65-95psig to account for measurement uncertainty.

FSS Operability, Inspection, and Testing Conclusions

The operability, inspection, and testing processes for the Building 332 fire water tank modification project are generally adequate. However, the assessment team identified some areas of weakness in the procurement of a replacement SS component (fusible plugs), the conduct of required testing of the water spray system, and the surveillance of the fire water tank pressure.

3.3 Follow-up on Previous EA Findings

The objective of this portion of the assessment was to assess the effectiveness of LLNS corrective actions in response to three findings (F-2, F-3, and F-4) originally identified in EA report *Independent Oversight Review of the Fire Protection Program at Lawrence Livermore National Laboratory – September 2013*. The assessment team also evaluated LLNS responses to related issues identified during the 2016 assessment that was documented in OAR-EA-LLNL-2016-08-15.

3.3.1 Fire Safety Conditions in the High Explosives Applications Facility (2013 Finding F-2)

2013 Finding F-2: *Several non-compliant fire safety conditions were identified during the HEAF walkdown/tour, including restricted egress, obstructed fire extinguishers, improperly stored flammable liquids, and an outdated placard.*

During the 2016 assessment, EA confirmed that several of the 2013 Finding F-2 issues had been resolved. However new, similar examples were noted:

- Combustible materials were stored under the stairs in the Gun Bay, including a shop vacuum, which was also wedged against a sprinkler head, contrary to the requirements of NFPA 13.
- An unsecured 2.5-gallon pressurized fire extinguisher was located on the floor of the Gun Bay, contrary to the requirements of NFPA 10, *Standard for Portable Fire Extinguishers*.
- Three storage cabinets for flammable liquids had been procured and installed in the high bay; however, the cabinets did not meet the specific design criteria required by NFPA 30, *Flammable and Combustible Liquids Code*.
- One sprinkler riser did not have a placard, and another riser placard had not been updated to reflect the actual sprinkler systems that the riser supplied. Additionally, the sprinkler system control valves were not identified with a sign indicating the system or portion of the system they control as required by NFPA 13.

LLNS tracked the original 2013 Finding F-2 in its Integrated Tracking System (ITS) and completed several actions in response to the finding. During this current assessment, LLNS personnel reported completing numerous actions in response to the 2016 assessment. These actions included removing combustible materials from under the Gun Bay stairs, roping off the area, and posting a sign to prevent further storage of combustibles in that location; properly securing the fire extinguisher; evaluating flammable liquid storage cabinets to verify adequacy; and updating sprinkler riser placards and control valve sign.

The assessment team reviewed recent photographs of pertinent areas, equipment, and signage to verify that the actions reported above were complete, and reviewed documentation concerning the design of the flammable liquid storage cabinets. The assessment team concludes that LLNS has satisfactorily addressed 2013 Finding F-2 and the similar issues identified in 2016.

3.3.2 Inspection, Testing, and Maintenance of Fire Water System (2013 Finding F-3)

2013 Finding F-3: *Inspection, Maintenance, and Testing of the fire water supply components are not in accordance with NFPA standards.*

During the 2013 assessment of LLNS maintenance personnel's inspection, testing, and maintenance (ITM) of the fire water supply components, fire hydrants, including isolation valves, were not being inspected or tested, and the frequencies for flushing of hydrants had been extended beyond the required frequencies specified in NFPA 25. LLNS tracked this finding in ITS and completed several actions.

During the 2016 assessment, this finding was expanded to articulate further concerns that LLNS had not demonstrated that a reliable and adequate water supply for fire protection is provided to LLNL as required by DOE Order 420.1C, including:

- The Emergency Management Division was not testing all fire hydrants annually in accordance with Lawrence Livermore Fire Department Policies and Procedures 1412 and NFPA frequencies. The status of progress on addressing this issue is detailed in Subsection 3.3.2.1 below.

- The last time LLNS operated any large group of isolation valves in the water utility system was November 2013, in response to the 2013 assessment. At the time of the 2016 assessment, LLNS had not completed its annual preventive maintenance for each water utility system main isolation valve. The status of progress on addressing this issue is detailed in Subsection 3.3.2.2 below.

- An interdepartmental letter, within the LLNS fire protection organization, stated that the LLNL water system is considered a water utility and that elements of the water utility would follow the standards established by the American Water Works Association (AWWA) and further implied that NFPA codes and standards only apply to fire protection systems from the isolation valve into the building. However, LLNS could not produce any formal documentation from LFO to LLNS validating this decision. The status of progress on addressing this issue is detailed in Subsection 3.3.2.3 below.

- At the time of the 2016 assessment, LLNS had not identified the critical valves necessary to maintain fire water service in the event of an emergency or crisis. The status of progress on addressing this issue is detailed in Subsection 3.3.2.4 below.

3.3.2.1 Annual Testing of Fire Hydrants

In 2017, LLNS implemented a software-based maintenance tracking system for testing of fire hydrants. Maintenance records for 2019 and 2020 confirm that fire hydrant maintenance and testing are performed in accordance with NFPA 25. Further, an August 2020 LFO assessment report determined that annual fire hydrant maintenance has been performed since 2018. Fire hydrant records demonstrate that the required flow test and the block valve exercising are performed on an annual schedule. The LLNS Fire Marshal collects data of the fire hydrant ITM and ensures that the ITM is compliant with NFPA 25.

Overall, the LLNS process and procedures for scheduling, tracking, performing, and documenting ITM are adequate with one exception. There is no formal mechanism for ensuring that necessary repairs are timely. On December 5, 2020, the fire department staff who completed ITM on a hydrant documented that the block valve would not reopen and "this hydrant is effectively out of service. Needs immediate repair." However, LLNS could not provide any records to verify that the problem was either resolved or scheduled for repair and did not realize that the fire hydrant still needed repair until they responded to the assessment team's request for information. This represents a potential weakness in issues management processes. (See **Section 8.0**.)

The assessment team concludes that LLNS has satisfactorily addressed this aspect of 2013 Finding F-3.

3.3.2.2 Inspection, Testing, and Maintenance of Water System Valves

Following the 2016 assessment, actions taken by LLNS to address the issue included adding additional staffing to resume the valve testing and updating the system for tracking maintenance from relying on hard copy documentation in binders to using a software-based maintenance tracking system. LLNS also replaced several of the oldest isolation valves and made substantial efforts to locate and mark buried valve boxes to facilitate future annual maintenance. The assessment team verified electronic records documenting isolation valve maintenance for 2019 and 2020 and concluded that LLNS has satisfactorily demonstrated that they have established a process and have adequate resources to perform periodic maintenance on the valves in the water supply system.

The LLNS FPPM Section 9.6.7 states, "The LLNL water system is considered a water utility and is to be maintained in accordance with standards of the American Water Works Association." Furthermore,

LLNL Fire Protection Engineering Standard Policy 2.8.0, *Water Utility and Fire Protection System Water Supply*, which was initiated and approved by LLNS, and concurred on by LFO, specifically requires certain portions of the LLNL water system to be maintained in accordance with the AWWA's Manual of Water Supply Practices M44, *Distribution Valves: Selection, Installation, Field Testing, and Maintenance* (M44). M44 states, in part, "All gate valves should be cycled from full open to full close and back to open at least once every five years." However, the LLNS annual valve maintenance procedure directs the technician to only close the valves approximately 25% and then back to open. During interviews, LLNS subject matter experts stated that their strategy of performing a less than full cycle (approximately 25% in the shut direction) at an interval of once per year meets or exceeds the AWWA recommendation. However, LLNS fire protection personnel have not performed or documented an engineering evaluation to support this assertion. (See **Deficiency D-LLNS-4**.)

The assessment team concludes that LLNS has satisfactorily addressed this aspect of 2013 Finding F-3 as written, and as further articulated in the 2016 assessment. However, the maintenance of isolation valves is not in accordance with LLNS's commitment to follow AWWA as specified in the LLNS FPPM, and LLNS has not developed an engineering justification for their current practice.

3.3.2.3 Formal Designation and Approval of Water System Boundaries and Applicable Standards

In a letter to LFO dated June 23, 2017, LLNS submitted Fire Protection Engineering Standard Policy 2.8.0, which delineated the sections of the LLNL water system that would be maintained in accordance with AWWA standards, and those that would be maintained in accordance with NFPA standards. This policy also states where the fire system begins and ends, and specifies which organization is responsible for ITM of the fire water system and the water utility system. LFO responded with a letter dated August 27, 2018, stating that it had reviewed and concurred with Fire Protection Engineering Standard Policy 2.8.0.

The assessment team concludes that LLNS has satisfactorily addressed this aspect of 2013 Finding F-3.

3.3.2.4 Identification of Critical Valves

M44 states, in reference to "Best Management Practices" for valve maintenance, that "It is difficult for water providers to schedule an annual scheduling of the operation and maintenance of each valve in their system. For this reason, it is important to identify the critical valves necessary to maintain the effective provision of service in an emergency or during a crisis. Once selected, it should be the intent of the agency to schedule maintenance and operation on these valves in a manner that can be achieved within a reasonable timeframe."

In a letter to LFO dated June 23, 2017, LLNS stated that it defined critical valves to be **all** [emphasis added] water main isolation valves, including all inline valves from the point source, to and including the curb service valves. The letter further stated that the turning and inspection process, as recommended by AWWA, which is therefore required by the FPPM and Fire Protection Engineering Standard Policy 2.8.0, shall be performed once every five years for each isolation valve. During interviews for this current assessment, LLNS staff members stated that "critical valves" have been subsequently redefined as only the isolation valves on circulating mains and the first valve on a branch main feeding a building. This new strategy is consistent with the intent of the M44 best management practice regarding identifying critical valves; however, the LFO fire protection lead noted that LFO had not been informed of this change. (See **OFI-LLNS-2**.)

The assessment team concludes that LLNS has satisfactorily addressed this aspect of 2013 Finding F-3.

3.3.3 Employee Awareness of Life Safety Deficiencies (2013 Finding F-4)

2013 Finding F-4: *Interim compensatory measures are insufficient at the facility level to ensure that the building occupants are aware of life safety deficiencies.*

The 2016 assessment determined that LLNS's proposed actions did not address developing a response plan that ensures that building occupants are aware of potential life safety deficiencies or establish compensatory measures at the facility level. LLNS tracked these issues in ITS. LLNS has since completed actions in response to this finding, including providing a hard copy of the applicable Facility Level Emergency Plans (FLEPs) to all employees for their primary work locations, as well as posting the relevant FLEPs at the entrances of the buildings. The assessment team reviewed a sample FLEP and photographs of the postings at various building entrances.

Based on the actions completed by LLNS, as well as the examples and photographs of FLEPs, the assessment team concludes that LLNS has satisfactorily addressed 2013 Finding F-4.

3.3.4 Follow-up of Previous Findings Conclusions

The three previous findings from the 2013 assessment (F-2, F-3, and F-4) have been adequately addressed through completed corrective actions. However, this current assessment identified a new issue, which is documented as a new deficiency, in that LLNS's application of maintenance standards described in M44 is inadequate and has no engineering justification.

4.0 BEST PRACTICES

There were no best practices identified as part of this assessment.

5.0 FINDINGS

Findings are deficiencies that warrant a high level of attention from management. If left uncorrected, findings could adversely affect the DOE mission, the environment, the safety or health of workers and the public, or national security. DOE line management and/or contractor organizations must develop and implement corrective action plans for findings. Cognizant DOE managers must use site- and program-specific issues management processes and systems developed in accordance with DOE Order 226.1, *Implementation of Department of Energy Oversight Policy*, to manage the corrective actions and track them to completion.

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Finding F-LLNS-1: LLNS did not ensure that the replacement fusible plug was listed by an approved organization as suitable for the intended purpose, as required by NFPA 15. This is contrary to quality assurance requirements to ensure that items are procured that meet established requirements and perform as specified. (10 CFR 830.122, Criterion 7)

6.0 DEFICIENCIES

Deficiencies are inadequacies in the implementation of an applicable requirement or standard. Deficiencies that did not meet the criteria for findings are listed below, with the expectation from DOE Order 227.1A for site managers to apply their local issues management processes for resolution.

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Deficiency D-LLNS-1: LLNS has not identified the boundary of the SS portion of the FSS within the air pressure monitoring sensor; therefore, the interface cannot be evaluated for a failure that could prevent the FSS from performing its safety function. (DOE Order 420.1C, Attachment 3, Section 3.a.(4))

Deficiency D-LLNS-2: LLNS has not updated the FHA to reflect water spray systems that protect the HEPA filtration system with the new functional classification, SS, as specified in the DSA. (DOE Order 420.1C, Attachment 2, Chapter II, Section 3.f.(1)(d)3a)

Deficiency D-LLNS-3: LLNS does not adequately conduct visual inspections of nozzles for internal obstructions when performing annual testing of the water spray system using nitrogen. (NFPA 25)

Deficiency D-LLNS-4: LLNS does not conduct isolation valve maintenance in accordance with applicable requirements. (LLNS FPPM)

7.0 OPPORTUNITIES FOR IMPROVEMENT

The assessment team identified two OFIs to assist cognizant managers in improving programs and operations. While OFIs may identify potential solutions to findings and deficiencies identified in assessment reports, they may also address other conditions observed during the assessment process. These OFIs are offered only as recommendations for line management consideration; they do not require formal resolution by management through a corrective action process and are not intended to be prescriptive or mandatory. Rather, they are suggestions that may assist site management in implementing best practices or provide potential solutions to issues identified during the assessment.

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OFI-LLNS-1: LLNS should consider an alternate means of introducing a test gas (such as a permanently installed test connection with an isolation valve) for the annual nitrogen flow test of the FSS that would preclude the potential for introducing contaminants to the water spray system.

OFI-LLNS-2: LLNS should consider formally notifying LFO of changes to various aspects of the fire protection system.

8.0 FOLLOW-UP ITEMS

EA will conduct an onsite assessment to follow up on the newly identified issues associated with the fire water storage tank modification project and water system isolation valve maintenance. Additionally, EA plans to conduct a future issues management assessment to follow up on identified weaknesses regarding the documentation and tracking of issues, such as the discrepancies noted during fire hydrant testing.

Appendix A
Supplemental Information

Dates of Assessment

Remote Assessment: March 2021

Office of Enterprise Assessments (EA) Management

John E. Dupuy, Director, Office of Enterprise Assessments
William F. West, Deputy Director, Office of Enterprise Assessments
Kevin G. Kilp, Director, Office of Environment, Safety and Health Assessments
Kevin M. Witt, Director, Office of Nuclear Safety and Environmental Assessments
Charles C. Kreager, Director, Office of Worker Safety and Health Assessments
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