



**Discovery of Contamination Spread at the Plutonium Finishing Plant
during Demolition Activities**

EM-RL--CPRC-PFP-2017-0018

CR-2018-0022

(DRAFT Rev. 2)

ROOT CAUSE EVALUATION REPORT

March 5, 2018

Team Leader: _____ Date: _____
Cause Analyst

Cause Analyst: _____ Date: _____

Responsible Manager: _____ Date: _____

Assistant Recovery
Manager: _____ Date: _____

Recovery Manager: _____ Date: _____

ESRB Chairman: _____ Date: _____

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EXECUTIVE SUMMARY

Between December 14 and December 18, 2017, contamination was detected outside of the Contamination Area (CA) at the Plutonium Finishing Plant (PFP) demolition zone, including around the PFP offices and on multiple vehicles located outside the radiological boundary. The consequences of this event were personnel exposure and potential radiological contamination leaving the Hanford Site.

The scope of this causal analysis is focused at the events leading up to and including the contamination spread outside the PFP CA and development of the corrective actions to prevent recurrence. Specific methods to be used upon resumption of demolition activities are under development at the time that this report is approved and will be fully vetted by the DOE-RL and the DOE Expert Panel. It should also be noted that studies of radiological emissions from Hanford are part of the routine National Emission Standards for Hazardous Air Pollutants Compliance Monitoring (NESHAPS) Program and are not addressed in this report.

A causal analysis team was chartered (reference Attachment 4), consisting of facility subject matter experts, program representatives, and independent mentors. Hanford Atomic Metal Trades Council Safety Representative also attended the analysis meetings; DOE-RL provided oversight. Based on documentation review and expert knowledge, the team utilized Barrier Analysis and Why Staircase analysis techniques to derive the causal factors. Six Judgments of Need were identified and subsequently mapped to the identified causes (Attachment 1). The analysis identified two Root Causes (RC), two Contributing Causes (CC), and two Extraneous Conditions Adverse to Quality (ECAQ). This report identifies failures in expected performance with respect to decision making, rigorous use of processes and work force communications. The compensatory actions for these themes are focused on preventing recurrence for the remainder of the PFP demolition, whereas longer term corrective actions are being implemented for the remaining cleanup work in progress at CHPRC.

Listed below are the Root Causes which when corrected, will prevent recurrence of the event or issue:

RC-01: Over-reliance on selective empirical data gathered during the course of, and following demolition was used in making decisions on the rate and methods of demolition.

Project Management relied on selective empirical data from workplace radiological indicators (usually continuous air monitors) as the primary set of work package controls to pace the rate of demolition. Prior to the December event, the workplace radiological indicators predominantly relying on the CAMs provided no evidence of a contamination spread, which gave false assurance that controls were effective. Air sampling data gathered during the course of demolition beginning in November 2016 (including strongback and Canyon wall/ceiling removal, performed through December 14, 2017) indicated controls were adequate. The confidence in the CAM array influenced the decision to increase the rate of demolition and provided assurance that debris piles were being adequately managed. There were, however, positive personnel lapel sample results that were not factored in to the empirical data evaluation. Considering these sample results as an indicator may have resulted in a different conclusion and outcome.

The spread of contamination on December 14 through December 18 demonstrated that the use of continuous air monitors (CAMs) as a near real-time process control did not effectively predict migration of non-respirable contamination.

The application of a fixative applied at 50% concentration mixed with water was implemented without a rigorous technical evaluation. The manufacturer of the fixative does not recommend any dilution. Diluting the fixative provided the ability to spray the fixative to reach the higher elevation of the PRF facility. At 100% strength, the fixative was too thick to be pumped and the disturbed areas could not be completely covered using traditional paint application equipment. Prior to the June 2017 event, the fixative was mixed at a ratio of 25:75. Corrective actions taken following that event included evaluating and increasing concentration levels to

50%. However, no technical basis or analysis was identified that confirmed that the diluted fixative would provide equivalent durability.

Preventive corrective actions have been developed to address RC-01 and include the following:

- Revise the Air Dispersion Model (ADM) for remaining Material at Risk (MAR) and facility configuration for the remaining scope to complete slab on grade.
- Evaluate and implement alternate models that take into account larger particles being swept in wind driven events.
- Define the new radiological boundary for stabilization to include criteria for expanding that boundary.
- Complete an engineering evaluation of fog/mist velocities and spatial distribution to develop dust destroyer placement strategies, to include set-back distance and approach angles to ensure effective coverage. Include fogger placement deployment criteria into associated demolition work packages.
- Complete an engineering evaluation to address the application of water or fixative through a water cannon, including the appropriate nozzle, nozzle setting, set-back distance and approach angles to ensure effective water/fixative application. Include cannon placement deployment criteria into associated demolition work packages.
- Complete a documented evaluation of the appropriate use of fixative (i.e., type, concentration levels, and adherence properties to materials) for PFP demolition activities.
- Develop and provide training to PFP Radiological Control personnel regarding 1) reliance on CAMs and 2) the indicators of the potential for contamination without warning from air samplers.
- Revise bi-annual re-qualification training for CHPRC RCTs and Radiological Control First Line Supervisors to include lessons learned from this event with regard to 1) Reliance on CAMs and 2) the indicators of the potential for contamination without warning from air samplers.
- Revise Courses 022801, *Initial Radiological Work Planning* and 022830, *Radiological Work Planning Refresher* to include lessons learned from this event with regard to 1) Reliance on CAMs and 2) the indicators of the potential for contamination without warning from air samplers.

RC-02: Risks and consequences associated with emerging and changing conditions were not adequately reviewed and evaluated.

PFP management planned for both 234-5Z and PRF to be in “slab on grade” status by September 30, 2017. Complications encountered in demolition and recovery from contamination events (e.g., the January and June 2017 events) resulted in a revised goal of December 31, 2017. The Project was in the challenging position of achieving safe and controlled demolition while attempting to maintain schedule progress, which included completion of TPA milestones and contractual commitment dates.

Changes to the demolition rate and methods occurred, as described below.

The ADM provided predictions based on assumptions on how demolition would be conducted, and provided the basis for the established controls for rate of demolition and accumulation of rubble/debris. Re-suspension of material at risk (MAR) from accumulated demolition rubble was not incorporated into the dispersion model (PNNL-20173) because it was assumed demolition debris would be removed as generated.

In the beginning stages of the PRF Canyon demolition, debris management was a limiting factor in the efficiency of the overall demolition process. The project alternated between physical demolition, rubble size reduction, and loading rubble. Size reduction and load out became a constraint on demolishing the structure. IONEX exhausters were added to PRF following the June 2017 event in order to provide contamination confinement. As the PRF canyon walls and roof were demolished, the benefit of using the two exhausters was diminished. Correspondingly, a process change was made to more rapidly demolish the PRF structure to minimize the risk of windborne contamination/airborne radioactivity spread from the partially demolished structure. Reducing the PRF Canyon walls to a rubble pile was thought to provide improved ability to manage contamination through the application of fixative and eventual soil cover. Although these changes were

managed in accordance with established procedures, the expected structured approach and associated rigor of the Hazard Review Board (HRB) process was not utilized to evaluate the cumulative impacts of the changes.

Emerging Issues (Leading Indicators):

The cumulative impact and significance of the events leading up to the December 2017 event were not recognized. Some amount of contamination is anticipated during open-air demolition, and each event was treated as a discrete event, individually discussed, and actions taken with apparent success. The individual events themselves did not reach a significance threshold that would have caused a more thorough evaluation. Although contamination had been found several times prior to the December 15 event, no contamination had been noted in the administrative area (trailer village). Although the individual events were managed and addressed, they were not considered from a holistic view or as indicators of weakness in the control set.

As management responded to individual contamination events, these individual events became routine responses, which normalized the condition over time. Normalization of deviance is the gradual process through which unacceptable practice or standards become acceptable. As the deviant standard is repeated without significant negative results, it becomes the norm for the organization. In this situation, the normalization of deviance resulted in the PFP Project assuming risk that was not fully analyzed, documented, or controlled.

The Central Radiological Control organization identified an increase in contamination issues in November 2017, but PFP Management thought that adjustments to fogging and fixative application would resolve the concern. As shown by the results of the routine monitoring processes used by the PFP Radiological Control organization supported the belief that the control set was working.

Available CHPRC processes to manage emerging and changing conditions (e.g., Hazard Review Boards, Radiological Control Change Management procedure, In-Process ALARA Review, informal post-job, Continuous Improvement meetings) were not consistently utilized.

Preventive corrective actions developed to address RC-02 include the following:

- Incorporate newly developed methods and controls into the applicable work packages. Provide specificity to controls to allow consistent field implementation.
- Establish external review and concurrence outside of PFP (e.g. HRB chair) for changes related to demolition work packages. Document the process.
- Develop thresholds and criteria for entering into the CHPRC Change Management processes (e.g., HRB, IPAR, informal post jobs).
- Establish requirements (to include tracking and trending) for frequency, timeliness, and formality in the use of radiological data to support decisions related to demolition.
- Establish near real-time protocols for surveying for contamination spread outside of the immediate demolition area.

Listed below are the Contributing Causes that collectively with the other causes, increased the likelihood of the event or issue, but alone did not cause the event or issue.

CC-01: Previous success of the application of fixative was assumed to provide equivalent protection to containerized debris or covering the debris with soil.

Fixative application, the use of water cannon and fogger application, and the management of debris piles are controls in the work package control set. Details for method or application of each are not defined in the work package (e.g., ensure 360 degree coverage of all material).

The control initially planned (minimize accumulation of demolition debris) was altered. Accumulation of demolition debris was determined to be acceptable based on empirical air sampling data and near real-time

airborne monitoring data provided by the CAM array. There was an inadequate degree of direction in the work control documents for protecting the debris piles while controlling contamination through the application of fixative.

Through performance of demolition activities and with the use of feedback from radiological workplace indicators including the CAM array, it was realized the demolition methods and associated controls could allow demolition to be conducted without exceeding radiological posting criteria for airborne radioactivity and contamination. Project management made the decision, based on prior success, to allow the demolition rate to be controlled based on feedback from radiological workplace indicators and the CAM array. Debris piles were allowed to remain at the demolition site and were managed through the use of fixative as a near-term control and soil coverage as a longer term control. These controls were incorrectly thought to provide equivalent protection to containing the debris as it was created.

CC-02: Radiological indicators near the PRF demolition site did not indicate the need to expand fixative applications or perform surveys in addition to the established monitoring plan.

During the performance of demolition activities, job coverage contamination surveys and continuous observation of the real-time air monitoring did not provide any indication that contamination was migrating out of the immediate demolition area. As previously experienced, the absence of elevated airborne radioactivity indicated the absence of spread or migration of contamination. Therefore, no additional radiological surveys were conducted beyond the immediate work area. Other indicators (e.g., cookie sheets, lapel data) were not formally trended. If the survey protocol had included areas outside of the immediate work area during demolition activities, any contamination that may have been present with no fixative applied could have been identified.

Listed below are the Extraneous Conditions Adverse to Quality, which are not causal to the event or issue, but were identified through the analysis process as needing to be addressed and corrected.

ECAQ-01: Communication and notifications.

Prompt notification to Operations Management, Senior Project Management, and the DOE-RL Facility Representative did not occur, because personnel at the facility did not implement ZCR-002, *Material Release*, procedure requirements regarding notifications once contamination was detected outside the demolition zone. These notifications were routinely made by Radiological Control Management (who were promptly notified by Radiological Control personnel at the facility), but this did not occur immediately following the discovery of contamination outside the demolition zone. This type of notification and lack of confirmation was not in accordance with procedure or with training for an off-normal response.

ECAQ-02: PFP Management did not adequately address all employee concerns and suggestions.

Throughout the course of demolition, workers provided suggestions, concerns, and lessons learned to the PFP management team in an attempt to improve both safety and efficiency. Pre and post job meetings, morning tailgate meetings, Safety Issue and Ideas logbook, and Stop Work are some of the various formal methods used by the workers to communicate their suggestions to management for discussion and resolution. Some worker input appeared to be incorporated into work processes; however, PFP management did not consistently provide formal feedback to the workers when suggestions were not incorporated.

Via informal communication, some workers shared prior experiences from other Hanford demolition projects that they thought could be beneficial. Some shared concerns about the process related to the use of fixatives and fogging. Feedback from some workers identified that PFP management was not always responsive to the informal input.

These communications, both formal and informal, represent a missed opportunity both to recognize the need to apply change management tools and to promote open communication with the workforce. Several actions are being taken to improve communications, solicit feedback, and provide updates to the PFP workers.

Corrective Actions

Actions taken to address RC-01 and RC-02 will also address the contributing causes. An additional corrective action was identified for CC-02 that establishes near real-time protocol for surveying for contamination spread outside of the immediate contamination area.

See Attachment 2 for a complete list of the 42 actions identified to address the event.

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ACRONYMS

AC	Apparent Cause
ACL	Administrative Control Level
ALARA	As Low As Reasonably Achievable
Am	Americium
AMW	ALARA Management Worksheet
ARA	Airborne Radioactivity Area
BED	Building Emergency Director
CA	Contamination Area
CAM	Continuous Air Monitor
CC	Contributing Cause
CHPRC	CH2M HILL Plateau Remediation Company
CONOPS	Conduct of Operations
CS	Cookie Sheet
D&D	Deactivation and Decommissioning
DAC	Derived Air Concentration
DOE-RL	Department of Energy, Richland Operations Office
DQO	Data Quality Objective
DSA	Documented Safety Analysis
ECAQ	Extraneous Condition Adverse to Quality
EOC	Extent of Condition
ESRB	Executive Safety Review Board
EVMS	Earned Value Management System
FR	DOE-RL Facility Representative

GGB	Gallery Gloveboxes
HCA	High Contamination Area
HEO	Heavy Equipment Operator
HRB	Hazard Review Board
ISM	Integrated Safety Management
ISOC	In-Situ Object Counting System
LL	Lessons Learned
MAR	Material at Risk
MO	Mobile Office
MREM	Millirem (Roentgen Equivalent Man)
NDA	Non-Destructive Assay
OPEX	Operating Experience
ORPS	Occurrence Reporting and Processing System
PBS	Polymeric Barrier System (fixative)
PFP	Plutonium Finishing Plant
PNNL	Pacific Northwest National Laboratory
POC	Point of Contact
PRCNS	Plateau Remediation Company Notification System
PRF	Plutonium Reclamation Facility
Pu	Plutonium
RBA	Radiological Buffer Area
RC	Root Cause
RCM	Radiological Control Manager
RCS	Radiological Control Supervisor
RCT	Radiological Control Technician

RMA	Radioactive Material Area
RWP	Radiological Work Permit
SB	Strongback
SCU	Survey Characterization Unit
SO	Shift Operations
SOI	Standing Operating Instruction
SOM	Shift Operations Manager
SPRU	Separations Process Research Unit
SSW	Senior Supervisory Watch
WCN	Work Change Notice
WP	Work Package

1.0 PROBLEM STATEMENT

Between December 14 and December 18, 2017, contamination was detected outside of the Contamination Area (CA) at the Plutonium Finishing Plant (PFP) demolition zone, including around the PFP offices and on multiple vehicles located outside the radiological boundary. The consequences of this event were personnel exposure and the potential for radiological contamination to leave the Hanford Site. Ancillary consequences included impacts to the credibility of CH2M HILL Plateau Remediation Company (CHPRC) and the U.S. Department of Energy, Richland Operations Office (DOE-RL) regarding Hanford Site workers, and public confidence in the ability to safely conduct demolition activities without adversely affecting personnel and the environment.

2.0 INTRODUCTION

Operations began at PFP in 1949. Until 1991, PFP's primary mission was processing plutonium metal into cylindrical ingots for defense purposes. Plutonium was separated and recovered from liquid and solid process streams. In 1991 the mission changed to plutonium-bearing material stabilization, cleanup, deactivation and decommissioning (D&D), and environmental restoration. Material stabilization campaigns and the mission for storage of stabilized plutonium materials were completed in December 2009 when the final containers of stored material were shipped off-site. The 2736-Z Complex facilities that had supported that mission were demolished in 2012. Cleanup and D&D activities remain ongoing in the remaining PFP facilities.

2.1 Facility Description

PFP is located in the 200 West Area of the Hanford Site, which occupies a mostly flat, semiarid area of about 1,400 km² (560 mi²) in southeastern Washington State. Public access to critical areas of the Hanford Site is limited. The entire Hanford Site is an administratively controlled area by DOE. The nearest point to PFP not subject to DOE access control is Washington State Highway 240, which is approximately 4,210 m (2.5 mi) south of the facility. For the purposes of calculating off-site doses, the closest public receptor to PFP is 12.5 km (7.4 mi) from the facility.

2.2 Background

Preparing for the demolition of the PFP began following the 1991 change of mission. Deactivation activities have been focused on source term reduction before actual demolition. The material at risk (MAR) in the Plutonium Reclamation Facility (PRF) was 21,000 g in 2008 and, through deactivation activities since that time, it was reduced to 2,233 g to ensure the safety and compliance of demolition activities. This reduction in MAR was accomplished during ten years of aggressive decontamination and material removal. Other demolition projects were reviewed, lessons learned gathered, experienced demolition personnel interviewed, and controls developed (see Section 2.3). Review of other plutonium facility demolitions (e.g., Rocky Flats Environmental Technology Site, 233-S, 209-E), other demolition challenges (e.g., Separations Process Research Unit [SPRU], K East Basin Chiller Pipe), and nuclear facility demolitions from across the Hanford Site and DOE complex were relied upon to form the basis for both demolition preparation and open-air demolition control sets. A demolition plan was developed and presented to a formal panel of industry experts. Additional feedback from the expert panel was incorporated into the demolition plan.

The project recognized the hazards associated with the open-air demolition of PFP and requested Pacific Northwest National Laboratory (PNNL) to develop PNNL-20173, *Air Dispersion Modeling of Radioactive Releases during Proposed PFP Complex Demolition Activities*. PNNL was chosen based on expertise in this area, familiarity with PFP, and their nationally recognized experts in the field of air dispersion.

PNNL-20173 provided valuable information regarding anticipated airborne radioactivity concentrations and distribution in the environment. PNNL-20173 also evaluated the potential for surface deposition from airborne radioactivity, including level and distribution in the environment. From that information, specific sampling

locations for both airborne radioactivity and contamination were developed. The predictions in PNNL-20173 formed the basis of initial radiological boundaries, which subsequently evolved through empirical data.

PNNL-20173 evaluated proposed controls and credited some controls, including fixatives, suppressive sprays, and fogging during demolition activities. The model was built around assumptions based on rate of demolition and debris accumulation. Technical staff reviewed empirical data and compared results to those predicted by the model. With the exception of upset conditions, which were mostly noted to have occurred because of ineffective implementation of controls, model predictions were consistent with field observations.

Airborne radioactivity and contamination were observed in locations where monitoring stations were placed based on model predictions. Radiological boundaries described by the model were accurately located for the modeled conditions that were experienced during demolition activities.

2.3 Controls and Indicators

A number of controls were provided including application of fixatives and water, ventilation system, minimization of the highly contaminated debris piles, rate of demolition, and monitoring of the weather conditions.

Aluminum disks, approximately 24 in. in diameter (commonly known as cookie sheets), were located outside the radiological boundary to include areas that were occupied by PFP administrative personnel (referred to as the trailer village). Although the cookie sheets were surveyed daily on swing shift, they were a lagging indicator of the work that had been conducted. Contamination surveys include cookie sheet surveys to evaluate total and removable contamination. As of December 15, 2017, forty-six cookie sheets were strategically located both inside and outside of the PFP Project demolition zone. On December 21, 2017, 14 cookie sheets (CS79 through CS92) were added as a result of the newly established radiological boundaries (Figure 7). Cookie sheets were routinely surveyed on swing shift. This information was tracked, however it was not formally evaluated for trends. Since the December 15, 2017 spread of contamination, cookie sheet surveys outside of the High CA/Airborne Radioactivity Area (ARA) were performed on day shift as well.

Contamination was identified by both air monitoring and routine surveys throughout demolition activities. The contamination was usually inside, or just outside, the established radiological boundary. In many cases, this was determined to be naturally occurring contamination (radon), which is often associated with temperature inversions. The smears taken decayed to non-detectable levels over a matter of hours. While contamination protocols were followed for each of these events, the repetitive identification of radon impacts human performance by decreasing the concern and sensitivity of personnel over time.

Air monitors, the use of fixatives, and water suppression were methods used to prevent and detect the spread of contamination and were documented in the work package. Air monitoring consists of real-time air monitoring and retrospective air sampling. Fourteen continuous air monitors (CAMs) and twenty-two air samplers are strategically located both inside and outside of the PFP Project demolition zone (Figure 6). Air filters are changed out daily on swing shift and initial field counts are recorded. Laboratory analysis consists of 3-day and 7-day decayed counts performed at the CHPRC Central Radiological Counting Facility.

2.4 Base Assumptions and Facts

The radiological hazard analysis for demolition focused on the two remaining and most probable exposure pathways: ingestion and inhalation. Combinations of engineering and administrative controls, supplemented with personal protective equipment, were developed to concurrently manage each hazard. PNNL-20173 served as a basis for establishing controls and monitoring to mitigate worker exposure. The modeling and predictions in PNNL-20173 were based on the assumptions that debris would be contained and that a conceptualized rate of demolition would be maintained.

Fundamental to the demolition mission was the inherent understanding that worker exposure/dose risk during demolition would be less than that during demolition preparations. Consistent with Integrated Safety Management (ISM) evaluations, three primary hazard-pathways to internal worker exposure were recognized, in increasing risk order, as ingestion, inhalation, and puncture. Direct delivery of plutonium to the blood stream represents the most serious exposure pathway and was a daily credible and managed risk during years of demolition preparation activities that involved hand cutting of highly contaminated facility components, including PRF Canyon pencil tanks, gloveboxes, product transfer piping, and ventilation ductwork. Additionally, demolition preparation activities required personnel to be in close proximity to significant quantities of plutonium, resulting in roughly 4 years of increased administrative control levels (ACLs) to accommodate external radiation exposure profiles. Demolition was viewed as a step reduction in worker exposure risk to both internal and external radiation hazards, effectively eliminating puncture hazards and alleviating the need for external radiation exposures above base ACLs of 500 mrem/yr.

Historical experience during facility operations, demolition preparations, and demolition activities to date fostered a conclusion, based on evidence, that control of airborne radioactivity and surface contamination was accomplished simultaneously. Correspondingly, it had been repeatedly reinforced over decades, and as recently as June 8, 2017, that a loss of control features resulted in spatially-concurrent distribution of both airborne radioactivity and surface contamination.

2.5 Demolition Evolution

Deactivation of 234-5Z had been in progress since 2009, and original plans were to demolish it prior to demolishing PRF. However, PRF was ready for demolition earlier than planned, while the 234-5Z preparations were still continuing. The decision was made to proceed with PRF demolition ahead of 234-5Z. Approximately 60% of PRF was demolished by June 2017. In June 2017, it was determined best to remove the southeast corner of 234-5Z to eliminate the wake effect, which was identified as a contributor to the June 8, 2017, contamination event. In August 2017, PNNL-20173 Rev 4 Add, *Air Dispersion Modeling of Radioactive Releases during Proposed PFP Complex Demolition Activities: Addendum*, was issued, which indicated simultaneous demolition of 234-5Z and PRF would not require revision of the control set. Once the southeast corner of 234-5Z was removed, demolition was performed on both buildings simultaneously.

Although ancillary structure demolition under the CHPRC contract had been ongoing for years at PFP, demolition of the first highly contaminated building (PRF) began in November 2016. Demolition began with the least contaminated portions of the building and progressed in series to the most contaminated portion of the building, the Canyon. This strategy was used to ensure that encountered issues would have less potential impact and the project would have the opportunity to learn with smaller consequence. Challenges were noted in containerizing and shipping building rubble, and a number of process changes were attempted to improve the pace of rubble loadout, which was restraining overall progress.

Through performance of demolition activities and with the use of feedback from radiological workplace indicators including the CAM array, it was realized the demolition methods and associated controls could allow demolition to be conducted without exceeding radiological posting criteria for airborne radioactivity and contamination. Project management made the decision, based on prior success, to allow demolition rate to be controlled based on feedback from radiological workplace indicators and the CAM array. Debris piles were allowed to remain at the demolition site and were managed through the use of fixative as a near-term control and soil coverage as a longer term control. These controls were believed to provide equivalent protection to containing the debris as it was created.

Suppression and fixative controls were effective until January 2017, when a spread of airborne radioactivity and contamination was noted to the west, along a building wake created by 234-5Z. A noted lapse in water suppression during debris relocation was determined as the most likely cause. Process controls were clarified and radiological boundaries increased.

Demolition resumed and controls continued to be effective until June 8, 2017, when another concurrent spread of contamination and airborne radioactivity was noted, again influenced by the building wake of 234-5Z. The extent and magnitude of this event exceeded the January 2017 condition, and significant changes were made to the control set, radiological boundaries, and demolition sequence. Changes to the control set included installation of exhausters, changes to fixative application, and additional controls for use of foggers. PNNL-20173 was revised to incorporate the new demolition sequence, which included targeted demolition of portions of 234-5Z to reduce the ability of building wake to influence airborne radioactivity and contamination distribution associated with PRF demolition. Additional radiological monitoring locations were included in process changes.

PFP management had planned to have both 234-5Z and PRF in “slab on grade” status by September 30, 2017. Complications encountered in demolition and recovery from contamination events, such as the January and June 2017 events, had resulted in a revised goal of December 31, 2017.

Demolition of PRF resumed on November 3, 2017. The enhanced control set performed well during the highest hazard portion of the Canyon demolition, removal of the gallery gloveboxes. Although airborne radioactivity and removable contamination were observed within the CAs, both level and distribution were within expected conditions described in PNNL-20173. Following removal of the gallery gloveboxes, the PRF Canyon had to be breached to access the strongbacks. A strongback is the metal framework that was used to attach pencil tanks to the PRF Canyon walls. Removal, size reduction, and packaging of the strongbacks represented the next most hazardous portion of Canyon demolition. During this phase, airborne radioactivity and removable contamination were observed within the demolition boundary, but controls continued to be effective.

Following the strongback campaign and removal of the overhead Canyon crane, the only remaining task was demolition of the Canyon structure. Based on the amount of residual plutonium on the Canyon walls ($\sim 3E13$ dpm), this represented the lowest source term portion of the Canyon campaign. The PFP Project's confidence in the control set was high following the successes in the earlier higher source term phases of the Canyon campaign. With removal of the gallery gloveboxes and strongbacks complete, PFP personnel believed that they could finish the remaining demolition work, safely and compliantly, to meet the scheduled deadline of December 31, 2017, for slab-on-grade status. The project continued to rely on proven PNNL-20173 and real-time feedback from CAMs near PRF to pace the work. Because of the amount of source term remaining, potential structural vulnerability of the residual structure to high winds, and eroding weather conditions, the PFP Project thought it was vulnerable to an environment-induced release of airborne radioactivity and/or radioactive contamination. Management determined the safest course of action would be to bring the walls down, apply a fixative, and cover the debris with soil within a few days for long-term storage.

According to PNNL-20173, demolition of the PRF Canyon represented 98% of all airborne emissions associated with demolishing the PFP complex. PNNL-20173 uses the amount of material available to be emitted in any given week as the basis for dispersion calculations. PNNL-20173 also included assumptions on how long Canyon demolition would occur. The expedited demolition challenged the base assumptions of PNNL-20173. To compensate, the project placed two CAMs (numbered 4 and 4A) in close proximity (within 100 ft) to PRF for Canyon demolition. These CAMs existed well within a 24 derived air concentration (DAC)-hr isopleth from the model, associated with concurrent demolition of the Canyon and Zone 4 of 234-5Z (Figure 2).

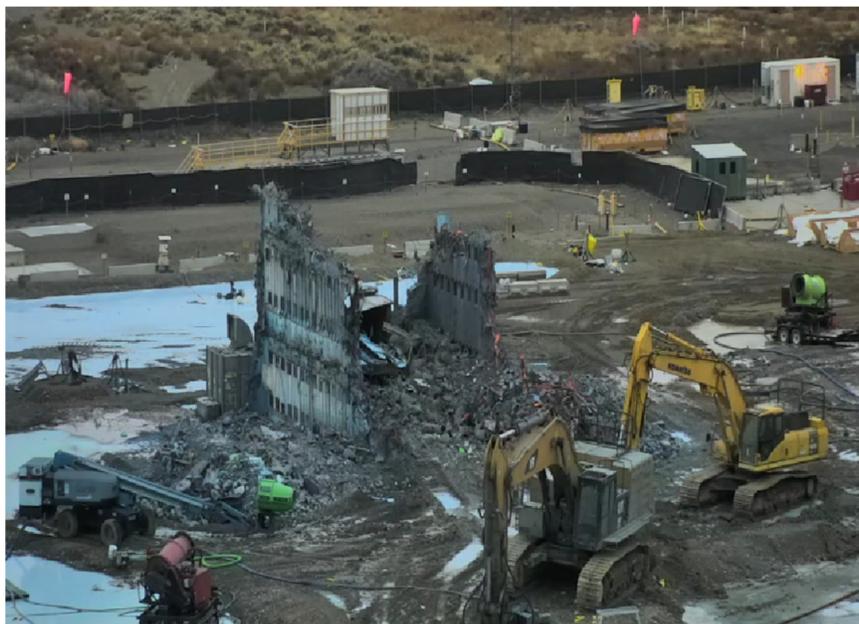


FIGURE 1 - REMAINING PRF STRUCTURE - 12/14/2017



FIGURE 2 - SOUTH SIDE VIEW OF 234-5Z

The Canyon demolition team was afforded 24-DAC-hr/week, as measured by CAMs numbered 4 and 4A, to pace Canyon demolition. By managing emissions at location 4/4A to no more than 24 DAC-hr/week, the Project believed they were within PNNL-20173 predictions that airborne radioactivity, as well as contamination, would be maintained with the established ARA. Correspondingly, demolition would either be slowed or stopped if emissions threatened the 24 DAC-hr allotment in a week, or they could be accelerated if emissions were being controlled below PNNL-20173 predictions. The data that was collected was informally tracked and evaluated. During Canyon demolition, both conditions were noted and the demolition pace was adjusted accordingly, in essentially real time.

3.0 EVENT DESCRIPTION

3.1 Conditions at the Time of the Event

Prior to dismantlement and stabilization of the buildings being complete, characterization had been performed to define remaining MAR form and distribution. Characterization information provided inputs into development of PNNL-20173 and the demolition plan. The PRF Canyon and Gallery Glovebox Characterization Summary is attached (see Attachment 10).

At the time of this event, 236-Z (PRF) had undergone major demolition efforts. The north and south walls and the roof had been completely removed, and the remaining walls were more than 50% removed (Figure 1). Major demolition efforts had taken place on 234-5Z (Figure 2) with the interior of the building open to the outside elements, making it vulnerable to wind conditions. All four walls, east to west and north to south, were open to the environment.

Debris piles containing rubble from both buildings remained. The majority of the PRF Canyon debris pile was contained interior to the remaining walls. Three smaller debris piles were located outside the Canyon footprint. The debris pile north of 234-5Z contained contaminated material. The pile to the south of the building contained material with higher levels of contamination.

3.2 Timeline

Note: Attachment 5 provides additional timeline information.

November 28, 2017 through December 7, 2017

Routine radiological monitoring by swing shift radiological control personnel identified localized indicators of potential contamination spread toward the south and west of the demolition boundary. This was a function of the work activity and possible gaps in the water suppression during the demolition activities. Established response actions were taken and no additional contamination was identified. Various daily demolition activities were taking place throughout this timeframe including 234-5Z demolition, special handled item removal, size reduction, and loadout, movement of PRF debris, PRF strongback removal, and partial PRF roof removal.

December 9, 2017

Initial lapel readings from two workers assigned to the fixative application station (waterdog station) on December 8, 2017, were found to be elevated at 2.97 and 1.42 DAC-hr. The workers were supporting the demolition efforts of PRF at the time. The need to ensure there were no gaps in the water suppression during demolition activities was discussed with the workers. Follow-on surveys did not identify contamination in the area. Fixed air sampler 9 (see Figure 6) reported .61 DAC. Demolition activities included 234-5Z Zone 5 demolition and size reduction and removal of the last six strongbacks from PRF.

December 12, 2017

Demolition activities included demolition of PRF Canyon walls and roof.

An initial lapel reading of 6.63 DAC-hr from one D&D worker assigned to the southwest loadout on December 9, 2017, was elevated. Six co-located worker's lapel air samples were <1 DAC-hr. Follow-on surveys identified 48 dpm/100 cm² removable on the telescoping boom manlift in the southwest radiological buffer area/radioactive material area (RBA/RMA). The area was subsequently posted as a CA. Due to the location of the equipment, no formal investigation was conducted to determine the source.

December 13, 2017

Lapel sampler results from two D&D workers assigned to the waterdog station at the southeast corner of the demolition zone on December 12, 2017, were elevated. Demolition activities were halted before work began for the day, and a Stop Work for all demolition activities was issued. Workers at the waterdog station were given whole body surveys and instructed to leave the area while investigative surveys were performed. Contamination surveys of the waterdog tent did not detect any contamination, and three air samples taken in the waterdog tent were all <0.30 DAC.

Contamination surveys performed south of the south material balance area fence discovered the following removable contamination levels:

- 4900 dpm/100 cm² alpha direct/total contamination was detected on the Basin Disposal Inc. container along the south fence. 4200 dpm/100 cm² direct/total alpha and 160 dpm/100 cm² removable alpha was detected on the jersey barrier. 1080 alpha direct/total dpm/100 cm² on air sampler lid and 1200 dpm/100 cm² direct/total alpha contamination on wood valve box southwest corner.
- Removable alpha contamination >20 dpm/100 cm² but <100 dpm/100 cm² was measured on manlift and concrete bollard.

Portions on the eastern and southern dirt road outside of the PFP fence were posted as a CA.

On swing shift, radiological control technicians (RCTs) discovered removable contamination on the following:

- CS78: 419 dpm/100 cm² removable alpha.
- Light plant near CS78: 546 dpm/100 cm² removable alpha.
- Black pipe near CS78: 250 dpm/100 cm² removable alpha.
- Spider box: total contamination of 3521 dpm/100 cm² total alpha and 3950 dpm/100 cm² total beta/gamma. A smear was not taken initially, but the RCT returned later with appropriate personal protective equipment and measured 1203 dpm/100 cm² removable alpha.
- Light plant outside the southwest fence: 65 dpm/100 cm² removable alpha.
- Exterior surface of Port-O-Let, south of the south fence: 158 dpm/100 cm² removable alpha.
- Electrical box south of the south fence: 240 dpm/100 cm² removable alpha.

The CA along the south fence was extended west to encompass the Port-O-Let, electrical box, and southwest light plant. A CA was established along the inside of the west fence and around the light plant near CS78.

When contamination was discovered near CS78 the RCT checked their boots and had counts above background for alpha and beta/gamma. Both boots had direct contamination, the highest of which was 2370 dpm/100 cm² total alpha, with no removable contamination. The boots were bagged and tagged as radioactive material. The RCT was given a whole body survey with no other contamination was detected. Most of the smears documented on this date were analyzed in the alpha spectrograph and confirmed to have counts within the region of interest for plutonium (Pu) and americium (Am).

December 14, 2017

The contamination area was expanded to the south and east side of the demolition zone, and airborne radioactivity controls were incorporated as part of the work package and Radiological Work Permit (RWP). The Stop Work was lifted at this point.

Workers were supporting the PRF demolition activities, elevated on a scissor lift to manage water and fixative suppression.

Radiological Control personnel discovered contamination of 2,000 dpm/100 cm² alpha direct and 10,000 dpm/100 cm² alpha transferable by swatch while performing investigative surveys of the soil CA south

of the PFP Project perimeter fence line (an area occupied by demolition personnel and access controlled for others). This discovery was initially categorized and reported as a Group 6B (4) Reporting Level-I, "Legacy Contamination," due to the location and characteristics of the contamination (increased activity noted below the soil surface, consistent with animal excretion deposition). This was later incorporated into the occurrence report (EM-RL—CPRC-PFP-2017-0018) for the December 2017 contamination spread.

December 15, 2017

Demolition was performed down to the remaining PRF wall level of approximately 6 feet. Approximately 1/3 of the rubble pile was covered with soil and fixative with the remaining rubble and wall were covered with fixative.

During swing shift, Radiological Control personnel were performing routine surveys following dayshift demolition activities. The surveys detected removable radioactive contamination of 698 dpm/100 cm² alpha direct on CS75 south of Mobile Office (MO) 2116. While performing a more extensive area survey, a speck of contamination measuring 13,600 dpm/100 cm² alpha was removable via tech smear from a government vehicle parked near MO2115. A recount of the smear on Sunday, December 17, 2017, revealed it had decayed to 8,470 dpm/100 cm² alpha removable. Further surveys identified 8,400 dpm/100 cm² alpha total on a jersey barrier near MO2117, and an additional tech smear on the same government vehicle read 13,160 dpm/100 cm² alpha removable. Additional contamination was identified on the ground and on a dumpster near the trailer village, as shown on the Attachment 9, December 15 graphic (page 82).

On the evening of December 15, 2017, notification from the lead RCT to an on-call Radiological Control Supervisor (RCS) was made via phone. The discovery of contamination on CS75, and additional locations in the surrounding area, was communicated to the RCS. No Operations Supervisor was on duty during swing shift. The RCS directed the area to be posted as a high-contamination area/airborne radioactivity area (HCA/ARA). At approximately 2130 hours, the RCS utilized text messaging to notify their immediate manager and one-over manager. There was no confirmation that this text message was received. Contrary to the requirements of ZCR-022, no attempt was made to notify the on-call Building Emergency Director or contact any other project personnel by phone.

December 16, 2017

Management directed that day shift on Saturday, December 16, would be a "no work" day for PFP personnel to allow them rest.

At 0130 on December 16, 2017, the lead RCT sent an electronic mail to the three project RCS, the facility Radiological Control Manager (RCM), and the project Director of Safety, Health, and Radiological Control. The electronic mail included a summary of the shift activities, alpha spectrometer results for some of the contamination detected that evening (all showed a mixture of Pu/Am), and a map of the newly established HCA/ARA.

Since Saturday was a scheduled day of rest for the project, it influenced staff monitoring of cellular phones and work electronic mails. On the morning of December 16, 2017, the facility RCM discussed conditions on the phone with the on-call RCS and they decided to have RCTs come in ahead of the scheduled dayshift on December 17, 2017, so that additional extent of condition surveys could be performed and conditions verified before crews arrived on Sunday.

December 17, 2017

On Sunday, the Shift Operations Manager (SOM) arrived at approximately 0600, ahead of the scheduled overtime crew, and noticed RCTs performing surveys in the administrative portions of the facility. At that

time, notification to the SOM occurred, initiating appropriate cascade notifications to both project, CH2M, and DOE officials.

Surveys identified additional contamination outside of the posted CA. The newly discovered expanded contaminated area was posted to a CA. The PRF debris pile (Figure 3) was covered with soil and soil cement for stabilization.



FIGURE 3 – DEBRIS PILES FROM PRF ON 12/17/2017

December 18, 2017

Between the hours of 0230 and 0545 on Monday morning, December 18, 2017, winds averaged 11.2 miles per hour (mph) with gusts up to 32.3 mph. A critique was held to review the contamination spread occurring on December 15 and 16. During the critique, one car was identified as being in the “No Parking” area next to the radiological boundary. Subsequently, one additional vehicle was determined to have been parked in the same location. Additional surveys, including surveys of vehicles, were performed outside the posted CA around the mobile office trailers at PFP. In the afternoon, several specks of non-removable contamination were identified, as well as one speck of removable contamination on an RCT’s boot. PFP personnel were directed to remain in their offices while surveys of the office trailer area were performed. No contamination was identified inside the office trailers, and no contamination was found on personnel exiting the office trailers. When personnel were released to go home, approximately 100 personal vehicles leaving the site were surveyed, and contamination was identified on five vehicles. The vehicles were controlled in an appropriately posted area. Subsequent surveys the following day proved that the contamination on one of the vehicles was radon.

One RCT decided to survey their own and another RCT’s personal vehicle, which resulted in detection of contamination that was not reported. The RCT made the decision to perform the survey because the vehicles had been parked near the RBA boundary. Although both RCTs knew contamination had been detected and at what level, they each independently elected to drive their vehicles home.

Polymeric barrier system (PBS) fixative was applied to areas in and around the trailers, and soil cement was applied between PRF and the trailer village in efforts to lock down contamination. The affected area was appropriately posted and controlled by the end of shift. Project management decided to remove access to the trailer areas due to concerns about further contamination and radon interference. Personnel in the trailers were assigned alternative reporting locations, which impacted the timeliness of providing support.

December 19, 2017

Management was informed that two RCTs may have driven their cars offsite after discovering contamination. Management interviewed both individuals and confirmed their vehicles had been driven offsite (both RCTs indicated they believed measured radioactivity resulted from radon progeny). The vehicles were appropriately controlled and surveyed, and both were released. Home surveys were conducted at the residences of both RCTs, and no contamination was found.

Surveys were performed at entry and exit roads to PFP, main roads, and trailer areas. Additional specks of contamination were identified. The highest level of contamination identified was 8,000 dpm/100 cm² alpha total. Surveys conducted since Monday, December 18, 2017, identified contamination on seven personal vehicles. Additionally, home surveys were offered to the owners of the privately owned vehicles. Six owners accepted and surveys were conducted (with no detection). One individual initially declined the offer and later requested a survey. One additional worker requested a home survey. This survey was conducted, also with no contamination identified. No contamination was noted on the interiors of personal vehicles.

3.3 Potential Sources of the Contamination

Although multiple potential sources of contamination existed within the demolition boundary (i.e., 234-5Z rubble along the north and south sides of the remaining structure, contaminated demolition equipment, soil contamination within the HCA/ARA, the partially demolished portion of 234-5Z, and PRF rubble), the most credible origin is PRF. The original discovery on the evening of December 15 was nearly a straight line downwind from PRF. The larger contamination spread discovered, following the early morning wind storm on December 18, was also directly downwind from PRF. Sources such as the residual 234-5Z structure or rubble to the north would have resulted in spread to locations other than where the contamination spread was found. Similarly, wind-blown contamination from parked demolition equipment on the west of 234-5Z, or rubble to the south of 234-5Z, would have been influenced by building wake and also resulted in a broader distribution of material to locations where contamination spread was not identified. Perhaps the most compelling variable for the PRF origin is the amount of contamination available for migration. Although other sources were considered, spatial distribution, combined with wind direction and amount of material at risk, support PRF as the source.

3.4 Current Facility Status

As of March 1 2018, the facility continues stabilization efforts and has completed surveys of personal vehicles and home surveys. No contamination was detected off the Hanford Site. Six of the personal vehicles have been returned to their owners. At the discretion of the owner, one of the vehicles was left onsite. Resurvey of the vehicle on January 26, 2018 found an additional speck of contamination. Decontamination of the vehicle was completed and an additional clearance survey was conducted, with contamination detected under the license plate cover. A final decontamination was performed followed by a clearance survey with no contamination detected.

All government vehicles assigned to PFP as well as government vehicles at PFP at the time of the event have been surveyed and/or decontaminated (outside of posted Radiological Areas).

Two isolated events indicating the transference of contamination to a boot and the steps of MO-287 (tracked on CR-2018-0223 and EM-RL--CPRC-PFP-0003/CR-2018-0396) have occurred since January 29, 2018.

Following several high wind events (average >20 mph; gusts >30 mph), contamination surveys continue to demonstrate no contamination outside of posted radiological boundaries of the PFP footprint. Monitoring for

airborne radioactivity continues to demonstrate no migration of airborne hazards beyond established airborne radioactivity areas. Considerable effort has been placed on stabilization of contamination using fixatives, paint, and soil cover. Efforts to apply fixatives to affected trailers and ground surfaces continue.

Project personnel have been relocated from the administrative support areas near PFP; government vehicles are being utilized to shuttle them to the facility for stabilization activities. An enlarged work control zone has been established around the PFP complex. This controlled area is under the access authorization of the PFP shift manager, to ensure coordination of Hanford work near PFP.

Additional administrative controls for notifications to the shift office, notifications to the Hanford Site, ongoing structural stability evaluation of the remaining 234-5Z structure, and contingency plans for high winds have been implemented.

DRAFT

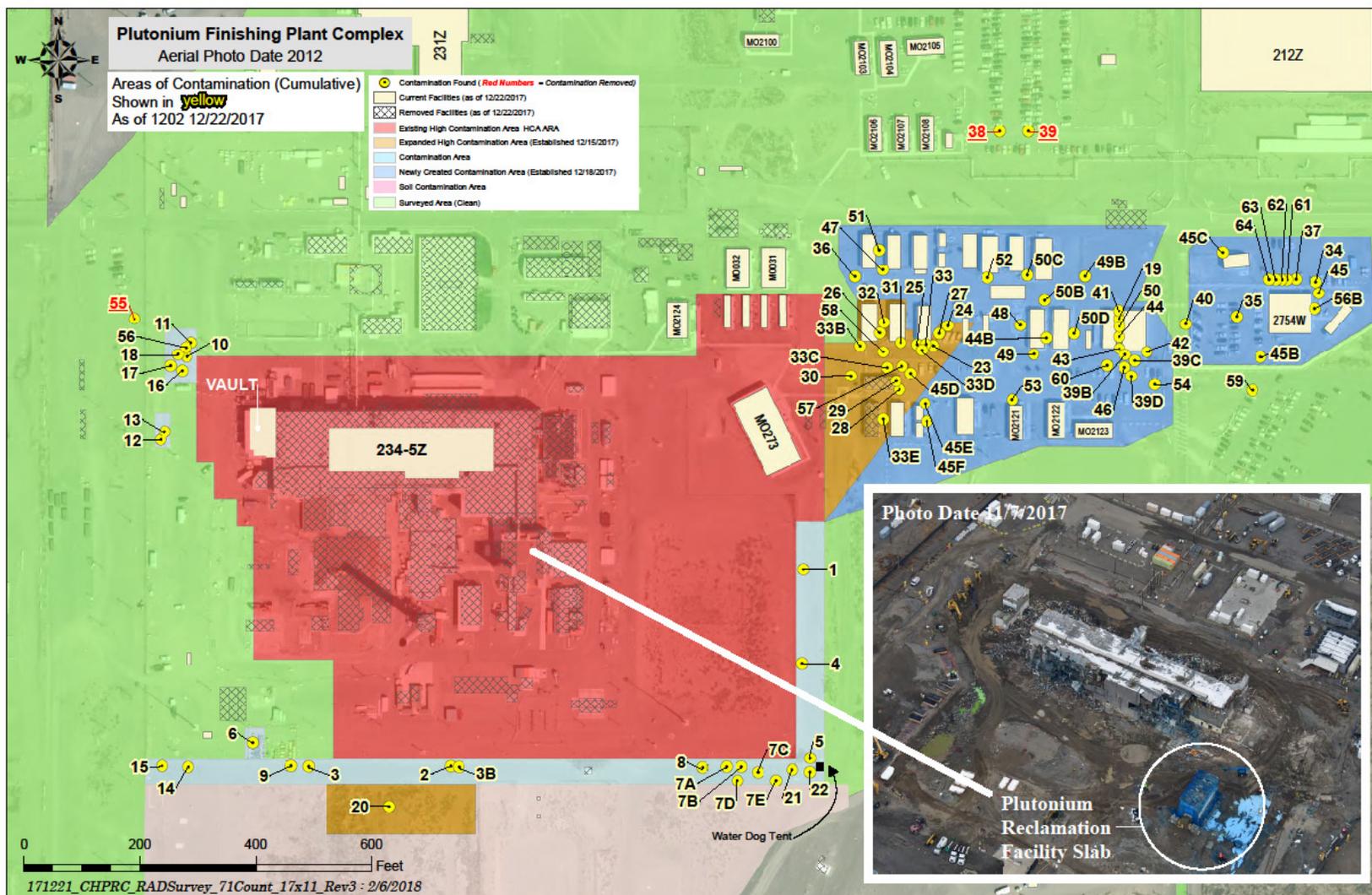


FIGURE 4 - COMPOSITE OF AREAS OF CONTAMINATION FOUND AS OF 12/22/2017

4.0 HISTORICAL EVENT REVIEW

A review of the Occurrence Reporting and Processing System (ORPS) was conducted to identify similar events within CHPRC over the last six years. The criterion used was spread of contamination during demolition activities. The historical search also reviewed prior off-site contamination events across the DOE complex for possible relevant causal factors and corrective actions.

Prior PFP Events relevant to the December 2017 event

EM-RL--CPRC-PFP-2012-0005, <i>Radiological Contamination Identified Outside Area which was Down-Posted After Demolition</i>
Summary of event: Contamination found on a concrete slab following demolition of 2736Z, ZA and ZB. Heavy rainfall had resulted in pooled water, which leached contamination from the unsealed concrete.
Causal Analysis Summary: Contrary to the ALARA Management Worksheet, not all potentially contaminated areas of the concrete slab had been treated with fixative, and the routine practice of placing a layer of gravel was not implemented as PFP intended to use for area as a future staging area for activities.
EM-RL--CPRC-PFP-2015-0011, <i>Management concern related to unfavorable trend in radiological contamination control</i>
Summary of Event: The occurrence report identified an unfavorable trend in radiological contamination control, some of which resulted in skin/clothing contaminations and higher than anticipated airborne radioactivity levels, and personnel injuries, primarily requiring first aid.
Causal Analysis Summary: The analysis identified that management did not adequately review and assess the risks and consequences associated with change when planning for the current D&D phase of work activities.
EM-RL--CPRC-PFP-2015-0017, <i>Low Levels of Contamination Discovered on Vortex Coolers and Interior of an Exhaust Hose</i>
Summary of Event: The report identified that contamination had been transported off-site when equipment with contamination was sent to Mission Support Alliance for maintenance, and subsequently some pieces of the equipment were sent to an off-site vendor location in Pennsylvania.
Causal Analysis Summary: The analysis identified that the CHPRC procedure/process for 67 per cent confidence level release surveys, combined with the assumption that some areas of the equipment were inaccessible and could not be contaminated, set up the conditions for the event. The assumptions for the release surveys had not been validated.
EM-RL--CPRC-PFP-2017-0003, <i>Contamination Discovered inside the Demolition Zone January 27, 2017</i>
Summary of Event: A CAM alarm that sounded at the PFP indicating possible radiological contamination outside the demolition area of the PRF. Personnel near the scene safely exited the area, and whole body surveys were performed. The PFP facility had completed the characterization of the event, and although contamination was found, it was confirmed contamination did not extend beyond the PFP boundary fence. There were no injuries or personnel contamination. At the time of the alarm, demolition activities involving the shear/multi-processor had been completed for the day and the work was isolated to debris pile relocation. Prior to the start of demolition of PRF, radiological source in the building was reduced by removing piping and structure or through decontamination methods including high pressure water washing and acid etching. This effort resulted in the final MAR number of 2,233 grams relative to the starting condition of 21,000 grams. In January, the fifth and sixth floors had been demolished and work was being

conducted at the second, third, and fourth floor levels. Work was being conducted to remove the floors and walls of the second and third floors.	
Causal Factors:	
RC-01: Inconsistent use of the terms of “demolition/demolition activities” contained in the work package resulted in the team not recognizing that debris pile relocation is a demolition activity	The work package instructions for demolition activities required “an engulfing water control to be applied to the area that is the potential contamination release point” and stated that, “no demolition activities may take place without the water application,” however the demo team did not recognize that debris pile relocation is a demolition activity.
CC-01: The work package instructions stated to use water/fixative suppression to “adequately control dust and airborne radioactivity.”	<p>The crew did not interpret the procedure to require constant use of suppression misting during debris pile relocation. Section 3.13.8 discusses: Wetting agents and lockdown material (water, amended water, fixative, or fogging application) will be used on building material/rubble piles to adequately control dust and airborne radioactivity during “demolition and load-out activities”. During demolition activities (e.g., shear cutting, size reduction, concrete rubblizing), and engulfing water control will be applied to the area that is the potential contamination release point. Misting/water-fogging devices will be used to deliver the suppressive water to the release point. No demolition activities may take place without the water application.</p> <p>This allowed the crew to exclude the debris pile relocation from “demolition activities” as well as determine how much water suppression misting was required to “adequately” control the dust and airborne radioactivity</p>

PFP Event – EM-RL--CPRC-PFP-2017-0013, Contamination during Gallery Glovebox Removal Demolition Activities, June 8, 2017	
Summary of Event: A CAM alarm that sounded while crews were removing and packaging the third section of Gallery Glovebox 2 nd West from the PRF (Figure 5). Demolition activities were stopped and RCTs began surveys in preparation to egress personnel. Several spots of contamination were found outside of posted radiological areas, the highest reading documented at 12,500 dpm/100 cm ² removable alpha contamination following the alarm. The CAM alarm was in the demolition zone at the Airborne Radioactivity Area boundary, in an area where contamination is expected to exist with the CAM alarm set point at eight DAC-hr.	
Causal Factors:	
AC-01: The work package control set was not adequate to prevent the release and maintain control of contamination.	<p>The controls identified in the work package are noted to be limited by the inputs which are provided. Several issues and potential areas of weakness of the control set were identified:</p> <ul style="list-style-type: none"> • Specific precautions regarding high-pressure streaming or fogging were not called out. • The boundary was not established at a distance far enough from the demolition area. • The method to collect real-time data used for wind limitations was not specified. • The fixative concentration may have been less than adequate. • Additional engineering controls were needed (e.g., ventilation, in regard to total gram value available for release).

<p>AC-02: Water did not keep the particulate contained within the radiological boundary.</p>	<p>The following issues could have contributed to the water not being as effective as expected in isolating particulate to the controlled area (within the boundary):</p> <ul style="list-style-type: none"> • The wind and other weather conditions. • Condition of the gram quantities of material. • Fixative application both before and after demolition.
<p>CC-01: The contamination and airborne radioactivity was not uniformly distributed on the ground and in the air as was anticipated in PNNL-20173.</p>	<p>The contamination was dispersed in a spotty and non-uniform manner beyond the boundary. Actual quantities were a factor of two times what was anticipated from PNNL-20173. The airborne radioactivity was more concentrated, greater than 10 times what was modeled.</p>
<p>CC-02: Fixative did not prevent the material from being propelled into the air as it had not been previously applied to inaccessible areas.</p>	<p>Because the deactivation methods employed did not afford access to the gaskets, glass, and mating surfaces of the gallery glovebox glass, they could not be accessed prior to demolition.</p>
<p>CC-03: The positioning or mode of force of the water may have pushed the contamination past fogging and/or overcame the application.</p>	<p>This event was significantly different in that it is a known fact the CAM alarm was directly related to the removal of the gallery glovebox. Use of the water cannon caused a straight stream of water providing a mode of force. During the demolition activity, several individuals observed the straight stream of water shooting into the jumper receptacles and consideration was given to the fact this could have pushed/dislodged contamination, causing it to become airborne. The fogger also had potential to create a mode of force pushing or dislodging contamination past the suppression efforts.</p>



FIGURE 5 - GALLERY GLOVEBOX 2ND WEST, SECTION 3 REMOVAL EFFORTS

Relevant Events at Other CHPRC Facilities

<ul style="list-style-type: none"> • EM-RL--CPRC-SNF-2008-0003, Contamination Detected Outside RBA at K East Demolition Site • EM-RL--CPRC-SNF-2009-0003, Contaminated Material Detected Outside of Contamination Area/Radiological Buffer Zone
<p>Description of events: Both reports identified pieces of unsecured contaminated insulation foam which were spread by high winds following demolition near the 105K East Building.</p>
<p>Summary of Causes: Causes indicated that previously suggested actions to secure the foam had not been acted upon, and that the risk of ambient weather conditions had not been addressed.</p>
<p>EM-RL-CPRC-SNF-2010-0007, Contamination Discovered Outside of Posted Area at 117KE Bunker at K East D4 Project - ARRA,</p>
<p>Description of event: The report described identification of several specks of contamination found following a high wind event.</p>
<p>Summary of Causes: Causes indicated that appropriate long-term measures to mitigate the potential for contamination to be blown out of the area were not implemented.</p>
<ul style="list-style-type: none"> • EM-RL--CPRC-WESF-2016-0003, Spread of Contamination During K-3 Filter Pit Grouting • EM-RL--CPRC-WESF-2016-0005, Contamination Found Outside Controlled Area • CR-2017-0044, High Dose Rates Identified in WESF Canyon • CR-2017-1240, W-130 Project work activities were not planned adequately commensurate with the risk to the worker and project
<p>Description of events: Although not related to demolition, the above occurrence reports were all issues which occurred due to inadequate radiological work planning which occurred for the W-130 WESF Ventilation and Stabilization upgrade.</p>
<p>Causal Analysis Summary: The causal analyses for CR-2017-1240, which addressed the accumulated events, identified that the level of risk acceptance for Project W-130 Planning and Implementation was not commensurate with the level of rigor necessary for an operating Category 2 Nuclear Facility, The W-130 Project developed reliance on expert based, rather than process based, planning and implementation, and the elements of the W-130 Project were not viewed as an integrated whole.</p>

Relevant Off-Site Events

<p>EM--WGI-G2H2-2010-0001, Management Concern - Operational Weaknesses</p>
<p>Description of event: The report identified two contamination events, one related to contamination found on workers shoes, and a second resulting in overflow of a water tank due to heavy rains related to demolition of the H3 building at the Separations Process Research Unit (SPRU).</p>
<p>Summary of Cause: Type B accident investigation identified failures to fully understand, characterize, and control the radiological hazard, and weaknesses in the work control process, specifically in that hazard controls were not verified as flowed down in to the work documents.</p>
<p>In 2016, PFP did a review of the failed barriers in this report against PFP demolition practices. The conclusion was that PFP had adequate controls in place to address the issues identified at SPRU.</p>

4.1 Comparison to Previous 2017 PFP Events

The radiological event experienced in December 2017 is different from the two events that occurred in January and June 2017. The most recent event did not provide the expected early and nearly real-time feedback normally experienced during demolition through CAM output. During plutonium production, stabilization, building characterization, and demolition preparations, the primary indication of a radiological event is the activation of a CAM alarm. Often, the alarm occurred without either measureable removable contamination or removable contamination below limits required for area postings. Adding to the confidence in airborne monitoring as an early indicator, there were many instances where fixed head monitoring showed elevated airborne contamination levels without removable contamination in the surrounding areas.

To complete a comparison to the previous events, the work being performed and the effect of the mitigation efforts must be discussed. During the January 2017 event, no building demolition was taking place; however, the demolition activity of debris relocation was being performed. Engulfing mist was the main mitigation method used to minimize contamination spread and the production of airborne radioactivity; no suppressive water was being used to maintain the material wet during movement.

During the June event, gallery gloveboxes were being removed from the building. These gloveboxes were a known source of high contamination hold-up (greater than 1,000 g of plutonium). Again, engulfing mist along with periodic use of a water cannon were the primary methods of mitigation to prevent a release to the environment. Upon removal of the 2nd floor West third glovebox section, workers introduced a straight stream of water from a water cannon into the jumper receptacle, likely dislodging contamination. Corrective actions were introduced for the removal of remaining gloveboxes, which included the following: no straight stream of water and the constant application of the engulfing mist, additional suppression equipment, adjustment to fixative concentration, installation of two exhausters at the south side of PRF, and revision of PNNL-20173 to incorporate the lessons learned of the event. The removal was performed successfully, providing confidence to the workers and management that mitigation efforts were effective.

The work being executed in December was the deconstruction and rubbleization of the PRF concrete walls and roof. Lessons learned from the previous events were being utilized, and the application of an engulfing mist was enhanced through the use of additional large-volume fogging equipment, a lower volume fogger on an elevation platform, and a water cannon. All evidence shows the building and rubble piles were completely engulfed. The addition of equipment and judicious application of water were put in place to provide corrective actions for the June event based on the previous success. Removal of gallery gloveboxes was not considered significantly different than demolition of the remaining PRF structure. The source term was significantly less in December than previous work, and contamination was stabilized due to the application of fixative during demolition preparation and after the gallery gloveboxes were removed. Additional fixative was applied after entering the Canyon through the northern end. However, based on the June 8 event, management missed an opportunity to be more proactive in evaluating and expanding the radiological control boundary.

5.0 EVALUATION OF ASSESSMENT PERFORMANCE

The Integrated Evaluation Plan was reviewed for the years 2015 through 2017 for Radiological Control Assessments performed at PFP (see Attachment 3, List of Assessments Reviewed). In addition to several program assessments, PFP management performed assessments in targeted areas to evaluate performance in monitoring, development and use of radiological control planning documents, and hazard control implementation. These assessments were thorough and self-critical. A review of the corresponding Condition Reports found that many issues were addressed by briefings or document changes.

Four assessments were conducted as “Quarterly Health Checks” of PFP radiological work practices performed by senior management in response to previous events. These appeared to be narrowly focused and did not result in any findings or observations. Following the Readiness Assessment activities for demolition, a follow-on assessment of radiological work practices was conducted in 2017. This assessment was self-critical and

identified several improvement opportunities related to field implementation of radiological controls that were addressed by substantive actions.

While PFP management observed key areas, the assessments did not identify potential weaknesses that might have served as leading indicators of the present event.

In February, 2018 Management Assessment PFP-2018-MA-20381, *Evaluation of Contractor Assurance Programs at the Plutonium Finishing Plant* was completed to assess the effectiveness of the CHPRC CAS as it relates to the activities associated with the PFP Closure Project. The scope of this assessment was to review performance over the last 12 months (calendar year 2017), assessing the elements of the CAS as they relate to the PFP Closure Project.

The purpose of the CAS is to mitigate risks associated with work processes by detection and resolution of issues impacting safety, effectiveness and efficiency of operations. PFPs approach to CAS was that of a facility/project with a finite end point. This approach diluted the rigor applied to the tools which make up the CAS system. Although the PFP met the performance objective (was compliant) the process was not fully effective.

The Management Assessment identified 3 Findings, 11 Opportunities for Improvement, and 1 Noteworthy Practice. These issues will be entered into CRRS and tracked to closure.

6.0 PROBLEM EVALUATION

A Root Cause Evaluation Team was chartered (see Attachment 4). The team reviewed the associated documentation and timeline to obtain an adequate understanding of the event. A Barrier Analysis was conducted reviewing barriers associated with demolition of 234-5Z and PRF (Attachment 6). Utilizing the information from the Barrier Analysis, a Why Analysis was performed (Attachment 7). Additionally, a Common Cause Analysis was completed that reviewed the January 27, 2017 event, the June 8, 2017 event, and the December 2017 event documented in this report (Attachment 8).

This analysis cumulatively resulted in the determination of two Root Causes (RCs) and two Contributing Causes.

RC-01: Over-reliance on selective empirical data gathered during the course of, and following, demolition was used in making decisions on the rate and methods of demolition.

Cause Code: A4B3C08 – Job scoping did not identify special circumstances and/or conditions.

A4B1C04 – Management follow-up or monitoring of activities did not identify problems.

A4B5C13 – Accuracy, effectiveness of change were not verified or not validated.

A3B3C06 – Individual underestimated the problem by using past events as basis.

A4B5C04 – Risks / consequences associated with change not adequately reviewed / assessed.

Project management continued to rely on selective empirical data from workplace radiological indicators as a means to evaluate the efficacy of work package controls and ultimately pace the demolition. Prior to the December event, workplace indicators predominantly relying on the CAMs provided no evidence of a contamination spread, which gave false assurance that controls were effective. However, lapel results were not immediately factored in to the empirical data evaluation and may have resulted in a different outcome. Latent weaknesses in the approach surfaced when contamination and airborne radioactivity migration disassociated. Air monitoring, contamination surveys, the use of fixatives and water suppression, and management of debris piles were methods used to prevent and detect the spread of contamination and are documented in the work package.

Air Monitoring and Contamination Surveys

The spread of contamination on December 14 through December 18 demonstrated that the use of continuous air monitors (CAMs) as a near real-time process control did not effectively predict migration of non-respirable contamination. The distribution of contamination that crossed the CA boundary was examined and discussed with PNNL Health Physics and Meteorology staff involved in air dispersion modeling for PFP demolition. PNNL staff noted that the contamination deposition was in the form of discrete specks as opposed to plumes of contamination and did not correspond with the airborne radioactivity sample results from the 14 CAMs and 22 air samplers that surround PRF. There are initial indications that this contamination consists of primarily large particles (i.e., specks of contamination that are too heavy to remain suspended in air long enough to be collected on the surface of an air sample filter).

The radiological control boundaries were established using PNNL-20173 *Air Dispersion Modeling of Radioactive Releases during Proposed PFP Complex Demolition Activities*, which contained data and empirical information that had been gathered during the preparation for and during the course of demolition of PFP structures. Following the January and June 2017 events, the boundary was further expanded in order to encompass the area affected by the releases during these events. However, the establishment of a larger boundary was not completed because no general spread of surface contamination had been experienced. The project did not consider an event would occur spreading contamination into the areas that were occupied by PFP administrative personnel (known as the trailer village) and beyond, without early warning from CAMs. It was assumed that there would be a corresponding concentration of contamination in the air, as in past events.

Air monitoring consists of real-time air monitoring and retrospective air sampling. Fourteen CAMs and twenty-two air samplers are strategically located both inside and outside of the PFP Project demolition zone (Figure 6). Air filters are changed out daily on swing shift and initial field counts are recorded. Laboratory analysis consists of 3-day and 7-day decayed counts performed at the CHPRC Central Radiological Counting Facility.

Contamination surveys include surveys of aluminum disks, approximately 24 in. in diameter (commonly known as cookie sheets), to evaluate total and removable contamination. As of December 15, 2017, 46 cookie sheets were strategically located both inside and outside of the PFP Project demolition zone (Figure 7). On December 21, 2017, 14 cookie sheets (CS79 through CS92) were added as a result of the newly established radiological boundaries (marked in red on Figure 7). Cookie sheets are surveyed daily on swing shift. Since the December 14, 2017, spread of contamination, cookie sheet surveys outside of the High CA/Airborne Radioactivity Area are also performed on day shift.

Cookie sheets are located outside the radiological boundary to include areas that were occupied by PFP administrative personnel in the trailer village. Although these were surveyed daily on swing shift, they were a lagging indicator of the work that had been conducted. However, they were also considered a leading indicator for work conditions prior to the work starting the next day.

Air sampling data gathered during the course of demolition beginning in November 2016 (including strongback and Canyon wall/ceiling removal, performed through December 14, 2017) indicated controls were adequate. The work crew's confidence in the CAM array influenced the decision to increase the rate of demolition and provided assurance that debris piles were being adequately managed.

12/7/2017

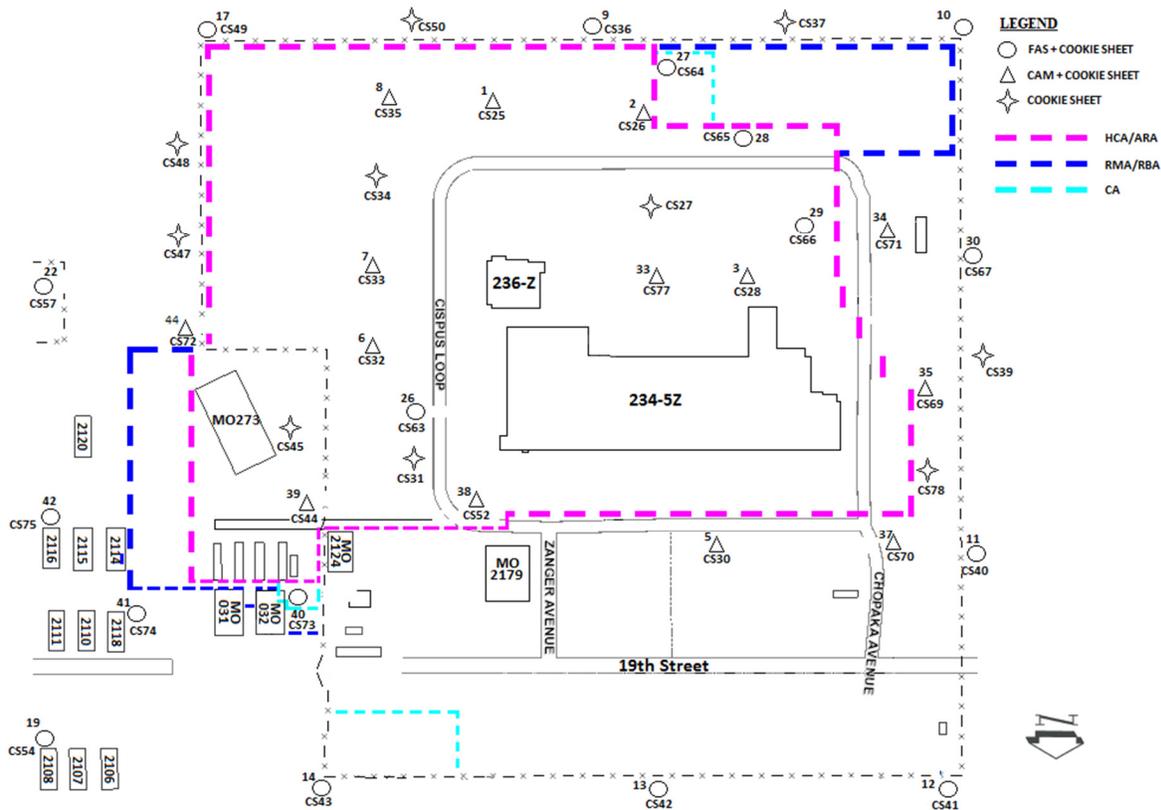
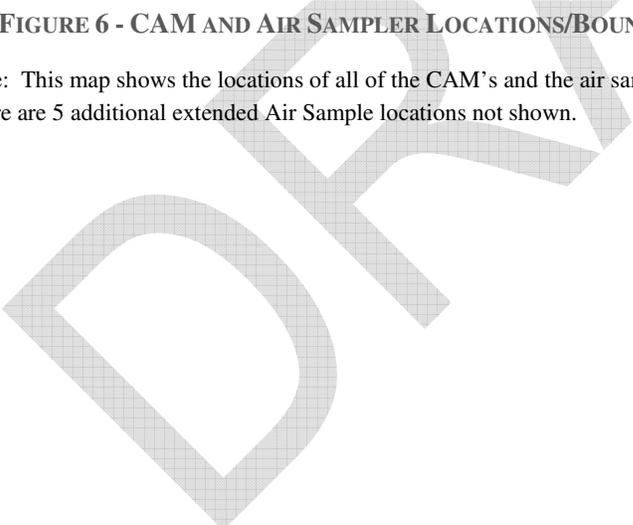


FIGURE 6 - CAM AND AIR SAMPLER LOCATIONS/BOUNDARIES REFLECT CONDITIONS ON 12/7/2017

Note: This map shows the locations of all of the CAM's and the air samplers that are located nearest the Demolition Zone. There are 5 additional extended Air Sample locations not shown.



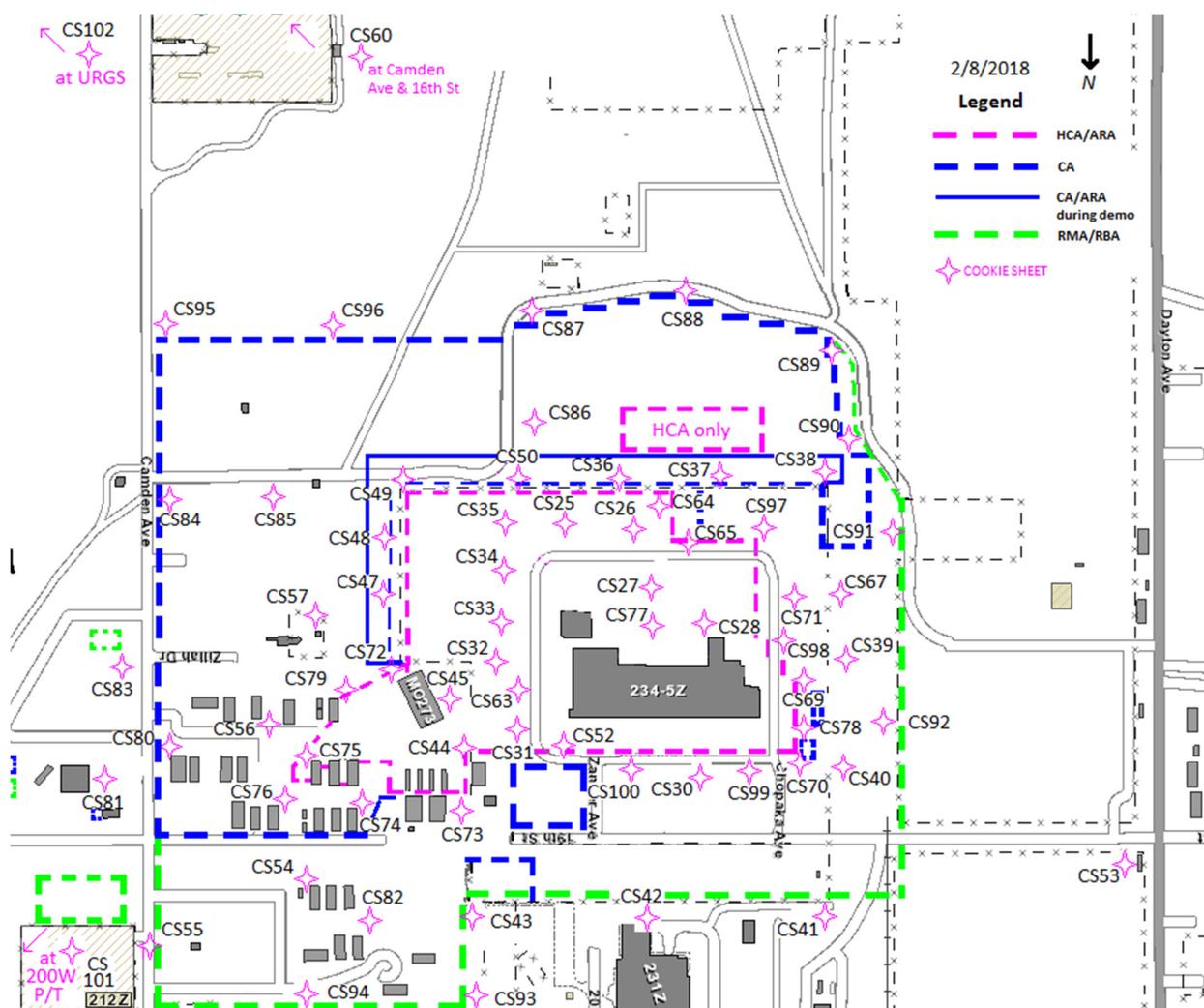


FIGURE 7 - COOKIE SHEET LOCATIONS/BOUNDARIES

The distribution of contamination that crossed the CA boundary was examined and discussed with PNNL Health Physics and Meteorology staff involved in air dispersion modeling for PFP demolition. PNNL staff noted that the contamination deposition was in the form of discrete specks as opposed to plumes of contamination and did not correspond with the airborne radioactivity sample results from the 14 CAMs and 22 air samplers that surround PRF. There are initial indications that this contamination consists of primarily large particles (i.e., specks of contamination that are too heavy to remain suspended in air long enough to be collected on the surface of an air sample filter). The large particles are considered to be non-respirable and fall outside PNNL-20173. The software used in air dispersion modeling does not have the capability to model the deposition location and range of discrete large particles of contamination. The predicted weekly air concentration depicted in Figure 9 assumes respirable particles. The condition of a contamination spread without corresponding airborne radioactivity had not been previously experienced.

Figures 8 and 9 show predicted levels of air exposure and ground deposition of contamination anticipated to occur during demolition.

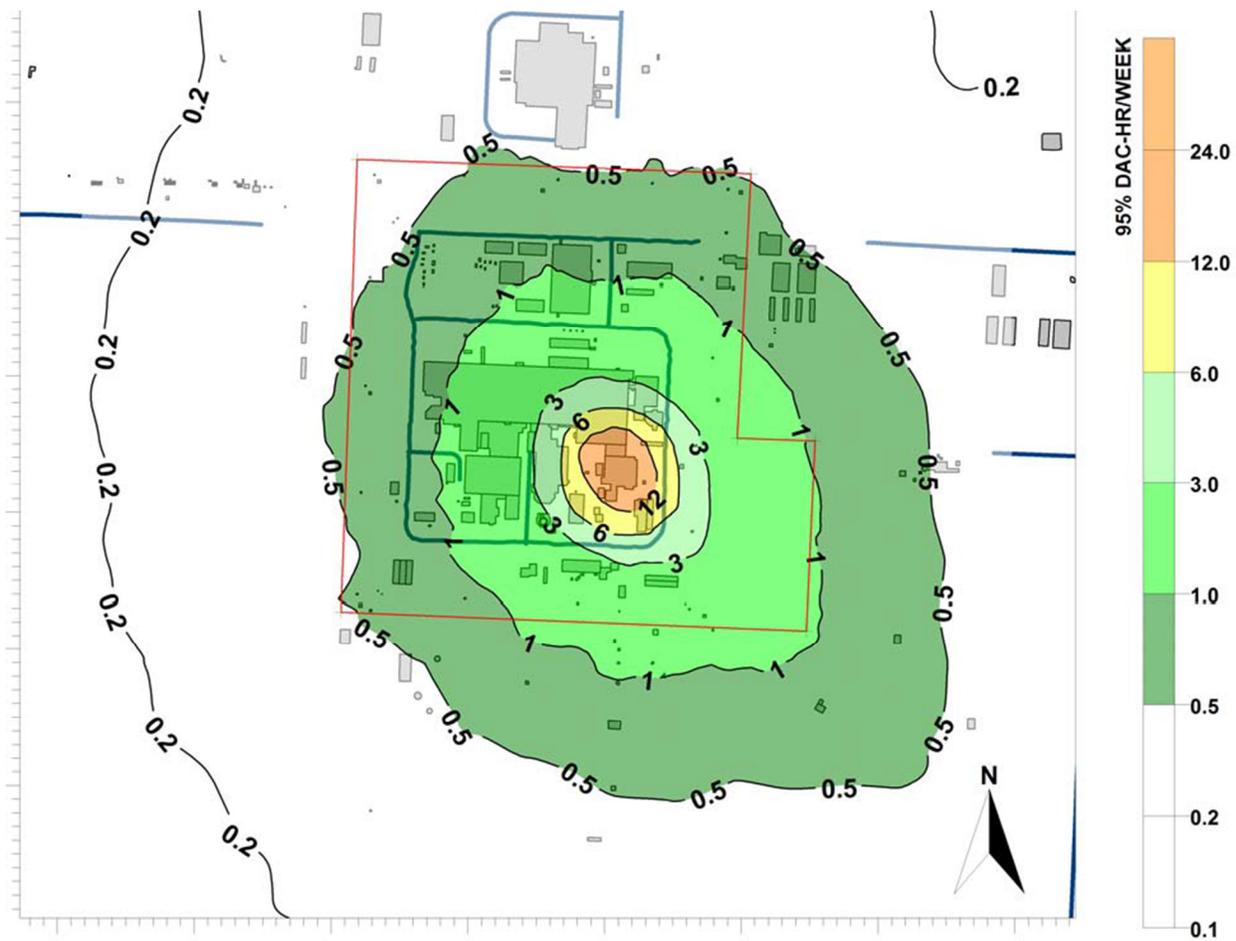


FIGURE 8 - PREDICTED 236-Z CELL DEMOLITION 95TH PERCENTILE WEEKLY AIR CONCENTRATIONS

DK

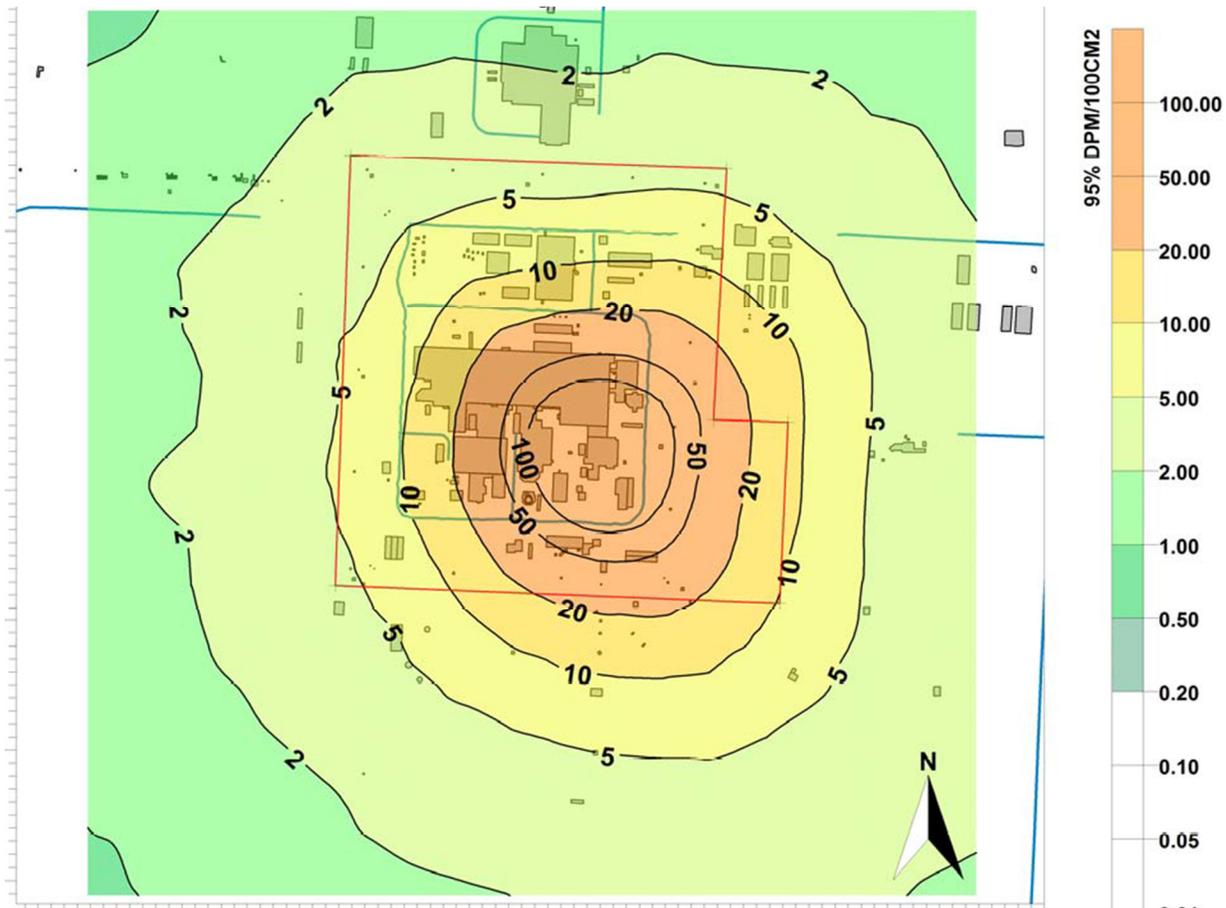


FIGURE 9 - PREDICTED 236-Z CELL DEMOLITION 95TH PERCENTILE SURFACE DEPOSITION

The outcome of the June 8, 2017, event drove the installation of exhausters that were placed at the double doors at the south wall of the PRF Canyon. Due to the removal of the roof, the exhausters were no longer effective; they were no longer in an enclosed area. These exhausters were intended to enhance the ventilation during the gallery glovebox removal, breaching of the Canyon, and removal of the strongbacks, providing a more efficient means of removal (Figure 8).

Fixative Application and Water Suppression

The application of a fixative applied at 50% concentration mixed with water had been concluded to bind contamination generated by the demolition efforts. Diluting the fixative provided more far-reaching capabilities of the suppression equipment. At 100% strength the fixative was too thick to be pumped and the disturbed areas could not be completely covered using traditional paint application equipment. Prior to the June 2017 event, the fixative was mixed at a ratio of 25:75. Corrective actions taken following the event included evaluating and increasing concentration levels to 50%. However, the manufacturer of the fixative does not recommend any dilution. No technical basis or analysis was identified that confirmed that the diluted fixative would provide equivalent durability.

In the standing building structure, some areas are not exposed until demolition occurs, exposing contamination. However, water is continuously applied at the point of the extraction while the demolition is occurring.

Adverse weather conditions (i.e., freezing rain) may also contribute to the fixative application being less effective. Rainfall could dilute the effectiveness of the fixative layer or impact the binding capabilities.

Fogging, a method of suppression during active demolition efforts, may have “lifted” (or provided longitudinal motive force) radioactive contamination and provided the motive force for moving contamination outside the radiological boundary. The fogging equipment produces 10,000 ft/min exit velocity (~114 mph). The considerable force caused by this could actually have aided the escape of the contamination to outside the radiological boundary.

Through experience gained during the performance of demolition activities and using feedback from radiological workplace indicators including the CAM array, it was concluded the demolition methods and associated controls could allow demolition to be conducted without exceeding radiological posting criteria for airborne radioactivity and contamination. Project management made the decision, based on prior success, to allow the demolition rate to be controlled based on feedback from radiological workplace indicators and the array of CAMs rather than the use of the control set assumed in the air dispersion model. Debris piles were allowed to remain at the demolition site and were managed through the use of fixative as a near-term control and soil coverage as a longer term control. These controls were believed to provide equivalent protection to containing the debris as it was created.

However, the potential for a “shadowing” effect, caused by structural members in the debris pile was not recognized in spite of the volume of fixative being utilized. Following this event, it is now recognized that without a 360 degree application, the back portion of the intended target of the debris pile may not receive a layer of fixative.

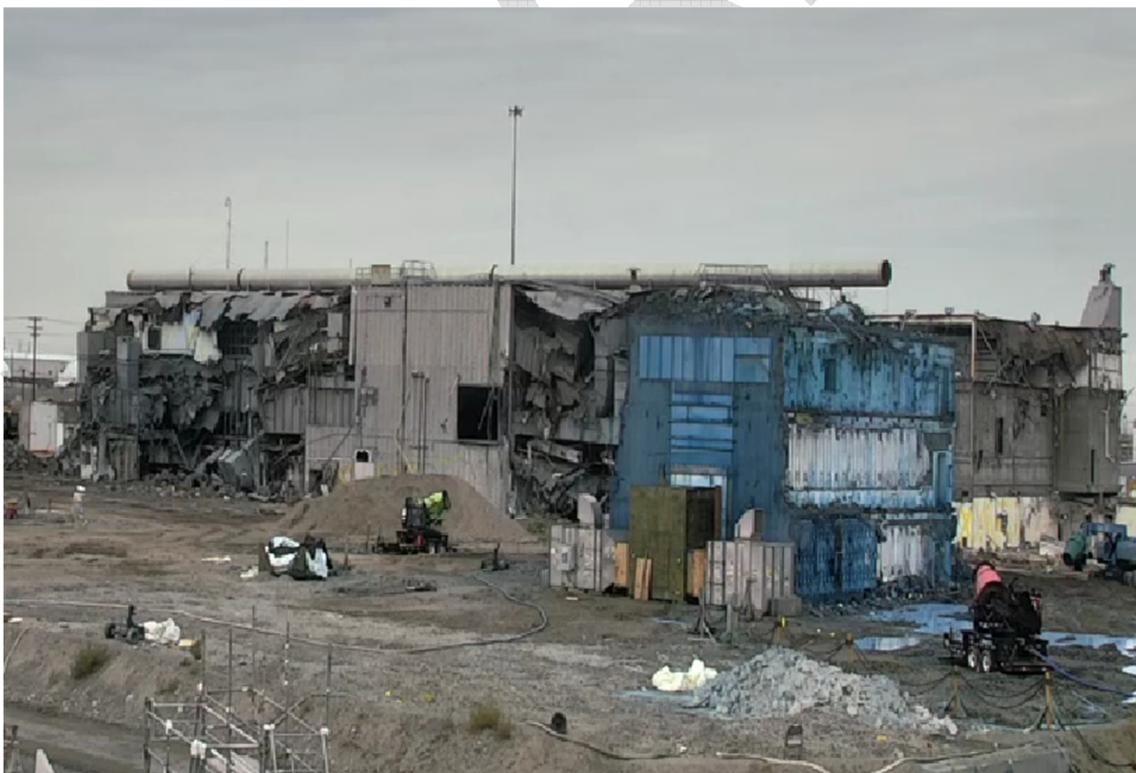


FIGURE 10 - PRF SOUTH WALL SHOWING THE ATTACHED HEPA EXHAUST UNITS (234-5Z SHOWN IN BACKGROUND)

RC-02: Risks and consequences associated with emerging and changing conditions were not adequately reviewed and evaluated.

Cause Code: A4B1C04 - Management follow-up or monitoring of activities did not identify problems.

A4B5C04 - Risks / consequences associated with change not adequately reviewed / assessed.

Available CHPRC processes to manage emerging and changing conditions (e.g., Hazard Review Boards [HRBs], Radiological Control Change Management procedure, In-Process ALARA Review, informal post-job, Continuous Improvement meetings) were not consistently utilized.

PFM management planned for both 234-5Z and PRF to be in “slab on grade” status by September 30, 2017. Complications encountered in demolition and recovery from contamination events (e.g., the January and June 2017 events) resulted in a revised goal of December 31, 2017. The Project was in the challenging position of achieving safe and controlled demolition while attempting to maintain schedule progress, which included completion of TPA milestones and contractual commitment dates.

Changes to the demolition rate and methods occurred, as described below:

In the beginning stages of the PRF Canyon demolition, debris management was a limiting factor in the efficiency of the overall demolition process. The project alternated between physical demolition, rubble size reduction, and loading soil sacks. Size reduction and loadout became a constraint on demolishing the structure. As the Canyon walls and roof were demolished, the benefit of using two 18,500 cfm negative air machines (IONEX exhausters that were added to PRF following the June 2017 event) was believed to be challenged by wind events that could influence, via chimney effect, the benefit of exhauster-provided directional air flow. Correspondingly, a process change was made to more rapidly demolish the PRF structure to minimize the risk of windborne contamination/airborne radioactivity spread. Reducing the PRF Canyon walls to a rubble pile was believed to provide improved ability to manage contamination through the application of fixative and eventual soil cover. Re-suspension of material at risk (MAR) from accumulated demolition debris was not incorporated into PNNL-20173 because it was assumed demolition debris would be removed as generated.

The air dispersion model provided predictions based on assumptions on how demolition would be conducted, and provided the basis for the established controls. The real-time adjustments to these controls were being made to address changing conditions. Although the rate of demolition was increased and the debris piles remained, installation of the IONEX exhausters were thought to be at least as conservative as the original controls. Although these changes were managed in accordance with established procedures, the expected structured approach and associated rigor of the HRB process was not utilized to evaluate the cumulative impacts of the changes.

Emerging Issues (Leading Indicators):

The cumulative impact and significance of the events leading up to the December 2017 event were not recognized. Some amount of contamination is anticipated during open-air demolition, and each event was treated as a discrete event, individually discussed, and actions taken with apparent success. The events themselves did not reach a significance threshold that would have caused a broader consideration. Although contamination had been found on the cookie sheets several times prior to the December 15 event, no contamination had been noted in the trailer village. Although the individual events were managed and addressed, they were not considered from a holistic view or as indicators of weakness in the control set.

As management responded to individual contamination events, these individual events became routine responses, which normalized the condition over time. Normalization of deviance is the gradual process through which unacceptable practice or standards become acceptable. As the deviant standard is repeated without significant negative results, it becomes the norm for the organization. In this situation, the normalization of deviance resulted in the PFP Project assuming risk that was not fully analyzed, documented, or controlled.

The Central Radiological Control organization identified an increase in contamination issues in November 2017, but PFP management believed that adjustments to fogging and fixative application would resolve the concern. As shown by the results of the routine monitoring processes used by the PFP Radiological Control organization supported the belief that the control set was working.

CC-01: Previous success of the application of fixative was assumed to provide equivalent protection to containerized debris or covering the debris with soil.

Cause Code: A5B2C08 – Incomplete/situation not covered.

A4B3C08 – Job scoping did not identify special circumstances and/or conditions.

Fixative application, the use of water cannon and fogger application, and the management of debris piles are controls in the work package control set. Details for method or application of each are not defined in the work package (e.g., ensure 360 degree coverage of all material).

The control initially planned (minimize accumulation of demolition debris) was altered. Accumulation of demolition debris was determined to be acceptable based on empirical air sampling data and near real-time airborne monitoring data provided by the CAM array. There was an inadequate degree of direction in the work control documents for protecting the debris piles while controlling contamination through the application of fixative.

Through performance of demolition activities and with use of feedback from radiological workplace indicators including the CAM array, it was realized the demolition methods and associated controls could allow demolition to be conducted without exceeding radiological posting criteria for airborne radioactivity and contamination. Project management made the collective decision, based on prior success, to allow demolition rate to be controlled based on feedback from radiological workplace indicators and the CAM array. Debris piles were allowed to remain at the demolition site and were managed through the use of fixative as a near-term control and soil coverage as a longer term control. These controls were believed to provide equivalent protection to containing the debris as it was created.

CC-02: Radiological indicators near the PRF demolition site did not indicate the need to expand fixative applications or perform surveys in addition to the established monitoring plan.

Cause Code: A4B5C01 – Problem identification did not identify a need for change.

A3B2C04 – Previous success in use of rule reinforced continued use of rule.

During the performance of demolition activities, job coverage contamination surveys and continuous observation of the real-time air monitoring did not provide any indication that contamination was migrating out of the immediate demolition area. As previously experienced, the absence of elevated airborne radioactivity indicated the absence of spread or migration of contamination. Therefore, no additional radiological surveys were conducted beyond the immediate work area. Other indicators (e.g., cookie sheets, lapel data) were not formally trended and evaluated for action. If the survey protocol had included areas outside of the immediate work area during demolition activities, any contamination that may have been present with no fixative applied could have been identified.

7.0 EXTENT OF CONDITION

A preliminary review of all CHPRC projects was conducted to identify activities that have, or could have, similarities to the PFP activities or pose risk due to new sensitivities. As a result of that review, some preliminary corrective actions have been implemented at other CHPRC projects.

In accordance with PRC-PRO-QA-052, Issues Management, a formal extent of condition shall be conducted to ask:

- What are the broader ramifications of the behavior or condition we are dealing with?
- Given what you know about this occurrence, what else would you expect to see?
- Is the CHPRC Engineering process being used across all projects to generate technical evaluations when deviating from manufacturers recommendations?

Issues identified in the causal analysis may be indicative of issues related to radiological engineering and control practices which may impact other CHPRC projects. To evaluate this extent of condition, a Jacobs Engineering corporate team is performing an independent assessment of the CHPRC Radiological Control program and perform a top to bottom review of PFP Project specific radiological control. Both of these reviews will evaluate not only technical requirements but will also include an evaluation of management and leadership effectiveness as a part of evaluating overall work culture.

A Management Assessment is also being conducted to evaluate the implementation of ISMS across CHPRC. This assessment is designed to challenge the status quo and focus on the effectiveness of implementation in the field. The assessment scope includes the following:

- Implementation of the ISMS
- Conduct of Operations
- Activity level Work Planning and Control
- Contractor Assurance System, including event investigation and follow up
- Surveillance and Maintenance

Any issues from the assessment will be processed per CHPRCs Issues Management program (PRC-PRO-QA-052).

8.0 EFFECTIVENESS REVIEW CRITERIA

An effectiveness review will be performed after completion of the last corrective action. The following criteria, at a minimum, shall be used:

- Review revised methods for water and fixative application to confirm they have been effective in controlling airborne contamination and contamination migration.
- Review revised air model revision to confirm modifications to the demolition approach are addressed.
- Review revised work documents to ensure the comprehensive control set has been reviewed and supports sufficient detail and configuration management through the HRB review process as applicable.
- Review documentation to confirm selected fixatives and modified application approach are effective for future demolition.
- Review the use of PFP management of change processes to ensure they are effectively being applied.
- Review PFP metrics to evaluate overall improved performance.
- Interview PFP personnel regarding the expectations for prompt notifications of abnormal events to the shift office. Review notification procedures and/or Shift Operating Instructions and associated changes and assess the effectiveness of the notification expectations communicated.

9.0 LESSONS LEARNED

This event occurred as a result of over-reliance on empirical data without supporting formal evaluation and analysis, as well as a failure to effectively utilize processes in place to ensure changing conditions and controls are evaluated with an appropriate level of rigor. Issues associated with response actions and communication exacerbated the consequences. A formal lessons learned will be issued into OPEX to capture specific lessons learned from this event (reference CA-43).

10.0 EXTRANEOUS CONDITION ADVERSE TO QUALITY

During the review, the following was determined to not be causal to the spread of contamination, but did adversely affect the response to the event. Corrective actions 24 - 31 will address this issue.

ECAQ-01: Communication and notifications.

Prompt notification to Operations Management, Senior Project Management, and the DOE-RL Facility Representative did not occur, because personnel at the facility did not implement ZCR-002, *Material Release*, procedure requirements regarding notifications once contamination was detected outside the demolition zone. These notifications were routinely made by Radiological Control Management (who were promptly notified by Radiological Control personnel at the facility), but this did not occur immediately following the discovery of contamination outside the demolition zone. This type of notification and lack of confirmation was not in accordance with procedure or with training for an off-normal response.

On the evening of December 15, 2017, notification from the lead RCT to an on-call RCS were made via phone. The discovery of contamination on cookie sheet 75, and additional locations in the surrounding area, was communicated to the RCS. The RCS directed the area to be posted as an HCA/ARA. Around 2130 hours, the RCS utilized text messaging to notify his immediate manager. No confirmation was received that this text message was received. Prior to the start of 234-5Z demo, the Documented Safety Analysis (DSA) underwent a phase change that no longer required the Shift Office to be manned on a 24-hour basis. Only during active demolition was the Building Emergency Director (BED), a member of the Operations group, required to be on-site. There was no BED on duty during swing shift on December 15. No attempt was made to notify the on-call BED or contact any other project personnel by phone.

At 0130 on December 16, 2017, the lead RCT sent an electronic mail to the three project RCSs, the facility RCM, and the project Director of Safety, Health, and Radiological Control. The electronic mail included a summary of the shift activities, alpha spectrometer results for some of the contamination detected that evening (all showed a mixture of Pu/Am), and a map of the newly established HCA/ARA.

Saturday was a scheduled day of rest for the project, which influenced staff monitoring of cellular phones and work electronic mails. On the morning of December 16, the facility RCM discussed conditions on the phone with the on-call RCS, and they decided to have RCTs come in ahead of the scheduled dayshift on December 17 so that additional extent of condition surveys could be performed and conditions verified before crews arrived on Sunday.

On Sunday, the SOM arrived ahead of the scheduled overtime crew and noticed RCTs performing surveys in the administrative portions of the facility. At that time, notification to the SOM occurred, initiating appropriate cascade notifications to both project, CH2M, and DOE officials.

Prompt notification to Operations Management, Senior Project Management, and the DOE-RL Facility Representative did not occur, because personnel at the facility did not adequately review and implement the procedural requirements regarding notifications once contamination was detected outside the demolition zone. These notifications were routinely made by Radiological Control Management (who were promptly notified by Radiological Control personnel at the facility), but this did not occur immediately following the discovery of

contamination outside the demolition zone. While Operations was not required to be onsite when demolition was not occurring, this practice may have contributed to the lack of urgency displayed by the personnel discovering the contamination. Previous events at PFP had demonstrated the importance of having Operations coordinate the response to upset conditions.

ECAQ-02: PFP Management did not adequately address all employee concerns and suggestions.

Throughout the course of demolition, workers provided suggestions, concerns, and lessons learned to the PFP management team in an attempt to improve both safety and efficiency. Pre and post job meetings, morning tailgate meetings, Safety Issue and Ideas logbook, and Stop Work are some of the various formal methods used by the workers to communicate their suggestions to management for discussion and resolution. Some worker input appeared to be incorporated into work processes; however, PFP management did not consistently provide formal feedback to the workers when suggestions were not incorporated.

Via informal communication, some workers shared prior experiences from other Hanford demolition projects that they thought could be beneficial. Some shared concerns about the process related to the use of fixatives and fogging. Feedback from some workers identified that PFP management was not always responsive to the informal input.

These communications, both formal and informal, represent a missed opportunity both to recognize the need to apply change management tools and to promote open communication with the workforce. Several actions are being taken to improve communications, solicit feedback, and provide updates to the PFP workers.

11.0 ATTACHMENTS

ATTACHMENT 1: JUDGMENTS OF NEED

JON	Conclusions	Judgments of Need
JON 1	<p>Over-reliance on selective empirical data gathered during the course of, and following demolition was used in making decisions on the rate and methods of demolition. (RC-01)</p>	<ul style="list-style-type: none"> • PFP Project needs to perform an Engineering evaluation for water and fixative application. • PFP needs to develop improved controls based on the Engineering evaluation of water and fixative application. • PFP Project needs to obtain a revised PNNL Air Dispersion Model to address the remaining Material at Risk. • Evaluate and implement alternate models that take into account larger particles being swept in wind driven events. • PFP needs to work with Stakeholders, both technical and public/.regulatory, to define new a radiological boundary and incorporate criteria for expanding or reducing that boundary.

		<ul style="list-style-type: none"> • PFP Project needs to apply the same rigor to modifications in HRB approved work packages as the original HRB review and approval. • CHPRC needs to provide lessons learned from this event to all radiological control personnel.
JON 2	<p>Risks and consequences associated with emerging and changing conditions were not adequately reviewed and evaluated. (RC-02)</p> <ul style="list-style-type: none"> • As processes were changed, informal change management tools were applied. • The cumulative aspect of the changes and events was not recognized and evaluated. • Assumed risk that was not fully analyzed. 	<ul style="list-style-type: none"> • PFP Project needs to improve implementation of a rigorous HRB process in accordance with established procedures. • PFP Project needs to establish thresholds and criteria for entering into the CHPRC change management processes, and provide training to personnel.
JON 3	<p>Previous success of the application of fixative was assumed to provide equivalent protection to containerized debris or covering the debris with soil. (CC-01)</p>	<ul style="list-style-type: none"> • PFP Project needs to formally evaluate appropriate use of fixative (type, concentration levels and adherence properties).
JON 4	<p>Radiological indicators near the PRF demolition site did not indicate the need to expand fixative applications or perform surveys in addition to the established monitoring plan. (CC-02)</p>	<ul style="list-style-type: none"> • CHPRC needs to provide lessons learned from this event to all radiological control personnel.
JON 5	<p>Communication and notifications (ECAQ-01)</p> <p>Conduct of Operations (Personnel performance) associated with communication and notifications allowed the spread of contamination to become more significant.</p>	<ul style="list-style-type: none"> • PFP and Functional Organizations need to establish actions to reinforce expectations for notifications and communications. • PFP needs to provide gap training to PFP personnel regarding the lessons learned of this event to include notification process, response to upset conditions, new boundaries, etc.
JON 6	<p>PFP Management did not provide sufficient response to all employee suggestions. (ECAQ-02)</p>	<ul style="list-style-type: none"> • PFP needs to establish routine in-person communications with the work force to solicit ideas and concerns as work progresses. These meetings should also be used as a basis for communicating progress, decisions, and priorities.

ATTACHMENT 2: CORRECTIVE ACTION PLAN

Corrective Action Number	Cause	Action Type	Action Description	Closure Requirements	Expected Results	Actionee	Completion Due Date
CA-01	All	Interim	Obtain analysis of samples of the contamination to support the development of improved controls.	Provide a closure statement. Attach a copy of the analysis results.	Provides basis for determining the controls.	Rad Program SME	4/23/2018
CA-02	RC-01 CC-01	Preventive	Based on engineering evaluation of fog/mist velocities and spatial distribution develop dust destroyer placement, to include set-back distance and approach angles to ensure engulfing fog without providing a motive force for transport of contamination. Include fogger placement deployment criteria into associated demolition work packages.	Provide a closure statement. Attach a copy of the engineering evaluation and the revised work documents.	Control of airborne radioactivity and contamination inside controlled contamination areas as to not affect personnel outside the radiological boundary.	Engineering	4/24/2018
CA-03	RC-01 CC-01 CC-02	Preventive	Based on engineering evaluation of the application of water or fixative through a water cannon, determine the appropriate nozzle, nozzle setting, to include set-back distance and approach angles to ensure water/fixative application without providing a motive force for transport of contamination and complete coverage of all newly exposed surfaces resulting from demolition. Include cannon placement deployment criteria into	Provide a closure statement. Attach a copy of the engineering evaluation and the revised work documents.	Control of airborne radioactivity and contamination inside controlled contamination areas as to not affect personnel outside the radiological boundary.	Engineering	5/1/2018

Corrective Action Number	Cause	Action Type	Action Description	Closure Requirements	Expected Results	Actionee	Completion Due Date
			associated demolition work packages.				
CA-04	RC-01 CC-01	Interim	Revise work package 2Z-18-00196, Apply Fixative to PFP Components, 2Z-17-01699, Demolition of 234-5Z Building, and 2Z-15-06342, Demolition of 236-Z Building to cease dilution of PBS (polymeric barrier system) fixative.	Copy of revised work packages.	Return to manufacturer's recommended use.	PFP D&D	Completed
CA-05	RC-01 CC-01	Preventive	Obtain a documented evaluation of the appropriate use of fixative (i.e., type, concentration levels, and adherence properties to materials) for PFP demolition activities.	Provide a closure statement and a copy of the documented evaluation.	Control of airborne radioactivity and contamination inside controlled contamination areas as to not affect personnel outside the radiological boundary.	Engineering	3/15/2018
CA-06	RC-01 CC-01 CC-02	Interim	Develop the training on new techniques and methods for control of airborne radioactivity and contamination.	Provide a closure statement. Attach a copy of the training needs analysis and approved training materials.	Improved control of airborne radioactivity and contamination.	Training	5/21/2018
CA-07	RC-01 CC-01 CC-02	Preventive	Provide training to applicable PFP personnel on the improved techniques and methods for control of airborne radioactivity and contamination.	Provide a closure statement. Attach a copy of the rosters indicating 90% participation. Track the remaining individuals to completion and attach a copy of the remaining rosters upon completion.	Improved control of airborne radioactivity and contamination.	Training	7/18/2018

Corrective Action Number	Cause	Action Type	Action Description	Closure Requirements	Expected Results	Actionee	Completion Due Date
CA-08	RC-01	Compensatory	Define the new radiological boundary for stabilization to include criteria for expanding that boundary.	Provide a closure statement. Attach a copy of the new boundary map.	Demonstrates stabilization is complete.	PFP Sr. Management	4/23/2018
CA-09			Implement the new radiological boundary for stabilization.	Provide a closure statement.	Control airborne radioactivity and contamination levels within regulatory requirements outside the boundary.	PFP Sr. Management	5/21/2018
CA-10	RC-01	Compensatory	Verify the new radiological boundary based on the revised ADM. Refine and adjust as required.	Provide a closure statement.	Control airborne radioactivity and contamination levels within regulatory requirements outside the boundary.	PFP Sr. Management	7/16/2018
CA-11	RC-01	Other	Revise the Air Dispersion Model for remaining Material At Risk and facility configuration for the remaining scope to complete slab on grade, taking into account larger particles being swept in wind driven events.	Provide a closure statement. Attach a copy of the revised ADM for the remainder of PRF and 234-5Z.	Control airborne radioactivity and contamination levels within regulatory requirements outside the boundary.	CHPRC Characterization	8/23/2018
CA-12	RC-01		Evaluate and implement alternate models that take into account larger particles being swept in wind driven events.	Provide a closure statement. Document and attach the white paper to the CR.	Control airborne radioactivity and contamination levels within regulatory requirements outside the boundary.	CHPRC Characterization	4/30/2018

Corrective Action Number	Cause	Action Type	Action Description	Closure Requirements	Expected Results	Actionee	Completion Due Date
CA-13	RC-01	Preventive	Re-define the PFP HRB membership	Provide a closure statement. Attach a copy of the communication	Identification of consistent objective evaluation by Subject Matter Experts (SMEs)	PFP Sr. Management	4/23/2018
CA-14	RC-01 RC-02	Preventive	Issue the expectations for the implementation of the HRB program at PFP.	Provide a closure statement. Attach a copy of the communication.	Consistent implementation and assurance that controls in PFP work packages will not be changed without the same rigor and control as originally established.	PFP Sr. Management	3/15/2018
CA-15	RC-01 CC-02	Preventive	Develop and provide training to PFP Radiological Control personnel regarding to 1) reliance on CAMs and 2) the indicators showed potential for contamination without warning from air samplers.	Provide a closure statement. Attach a copy of the course materials and the roster indicating 100% completion.	PFP personnel will be knowledgeable of the importance of comprehensive monitoring protocols.	CHPRC Radiological Control	4/24/2018
CA-16	RC-01 CC-02	Preventive	Revise bi-annual re-qualification training for CHPRC RCTs and Radiological Control First Line Supervisors to include lessons learned from this event with regard to 1) Reliance on CAMs and 2) the indicators showed potential for contamination without warning from air samplers.	Provide a closure statement. Attach a copy of the revised qualification training materials.	CHPRC RCTs and Radiological Control Supervisors will be knowledgeable in the importance of comprehensive monitoring protocols.	CHPRC Radiological Control	6/4/2018

Corrective Action Number	Cause	Action Type	Action Description	Closure Requirements	Expected Results	Actionee	Completion Due Date
CA-17	RC-01 CC-02	Preventive	Revise Courses 022801, <i>Initial Radiological Work Planning</i> and 022830, <i>Radiological Work Planning Refresher</i> to include lessons learned from this event with regard to 1) Reliance on CAMs and 2) the indicators showed potential for contamination without warning from air samplers.	Provide a closure statement. Attach a copy of the revised courses.	CHPRC Radiological Work Planners will be knowledgeable in the importance of comprehensive monitoring protocols.	CHPRC Radiological Control	6/4/2018
CA-18	RC-01 RC-02 CC-01 CC-02	Preventive	Incorporate newly developed methods and controls into the applicable work packages to address CA-02 and CA-03. Provide specificity to controls to allow consistent field implementation.	Provide a closure statement. Provide a listing of work packages needed to complete demolition and attach a copy of the revised work packages.	Improved control of airborne radioactivity and contamination.	PFP D&D	4/24/2018
CA-19	RC-02	Compensatory	Establish external review and concurrence outside of PFP (e.g. HRB chair) for changes related to demolition work packages. Document the process.	Provide a closure statement. Attach a copy of the HRB assignments.	Objective review of changes to demolition work package.	PFP Sr. Management	Completed 2/15/2018
CA-20	RC-02	Preventive	Develop thresholds and criteria for entering into the CHPRC Change Management processes (e.g., HRB, IPAR, informal post jobs).	Provide a closure statement. Attach a copy of the established document.	Improved management of change.	PFP Sr. Management	4/24/2018
CA-21	RC-02	Remedial	Perform a stand-up presentation on the thresholds described in CA-20 to PFP Management and supervision.	Provide a closure statement. Attach a copy of the presentation and the roster indicating 90% completion.	Improved management of change.	PFP Sr. Management	4/5/2018

Corrective Action Number	Cause	Action Type	Action Description	Closure Requirements	Expected Results	Actionee	Completion Due Date
CA-22	RC-02 CC-02	Preventive	Establish A formalized radiological contamination tracking and trending process that allows for making educated decisions during demolition of the remainder of the PFP work scope.	Provide a closure statement. Attach a copy of the requirements document.	Review of current data in making decisions during the demolition activities.	PFP Radiological Control	4/24/2018
CA-23	CC-02	Preventive	Establish near real-time protocols for surveying for contamination spread outside of the immediate demolition area.	Provide a closure statement. Attach a copy of the work document.	Identification of contamination to ensure appropriate fixative application to mitigate the migration of contamination outside the established radiological boundaries.	PFP Radiological Control	5/1/2018
CA-24	ECAQ -01	Remedial	Provide direction for notification to the shift office for abnormal conditions as they occur.	Provide a closure statement. Attach a copy of the SOI.	Timely and accurate notifications.	PFP Operations	1/4/2017 Complete
CA-25	ECAQ -01	Remedial	Communication expectations on notifications to Operations shift office in PFP all hands briefing.	Closure statement. Attach copy of briefing points and meeting rosters.	Timely and accurate notifications.	PFP Sr Management	Completed 2/15/2018
CA-26	ECAQ -01	Remedial	Issue expectations on notifications to Operations shift office to functional organizations.	Closure statement. Copy of Memorandum(s) showing distribution.	Timely and accurate notifications.	CHPRC Sr Management	4/12/2018
CA-27	ECAQ -01	Remedial	Provide gap training to PFP personnel regarding this event to include notification process, response to upset	Provide a closure statement. Attach a copy of the training materials and course completion rosters to indicate 90%	PFP employees knowledgeable in the notifications and response actions.	PFP Operations	7/18/2018

Corrective Action Number	Cause	Action Type	Action Description	Closure Requirements	Expected Results	Actionee	Completion Due Date
			conditions, new boundaries, etc.	completion. Follow up to 100% completion.			
CA-28	ECAQ -01	Remedial	Revise CHPRC General Employee Training to incorporate information on notifications to Operations Management and voice-to-voice communication during notification.	Closure statement and copy of revised course materials.	Timely and accurate notifications.	CHPRC Training	4/30/2018
CA-29	ECAQ -01	Remedial	Provide direction to the shift office to utilize PRCNS for notification of abnormal events to off-project POCs.	Provide a closure statement. Attach a copy of the SOI.	Timely and accurate notifications.	PFP Operations	1/11/2018 Complete
CA-30	ECAQ -01	Other	Review the PFP emergency response procedures for accurate telephone number to be used for notification to the shift office.	Provide a closure statement to include the outcome of the review. Attach revised copies as appropriate.	Timely and accurate notifications.	PFP Operations	1/25/2018 Complete
CA-31	ECAQ -02	Remedial	Re-establish routine Labor/Management meetings with the Bargaining Unit to solicit feedback and provide updates on priorities and path forward.	Provide a closure statement.	Improve communication and triggers for change management.	PFP D&D	3/29/2018
CA-32	Other	Other	Document a Worksite Assessment (WSA) to record worker feedback on the causal analysis and corrective action plan.	Provide a closure statement. Attach copy of approved WSA.	Improve communication and triggers for change management.	PFP Operations	3/29/2018
CA-33	Other	Other	Perform an Independent Review of the implemented actions to date.	Provide a closure statement. Attach a copy of the Work Site Assessment (WSA) Review report. Add CAs as appropriate.	Determine the effectiveness of the actions taken in preventing additional events.	PFP Sr. Management	7/2/2018

Corrective Action Number	Cause	Action Type	Action Description	Closure Requirements	Expected Results	Actionee	Completion Due Date
CA-34	Other	Other	Perform an Independent Review of the implemented actions to date.	Provide a closure statement. Attach a copy of the WSA report. Add CAs as appropriate.	Determine the effectiveness of the actions taken in preventing additional events.	PFP Sr. Management	9/4/2018
CA-35	Other	Other	Perform an Independent Review of the implemented actions to date.	Provide a closure statement. Attach a copy of the WSA report. Add CAs as appropriate.	Determine the effectiveness of the actions taken in preventing additional events.	PFP Sr. Management	11/5/2018
CA-36	Other	Other	Develop a logbook to document the Senior Supervisory Watch (SSW) activity, to include what the SSW was asked to look at by the Project, as well as what was looked at.	Provide a closure statement to include the location of the logbook.	Ability to review the previous assessments for reference.	PFP Operations	Complete 2/22/2018
CA-37	Other	Other	Provide clear set of expectations for SSW oversight, feedback to the operations project and documentation.	Closure Statement and memo documenting expectations for conduct of SSW.	Ability to review the previous assessments for reference.	PFP Sr. Management	3/29/2018
CA-38	Other	Remedial	Relocate PFP workforce to outside the newly established PFP work zone.	Provide a copy of the approved infrastructure and logistical support plan.	Provide safe and compliant access.	PFP D&D	Complete
CA-39	Other	Other	Communicate the stabilization boundary changes to Hanford site personnel.	Provide a closure statement. Attach a copy of the communication.	Informed Hanford site personnel.	PFP Sr. Management	Complete 2/21/2018
CA-40	Other	Other	Complete an assessment of CHPRC Radiological Control practices.	Provide a closure statement and copy of completed assessment.	Identify areas of potential weakness that may impact PFP as well as other CHPRC projects.	PFP Recovery Manager	4/24/2018

Corrective Action Number	Cause	Action Type	Action Description	Closure Requirements	Expected Results	Actionee	Completion Due Date
CA-41	NA	Other	Appropriate personnel actions were taken.	Provide a closure statement.	Personnel held accountable.	PFP Sr. Management	Complete 1/18/2018
CA-42	EOC	EOC	Conduct a formal extent of condition review of non-PFP facilities and activities across CHPRC as described in section 7 of the RCE report. Results to be provided to the CHPRC Executive Safety Review Board (ESRB).	Provide a closure statement. Attach a copy of the documented extent of condition.	Identify weaknesses in other CHPRC projects that may be similar to PFP.	CHPRC Sr Management	4/30/2018
CA-43	Other	LL	Write and submit a Lessons Learned to OPEX to address the issues identified in section 9.0 of this report.	Provide a closure statement. Attach a copy of the published Lessons Learned to this report.	Provide information for future demolition projects in an effort to prevent contamination spread outside the Radiological Boundaries.	PFP Sr Management	6/14/2018

ATTACHMENT 3: LIST OF ASSESSMENTS REVIEWED

PFPP-2015-WSA-15611, ALARA Management Worksheets

PFPP-2015-WSA-14659, Radiological Dose Monitoring

PFPP-2015-WSA-14615, Air Flow Management

PFPP-2015-WSA-16340, Use of Supporting Documents in Work Planning

SHS&Q-2015-WSA-14629, Review of Radiological Work Planning (Multi-facility)

PFPP-2016-WSA-14664, Level B Suit Egress Activities

PFPP-2016-WSA-16988, RWP Effectiveness

PFPP-2016-WSA-17001, Quarterly Health Check

PFPP-2016-WSA-17372, AMW Dose Estimates

PFPP-2016-WSA-16081, Boundary Control – Partial Entries

PFPP-2016-WSA-17002, Quarterly Health Check

PFPP-2016-WSA-17602, Estimated Dose Rates

PFPP-2016-WSA-18060, Technical Work Documents

PFPP-2017-MA-18836, Follow-on to Readiness Assessment

PFPP-2017-WSA-17003, Quarterly Health Checks

PFPP-2017-WSA-18670, Radiological Hazard Screening

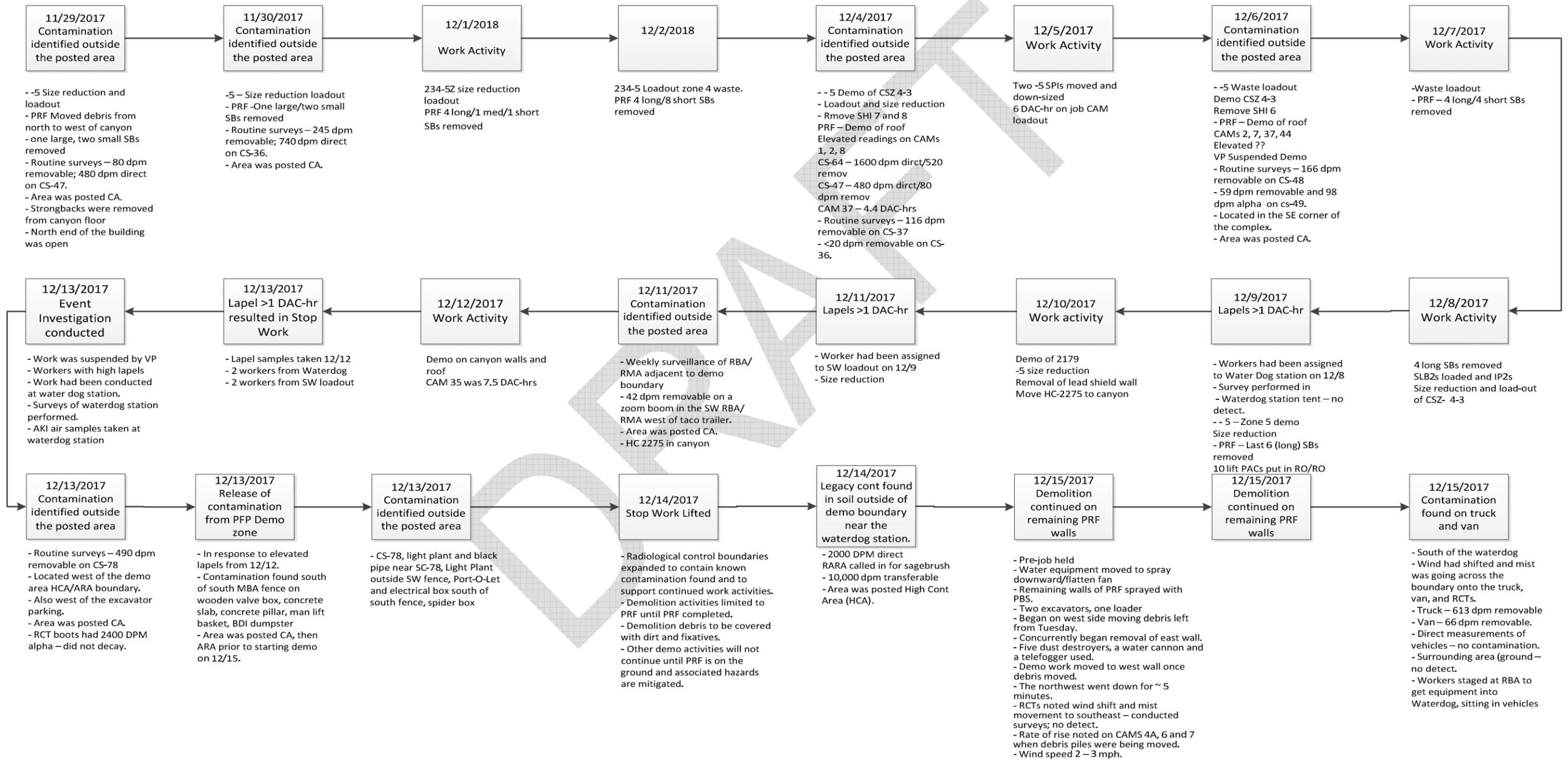
SHS&Q-2017-WSA-19159, 236-Z Demolition Radiological Activities

ATTACHMENT 4: CAUSE EVALUATION TEAM

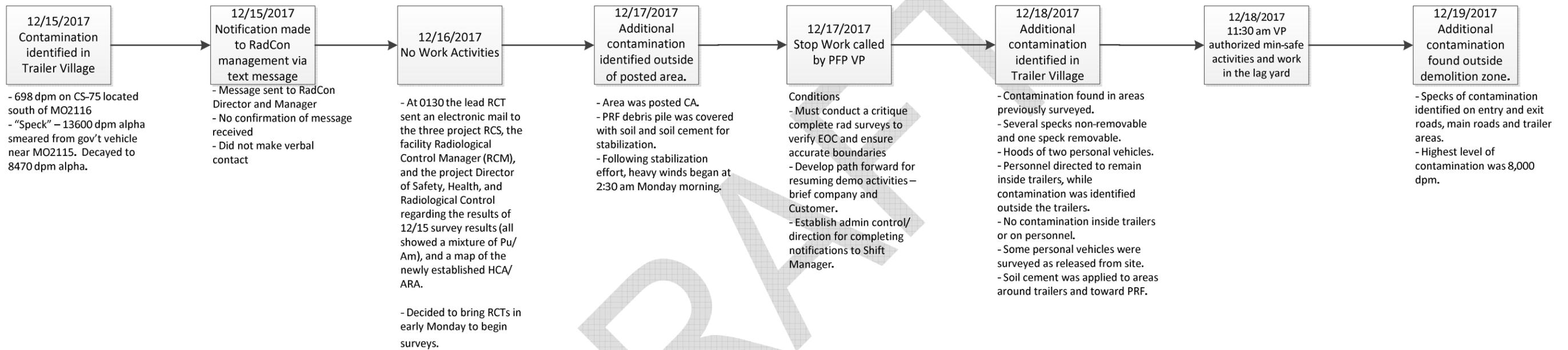
Kelly A. Wooley	PFP Vice President, Responsible Manager
Julie A. Knodel	CHPRC/PFP Issues Management, Team Leader
Beth Poole	CHPRC/W&FMP Issues Management
Darren M. Boone	PFP Director of Operations
D. Todd Southerland	PFP Director of Radiological Control, Industrial Hygiene and Safety
Tim L. Trevis	PFP Director of Demolition
Eric D. McKamey	PFP Radiological Control Manager
Michael K. Foster	PFP Radiological Control First Line Manager
Hans A. Showalter	PFP HAMTC Safety Representative
Sheila R. Godfrey	CHPRC Radiological Protection Programs Manager
Derek Thornton	CHPRC Contractor and Quality Assurance
Wayne D. Schofield	MSA Worker Protection
William J. Leonard	WAI ESH&Q Manager - Independent Subject Matter Expert, Cause Analysis

ATTACHMENT 5: TIMELINE

Between December 14 and December 18, 2017, contamination was detected outside of the Contamination Area (CA) at the Plutonium Finishing Plant (PFP) demolition zone, including around the PFP offices and on government and personal vehicles located outside the demolition zone. This resulted in the potential for personnel exposure.



Between December 14 and December 18, 2017, contamination was detected outside of the Contamination Area (CA) at the Plutonium Finishing Plant (PFP) demolition zone, including around the PFP offices and on government and personal vehicles located outside the demolition zone. This resulted in the potential for personnel exposure.



ATTACHMENT 6: BARRIER ANALYSIS

		Hazard	Barrier	Target	Effective	Used/ Not Used	Comments/Consequences
1	PRF	Release of Contaminated Material Remaining in Building Under Open Air Demo Beyond Radiological Boundaries.	Limits specified in DQO	Minimize amount of radioactivity available for re-suspension during demolition	Yes	Used	Less contamination remaining with the gallery gloveboxes and strongbacks removed. Removal of the strongbacks did not indicate contamination issues.
2	PRF	Release of Contaminated Material Remaining in Building Under Open Air Demo Beyond Radiological Boundaries.	Characterization of contamination	Ensure limits specified in DQO are met	Yes	Used	The keyways had contamination remaining; three keyways were vacuumed (horizontal surfaces of the plugs) - contents were NDAd The actual keyways were not. Fixative had not been applied to keyways at this point. 238 g Pu associated with the walls; includes assumption for remnants in keyholes. 880 g Pu walls and strongbacks. Some left behind when gloveboxes were removed. Material was adhered in the keyholes. Rubble more than anticipated would be required due to angle iron re-enforcement for SBs Estimates were conservative - on the high side. Characterization was good.

		Hazard	Barrier	Target	Effective	Used/ Not Used	Comments/Consequences
3	PRF	Release of Contaminated Material Remaining in Building Under Open Air Demo Beyond Radiological Boundaries.	Plan for large debris pieces to be removed.	Minimize disturbance of radioactive material.	Yes	Not Used	Smaller bites than planned began following the removal of the first set of strongbacks - exhauster still running. No controls in the work package for debris size. "Minimize" statement in WP. Viewed as a good practice - ALARA
4	PRF	Release of Contaminated Material Remaining in Building Under Open Air Demo Beyond Radiological Boundaries.	Lockdown of contamination on interior Canyon walls prior to demolition	Minimize /limit generation of contamination and airborne radioactivity	Yes	Used	Most exposed surfaces were locked down well - however some were oily and did not hold. Horizontal platform in Maintenance cell (at north wall) was very oily and fixative did not adhere well.
5	PRF	Release of Contaminated Material Remaining in Building Under Open Air Demo Beyond Radiological Boundaries.	Exhausters installed at south wall	To minimize the spread of contamination while handling high gram value waste	Yes	Used	Effective up until the time the roof was removed. At the time the north wall was removed airflow was visible into PRF. Installed prior to the re-start of PRF demolition. Removed December 7, 2017.
6	PRF	Release of Contaminated Material Remaining in Building Under Open Air Demo Beyond Radiological Boundaries.	Rate of the demolition activity was incorporated into the planning (two strongbacks per day, to include wall and size reduction efforts)	Minimize /limit generation of contamination and airborne radioactivity	Unknown	Not Used	Based on additional controls put in place (results of real time monitoring, lack of wind, DAC hours per week, expected characteristics of remaining source term, etc.) it was determined to increase the allowed number of strongbacks removed.

		Hazard	Barrier	Target	Effective	Used/ Not Used	Comments/Consequences
7	PRF	Release of Contaminated Material Remaining in Building Under Open Air Demo Beyond Radiological Boundaries.	Water or water with fixative application	To reduce airborne radioactivity levels by a mitigating factor of 10.	Unknown	Used	Misting and water suppression is effective. Mitigating Factor of 10 was determined for fixative. Assumptions derived from PNNL-20173
8	PRF	Release of Contaminated Material Remaining in Building Under Open Air Demo Beyond Radiological Boundaries.	Size of the Radiological Control Boundaries	Provide a posted radiological boundary large enough to contain contamination and airborne radioactivity	No	Used	Contamination and airborne radioactivity spread outside the boundary during the time period starting December 8, 2017. Expanded boundary directionally to address incidents but did not broaden the entire boundary.
9	PRF	Release of Contaminated Material Remaining in Building Under Open Air Demo Beyond Radiological Boundaries.	PFP Real-time Air Monitoring Protocol as defined in the AMW.	Monitor the weekly DAC-hr allowance.	Yes	Used	Monitored daily and would stop demo activities if approaching numbers higher than desired. During the week of December 4th, work was stopped on demo due to the accumulated DAC-hr for the week, although max not reached. Was not always picking up releases on the CAMs. Radon made monitoring more difficult.
10	PRF	Release of Contaminated Material Remaining in Building Under Open Air Demo Beyond Radiological Boundaries.	PFP Real-time Air Monitoring Protocol as defined in the AMW. Real time indication of airborne radioactivity to assist in controlling the demolition.	Prevent boundary CAM alarms.	Yes	Used	No CAM alarms noted. The number of CAMs was increased due to the additional demo activities and increased perimeters since June 2017. Didn't anticipate the spread of contamination to come without a plume of airborne radioactivity that the CAMs would have seen.

		Hazard	Barrier	Target	Effective	Used/ Not Used	Comments/Consequences
11	PRF	Release of Contaminated Material Remaining in Building Under Open Air Demo Beyond Radiological Boundaries.	PFP Air Monitoring (real-time and fixed head air) Protocol as defined in the AMW to assist in controlling the demolition.	Prevent spread of contamination outside of boundaries	No	Used	<p>The CAMs did not pick up or see the contamination that was found outside the demo area. Fixed head air samplers (not real-time) results were <0.3 DAC-hr. Failed on the 9th (lapels). Failed on the 15th (CAMs inside showed indication but not CAMs outside).</p> <p>Didn't anticipate the spread of contamination to come without a plume of airborne radioactivity that the CAMs would have seen.</p>
12	PRF	Release of Contaminated Material Remaining in Building Under Open Air Demo Beyond Radiological Boundaries.	Water or water with fixative application	Minimize spread of contamination outside of boundaries	Yes - Airborne No- Contamination Spread	Used	<p>The water and fixative did "minimize" the spread of contamination but not to 100% like was expected with the other controls in place, however was not an expectation to be 100%.</p> <p>It is unknown when the release did happen - before or after the demo?</p> <p>Increased suppression equipment from 1 high volume fogger, 2 telefoggers and 2 water cannons in June to 5 high volume foggers, 1 telefogger.</p> <p>Applied water suppression to engulf the entire area.</p> <p>Re-positioned the high volume foggers (fans on units pushing air) to provide a flatter trajectory and minimize "lofting" contamination.</p> <p>PNNL-20173 assumes reduction by 90%.</p>

		Hazard	Barrier	Target	Effective	Used/ Not Used	Comments/Consequences
13	PRF	Contaminated Material not Controlled within Debris Pile	Concentration of PBS	Hold particulate in place - minimize spread of contamination	Yes	Used	<p>Rad/Eng analyzed to determine PBS concentration - 50% was determined to be optimal for safety for worker, ease of use. Documented on CR-2017-1136 (CA). Paper calculation - no formal testing. Qualitative vs. quantitative.</p> <p>Started at 100% when demolition preparation work began on PRF</p> <p>Began covering debris with soil.</p> <p>Accepted practice to dilute.</p> <p>Had to apply repeatedly to maintain durability.</p> <p>Did not include temperature testing. Manufacturer recommended 35 degrees. Unknown if the conditions it was used under could have affected the effectiveness.</p>
14	PRF	Contaminated Material not Controlled within Debris Pile	Meteorological Monitoring	Minimize spread of contamination	No	Used	<p>15 mph Wind Limit Shut down work regardless of wind speed if unable to control debris. The wind speeds were evaluated for the upcoming days and the forecast for winds through the next week. There was a sense of urgency to get the soil cap in place on Sunday prior to forecasted high winds. Fixative was applied up to the berm edge on Friday.</p> <p>Lacked the confidence in ability to apply the fixative to where the contamination most likely was located.</p>

		Hazard	Barrier	Target	Effective	Used/ Not Used	Comments/Consequences
15	PRF	Contaminated Material not Controlled within Debris Pile	Soil Cap	Long term in holding contamination in place.	Yes	Not Used	<p>Debris pile not fully covered (half of footprint of the Canyon Debris from stem walls had PBS - no soil. Second loader was in place moving the debris from the wall. High HEO activity level focused on PRF. Applied fixative as went. Applied to east wall - none on west. One water canon in use spraying north to south - causing shadowing effect. Hoses are a limiting factor in movement. Debris piles 8-10 ft high. Plan was to place dirt over pile on Sunday, but did get half the pile covered on Friday.</p> <p>Failed to see indirect consequences resulting from failure to remove debris or water cannon. Not recognized immediately and failed to change approach</p>
16	PRF	Contaminated Material not Controlled within Debris Pile	Water or water with fixative application	Minimize airborne contamination	Yes	Not Used	There was one airborne posting violation on Friday, December 8, 2017 - partially effective. All demo activities were occurring.
17	PRF	Contaminated Material not Controlled within Debris Pile	Limit the amount of debris allowable on the ground	Minimize spread of contamination outside the boundary	Yes	Not Used	Chose to cover the debris rather than loadout to accelerate the demo activities. Believed that fixative application provided equivalent protection to limiting the amount of debris Required re-location of debris pile.

		Hazard	Barrier	Target	Effective	Used/ Not Used	Comments/Consequences
18	PRF	Airborne Contamination Released Beyond Boundary Established for Planned Work Evolution	CAM	Early Warning mechanism for airborne radioactivity.	No	Used	Counted on seeing rate of rise due to particulate. R of R was noted inside the HCA/ARA boundary - not outside on the 15th. Following 6/8 event added job coverage CAMS as close to demo activity as possible - set at 80 DAC-hr. Outside the berm established for demo activities, inside the HCA/ARA CAMS were set at 24 DAC hr. 8 DAC-hr at the HCA/ARA boundary. High lapel readings (south) did not line up with CS surveys (east). No indicators of the high lapels. CAMS were all working properly, source checked, within calibration, found to be operational prior to demo, monitored by RCTs. Used to control rate of demo.
19	PRF	Contamination Released Beyond Boundary Established for Planned Work Evolution	CAM	Early Warning mechanism for contamination spread.	No	Used	In addition to item 18 - False sense of security that the CAM will provide the early warning of a contamination spread. Monitor rate of rise and apply fixative and/or stop demo. Filters are counted after they have been pulled each day. Maintenance and Calibration evaluation determined the CAMs have been fully functional.

		Hazard	Barrier	Target	Effective	Used/ Not Used	Comments/Consequences
20	PRF	Contamination Released Beyond Boundary Established for Planned Work Evolution	Dust Suppression - water/fixative	Control contamination.	No	Used	Seven applicators adjustments made to ensure fully engulfed building. Lofted mist observed. Re-located high volume fogger closer. Re-positioned to mitigate lofting. Contamination found on two government located to the south on December 15, 2017. Additional high volume foggers was a CA taken from June event. Contamination was entrained in the water and carried beyond the boundaries. Did not get results from direct survey - was from smearable.
21	PRF	Contamination Released Beyond Boundary Established for Planned Work Evolution	Training and Qualification of Workers	Safe and compliant execution of the work activity	Yes	Used	Followed their work package. No mistake on their part. Efforts following June event to fully understand engulfment.
22	PRF	Contamination Released Beyond Boundary Established for Planned Work Evolution	Management (Manager Up) Oversight and Evaluation	Safe and compliant execution of the work activity.	No	Used	December 15, 2017 - SSW was involved, provided feedback. Communication flowed up to the time demo work was completed for the day. Different SSWs throughout the week. A collective view of the contamination events starting November 29 th was not realized - was discretely evaluated daily. Very conscious/focused on the impending weather (wind) - the 15 th was the last perfect day to get the building down.

		Hazard	Barrier	Target	Effective	Used/ Not Used	Comments/Consequences
23	PRF	Contamination Released Beyond Boundary Established for Planned Work Evolution	Routine Contamination Surveys	Provides data and trends of job evolution to minimize spread and provide info for the upcoming activities.	Not considered a hard barrier - did perform as intended.	Used	<p>Cookie sheets were surveyed daily per task instructions which includes a map of the locations of the cookies sheets. Cookie sheet surveys were conducted based on indicators of need/abnormal. Did not survey cookie sheets during active demolition activities.</p> <p>Reached an action level resulting in application of fixative.</p> <p>Indicator of issue December 15, 2017, evening.</p> <p>Provides info to keep from exceeding limits beyond the boundary.</p> <p>Would have been effective if the area had been surveyed and spread contamination removed, this wasn't done</p>
24	PRF	Contamination Released Beyond Boundary Established for Planned Work Evolution	Work package	Provides direction for contamination control.	No	Used	<p>Defines Controls in the work package - rubbleizing, application of fixative, suppression equipment. Followed work package instructions.</p> <p>Directs application of fixative but does not specifically call out to cover all newly exposed surfaces.</p> <p>Soil cap was a decision outside of work package direction. It is not listed in the work package.</p> <p>WCN to allow the excavator to drive on the debris pile if covered with soil - not listed as a Rad control.</p>
25	PRF	Contamination Released Beyond Boundary Established for Planned Work Evolution	<p>CONOPS/Stop Work</p> <ul style="list-style-type: none"> - Conduct critique - Complete rad surveys - Develop path forward - Establish admin control/direction for completing notifications of upset conditions. 	Safe and compliant execution of the work activity.	Not a Barrier	Not Used - Not a Barrier	<p>One Employee Stop Work</p> <p>One Stop Work by PFP VP</p> <p>Reactive to the high lapels.</p> <p>Event investigation took place.</p>

		Hazard	Barrier	Target	Effective	Used/ Not Used	Comments/Consequences
26	PRF	Contamination Released Beyond Boundary Established for Planned Work Evolution	SSW - Program and PFP	Safe and compliant execution of the work activity.	Yes	Used	No turnover between SSWs. Ensures issues are addressed properly. Ensures procedures are followed. Was as intended.
27	PRF	Contamination Released Beyond Boundary Established for Planned Work Evolution	Shift Manager	Safe and compliant execution of the work activity.	Yes	Used	Ensures issues are addressed properly. Ensures procedures are followed. Was as intended.
28	PRF	Contamination Released Beyond Boundary Established for Planned Work Evolution	CONOPS/ Communications	Safe and compliant execution of the work activity.	Yes	Used	Daily morning and afternoon meetings held with PFP management. Three-way communications, repeat backs, shift turnover. Lots of radio chatter - good communication.
29	PRF	Contamination Released Beyond Boundary Established for Planned Work Evolution	CONOPS - Response and Notification of Upset Conditions	Safe and compliant execution of the work activity.	No	Partially	Communication of the survey results did not immediately reach Operations level. A text was sent to RadCon Manager and Director - no verbal notification. On Saturday, Program and VP notified. Brought RCTs in at 1 am - developed game plan and began surveys. SO/FR no informed until 6:15 am meeting. Did not follow PRC-PRO-EM-060. Level of confusion created with the work team coming in for planned work on Sunday - blocked off parking lots, late performance of pre-job, etc.

		Hazard	Barrier	Target	Effective	Used/ Not Used	Comments/Consequences
30	PRF	Contamination Released Beyond Boundary Established for Planned Work Evolution	CONOPS - Radiological Control Execution	Safe and compliant execution of the work activity.	Unknown	Used	Develop RWP, establish protections for the worker and the environment, routine surveillance program, task descriptions. During execution of work, all employees are responsible. Responded to the indicators outside the boundary. Made notifications during the day on December 15 th - considered to be a discreet singular event overcome by water suppression and soil coverage. Re-positioned east high volume fogger flatter and closer, applied fixative.
31			CONOPS Trend Analysis	Safe and compliant execution of the work activity.	No	Used	Looked at small windows of time but did not step back enough to recognize. Informal trending took place but no actions were taken. Formal trending had not occurred at the time of the event - middle of the month timeframe.
32	PRF	Contamination Released Beyond Boundary Established for Planned Work Evolution	Management Decision Processes	Safe and compliant execution of the work activity.	No	Used	No singular decisions - informed decisions with input from directors. Had to deal with decisions made years past that could not be undone. Did not occur to us that we could not control the spread of contamination. Dealt with singular events; did not recognize trend.
33	234-5Z	Contaminated Material Remaining in Building	Limits specified in DQO	Minimize amount of radioactivity available for re-suspension during demolition.	Yes	Used	Less contamination remaining with the gallery gloveboxes and strongbacks removed. While removing the strongbacks did not have contamination issues.

		Hazard	Barrier	Target	Effective	Used/ Not Used	Comments/Consequences
34	234-5Z	Contaminated Material Remaining in Building	Characterization of Contamination	Ensure limits specified in DQO are met	Yes	Used	The keyways had contamination remaining; three keyways were vacuumed (horizontal surfaces of the plugs) - contents were NDAD The actual keyways were not. Fixative had not been applied to keyways at this point. 238 g Pu associated with the walls; includes assumption for remnants in keyholes 880 g Pu walls and strongbacks. Some left behind when gloveboxes were removed. Material was adhered in the keyholes. Still not convinced we knew all that was remaining after SB removal. Rubblized more than anticipated would be required due to angle iron re-enforcement for SBs. Estimates were conservative - on the high side. Characterization was good.
35	234-5Z	Contaminated Material Remaining in Building	Application of fixative/epoxy for remaining materials.	Minimize spread of contamination.	Unknown	Used	Epoxy filled pipes - experience to date with demolition has been good. > 10 - 2 Million dpm/100 cm ² - epoxy > 2 million - removed or left alone and identified as a special handled item. E3/E4 ventilation duct open on south side of -5, starting at west end of -5, going east. (~80 to the west) with the building, duct open at this time. Opened in November timeframe. Since previous events have conducted further investigation of remaining contamination. Removed or foamed more contaminated items.

		Hazard	Barrier	Target	Effective	Used/ Not Used	Comments/Consequences
36	234-5Z	Contaminated Material Remaining in Building	Water or water with fixative application	Minimize spread of contamination.	Unknown	Used	Misting and water suppression is effective. Mitigating factor of 10 was determined for fixative. Assumptions derived from PNNL-20173
37	234-5Z	Contaminated Material not Controlled within North Debris Pile (lowest amount of source term)	Water or water with fixative application	Minimize spread of contamination.	Yes	Used	Minimal water application. Applied fixative based on rad levels while manipulating or disturbing debris pile. Fixative application was by permission or per work package. How much previously applied, weather conditions, considered by Rad Director.
38	234-5Z	Contaminated Material not Controlled within North Debris Pile (lowest amount of source term)	Meteorological Monitoring	Minimize spread of contamination.	Yes	Used	25 mph limit for processing. Shut down regardless of wind speed in unable to control debris. Very little loose contamination in the north pile.
39	234-5Z	Contaminated Material not Controlled within South Debris Pile	Water or water with fixative application	Minimize airborne contamination.	Yes	Used	There was one airborne posting violation on Friday, December 8 th - partially effective. All demo activities were occurring. Water suppression going at all times of debris movement. No work related to -5 debris during time of contamination spread.
40	234-5Z	Contaminated Material not Controlled within South Debris Pile	Water or water with fixative application	Minimize spread of contamination.	Yes	Used	Misting and water suppression is effective. Mitigating Factor of 10 was determined for fixative. Assumptions derived from PNNL-20173.

		Hazard	Barrier	Target	Effective	Used/ Not Used	Comments/Consequences
41	234-5Z	Contaminated Material not Controlled within South Debris Pile	Water or water with fixative application	Minimize spread of contamination outside of boundaries.	Yes - Airborne No-Contamination Spread	Used	<p>The water and fixative did “minimize” the spread of contamination but not to 100% like we expected with the other controls in place, however was not an expectation to be 100%.</p> <p>It is unknown when the release did happen - before or after the demo?</p> <p>On December 15, 2017 the south debris pile was not manipulated.</p>
42	234-5Z	Contaminated Material not Controlled within South Debris Pile	Concentration of PBS	Hold particulate in place - minimize spread of contamination.	Yes	Used	<p>Designed to be used as a paint - we used as a coating agent.</p> <p>Rad/Engineering analyzed to determine PBS concentration - 50% was determined to be optimal for safety for worker, ease of use. Documented on CR-2017-1136 (CA). Paper calculation - no formal testing. Qualitative vs. Quantitative.</p> <p>Started at 100% when demolition preparation work began on PRF.</p> <p>Began covering debris with soil.</p> <p>Accepted practice to dilute.</p> <p>Had to apply repeatedly to maintain durability.</p> <p>Did not include temperature testing.</p> <p>Manufacturer recommended 35 degrees.</p> <p>Unknown if the conditions it was used under could have affected the effectiveness.</p>

		Hazard	Barrier	Target	Effective	Used/ Not Used	Comments/Consequences
43	234-5Z	Contaminated Material not Controlled within North Debris Piles	Limit the amount of debris allowable on the ground	Minimize spread of contamination outside the boundary.	Unknown	Not Used	Listed in PRF Did not focus on load-out as much with the north - less risk. Applied fixative every 33 minimum. Load-out rate was partially based on the radiological data of the material.
44	234-5Z	Contaminated Material not Controlled within South Debris Piles	Limit the amount of debris allowable on the ground	Minimize spread of contamination outside the boundary.	Unknown	Not Used	Listed in PRF. Size reduced SHI. Original plan was for real-time loadout with limited debris allowed on the ground. Determined better control of contamination on the ground with fixative than remaining exposed sections of -5. Demo is stopped from time to time for allow for debris load-out. Set up multiple can load-out. Applied fixative every three days minimum. Load-out rate was partially based on the material.

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		Hazard	Barrier	Target	Effective	Used/ Not Used	Comments/Consequences
45	234-5Z	Contamination Released Beyond Boundary Established for Planned Work Evolution	CAM	Early Warning mechanism.	No	Used	Counted on seeing rate of rise due to particulate. R of R was noted inside the HCA/ARA boundary - not outside on the 15th. Following 6/8 event added job coverage CAMS as close to demo activity as possible - set at 80 DAC-hr. Outside the berm established for demo activities, inside the HCA/ARA CAMS were set at 24 DAC hr. 8 DAC-hr at the HCA/ARA boundary. High lapel readings (south) did not line up with CS surveys (east). No indicators of the high lapels. CAMS were all working properly, source checked, within calibration, found to be operational prior to demo, monitored by RCTs. Used to control rate of demo. Lag time between actual surveys conducted on CS. Particulate not evenly distributed in the air.
46	234-5Z	Contamination Released Beyond Boundary Established for Planned Work Evolution	PFP Real-time Air Monitoring Protocol as defined in the AMW.	Monitor the weekly DAC-hr allowance.	Yes	Used	Monitored daily and would stop demo activities if approaching numbers higher than desired. During the week of December 4, work was stopped on demo due to the accumulated DAC-hr for the week, although max not reached. Was not always picking up releases on the CAMs. Radon made monitoring more difficult.

		Hazard	Barrier	Target	Effective	Used/ Not Used	Comments/Consequences
47	234-5Z	Contamination Released Beyond Boundary Established for Planned Work Evolution	PFP Real-time Air Monitoring Protocol as defined in the AMW. Real-time indication of airborne radioactivity to assist in controlling the demolition.	Limit exposure from airborne radioactivity.	Yes	Used	No CAM alarms noted. The number of CAMs was increased due to the additional demo activities and increased perimeters since June 2017.
48	234-5Z	Contamination Released Beyond Boundary Established for Planned Work Evolution	PFP Air Monitoring (real-time and fixed head air) Protocol as defined in the AMW to assist in controlling the demolition.	Prevent spread of contamination outside of boundaries.	No	Used	Listed in PRF. No demolition on 234-5Z activities taking place 12-14 / 12-18. The building is open with exposure to source term still remaining. Particulate not evenly distributed in the air.
49	234-5Z	Contamination Released Beyond Boundary Established for Planned Work Evolution	Dust Suppression - water/fixative.	Control contamination.	Unknown	Used	Listed in PRF. Applied to the best of ability on an open building. Opportunity for shadowing effect.
50	234-5Z	Contamination Released Beyond Boundary Established for Planned Work Evolution	Training and Qualification of Workforce.	Management of contamination.	Yes	Used	Followed their work package. No mistake on their part. Efforts following June event to fully understand engulfment.

		Hazard	Barrier	Target	Effective	Used/ Not Used	Comments/Consequences
51	234-5Z	Contamination Released Beyond Boundary Established for Planned Work Evolution	Management (Manager Level and Up) Oversight and Evaluation	Safe and compliant execution of the work activity.	No	Used	December 15, 2017 - SSW was involved, provided feedback. Communication flowed up to the time demo work was completed for the day. Different SSWs throughout the week. A collective view of the contamination events starting November 29 th was not realized - was discretely evaluated daily. Very conscious/focused on the impending weather (wind) - the 15th was the last perfect day to get the building down.
52	234-5Z	Contamination Released Beyond Boundary Established for Planned Work Evolution	Building Preparation	Removal or fixative applied to highly contaminated components and systems.	Unknown	Used	SHI left in place as determined through characterization. Some have been removed, some still in place and have been disturbed but not breached. Some are filled with epoxy, some had fixative applied.
53	234-5Z	Contamination Released Beyond Boundary Established for Planned Work Evolution	Routine Contamination Surveys	Provides data and trends of job evolution to minimize spread and provide info for the upcoming activities.	Not considered a hard barrier - did perform as intended.	Used	Cookie sheets were surveyed per standard protocol - daily surveys. CS surveys were conducted based on indicators of need/abnormal. Did not survey cookie sheets following demo activities. Reached an action level resulting in application of fixative. Indicator of issue December 15, 2017, evening. Provides info to keep from exceeding limits beyond the boundary.

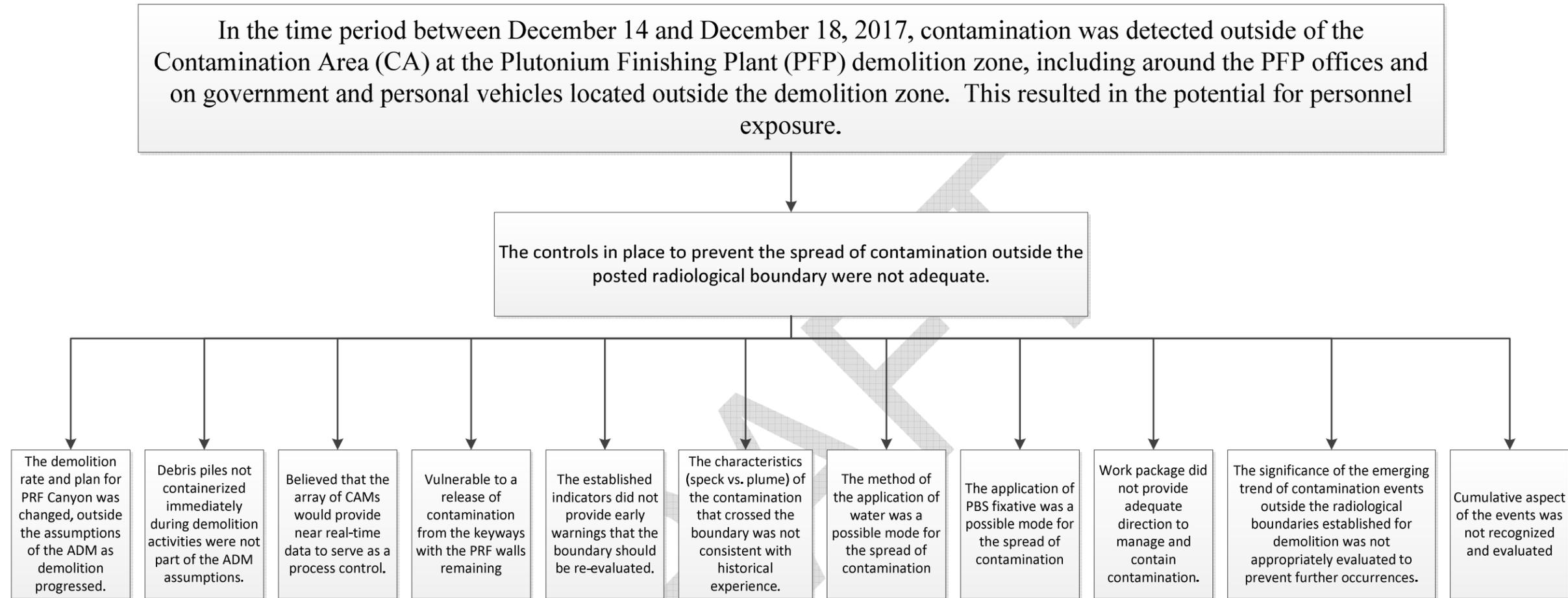
		Hazard	Barrier	Target	Effective	Used/ Not Used	Comments/Consequences
54	234-5Z	Contamination Released Beyond Boundary Established for Planned Work Evolution	Work package	Provides direction for contamination control.	No	Used	Defines controls in the work package - rubblizing, application of fixative, suppression equipment. Followed work package instructions. Directs application of fixative but does not specifically call out to cover all newly exposed surfaces. Soil cap was a decision outside of work package direction. It is not listed in the work package. WCN to allow the excavator to drive on the debris pile if covered with soil - not listed as a Rad control.
55	234-5Z	Contamination Released Beyond Boundary Established for Planned Work Evolution	CONOPS - Response and Notification of Upset Conditions	Safe and compliant execution of the work activity.	No	Partially	Communication of the survey results did not immediately reach Operations level. A text was sent to RADCON Manager and Director - no verbal notification. On Saturday, Program and VP notified. Brought RCTs in at 1 am - developed game plan and began surveys. SO/FR no informed until 6:15 am meeting. Did not follow PRC-PRO-EM-060. Level of confusion created with the work team coming in for planned work on Sunday - blocked off parking lots, late performance of pre-job, etc.
56	234-5Z	Contamination Released Beyond Boundary Established for Planned Work Evolution	CONOPS - Communications	Safe and compliant execution of the work activity.	Yes	Used	Daily morning and afternoon meetings held with PFP management. Three-way communications, repeat backs, shift turnover. Lots of radio chatter - good communication.

		Hazard	Barrier	Target	Effective	Used/ Not Used	Comments/Consequences
57	234-5Z	Contamination Released Beyond Boundary Established for Planned Work Evolution	CONOPS- Radiological Control Execution	Safe and compliant execution of the work activity.	Unknown	Used	Develop RWP, establish protections for the worker and the environment, routine surveillance program, task descriptions. During execution of work, all employees are responsible. Responded to the indicators outside the boundary. Made notifications during the day on December 15, 2017 - considered to be a discreet singular event overcome by water suppression and soil coverage. Re-positioned east high volume fogger flatter and closer, applied fixative.
58	234-5Z	Contamination Released Beyond Boundary Established for Planned Work Evolution	CONOPS - Trend Analysis	Safe and compliant execution of the work activity.	No	Used	Looked at small windows of time but did not step back enough to recognize. Informal trending took place but no actions were taken. Formal trending had not occurred at the time of the event - middle of the month timeframe.
59	234-5Z	Contamination Released Beyond Boundary Established for Planned Work Evolution	Management Decision Processes	Safe and compliant execution of the work activity.	No	Used	No singular decisions - informed decisions with input from directors. Had to deal with decisions made years past that could not be undone. Did not occur to us that we could not control the spread of contamination. Dealt with singular events; did not recognize trend.

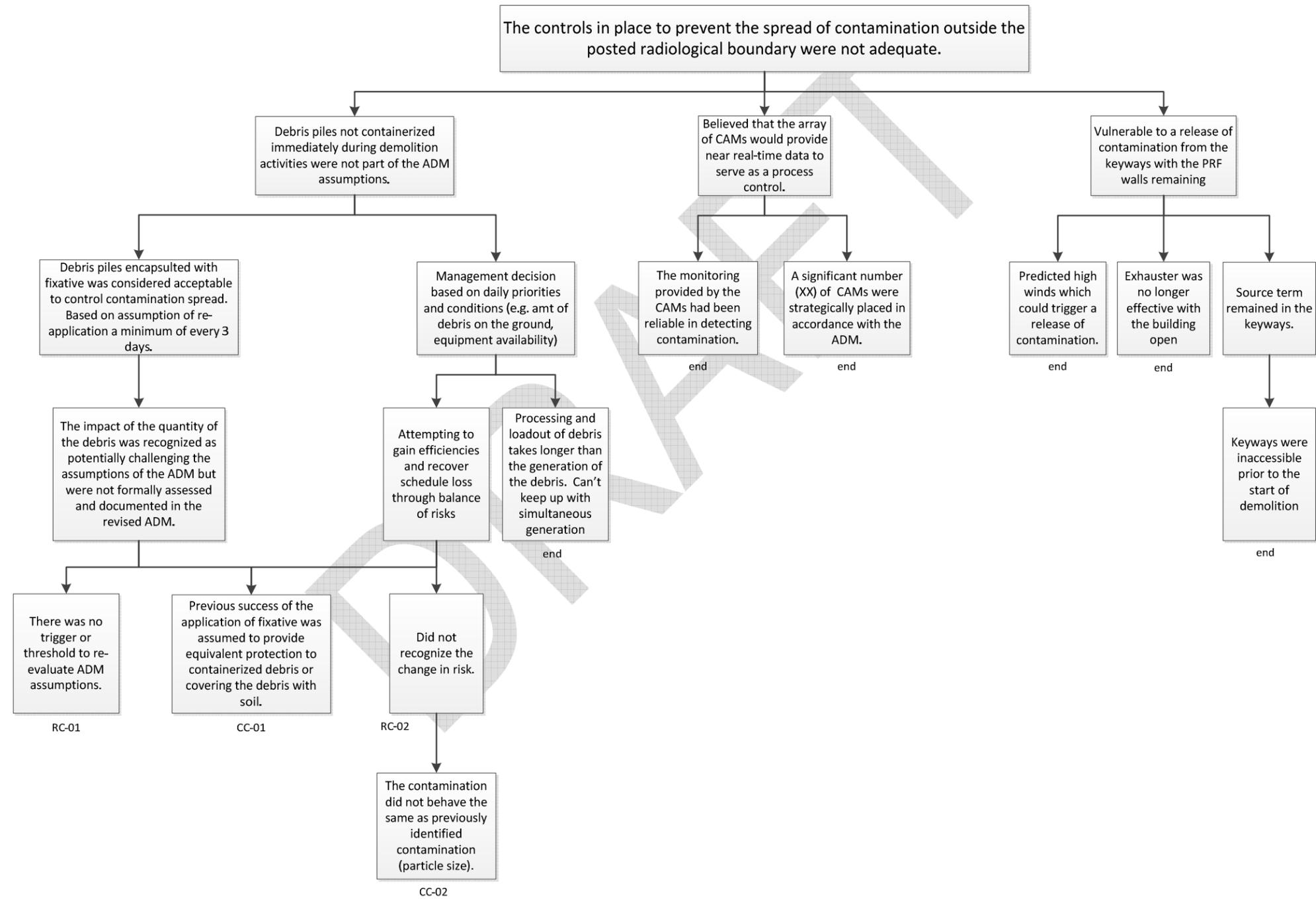
		Hazard	Barrier	Target	Effective	Used/ Not Used	Comments/Consequences
60	Heavy Equipment	Contamination migrating outside the boundaries	Equipment is hosed off prior to relocation.	Reduce source term remaining on the equipment to prevent the spread of contamination.	No	Used	<p>The equipment is hosed off with water or fixative prior to moving from one work area to another. Tracks are cycled and sprayed.</p> <p>Inconsistent application resulted in inconsistent results.</p> <p>Results could vary with type of equipment used and performance and management of the work step.</p> <p>In-board tracks were inaccessible to rinsing.</p> <p>Did not conduct surveys after hosing down.</p> <p>Once dried, potential for contamination migration.</p> <p>PRF equipment was never moved to the west side parking.</p> <p>Parking restrictions due to fire hazards, placing the equipment nearer to the boundary.</p>
61		Contamination migrating outside the boundaries	Training of workforce	Consistent gross decontamination of the equipment.	No	Not Used	<p>Expectations were not clearly defined or enforced.</p> <p>Did not require fixative application following use in the work package.</p>

		Hazard	Barrier	Target	Effective	Used/ Not Used	Comments/Consequences
62	Load-out	Contamination migrating outside the boundaries	Bucket surveys	Indicator for action levels.	Yes	Used	Activity > 200,000 would expand the boundary of the CA. More source term, higher potential contamination migration. No load-out work activities taking place. Established CA with no indication of elevated contamination levels.
63	Load-out	Contamination migrating outside the boundaries	Water/fixative applications	Minimize spread of contamination outside the boundary.	Yes	Used	RCTs monitored drips and identified contamination requiring Decon/control. Was effective in controlling dust.
64		Generation of airborne radioactivity	Water/fixative applications	Minimize spread of airborne radioactivity outside the boundary.	No	Used	Continuous use for south debris piles (requirement for suppression during load-out) and as-needed for north debris pile (requirement to be kept wet).
65	Load-out	Generation of airborne radioactivity	Bucket surveys for -5. IP-1 super sac surveys for PRF.	Indicator for action levels.	No	Used	Activity > 200,000 would expand the boundary of the CA. More source term, higher potential contamination migration. No load-out work activities taking place. Established CA with no indication of elevated contamination levels. January 7, 2018 - workers had elevated lapel > 1 DAC-hr. on December 9, 2017 (PRF waste Load-out). Potential exists for cross contamination of that lapel filter.
66	Load-out	Generation of airborne radioactivity	CAMS	Indicator for action levels.	No	Used	No indication of airborne radioactivity in the work area until later with the lapel count.

ATTACHMENT 7: WHY ANALYSIS

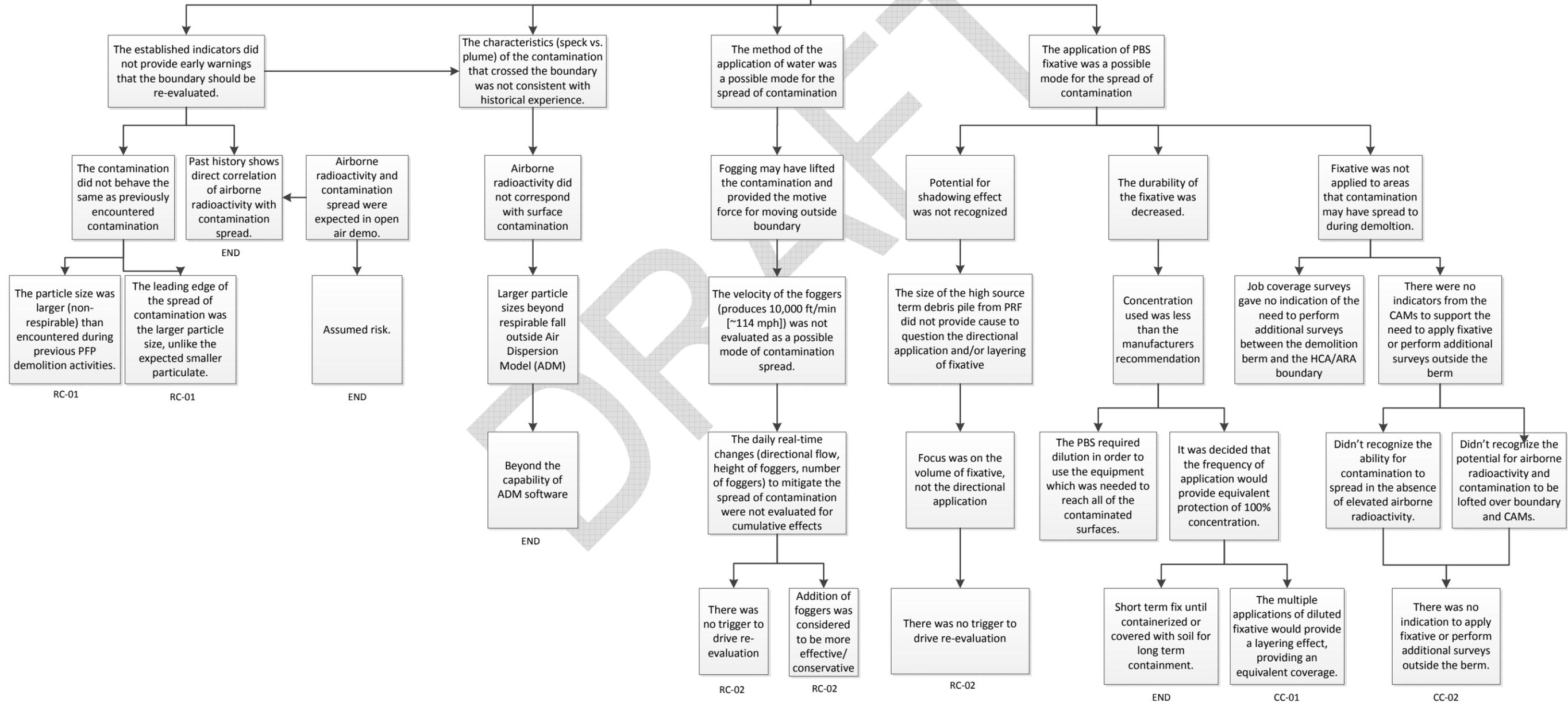


In the time period between December 14 and December 18, 2017, contamination was detected outside of the Contamination Area (CA) at the Plutonium Finishing Plant (PFP) demolition zone, including around the PFP offices and on government and personal vehicles located outside the demolition zone. This resulted in the potential for personnel exposure.

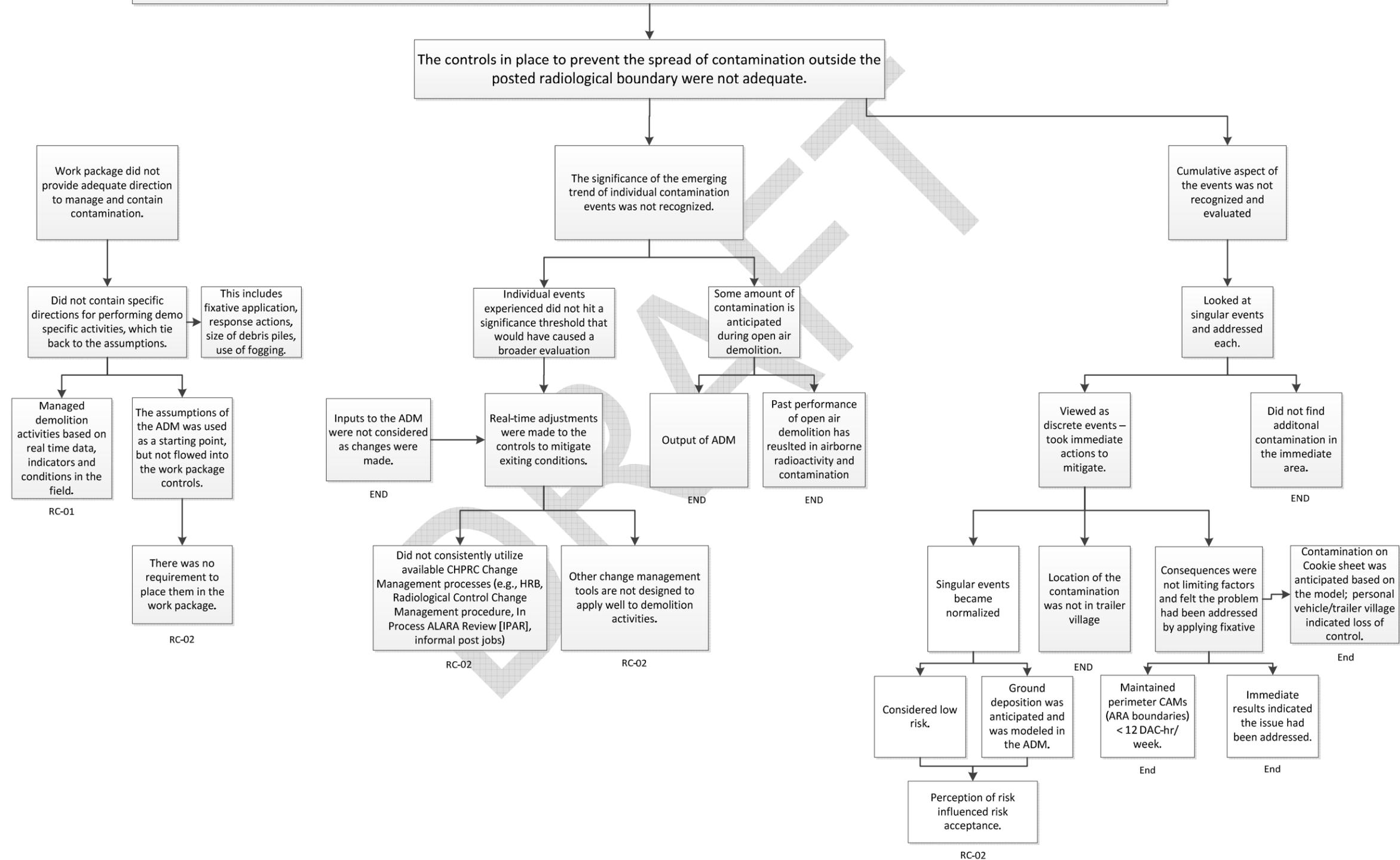


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The controls in place to prevent the spread of contamination outside the posted radiological boundary were not adequate.

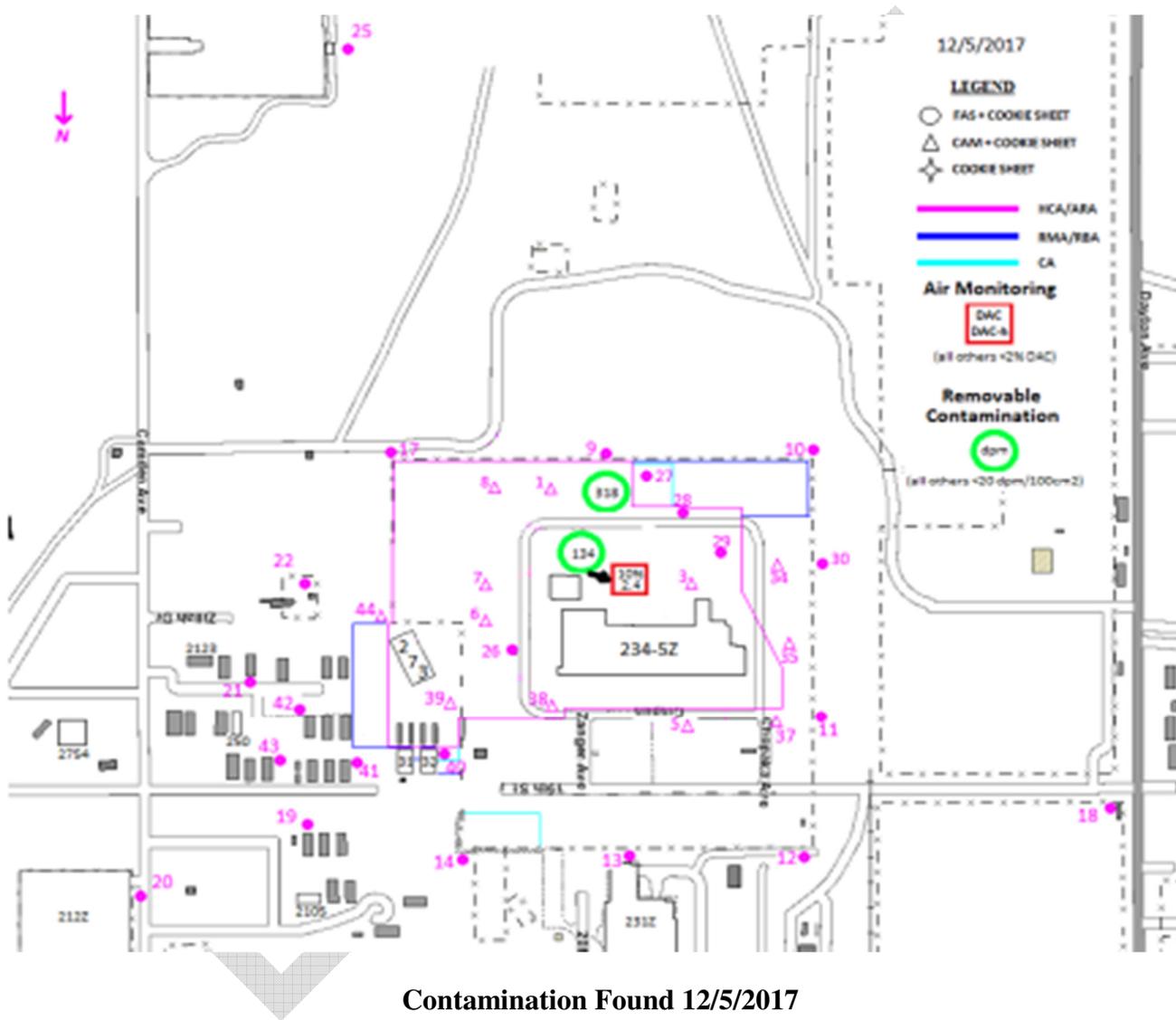


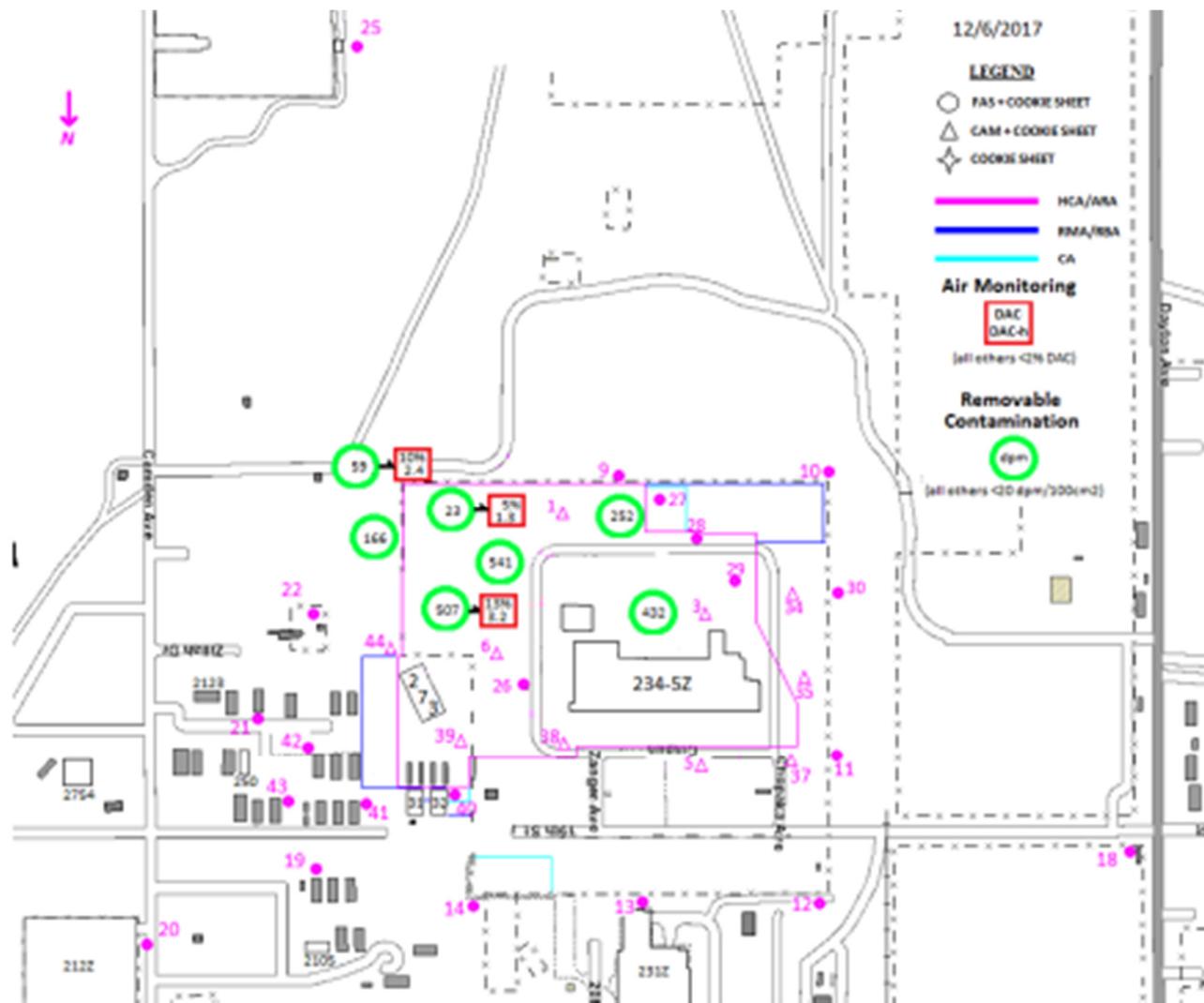
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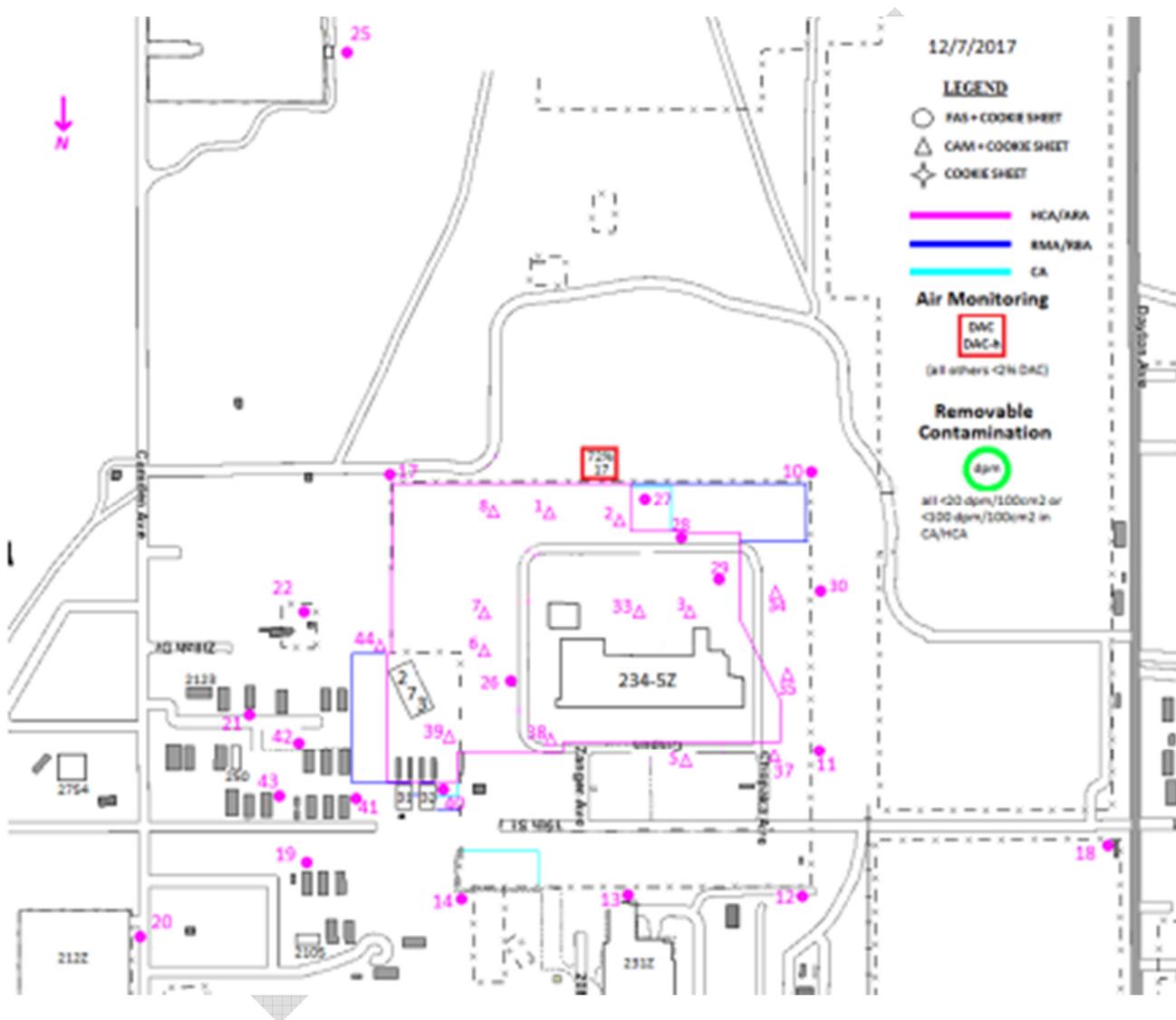
ATTACHMENT 8: COMMON CAUSE ANALYSIS

Event	Date Identified	Description Of Issue	Activity Taking Place	Other Conditions	CAMs Alarmed	CAM Location	Weather Conditions	Water Applied	Water Application	Fixative Application	Fixative Concentration	Telefogger Use	Dust Destroyers Use	Cannon Use	Procedures Followed	Procedures Adequacy	Radiological Boundary Size	Demo Rate	Trends	Contamination Characteristics	Debris Pile	Soil Cap	Notification	Off-shift Activity	Change Management
CR-2017-0104	1/27/2017	Contamination Outside CA	Movement of Debris Pile		Yes	No	No	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes	Yes	No	No	No	Yes	No	No	No	No
CR-2017-1136	6/8/2017	Rate of Rise Exceeded Set Point	Removal of third section of Gallery Glovebox 2nd West		Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	No	No	No	No	No	Yes
CR-2018-0022	12/15/2017	Contamination Outside CA	Final demo of PRF and debris pile management	234-5 open in all directions exposing contaminated areas. Debris Piles from 234-5Z remained. Work in these areas was suspended.	No	No	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	no	Yes	Yes
<p>No - indicates not causal to the event, Yes - indicates causal to the event. Indicates common to at least two of the events.</p> <p>Team discussion while working the common cause supports the following the causes of the barrier and why analyses:</p> <ul style="list-style-type: none"> Radiological boundary size was inadequate. Controls in the work package were inadequate to prevent the spread of contamination. Methods and techniques used in control of airborne radioactivity and contamination were inadequate to prevent the spread of contamination. Management of change was LTA. 																									

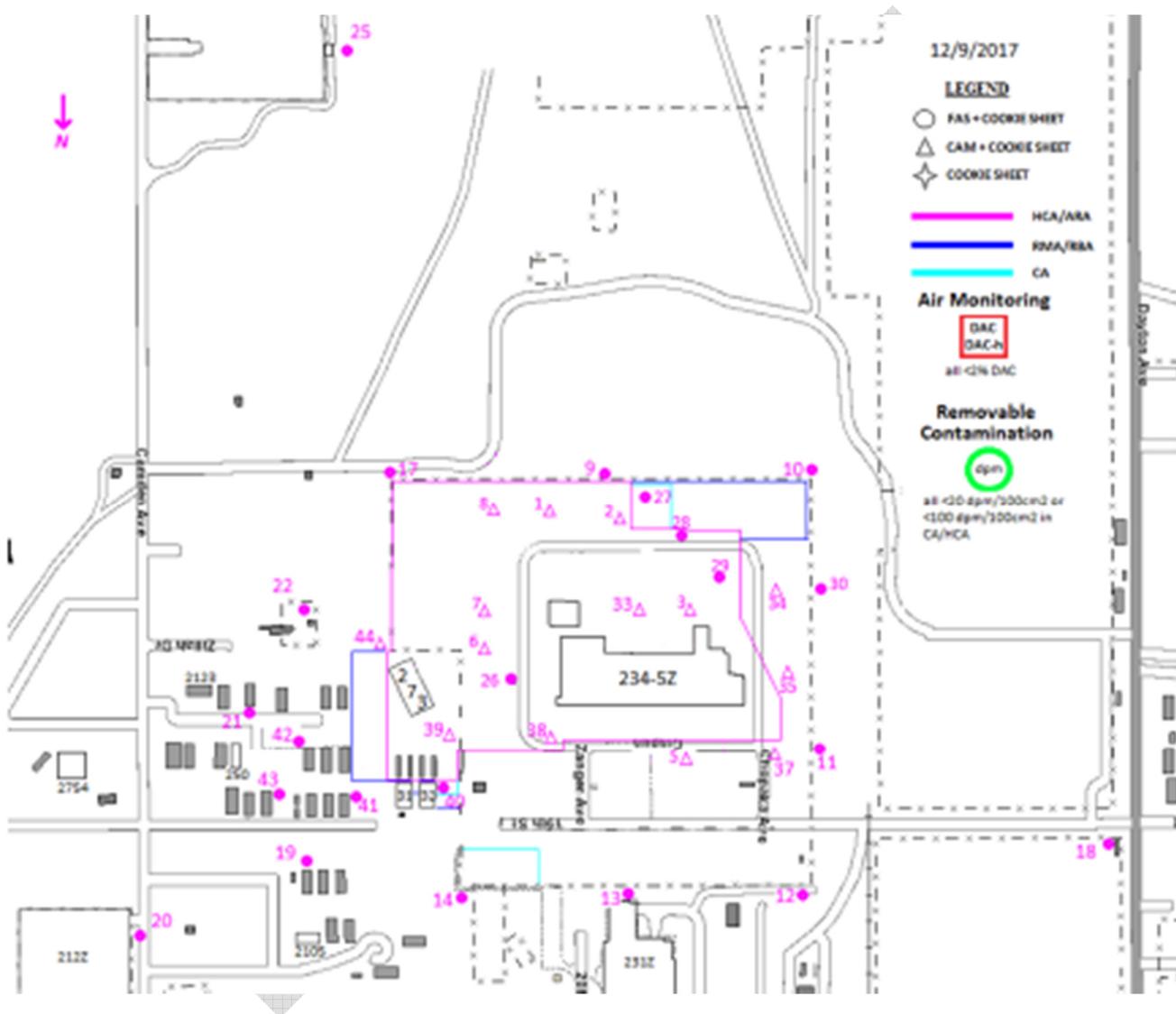




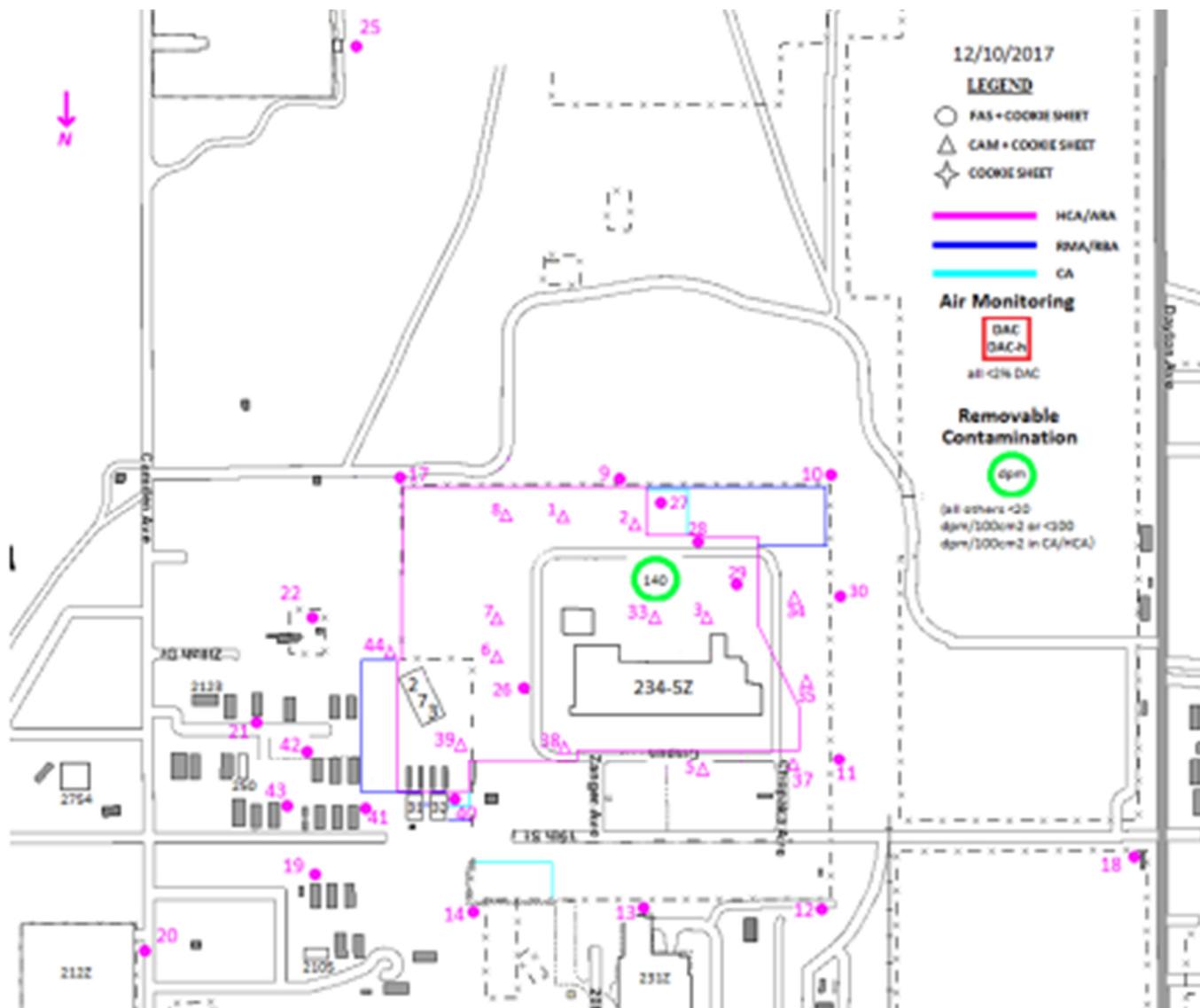
Contamination Found 12/6/2017



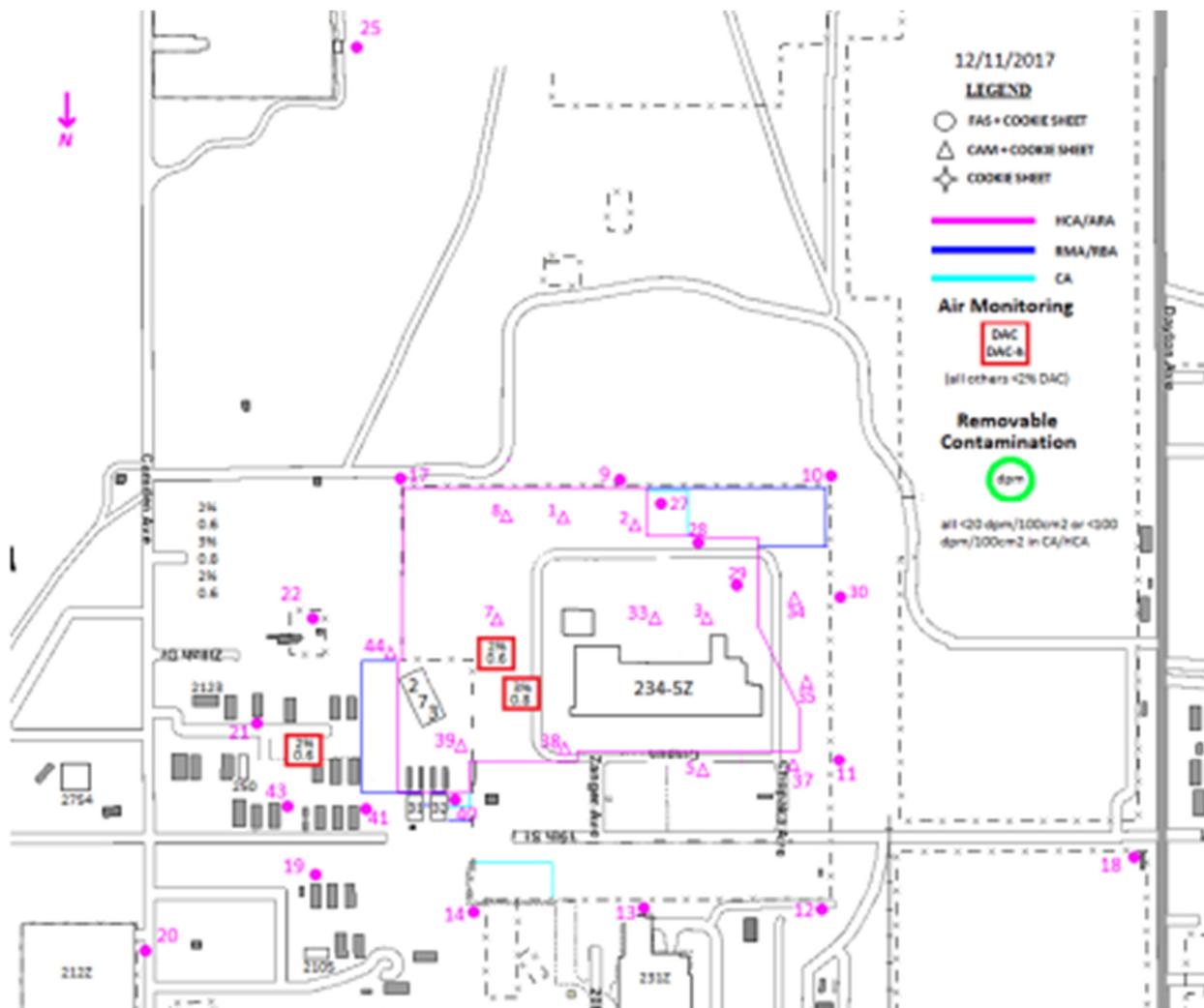
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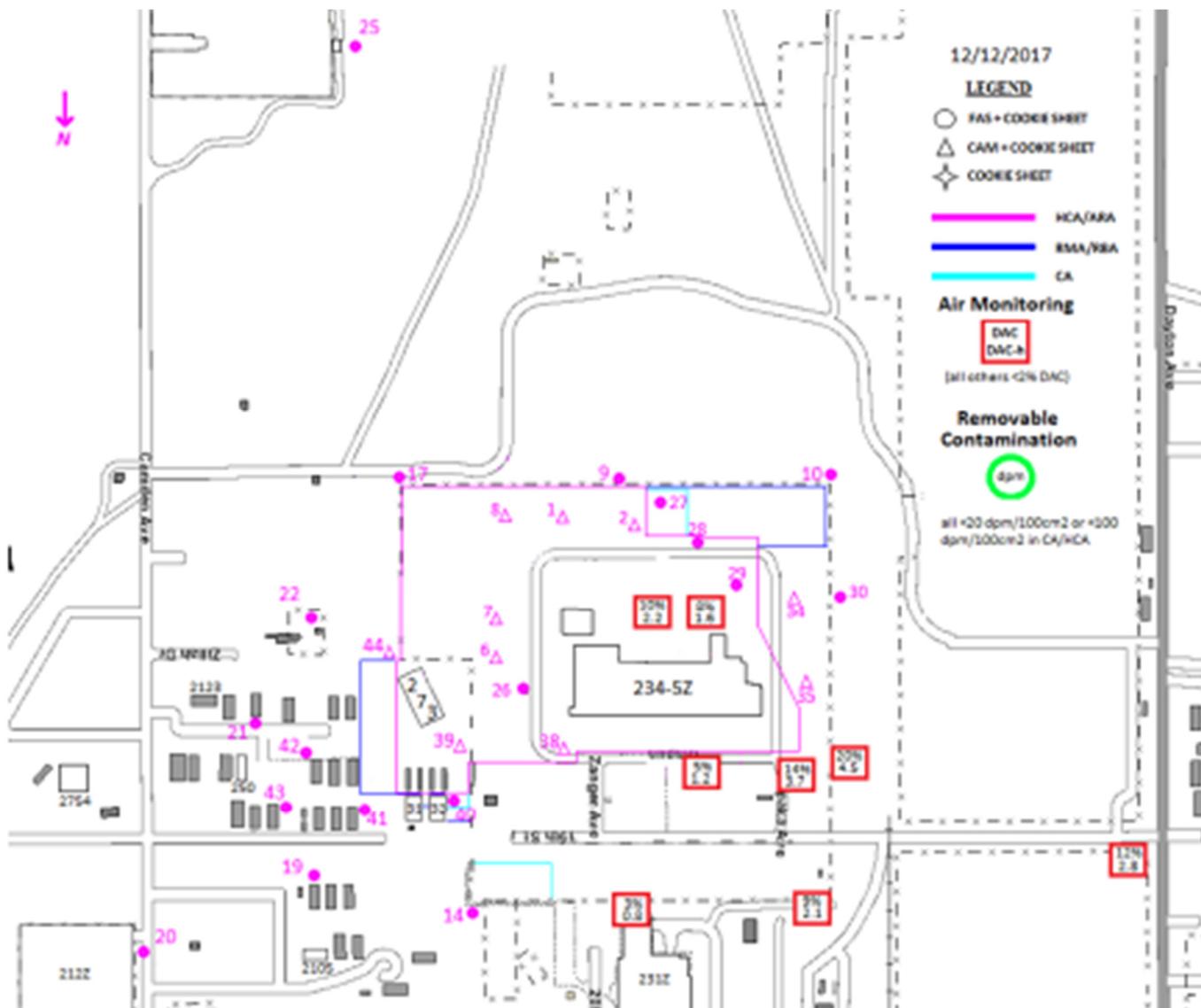
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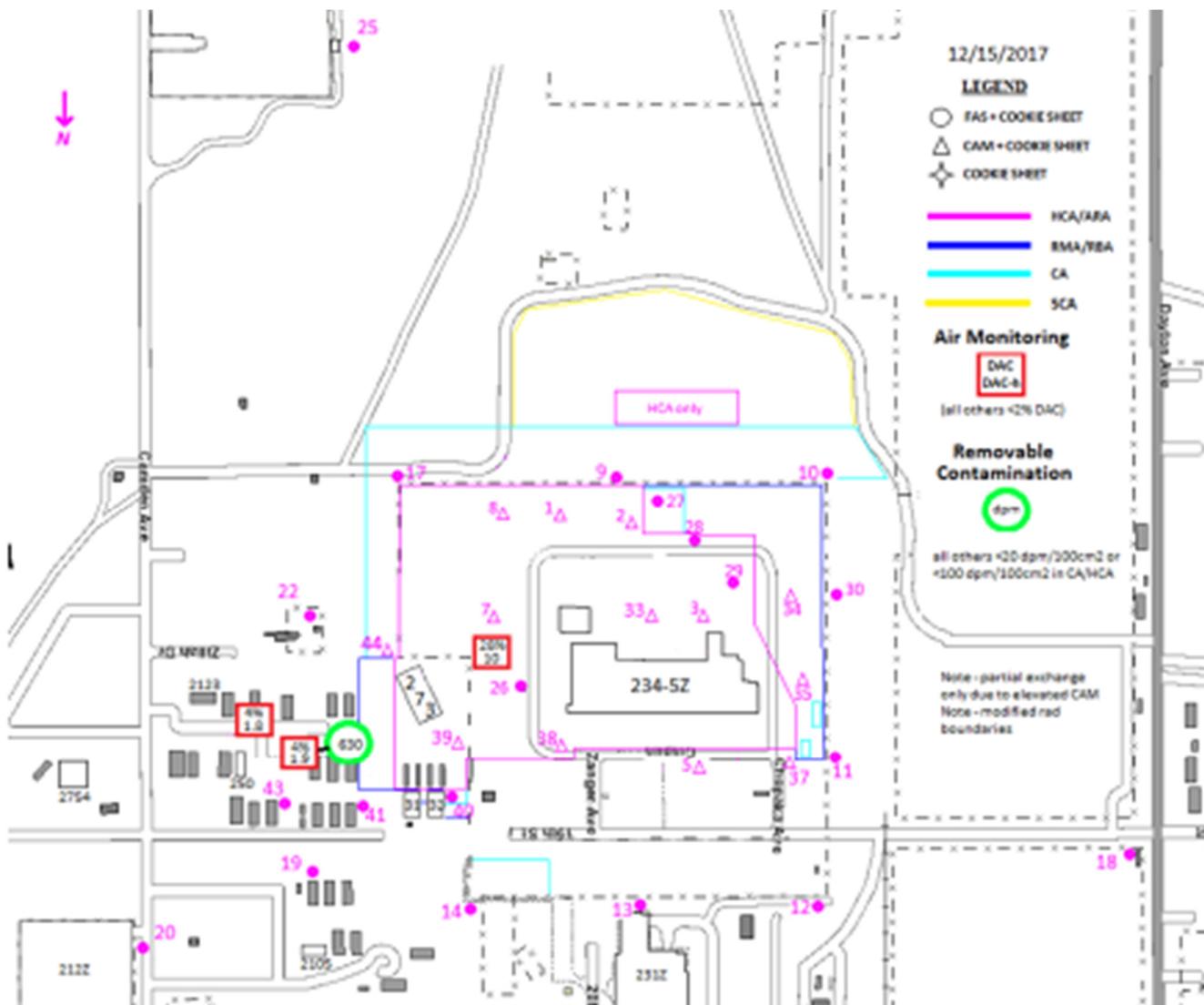
Contamination Found 12/10/2017



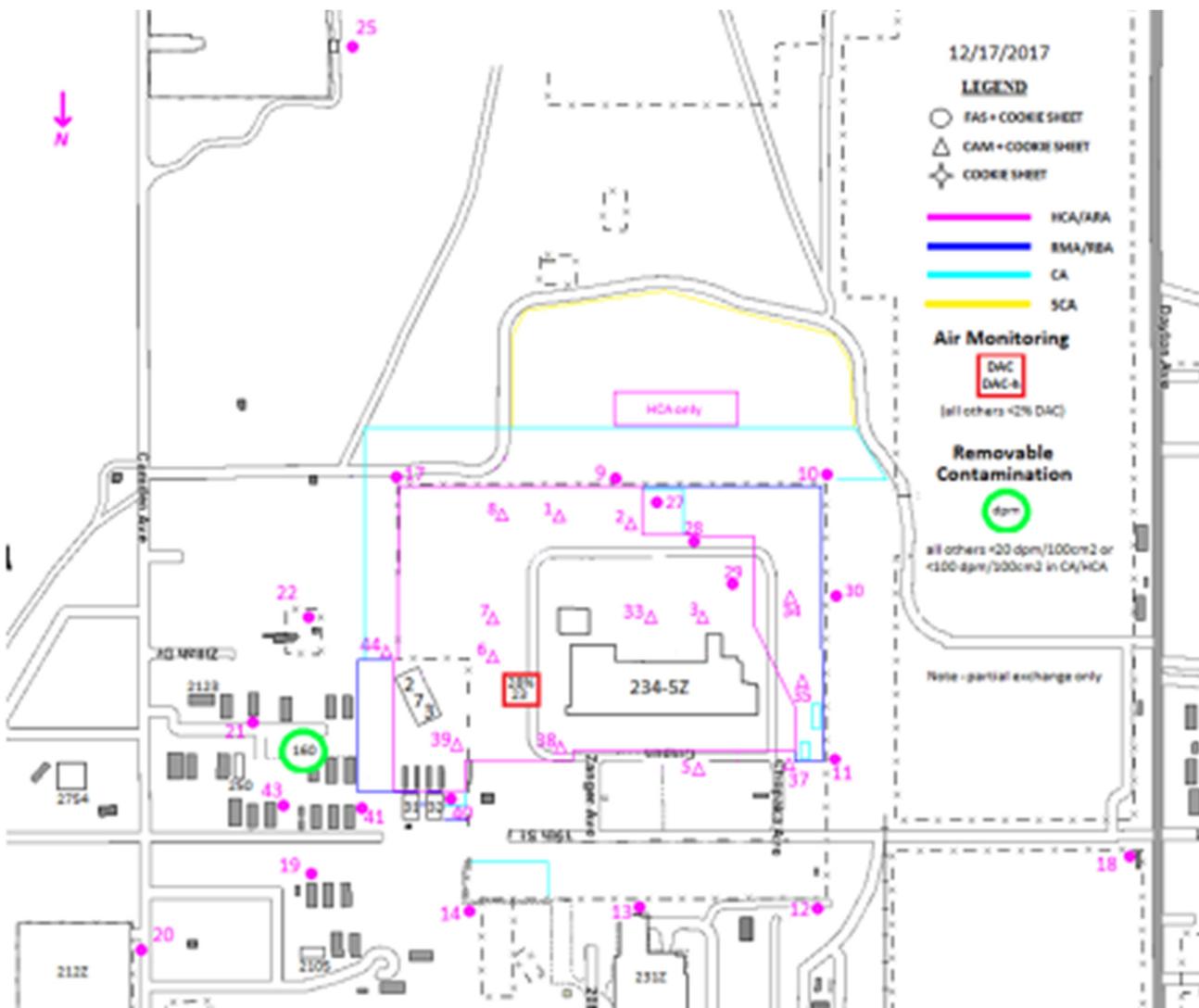
Contamination Found 12/11/2017



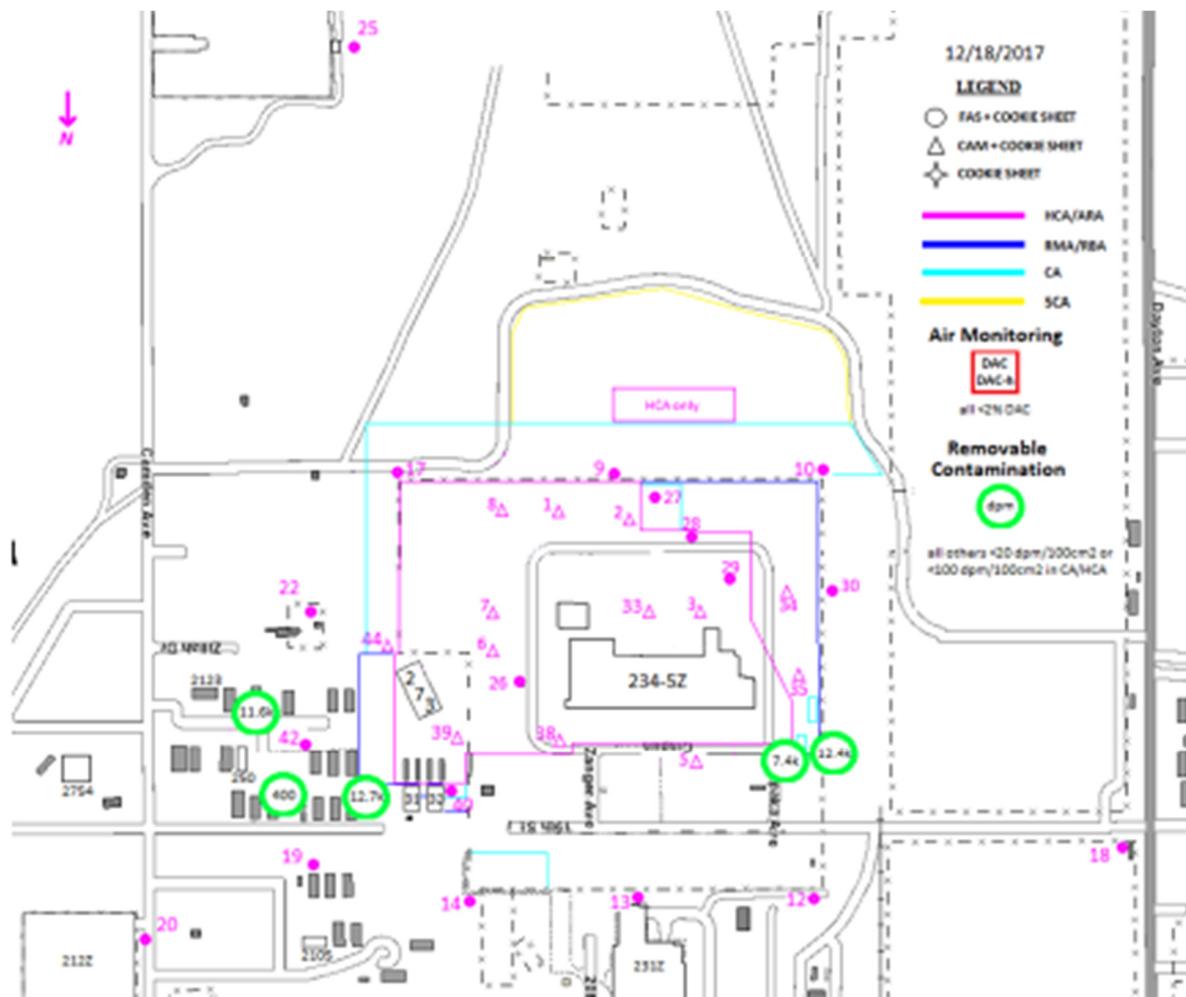
Contamination Found 12/12/2017



Contamination Found 12/15/2017



Contamination Found 12/17/2017



Contamination Found 12/18/2017

ATTACHMENT 10 : CHARACTERIZATION SUMMARY

Peter M. Sauer, Author

1.0 Buildup of the Material at Risk Source Term

For demolition of PRF down to the Canyon, the material at risk (MAR) was presumed to consist of the northern maintenance cell/mezzanine area and two separate uniform distributions (above/below 22 ft elevation) with an overlay of hotspots. The MAR quantification consisted of a buildup of the following discrete sources:

- The inherent part of the back wall portion of Gallery Gloveboxes (GGBs) retained with Canyon wall after separation, as well as residuals associated with jumper receptacle inserts.
- The North wall, Crane Mezzanine, and Maintenance Cell structure, including the shield wall.
- The Upper Region Survey Characterization Unit (SCU), which accounted for uniformly distributed material at the 22-32 ft elevation and ceiling.
- East and West wall Survey Characterization Unit, which accounted for a uniform MAR distribution below the 22 ft elevation.
- Added sources consisting of a Hotspot Registry and any nondestructive assay (NDA) reported areal surface holdup (g-Pu/sf) solely on concrete in the maintenance cell/mezzanine that was in excess of the range supported by the east and west Wall SCU. These added sources accounted for variation in the uniformity presumed by the SCU approach.

2.0 Utilization of Multiple Sensors and Approaches to Quantify Holdup

Throughout facility deactivation, the characterization effort remained sensitive to the high-hazard work associated with personnel entries into the PRF Canyon. As such, data collection supporting the characterization of the Canyon was diverse, reflecting an emphasis that deployed sensors by crane and minimized Canyon entries by workers in supplied breathing air. The following sensors were employed:

SRNL GrayQb Gamma Imaging. This system mapped a majority of the PRF Canyon internal surface area. The system had an advantage of isolating hotspots from emissions of all photon energies. Its disadvantage was that the system had no photon energy discrimination, and therefore could not be used to quantify holdup. The GrayQb provided the first insight into the radioactive material distribution in the Canyon in September 2015 while floor pan cleanout was in progress. The surveys revealed that there was no correlation with hold-up and visible deterioration of painted surfaces beneath strongback jumper receptacle inserts. The GrayQb surveys guided the characterization approach, supporting the identification of the upper region and lower 22 ft survey characterization units.

The Polaris H3D Gamma Imaging System. This sensor mapped the Canyon after the PRF floor was grouted in January 2016 and again after wash-down. The sensor delivered hotspot imaging and an energy spectrum produced by a cadmium-zinc-telluride semi-conductor detector. The instrument was capable of fully mapping the PRF Canyon in a single day when deployed by crane, resolving 200M dpm/100 cm² within 6 minutes at a 6 ft standoff. Polaris surveys completed prior to wall wash-down collaborated GrayQb results, and also resolved the added lower strength hotspots. These survey results were used to construct the Hotspot Registry and

inform selection of strongbacks pulled to investigate holdup on/within jumper receptacles. Surveys taken after wash-down showed that the process effectively eliminated several hotspots. Other hotspots, however, remained or moved to lower elevations or collected at a strongback. These were brought forward into the final quantification of the Hotspot Registry.

In-Situ Object Counting System Nondestructive Assay. The final high-resolution (high purity germanium [HPGe]) NDA pursuant to Safeguards termination of the walls and strongbacks was performed by deploying the In-Situ Object Counting System (ISOCs) with the Canyon crane. Measurements were completed at 5 ft (west wall) and 8 ft (east wall) standoffs to capture source material from both the walls and strongbacks. After these measurements, there was an opportunity to collect near-field measurements (within 2 ft of the Canyon wall) in accessible areas of the Canyon with little source interference from strongbacks. As the Polaris system was not calibrated for quantification measurements, the near field ISOCs measurements were used to quantify hot spots. After termination, the GGB's ISOCs measurements were used to characterize the back wall residual that would be retained and demolished with the Canyon concrete. ISOCs was also used to quantify the holdup in the maintenance cell and mezzanine areas.

Ludlum 195 High-Range Alpha Probe Measurements. This was selected as the primary source of Canyon wall characterization data. While the Ludlum surveys required Canyon entry in order to survey, significantly disturbing prevailing contamination during the survey was not necessary. A key advantage of using Ludlum surveys is the timely acquisition of results of the collected data. The disadvantage is the range limit of the instrument inside the PRF Canyon. While a 2B dpm/100 cm² range is indeed high, if collection were 100 percent efficient such a source would only represent approximately 10 mg-Pu within the area of measurement. Any greater holdup would over-range the instrument; however, as the areal Pu holdup in the Canyon had penetrated the concrete, the Ludlum was able to resolve higher source term without over-ranging. Throughout the Ludlum survey only 4 out of 89 measurements were off-scale. This condition, as well as the lower than expected MAR values reported by final NDA for the walls and strongbacks, helped demonstrate that the deactivation crew had successfully decontaminated the PRF Canyon to residual radioactivity levels within tolerances of the Air Dispersion Model inputs. Ludlum alpha surveys were also used to quantify residuals associated with the strongback jumper receptacle inserts.

Wall Scabble Samples. In order to correlate the Ludlum survey data to a quantified holdup, intrusive wall samples were necessary. At a specified sample point, a 1.5 ft² area was surveyed to isolate a 6 in. by 6 in. (0.25 ft²) template area for scabbling. Surveys were performed before and after scabbling to a depth of 0.5-in. to determine the extent of penetration to the wall. In all cases, over 90 percent of the Pu contamination was removed. The scabbled material was collected in sample cans that and were sealed for sample NDA measurement using an HPGe detector in controlled geometry with low background. A regression of the NDA sample results was then used to correlate the Ludlum alpha surveys results in units of M dpm/100 cm² to g-Pu/sf, such that the total holdup was computed by multiplying by the SCU surface area.

Strongback Investigation. As introduced above, before Canyon wash-down and in conjunction with Safeguards termination, there was need to determine whether or not material holdup on/within strongback penetration blocks was adhered. Polaris results were used to select candidate strongbacks would be retrieved and examined. Strongbacks in column positions EC, WF, and WR were removed, and while there were minor visible deposits the material had adhered to the strongback and required chipping away using reach tools deployed through glovebox penetrations. The chipped material was vacuumed into bags and the GGB sealed. Field Na-I package NDA indicated that holdup removed was on the order of 1-3 g-Pu. Due to the adhered

form and low gram values found at a hotspot, Safeguards termination proceeded without need to pull additional strongbacks.

3.0 Utilization of Multiple Sensors and Approaches to Quantify Holdup

The characterization effort was focused on data collection necessary to achieve key deactivation and pre-demolition milestones. First, by programmatic requirement, NDA data were collected pursuant to Safeguards termination. The total prevailing holdup on either side of the PRF Canyon was quantified, and the challenge at hand was to collect data to further distribute this total source term to align with inputs of the air dispersion Model and ensure that the low-level waste rubble was Environmental Restoration Disposal Facility compliant. (Source terms quantified for air dispersion input also served to establish criticality accident incredibility status.) As depicted in the Figure 11 conceptual model, five discrete sources were confined within close proximity and quantified by two separate NDA evolutions. After Safeguards termination, data were added from further deployment of NDA and/or radiological surveys and wall sampling was utilized.

The approach taken by the facility characterization effort relied on the total holdup quantified by Safeguards termination. Namely, since Safeguards terminated residuals in the Canyon based on measurement of both the walls and the strongbacks, the holdup in concrete derived from wall sampling and alpha surveys was subtracted from the NDA values to discriminate the discrete strongback source term.

$$\text{UCL95(Canyon Walls and Strongbacks)} - \text{UCL95(Canyon Walls)} = \text{UCL95(Strongbacks)}$$

Similarly, the NDA termination value for the GGB's as a whole was viewed as a maximum. As the GGBs were, by design, an inherent part of the Canyon structure, and thereby could not be separated as a whole, there was need to account for the amount of holdup that would be retained by the Canyon walls after separation. Further ISOCs NDA of back wall surfaces completed after termination were not treated as an added source. Rather, the back wall measurements were used to apportion the amount of the whole box holdup that would be retained.

The basic premise was that project data quality objectives (DQO) would be satisfied using the total holdup quantified by Safeguards termination values, and there would be no need for further decontamination or re-characterization effort after termination. This was the case.

