Joint Investigation Report

Sealed Source Recovery at the University of Washington Harborview Training and Research Facility Results in Release of Cesium-137 on May 2, 2019

March 30, 2020

Disclaimer

This report is an independent product of the Joint National Nuclear Security Administration/Triad National Security, LLC (NNSA/Triad) Investigation Team (JIT) appointed by Theodore A. Wyka, Cognizant Secretarial Officer for Safety, Office of Safety, Infrastructure and Operations. The Team was appointed to perform an investigation and to prepare an investigation report.

The discussion of the facts as determined by the Team and the views expressed in the report do not assume, and are not intended to establish, the existence of any duty at law on the part of the United States (U.S.) Government, its employees or agents, contractors, their employees or agents, or subcontractors at any tier, or any other party.

This report neither determines nor implies liability.

Release Authorization

On May 30, 2019, a JIT was appointed to perform an investigation to identify Lessons Learned from the May 2, 2019 breach of a cesium-137 sealed source and resultant spread of contamination at the University of Washington (UW) Harborview Research and Training Facility (HRT). This was a joint investigation involving NNSA employees and Triad National Security, LLC (Triad) employees (as the Management and Operating [M&O] contractor, or simply the M&O). The Team's responsibilities have been completed with respect to this investigation. The analysis and identification of the contributing causes (CCs), the root cause (RC), and the Judgments of Need (JONs) resulting from this investigation were consistent with methodology discussed in the Department of Energy (DOE) Order 225.1B, *Accident Investigations*, dated March 4, 2011.

The report of the JIT has been accepted, and the authorization to release this report for general distribution has been granted.

Theodore Wyka

Theodore Wyka
Cognizant Secretarial Officer for Safety
Office of Safety, Infrastructure and Operations

March 30, 2020
Date

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Definitions

Mobile Hot Cell (MHC)	An INIS-designed carbon steel box 56” L x 56” W x 46” H. Unlike a traditional hot cell, the MHC is not configured with a viewing window. Rather, five digital cameras feed a Monitor attached to the side of the MHC to allow the operators to view the MHC activities. Four of the cameras are fixed and one is available to be handled with the manipulators. The walls are 12” thick, and the top and bottom of the box are 8” thick. The total weight is approximately 33,500 pounds. The volume inside the assembled box was approximately 32”L x 32”W x 30”H. The top of the box has two 8” openings to accommodate manipulators used to remotely handle the sources.
Source Holder	Consists of the source tube and tungsten rod that are joined by a threaded connection and secured by a locking pin, and a lifting rod attached to the top of the tungsten rod. Reference Figure 4.
Source Tube	An aluminum holder containing the source capsule.
Stakeholder	Organizations and individuals with an interest or concern in source recovery activities; to include, but not limited to, programmatic owners, contractual workers, regulatory authority, facility owner, safety expertise, and emergency and medical response.

Acronyms

AdSTR	Administrative Subcontract Technical Representative
AEA	Atomic Energy Act
ALARA	As Low As Reasonably Achievable
Anti-C’s	Anticontamination Clothing
ARSO	Associate Radiological Safety Officer
ASM	Acquisition Services Management
CAM	Continuous Air Monitor
CC	Contributing Cause
CFR	Code of Federal Regulations
Ci	Curie
CoCA	Certificate of Competent Authority
CON	Conclusion
cpm	Counts per Minute
Cs	Cesium
Cs Cl	Cesium Chloride
CST	[WA] Civil Support Team
DAC	Derived Air Concentration
DC	Direct Cause
DEAR	Department of Energy Acquisition Regulation
CECON 1	[SFD] Decontamination Team
DOE	Department of Energy
DOH	[WA] Department of Health
DOT	Department of Transportation
EH&S	Environment, Health and Safety

ES&H	Environment, Safety and Health
FBI	Federal Bureau of Investigation
FM	Facility Manager
FTL	Federal Team Leader
HAZMAT	Hazardous Materials
HMC	Harborview Medical Center
HP	Health Physicist
HPI	Human Performance Improvement
HQ	Headquarters
HRT	Harborview Research and Training Facility
HVAC	Heating, Ventilation, and Air Conditioning
IC	Incident Command
IDD	In-Device Delay
IDIQ	Indefinite Delivery, Indefinite Quantity
INIS	International Isotopes Inc.
ISM	Integrated Safety Management
ISMS	Integrated Safety Management System
JHA	Job Hazard Analysis
JIT	Joint Investigation Team
JLS	JL Shepherd & Associates
JON	Judgement of Need
LANL	Los Alamos National Laboratory
LED	Light-emitting Diodes [lighting]
LM	Left Manipulator
LPTA	Least Price Technically Acceptable
M&O	Management & Operating [Contractor]
MHC	Mobile Hot Cell
mR/hr	Milliroentgens per Hour (also appears as mr/hr)
NA-LA	NNSA Los Alamos Field Office
NEN	Nuclear Engineering and Non-Proliferation
NG	[WA] National Guard
NIT	National Incident Team
NNSA	National Nuclear Security Administration
NRC	Nuclear Regulatory Commission
OE	Over Encapsulation
OJT	On-the-Job Training
OROC	Oak Ridge Operations Center
OSRP	Off-Site Source Recovery Program
P&T	Packaging and Transportation
PAAA	Price-Anderson Amendment Act
PI	Principal Investigator
PIC	Person in Charge
PPE	Personal Protective Equipment
QA	Quality Assurance
QL	Quality Level
RAP	[DOE] Radiological Assistance Program
RC	Root Cause
REAC/TS	Radiation Emergency Assistance Center/Training Site

RCO	Regulatory Compliance Officer
RCT	Radiological Control Technician
R/hr	Roentgens per Hour
RFQ	Request for Quote
RM	Right Manipulator
RSO	Radiological Safety Officer
RWP	Radiological Work Permit
SEO	Senior Energy Official
SFD	Seattle Fire Department
SME	Subject Matter Expert
SMP	Safety Management Programs
SOW	Statement of Work
STR	Subcontract Technical Representative
SwRI	Southwest Research Institute
Triad	Triad National Security, LLC
U.S.	United States [of America]
UW	The University of Washington
WA	[State of] Washington
WMD	Weapons of Mass Destruction

Executive Summary

Introduction

On May 2, 2019 International Isotopes, Inc. (INIS), a subcontractor to Triad National Security, LLC (Management and Operations [M&O] contractor for Los Alamos National Laboratory), inadvertently breached a sealed cesium-137 source at the University of Washington (UW), Harborview Medical Center, Research and Training Building (HRT) in downtown Seattle while attempting to recover the source for the NNSA Off Site Source Recovery Program (OSRP). The source breach resulted in contamination of personnel, the building, and a release of material to the environment. A Joint Investigation Team (JIT) co-led by National Nuclear Security Administration (NNSA) and Triad completed a thorough review of the event to identify the root and contributing causes. The investigation followed the principles defined in DOE O 225.1B, Accident Investigations.

This event was preventable. It was the result of weak and partially implemented processes within the Department of Energy, Triad, and INIS. These weaknesses established conditions where the event was likely to happen. The JIT views this event as a near miss to a significant event in that only a small amount of the 2900 curies of cesium was released. The JIT identified several opportunities for improvement and the need for corrective actions.

Accident Description

INIS was selected by Triad to recover a 2900-curie sealed source from the Harborview Research and Training Facility (HRT). The INIS bid to "over-encapsulate" the source required removal of the source from the source holder in the field. This was accomplished using a high-speed cut-off saw inside the INIS-designed Mobile Hot Cell (MHC). The plan was to grind down the ends of a roll-pin, unthread, and open the source holder. Grinding down the roll pin was accomplished, but the tungsten rod on the source holder would not unthread. INIS proceeded to make several circumferential cuts on the aluminum body of the source holder in an area they believed to contain the threaded portion of the rod. The cuts penetrated the sealed source capsule several times to various depths. A small amount of the cesium was released, resulting in internal and external contamination of workers and observers, and widespread contamination throughout the HRT and local environment.

This event was unprecedented, which led to challenges for the responding organizations. Lack of clear roles and responsibilities between UW, Triad, INIS, NNSA, and Washington State regulators complicated the response. Initial response was conducted by the Seattle Fire Department with support from other agencies. Follow-up response included deployment of members of the Department of Energy (DOE) Radiation Assistance Program (RAP) group to perform contamination surveys for site characterization. After RAP departure on May 5th, the event response was disjointed without a unified incident command structure. UW was challenged to address the needs of stakeholders including HRT occupants and the Washington Department of Health (DOH). The lack of a unified incident command structure resulted in little progress toward characterizing the spread of contamination and planning for the HRT recovery. On May 15th, NNSA and Triad resources arrived onsite. UW requested NNSA and Triad facilitate the establishment of a formal unified command. A formal structure was established. The unified command structure has been necessary and effective for recovery planning and operations.

JIT Evaluation

The JIT determined:

Removing a source from a source holder in the field with high-speed cutting tools and without positive containment should not have been allowed. The recovery of this source could have been achieved without removing the source from the source holder.

The NNSA is the lead Agency for the Offsite Source Recovery Program (OSRP). DOE M&O contractors follow DOE acquisition regulation to subcontract with the Nuclear Regulatory Commission (NRC) licensees to recover NRC licensed sources. This creates a complex regulatory environment that is not clearly understood by NNSA or Triad. That resulted in regulatory flow down confusion in the Triad/INIS subcontract.

Oversight roles, responsibilities, authorities, and accountabilities between regulators are confusing and are not understood by the NNSA and Triad for high-activity beta/gamma offsite source recoveries. Without clearly defined oversight roles, responsibilities, authorities, and accountabilities, organizations with oversight responsibility relied on the INIS NRC license as an indication that work would be performed safely and in compliance with environmental, safety, and health requirements.

The Triad contracting process does not implement Integrated Safety Management (ISM) for off-site work (i.e., outside LANL). The environmental, safety, and health hazards for this activity were not reviewed or understood by Triad safety and operations personnel.

This event revealed weaknesses in several INIS Field Operations work planning and control processes. As a result, INIS personnel did not fully understand the hazards or the necessary hazard controls associated with removing the 2900 curie cesium-137 source from a the source holder using a high-speed cutting saw. Specifically, INIS never identified breaching the source as a potential hazard.

The JIT concluded that the likelihood of this event would have been significantly reduced if the option to remove the source from the source holder had not been selected and there were clear roles and responsibilities leading to the flow-down of requirements.

Direct, Root, and Contributing Causes

The JIT determined the following causes of the accident:

- DC – the immediate events or conditions that caused the accident.
  - **DC:** Cesium was released as a result of cutting operations on the source holder assembly.
- RC – Causal factors that, if corrected, would prevent recurrence of the same or similar accidents.
  - **RC-1:** Triad contracting process does not effectively implement safety requirements for off-site work.

RC-2: DOE is managing work regulated by the NRC or an Agreement State without clearly defined roles and responsibilities.

- CC – Events or conditions that, collectively with other causes, increased the likelihood or severity of an accident, but that individually did not cause the accident.

CC-1: INIS conducted work inconsistent with a robust safety culture.

CC-2: Safety requirements not flowed down by Triad.

CC-3: Safety oversight was not effective, due to unclear roles and responsibilities.

CC-4: No formal leadership mechanism was developed in response to the event.

Table ES-I summarizes the Conclusions (CONs) and Judgments of Need (JONs) determined by the Team. The CONs are derived from the analytical results performed during this investigation for determining what happened and why it happened. Also listed are JONs determined by the Team as managerial controls and safety measures necessary to prevent or minimize the probability or severity of a recurrence of this type of accident.

Table ES-I: Conclusions and Judgments of Need as determined by the JIT

Conclusions	Judgments of Need
• DOE is responsible for operations conducted by subcontractors operating under a NRC license without corresponding oversight. [CON-1] • DOE is managing work outside of its regulatory authority, and relying on the NRC licensing process to ensure safety of high-activity beta/gamma source recovery operations. [CON-2] • Application of DOE DEAR requirements is not understood by NA-21 for subcontracted NRC-regulated work. [CON-3] • DOE has not evaluated how work is to be conducted when another agency has regulatory authority. [CON-4] • DOE and NRC roles and responsibilities for gamma source recovery are not clearly defined or documented when DOE is conducting the work. [CON-5]	• NA-21 needs to work with NRC to clarify roles, responsibilities, authorities, and accountabilities for requirements and methods for conducting source recovery work, and oversight of NRC/Agreement State-licensed recovery work. [JON-1]
• DOT regulation allowance for self-certification inadvertently and negatively impacted operational safety. [CON-6]	• NA-21, with support from NA-50, needs to work with DOT to evaluate the feasibility of a publically-accessible domestic special form registry to support shipments of special form sealed sources (similar to the requirements for the international CoCAs). [JON-2]
• DOE responsibilities, authorities, and accountability for NRC/Agreement State-licensed source recovery were not clearly	• NA-21 needs to establish a policy to ensure stakeholders are informed of, and agree to, responsibilities, authorities, and

Table ES-I: Conclusions and Judgments of Need as determined by the JIT

Conclusions	Judgments of Need
communicated to the stakeholders involved. [CON-7] • Having a NRC license was viewed by Triad, DOH, and UW as evidence of technical competency and assurance the work would be conducted safely. This led Triad, DOH, and UW to incorrectly assume that INIS would perform the work safely, which resulted in complacency of oversight. [CON-8]	accountability for retrieval of NRC-licensed sources. [JON-3]
• DOE does not have a mechanism to provide oversight of Triad off-site subcontracted activities. [CON-9] • Triad does not have formal processes in place to train personnel to oversee off-site work performed by subcontractors. [CON-10] • Triad did not meet requirements for developing, awarding, and management of off-site subcontracts, as identified in the prime contract. [CON-11] • Triad did not evaluate work practices and procedures, due to concerns over directing subcontractor work and incurring corporate responsibility. [CON-12] • Triad does not have established requirements for STR responsibilities for off-site work. [CON-13] • Application of the DEAR ISM requirements was not consistently applied during contract processing or conduct of the work. [CON-14] • Contracting processes/practices did not include evaluation of environment, safety, health, and quality assurance for RFQ development, or technical evaluation of contract submittals for off-site work. [CON-15]	• NA-21 prime contractors managing OSRP source recovery operations need to develop a strategy to ensure source recovery work plans and procedures are within the scope of the applicable NRC License prior to approval to commence work. [JON-4] • NNSA needs to evaluate oversight requirements for off-site work conducted by M&Os and their subcontractors. [JON-5] • Triad needs to assure that prime contract safety requirements are identified, developed and implemented for off-site subcontracted work. [JON-6] • Triad needs to establish a process to assure that off-site subcontracted work is accurately characterized and ensures that subcontractors have effectively implemented ISMS. [JON-7]
• The elements of integrated safety management, as required by the DEAR Clause in the contract for a rigorous and credible safety program, were not implemented by INIS for the source recovery work. [CON-16] • Analysis of the work hazards (including potential contamination events), developing controls, incorporating controls into procedures, and performing work in accordance with procedures was not	NA-21 needs to collaborate with prime contractors managing OSRP source recovery operations to ensure selection of subcontractors that: – Implement a formal and rigorous hazard analysis and work planning and control program in accordance with ISMS principles;

Table ES-I: Conclusions and Judgments of Need as determined by the JIT

Conclusions	Judgments of Need
conducted or communicated to stakeholders. [CON-17] • A lack of separation between safety leadership and corporate responsibilities within INIS resulted in prioritization of mission completion over safe conduct of work. [CON-18] • INIS has not implemented a robust safety culture in accordance with the NRC licensing guidance. [CON-19] • INIS' quality assurance processes do not ensure adequate procedures for personnel conducting hazardous operations. [CON-20] • Lack of proper radiological controls resulted in radiation exposure to unmonitored individuals and lack of identification of the spread of contamination. [CON-21] • INIS' lack of preparedness for consequence mitigation increased the spread of contamination to the facility and personnel. [CON-22] • Spread of contamination occurred because the potential for breaching the source was not considered or reevaluated when power tools were used, or when additional cutting operations that increased the chance of breaching the source (e.g., radial cutting) were performed. [CON-23] • Opportunities to stop and pause operations were missed, and changes in process conditions were not evaluated which could have prevented or limited the spread of contamination. [CON-24] • The breach was not immediately identified because contamination controls, such as swipes, and instrumentation were not utilized. [CON-25]	– Have a robust safety culture in accordance with the NRC Safety Culture requirements; – Have and maintain emergency response plans for off-site recoveries that ensure integration with local response assets. – Communicates the full scope of work to ensure all stakeholders understand the work method, including key steps, hazards, and controls. [JON-8]
• After RAP departure, recovery activities were fragmented and ineffective until establishment of Unified Command due to lack of emergency response pre-planning and ineffective communications [CON-26]	• NA-80 needs to develop a process to provide advice and assistance to local response leads at the conclusion of RAP assessment operations, based on RAP FTL recommendations. [JON-9]

1.0 Introduction

1.1 Appointment of the Team

JIT members were appointed separately by the NNSA Cognizant Secretarial Officer for Safety and Triad Management. The JIT is co-chaired by a staff member from each entity. The JIT will report the results to appropriate NNSA and Laboratory Management. The appointment memoranda are located in Appendix A of this report.

This event did not initially meet the criteria for an investigation as defined in DOE O 225.1B, *Accident Investigations*. The JIT appointment was delayed due to discussions between NNSA Headquarters (HQ) and the State of Washington on the need for a federally appointed team. However, ultimately the decision was made to conduct an accident investigation due to the likely public interest in the incident and estimated cleanup costs.

The JIT began its activities on June 3, 2019, and completed its investigation on December 19, 2019.

1.2 Purpose, Scope, and Methodology of the Investigation

The purpose of the JIT's investigation was to identify relevant facts; analyze the facts to determine the direct, contributing, and root causes of the event; develop conclusions; and determine JONs for actions that, when implemented, should prevent recurrence of similar events. The JIT's scope was the event and the emergency response activities. The timeframe of consideration for the JIT was until the unified command was established on May 15.

The JIT used methods described in DOE Order 225.1B, including:

- Gathering facts relevant to the event through interviews and reviews of documents and other evidence such as photographs, visits to the event scene, and working with DOE organizations to gather information from contaminated articles recovered from the event scene;
- Analyzing the facts to identify the causal factors using event and causal factors analysis, barrier analysis, change analysis, and Integrated Safety Management (ISM) analysis; and
- Developing conclusions and subsequent JONs based on the causal factors of the event that lead to the development of lessons learned and corrective actions to prevent recurrence of this type of incident.

Figure 1 defines the incident investigation terminology used throughout this report.

Incident Investigation Terminology
A **causal factor** is an event or condition in the accident sequence that contributes to the unwanted result. Causal factors may be categorized as direct cause(s), root cause(s), and contributing cause(s). The **direct cause** of an accident is the immediate event(s) or condition(s) that caused the accident. **Root causes** are causal factors that, if corrected, would prevent recurrence of the same or similar accidents. Root causes may be derived from or encompass several contributing causes. They are higher-order, fundamental causal factors that address classes of deficiencies rather than single problems or faults. **Contributing causes** are events or conditions that, collectively with other causes, increased the likelihood or severity of an accident but that individually did not cause the accident. Contributing causes may be longstanding conditions or a series of prior events that, alone, were not sufficient to cause the accident, but were necessary for it to occur. Contributing causes are the events and conditions that "set the stage" for the event and, if allowed to persist or reoccur, increase the probability or severity of future events or accidents. **Event and causal factors analysis** includes charting that depicts the logical sequence of facts of events and conditions, the use of deductive reasoning to determine the events or conditions that contributed to the accident, and causal factors identified by the JIT through the deductive reasoning that allowed the accident to occur. **Barrier analysis** identifies the hazards, as well as the targets (people or objects) being protected from the hazards. The JIT then reviews the physical or administrative controls, or barriers, that management systems put in place to separate the hazards from the targets, and establishes how well the barriers performed. **Change analysis** is a systematic approach that examines planned or unplanned changes in a system to determine any undesirable results related to the accident.

Figure 1: Incident Investigation Terminology

1.3 Organizations

1.3.1 Federal

1.3.1.1 Office of Defense Nuclear Nonproliferation, NA-20

NA-20 is the NNSA office responsible for the nuclear nonproliferation mission of NNSA that includes securing and disposing of surplus weapons-usable nuclear and radiological materials. NA-20 provides policy and technical leadership to limit or prevent the spread of materials, technology, and expertise relating to Weapons of Mass Destruction (WMD); advance technologies to detect the proliferation of WMD worldwide; and eliminate or secure inventories of surplus materials and infrastructure usable for nuclear weapons.

The mission of the Office of Global Material Security, NA-21, within NA-20, is to prevent terrorists from acquiring nuclear or radiological material that could be used in an attack on the United States, its interests, or allies. NA-21 works with partners worldwide to secure nuclear and radiological material, and to detect and deter trafficking of this material.

https://www.energy.gov/nnsa/missions/nonproliferation

1.3.1.2 Office of Counterterrorism and Counterproliferation, NA-80

NA-80 is an office within the NNSA. Its mission is to advance counterterrorism and counterproliferation through innovative science, technology, and policy-driven solutions.

The Office of Nuclear Incident Response, NA-84, within NA-80, serves as the technical leader in responding to and resolving nuclear and radiological threats worldwide. It includes expertise in the areas of radiological search, render safe, and consequence management.

The Radiological Assistance Program (RAP) within NA-84 provides advice and radiological assistance for incidents involving radioactive materials that pose a threat to the public health and safety or the environment. RAP can provide field deployable teams of health physics professionals equipped to conduct radiological search, monitoring, and assessment activities.

https://www.energy.gov/nnsa/nuclear-incident-response

1.3.2 Contractors

1.3.2.1 Triad National Security, LLC, Triad

Triad is the M&O contractor responsible for managing and operating the Los Alamos National Laboratory.

1.3.2.1.1 International Threat Reduction, NEN-3

Nuclear Engineering and Non-Proliferation-3 (NEN-3) supports the Off-Site Source Recovery Program (OSRP) in its mission to recover excess, unwanted, and abandoned radioactive sealed sources that pose a potential risk to national security, public health, and safety. OSRP contributes to national security by elimination from the environment excess radioactive sources that could be used in a Radiological Dispersion Device (“dirty bomb”) or for other malicious purposes.

1.3.2.1.2 Acquisitions Services Management

The Acquisition Services Management (ASM) group provides customer service in procurement, including subcontracting for off-site source recovery services. The quality procurement process incorporates a graded approach for managing procurement actions at a level of rigor commensurate with the risk.

1.3.2.2 Subcontractors

1.3.2.2.1 International Isotopes Inc. (INIS)

INIS produces products for nuclear medicine, molecular imaging, and cancer therapy, and provides services to the nuclear industry, such as source recovery. INIS Radiological Field Services operates under a U.S. Nuclear Regulatory Commission (NRC) possession and use license. As a Triad subcontractor, INIS recovers high-activity beta/gamma sources for the OSRP.

http://www.intisoid.com/index.php/radiological-services/

1.3.2.2.2 Chase Environmental Group

As an INIS subcontractor, Chase Environmental Group (Chase) is an environmental contractor specializing in environmental cleanup, radioactive decontamination and decommissioning, drilling support for field investigations, in situ treatment technologies, tank removal, and other specialty field services.

http://chaseenv.com/

1.3.3 State of Washington

1.3.3.1 University of Washington (UW)

UW owns and manages the HRT Facility. They have a long-standing partnership with the Harborview Medical Center (HMC). Together, UW and the HMC conduct research in key medical areas, for which the HRT plays a crucial role.

https://www.uwmedicine.org/locations/harborview-medical-center#main-tab-tab---overview

1.3.3.2 State of Washington Department of Health

The State of Washington Department of Health (DOH) works with others to protect and improve the health of all people in Washington State by:

- Leading changes in policies, systems, and environments to prevent illness and injury;
- Promoting healthy families and communities;
- Encouraging healthy lifestyles; and
- Focusing on places where people live, learn, work, recreate, seek healthcare, and worship.

The Office of Radiation Protection within the DOH works to protect the health and safety of people in Washington from unnecessary exposure to radiation.

The State of Washington has entered into an Agreement with the NRC that give them the regulatory authority to license and inspect byproduct, source, and less than critical mass quantities of special nuclear materials used or possessed within their borders. The Office of Radiation Protection within the DOH implements the agreement for the State of Washington. The Office of Radiation Protection has regulatory authority for the Harborview Medical Center.

https://www.doh.wa.gov/CommunityandEnvironment/Radiation

1.4 Facility Descriptions

1.4.1 Harborview Medical Center

The Harborview Medical Center (HMC) is a comprehensive healthcare facility dedicated to providing specialized care for patients from throughout the Pacific Northwest.

HMC provides specialized care for a broad spectrum of patients. Their services include emergency medicine, trauma and burn care, neurosciences, ophthalmology, vascular surgery, HIV/AIDS treatment, and rehabilitation medicine.

The HMC is the only designated Level I adult and pediatric trauma and burn center in the state of Washington, and is the disaster preparedness and disaster control hospital for Seattle and King County.

1.4.2 Harborview Research and Training Facility (HRT)

The UW Research Programs at HMC Campus are located in the HRT, in downtown Seattle, Washington; a city with a population of approximately 750,000 (Figure 2). The Harborview faculty obtains over $240 million in research and training funding per year, performing translational and basic research, as well as clinical studies and treatment trials, and epidemiology and health services research. The HRT houses an auditorium, training and meeting rooms, as well as wet laboratories, tissue culture rooms, shared facilities, a vivarium, and faculty offices. Lab-based research includes cell biology, neurosciences, vascular biology, inflammation, infectious diseases, lung biology, and microbial pathogenesis. The HRT is operated through the joint efforts of the UW School of Medicine and HMC, who provide laboratory facilities and research offices for HMC-based faculty. Other clinical and outcomes research programs occupy space across the HMC campus. The HRT building site is sloped, so that the second floor loading dock, where the incident occurred, is actually at ground level on the east side of the building (Figure 3).

Figure 2: Aerial Image of Harborview Medical Center Complex and Surrounding Area

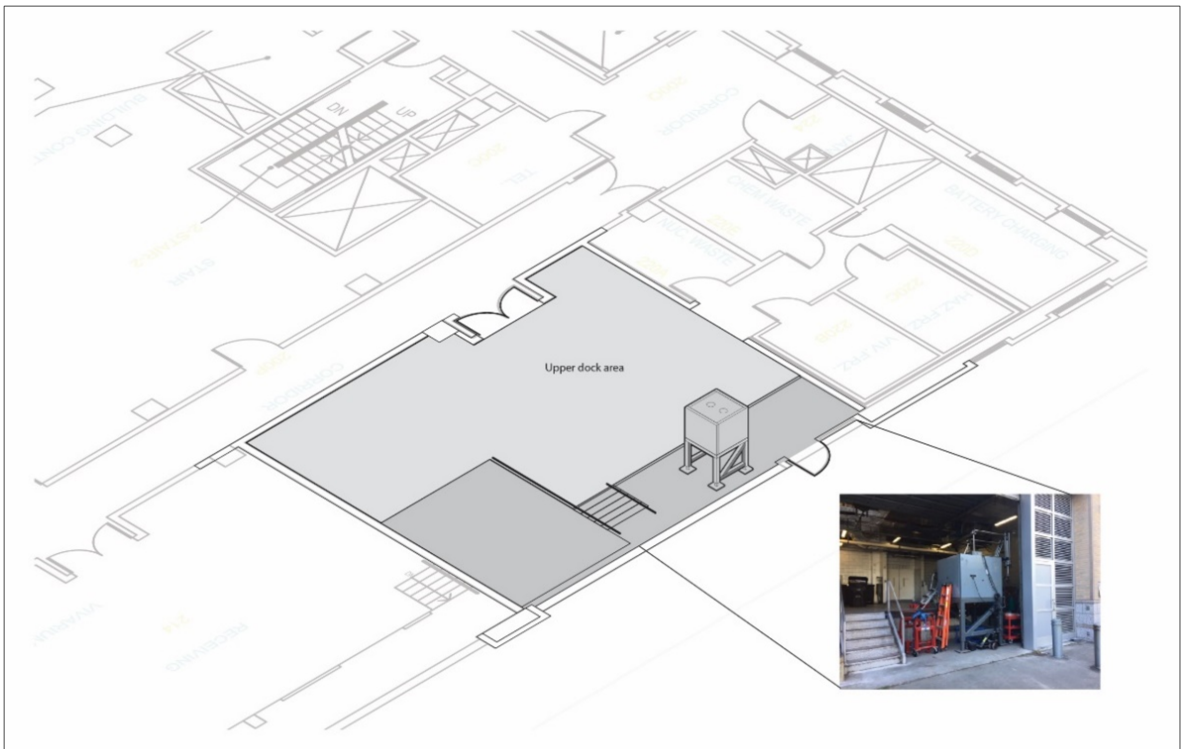


Figure 3: Harborview Research and Training Facility with MHC Location

1.5 Equipment

1.5.1 Source

1.5.1.1 Source Capsule

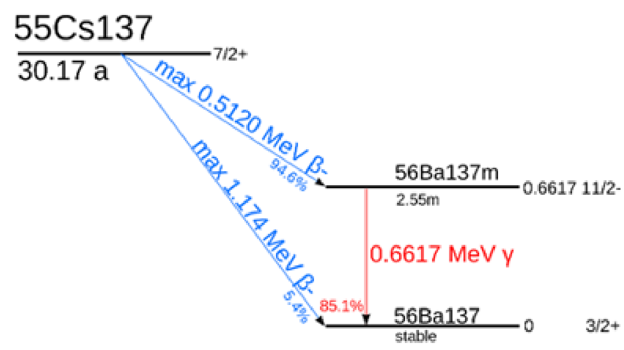
The cesium-137 (Cs-137) source consists of a stainless steel, double-encapsulated case outer shell. Each shell has a thin wall thickness. In November of 2000, the assay value of the source was 4,350 curies (Ci), but has since decayed to approximately 2,900 Ci. The chemical makeup is cesium chloride (CsCl), originally formed as pressed pellets, but has likely converted to a powder, similar to talc. The source currently emits a radiation field of approximately 10,000 roentgen per hour (R/hr) at 30 cm. This dose rate will result in a radiation worker reaching their federal annual exposure limit in less than 2 seconds.

1.5.1.2 Source Holder

The Mark I irradiator utilizes a Model 6810 source capsule. The Model 6810 source capsules are designed to be used in irradiators, calibrators, and dry-well facilities. A Source Holder is machined to fit each category of source capsule. Sources containing large Ci quantities are normally in heavily shielded devices which bear a label that reveals the type, quantity of radioactive material, and source serial number. The sources vary in length (Figure 4).

What is Cesium-137?

Cesium-137 (Cs-137) is a radioactive isotope of cesium, which is one of the more common fission products created in nuclear reactors, and is categorized as byproduct material by the Nuclear Regulatory Commission (NRC). It is among the most problematic of the short-to-medium-lifetime fission products because it easily moves and spreads in nature due to the high water solubility of cesium's most common chemical compounds, which are salts (such as cesium chloride).



Cesium-137 decay chain

Cesium Chloride

Cs-137 has a half-life of 30.17 years. 94.6% decays by beta emission to Ba-137m. Ba-137m has a half-life of about 153 seconds, and is responsible for all of the emissions of gamma rays in samples of Cs-137. One gram of Cs-137 has an activity of about 87 Curies.

Cs-137 reacts with water, producing a water-soluble compound (cesium hydroxide). The biological behavior of Cs-137 is similar to that of potassium. After entering the body, Cs-137 gets distributed throughout the body, with the highest concentrations in soft tissue. The biological half-life of cesium is about 70 days.

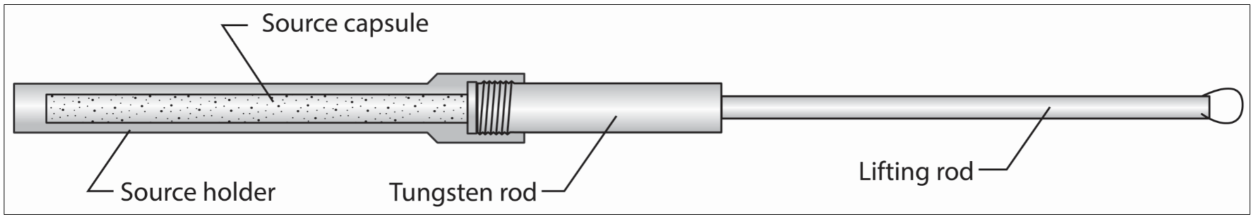


Figure 4: Notional Diagram of Source Holder

The NRC Registry of Radioactive Sealed Sources and Devices, Safety Evaluation of Sealed Source, CA-0598-S-119-S, dated April 2, 1990, identifies the configuration of a Source Holder (Figure 5). This figure was the only information publically available to support work planning for this operation.

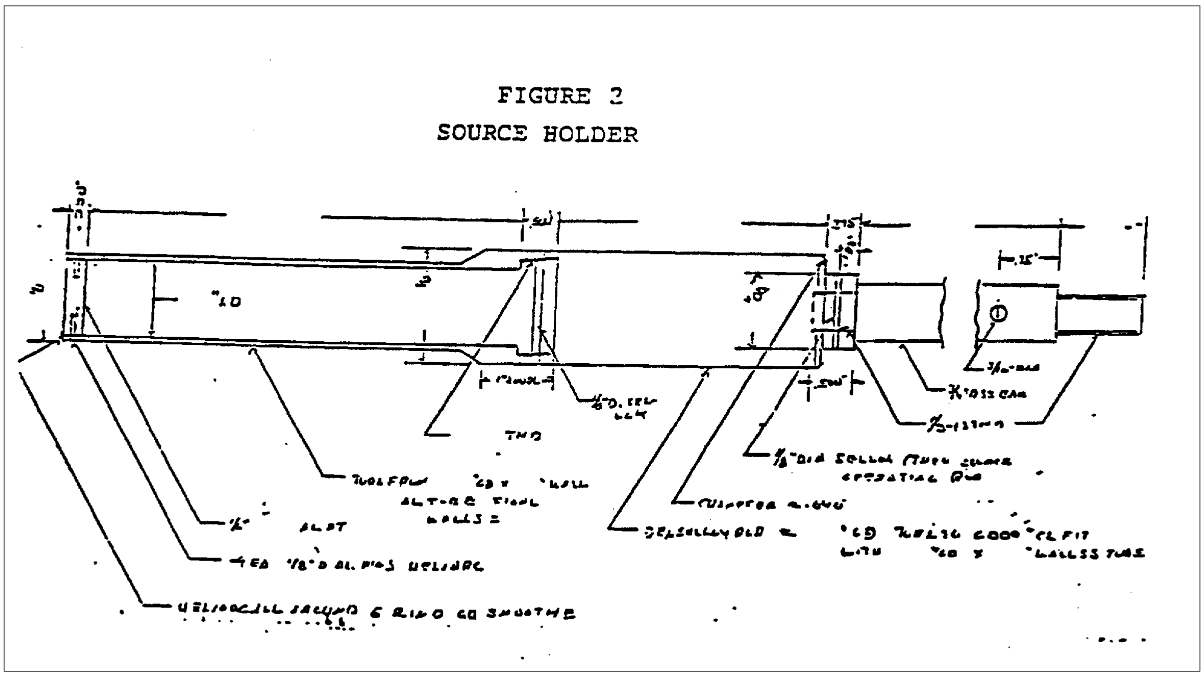


Figure 5: Source Holder Diagram (from the NRC Registry of Sealed Sources)

The JLS 6810 Series source holders are composed of an aluminum source tube or cup that is closed on one end and internally threaded on the open end, a tungsten shield rod that is threaded on one end to accept the aluminum tube, and a lifting rod attached to the opposite end of the tungsten rod. The source holder is fitted with a steel pin (roll pin), configured transverse to the major axis of the source holder where the aluminum tube and tungsten rod overlap, to prevent unthreading of the aluminum tube while the source holder is in service.

JL Shepherd & Associates (JLS) fabricated each source holder to specifically accommodate customer radiation specifications. The source holder is fabricated to accommodate a particular source capsule configuration. The source holder aluminum tube and tungsten rod is pre-assembled (without a live source) and the roll pin hole is pre-drilled through the aluminum and tungsten, close to the end of the aluminum tube, to facilitate the later loading of a live source. The JIT observed a number of model 6810 source holders at JLS that included the entire range of applicable source capsule lengths. Depending on the source configuration, the tungsten rod may overlap the aluminum tube by varying amounts.

1.5.2 Irradiator

The JLS Mark 1 series irradiators are employed in various applications in biological science to irradiate tissue samples at high dose rates. The Mark 1 is configured to customer specifications to meet end-user requirements. A wide range of cesium-137 source strengths is supported. Minimal external radiation levels allow it to be used in any laboratory environments, in accordance with As Low As Reasonably Achievable (ALARA) policy.

The JLS Mark 1-68 uses the JLS 6810 series, double-encapsulated source capsules, and are self-certified by JLS to meet Code of Federal Regulations (CFR) 49 CFR "special form."

External radiation levels for the UW HRT device were measured by JLS upon delivery to UW in 2003, and ranged from <0.25 milliroentgens per hour (mR/hr) to <6 mR/hr at the surface of the irradiator when the source was in the deployed position, and <0.1 to <0.7 mR/hr with the source in the shielded position. The JLS Mark 1-68 weighs about 5,800 pounds.

The cesium source is mounted in a source holder, which is moved from the shielded "off" position into the irradiate position, and vice versa, by pneumatic cylinders. Multiple electro-mechanical interlocks prohibit the source from being raised if the chamber access door is not closed and locked, and prevent the door from being opened if the source is not in the fully shielded position. Safety features include gravity and spring-assisted return to fully shielded position, in the event of loss of electrical power or pneumatic pressure. Environmental safety features protect from fire, flooding, seismic activity, and nearby explosions, to prevent the release of radioactivity.

1.5.2.1 In-Device Delay Kits

After the September 11, 2001 terrorist attacks, the U.S. government pursued programs to lessen the public risk from additional attack vectors, and identified high-activity beta/gamma irradiator sources as a risk. One strategy to reduce that risk was to remove these sources from public use through the OSRP. Another strategy was to develop solutions to harden these sources from being easily targeted for diversion. NA-20, in conjunction with Sandia National Laboratories' Center for Global Security Cooperation and the irradiator manufacturers, have developed hardware to make high-activity gamma sources more difficult to remove for nefarious purposes.

The In-Device Delay (IDD) program is managed by the NNSA Office of Radiological Security (NA-212). The IDD program collaborates with the manufacturers of these devices to design enhancements to make illicit removal of sources more time consuming, to increase the likelihood of successful interdiction by law enforcement.

1.5.3 Mobile Hot Cell (MHC)

The MHC is an INIS-designed carbon steel box 56" L x 56" W x 46" H (Figure 6). Unlike a traditional hot cell, the MHC is not configured with a viewing window. Rather, five digital cameras feed a monitor attached to the side of the MHC, to allow the operators to view activities inside the MHC. Four of the cameras are fixed and one is available to be handled with the manipulators. The walls are 12" thick, and the top and bottom of the box are each 8" thick. The total weight is approximately 33,500 pounds. The volume inside the assembled box is approximately 32" L x 32" W x 30" H. The top of the box has two 8" openings, to accommodate manipulators used to remotely handle the sources. There are openings on the side and bottom to facilitate mating a cask and irradiator for source transfers. The MHC at the HRT was configured on top of a 56" stand. This allowed the irradiator to be mated to the bottom of cell through a 15" opening. An additional shield (donut shield) was available for this configuration. The donut shield is designed to reduce the amount of radiation shine from the bottom of the MHC. The MHC is open to the environment and has no containment capability for loose contamination.

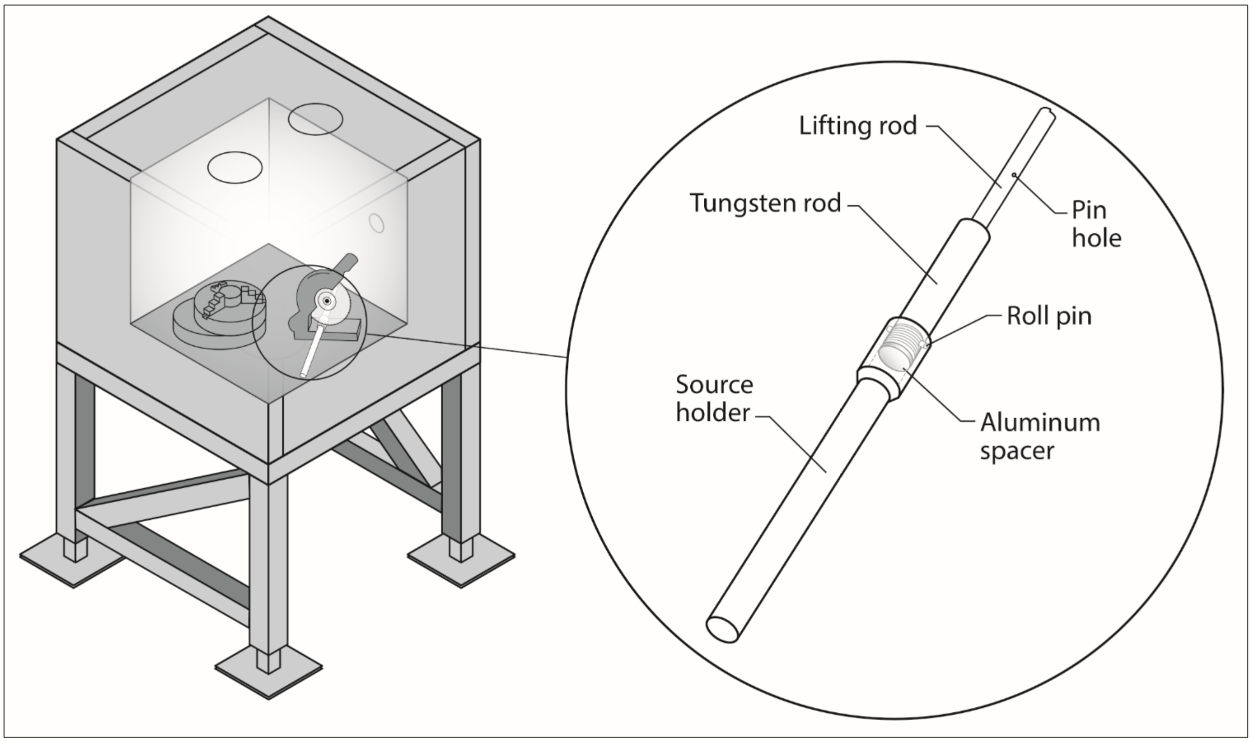


Figure 6: Mobile Hot Cell and Source Holder

To facilitate removing the source capsule from the source holder, the following equipment was in the MHC:

- An off-the-shelf electric cut-off saw fitted with a 6" x 0.04" thick cut-off wheel. The power switch was secured in the "On" position using electrical tape. Power was provided to the saw by manually connecting and disconnecting the saw to an extension cord outside of the MHC. The cut-off saw had a clamp modified to provide a contour on the clamp jaw.
- A welder used to seal the special form encapsulation for shipment.
- Two pipe wrenches.
- A mirror on the back wall to increase the viewing of the operation.
- An approximately 18" long, ¼" thick half-moon lead supplemental shielding.

- LED lights.
- A lead pig on wheels (8” diameter).

1.5.4 Transfer Cask

The transfer cask is a steel-encased lead storage container designed to provide robust shielding for high-activity beta/gamma radiation sealed source(s) storage. The transfer cask mates to the transfer port of the MHC. It is used by INIS to hold sources for storage until the radioactive contents can be transferred into an appropriate transportation package, since the transfer cask cannot be used for over-the-road transportation of radiological material (Figure 7).

Figure 7: INIS Transfer Cask

1.5.5 Transportation Cask

The NPI-20WC-6 MkII Type B Package (USA/9215/B(U)) is a NRC-certified Type B package that is manufactured by Neutron Products, Inc. It is authorized to hold radiological content including Cs-137 and Co-60, with maximum isotope content of 20,600 Ci and 15,000 Ci, respectively. Content limits are dependent on associated drum assembly configurations. Both isotopes must be shipped as sealed sources that meet the requirements of special form radioactive material (10 CFR 71.75 and 49 CFR 173.469).

The NPI-20WC-6 MkII Type B Package is a steel-encased, lead shielded cask, contained within a wooden over pack with a steel outer shell. The cask is 24” in diameter and holds the different drum assemblies. Positive closure of the shielded cask is accomplished by bolted covers at each end of the cavity. The overpack outer diameter is 55” with a height of 59”. The maximum gross weight is 6,000 pounds.

2.0 Background

2.1 DOE Programs and Oversight

2.1.1 Origins of the Off-Site Source Recovery Program

The Radioactive Source Recovery Program was conceived in 1994 by the DOE Office of Waste Management to address the urgent need to create a process to manage radioactive sources that had no path to disposal. The Radioactive Source Recovery Program was introduced in 1997 at LANL from a collaboration between the U.S. NRC and DOE. The NRC had identified a partial list of disused actinide sealed sources that DOE would collect and dispose of. DOE established the OSRP in 1998 after successful initial source recoveries.

The June 4, 1999 Memorandum from the DOE Albuquerque Operations Office, Waste Management Division to the Nuclear Production Division, *Offsite Recovery Project – Acknowledgement of Responsibility,* acknowledged responsibility for the OSRP project, and specifically accepts certain risks, including "*a conscious acceptance by the Department of the financial mortgage it creates,*" along with the responsibility for "*good management principles*" that "*require an understanding of the programmatic risks of doing work in a particular fashion.*"

In 2002, the NRC requested that DOE Office of Environmental Management (DOE-EM) accelerate the recovery of sources, and proposed that an additional 5,000 sources be recovered in the following 18 months. In October 2003, OSRP was moved from DOE-EM to the NNSA's Office of Global Threat Reduction. In March 2004, the OSRP scope expanded and responsibility transferred to the Nuclear and Radiological Threat Reduction Task Force (NA-20.2). The expanded scope included the materials that could be used for a radiological dispersion device, including beta/gamma sources like cesium. In August 2004, OSRP recovered their first high-activity cesium device (400 Ci). There is no record of any hazard analysis being conducted when the program was transferred from DOE-EM to NNSA, or when the expanded scope of high-activity source recovery was added to the program.

OSRP currently resides in the NNSA Office of Radiological Security, NA-212, within the NA-21 Global Material Security organization. NA-212 engages Triad through the LANL Management & Operating contract. The LANL OSRP Program resides within the Global Security Directorate. Primary management is within the NEN Division.

The NA-21 21.2.1.1.2, *Offsite Source Recovery Program FY19 Project Work Plan*, outlines the planned execution of the program for this fiscal year. Primary emphasis in the plan is on the packaging and transportation elements of source recoveries. It does not address ISM principles, nor does it address safety during source recovery. Programmatic-level documents for work conducted at DOE facilities typically omit ISM principles because the work is conducted in accordance with facility requirements. High-activity beta/gamma source recovery activities are unique in that the work is conducted off-site and not conducted under DOE oversight. NRC/Agreement State-licensed subcontractors recover high-activity beta/gamma sources, like the Harborview source. Sources are transported for staging and consolidation. They are ultimately destined for waste disposal and removal from the NRC National Source Tracking System.

OSRP has successfully recovered hundreds of high-activity beta/gamma sources through these contracting processes without mishap.

ANALYSIS

The OSRP metrics focus on production (number of sources recovered), packaging, and transportation, but not on safety during source recoveries. Individuals in NA-21 were cognizant of the relative risks associated with recovery operations; however, expectations were not flowed into program direction documents because the focus was on production.

The OSRP has not analyzed the hazards associated with source removal activities in the field, analyzed the increased hazard from high activity source recoveries, or applied the principles of ISM to the OSRP. Since operations did not occur at DOE facilities and are governed only by program documents that lacked safety cautions and controls, opportunities were missed to evaluate the program as the scope evolved and it was transferred to different entities.

The JIT was unable to identify records that indicated a safety risk assessment/analysis was performed as OSRP operations evolved from a DOE-managed activity, utilizing M&O staff and procedures for low-activity source recoveries, to subcontracting with NRC/Agreement State-licensed vendors for high-activity beta/gamma source recoveries. Hazards were not evaluated when the program was transferred from the DOE Office of Environmental Management (DOE-EM) to NNSA in 2003, or when the scope was changed to include high-activity beta/gamma sources. For this specific source removal operation, hazards were not analyzed for removing the source from the source holder. Therefore, the OSRP did not have a complete understanding of the increased safety risk in the high-activity beta/gamma source recoveries.

Identified Causal Factors:

Operations were not analyzed, controlled, or implemented as would be expected for a typical DOE operation (CF-C16)

Safety oversight was not effective due to unclear roles and responsibilities (CC-3)

DOE is managing work regulated by the NRC or an Agreement State without clearly defined roles and responsibilities (RC-2)

2.1.2 Regulatory Framework: NRC, DOE, and DOT

2.1.2.1 NRC Regulatory Framework

The NRC regulatory authority includes the oversight of byproduct material, such as cesium-137, as defined in the Atomic Energy Act (AEA) in the United States. A potential by product material user must first become licensed by the NRC, whereby the license establishes the conditions for the possession and use of byproduct material. The AEA authorizes the NRC to enter into Agreement to relinquish the NRC’s regulatory authority and allows individual states to assume regulatory authority to license and inspect byproduct, source and certain quantities of special nuclear materials within their borders. The State of Washington has been an Agreement State since 1966, and its agreement is implemented by the DOH. UW is licensed by the State of Washington for the radioactive material in the irradiator at HRT.

INIS is based in Idaho, a non-Agreement State, which requires that INIS be licensed by the NRC. As the State of Washington is an NRC Agreement State, INIS must apply for, and be granted, reciprocity from the State of Washington to do any work involving licensed radioactive material in the State under the conditions of the NRC license and applicable State of Washington requirements.

INIS's NRC License, Amendment 35, was granted on March 4, 2019 by NRC Region IV. INIS applied for reciprocal recognition of their NRC license with the DOH, Office of Radiation Protection, on April 3, 2019. DOH granted INIS reciprocity with restrictions and conditions on April 10, 2019, for a period of one year ending on April 30, 2020. License Condition 9L of the INIS license contains the authorized use description related to cesium-137 and OSRP source recoveries. It specifically authorizes INIS to conduct direct transfer and shipping operations with the JLS Model 6810 cesium-137 sealed sources.

License Condition 7. L of the INIS license identifies the chemical and/or physical form of sealed sources that INIS is allowed to handle/ship, including the JLS Model 6810 sealed source.

License Condition L. 9. (i) discusses the authorized INIS activities, and states:

> "Shipping and transfer of sealed sources to persons authorized to receive the licensed material pursuant to the terms and conditions of specific licenses issued by the U.S. Nuclear Regulatory Commission or equivalent regulations of an Agreement State. In addition, shipping and transfer of sealed sources in support of Requests for Proposal from the U.S. Department of Energy's Off-Site Source Recovery Program, including the Conference of Radiation Control Program Directors' [Source Collection and Threat Reduction] Program. Shipping to include shipper of record duties such as preparing shipping documents and notifications, performing radiation and contamination surveys, package marking and labeling, and package integrity verifications such as leak tests. Pre-shipment activities such as preparing contents for loading, loading the package, and storing of contents within a package are limited to those sources contained in devices that have been designed for transport with sources installed or for those sources contained in an inner shielded cask as part of a package consisting of an inner cask and over pack and for devices whose sources are contained in a source drawer(s) designed to accommodate the transfer of sources from the device and into a transportation container either directly or using a transfer shield."

License Condition L. 9. (iii) states that:

> "Sources may be transferred between devices not specifically listed in paragraph (ii) directly into a transportation package utilizing the International Isotopes, Inc. (INIS) mobile hot cell as long as the compatibility of the device with the mobile hot cell is evaluated and approved by the International Isotopes, Inc. ALARA Safety Committee and this evaluation and approval is conducted and documented in accordance with International Isotopes, Inc. procedure OP-QMS-011 Rev. C, Product and Equipment Development and Design Control as described in letter dated April 16, 2016."

License Condition L. 9. (iv) states in part that:

> "Sources may be transferred directly between the transportation package and the device as long as the transportation package and the device are designed to support the transfer of sources contained in a source drawer or basket and the transportation package and device are compatible with each other…"

The INIS license includes a number of Conditions that are germane to source recovery activities.

License Condition 16 states:

> "Sealed sources or detector cells containing licensed material shall not be opened or sources removed from source holders by the licensee except as specifically authorized by this license."

Note: The NRC Registry of Radioactive Sealed Sources and Devices, Safety Evaluation of Sealed Source, CA-0598-S-119-S, November 9, 1998, for the JLS Model 6810 family of Special Form Source Capsules, identifies a "Typical Source Holder" as an assembly that includes an aluminum tube, tungsten rod, and attached lifting rod. An accompanying table indicated a range of source lengths from 0.5-15.5" in length with a diameter of 0.6875". Nowhere else in the license is there anything that specifically states that INIS is authorized to remove special form sealed sources from their source holders during field services recoveries utilizing the MHC.

License Condition 23 states:

> "Notwithstanding the requirements of License Condition 24, the licensee is authorized to make program changes and changes to procedures specifically identified in the application dated March 23, 2010, letter dated August 25, 2010 enclosing procedures, electronic mail dated August 11, 2010, and letter dated May 22, 2012, which were previously approved by the U.S. Nuclear Regulatory Commission and incorporated into the license without prior Commission approval as long as:
>
> A. The proposed revision is documented, reviewed, and approved by the licensee's Radiation Safety Committee in accordance with established procedures prior to implementation;
> B. The revised program is in accordance with regulatory requirements, will not change the license conditions, and will not decrease the effectiveness of the Radiation Safety Program;
> C. The licensee's staff is trained in the revised procedures prior to implementation; and
> D. The licensee's audit program evaluates the effectiveness of the change and its implementation."

From the INIS NRC License Modification request, NRC J.ML13331A799 – INIS response to question 4.E regarding methods to restricting access to area with high dose rates during transfer operations: "*When possible the mobile hot cell will be located in an area that contains fixed barriers, such as walls and lockable doors. Rope barriers with signage will be established to identify radiation area boundaries (dose rate in excess of 5 mr/hr) and at least 2 International Isotopes Inc. employees will be present during transfer operations to visually monitor the area.*"

ANALYSIS

The INIS NRC License, Amendment 35, was granted after the source recovery task order subcontract was awarded, but before the DOH reciprocity application. It is not known to the JIT what changes were made between Amendment 35 and the previous version. However, there does not appear to be any difference in the license conditions applicable to this activity. Amendment 34 was included in the INIS Request for Quote (RFQ) for the UW recoveries.

The JIT determined that the license authorizes a process for INIS to transfer Cs-137 sealed sources from devices not specifically listed (e.g., JLS Mark 1-68) directly into a transportation package in the field using the MHC. Specifically, the INIS NRC License Condition L, which applies to Cs-137 use, as quoted above, authorizes INIS to conduct direct transfer and shipping of JLS Model 6810 series sources, identifies specifically approved devices, and provides a process for evaluating the compatibility for the use of non-specified devices. Furthermore, it authorizes source transfers using the INIS MHC, and authorization to transfer sources directly between the transportation package and the device, as long as they are designed to support transfer of sources contained in a source drawer or basket, and the transportation package and device are compatible. Nowhere in the license is there specific authorization to remove special form sealed sources from their source holders during field services recoveries using the MHC. Therefore:

- INIS was authorized to perform direct source transfers to a transportation package; however
- The JLS Mark 1-68 irradiator was not specifically listed for use with the MHC; but
- Use of the MHC with non-specified devices must be evaluated, approved, and documented in accordance with procedures (even then, that approval is limited to direct transfers into a transportation package).

Identified Causal Factors:

It was unclear who was responsible for safety oversight of the work (CF-BZZ)

Operations were not analyzed, controlled, or implemented as would be expected for a typical DOE operation (CF-C16)

INIS was allowed to conduct operations without technical or safety oversight from stakeholders (CF-B1)

INIS conducted work inconsistent with a robust safety culture (CC-1)

Safety oversight was not effective due to unclear roles and responsibilities (CC-3)

DOE is managing work regulated by the NRC or an Agreement State without clearly defined roles and responsibilities (RC-2)

2.1.2.2 DOE Regulatory Framework

The DOE self-regulates the nuclear and radiological work performed on their behalf by contractors. DOE is the authorizing authority and regulator. For example, the DOE regulates occupational radiation protection through 10 CFR 835 by reviewing, approving, and conducting oversight of contractor Radiation Protection Programs (RPPs). The DOE typically provides program funding and owns the facilities and materials. Plans, procedures, training, and performance evaluations are all included in both contractor and federal oversight activities. For this event, DOE has primary regulatory authority for Triad and is the funding agency for the work (Reference 2.1.3.1). Based on the subcontract language for this event, it is unclear which radiation protection regulation applied.

2.1.2.3 DOT Regulatory Framework

The mission of the Department of Transportation (DOT) is to ensure that the U.S. has the safest, most efficient, and modern transportation system in the world, that improves the quality of life for all American people and communities.

The DOT establishes and enforces compliance of regulations and requirements of over the public road transport of hazardous material. The DOT also establishes the minimum design and performance requirements for packages that contain hazardous material. This includes the different categories of radioactive material packages.

In Title 49 CFR 173.469, the DOT prescribes the testing requirements for radioactive material to be special form Class 7. If a design agency of special form Class 7 design can pass the tests of 49 CFR 173.469 (same as 10 CFR 71.75), they can consider the material to be special form. For domestic use of special form Class 7, DOT does not require approval or initial review of the design.

DOT 49 CFR 173.476 allows the designer/manufacturer of sealed sources to self-certify their designs. Documentation of the design or 49 CFR 173.469 testing results is not required to be reviewed and approved by DOT prior to use. This is only true for sources manufactured for domestic use, which is the case for the JL Shepherd sources that were slated for recovery at UW. If a designer/manufacturer intends to export the source, design and testing documentation is provided to DOT for review and approval of a Certificate of Competent Authority (CoCA).

Designers and manufacturers of domestic sealed sources are held accountable to the aforementioned DOT requirements in 49 CFR 173.476 with the 2-year shipping documentation retention requirement. Any time within the 2 years, DOT can request shipping documents, to include the design and certification documentation of the sealed source.

ANALYSIS

INIS was not the manufacturer of the sealed source; therefore, they did not have the design information or source certificate. A competing bid for the recovery work included shipping the source in the source holder without over encapsulation in the NPI-20WC-6 MkII. The JIT determined that removal of the source from the source holder was unnecessary for this recovery operation.

INIS chose to remove the source from the source holder and over-encapsulate it in their own self-certified special form container. This was done in order to make a DOT-compliant shipment of the source. INIS had an opportunity to purchase the source certificate information from JLS, but decided the over encapsulation route was cheaper. The JIT determined that the DOT regulatory process, such as not having a source registry, complicated the work planning process for INIS and influenced their plans to cut into the source holder.

Identified Causal Factors:

Domestic self-certified special form certificates are a commodity that resulted in a cost determination over safety (CF-CAAA)

INIS decided to over encapsulate the source rather than buying the design information from JL Shepherd (CF-1H)

2.1.3 OSRP Oversight (NRC, DOE, NA-212, LANL, Licensees, etc.)

2.1.3.1 DOE/NNSA Oversight

NNSA has oversight responsibility of Triad's subcontracting processes, as identified in the Prime Contract. NNSA does not have a direct contracting relationship with the subcontractor and the work was not conducted on a NNSA-owned facility. As a result, NNSA does not have direct oversight authority of the subcontracted work.

2.1.3.1.1 Office of Radiological Security (NA-212)

DOE/NNSA have both regulatory and program/contract execution oversight authorities and responsibilities. NA-212, within NA-21, is responsible for oversight of the OSRP program execution, budget, and deliverables. They implement oversight through their program plan and deliverables tracking system. Their primary performance metric is the number of source recoveries per year.

2.1.3.1.2 NNSA Los Alamos Field Office (NA-LA)

NA-LA has primary oversight responsibility for the LANL M&O contractor (Triad). NA-LA conducts oversight of Triad subcontracting processes through the Assistant Manager for Business and Contract Management. Oversight is largely systems-based in accordance with governance initiatives. Transactional oversight is focused on on-site work activities. NA-LA reviews Triad subcontractor processes as a whole, but has not reviewed the Triad OSRP process directly.

ANALYSIS

No direct oversight of subcontracting for off-site work activities has been conducted. As a result, NA-LA did not recognize that P850, *Subcontract Technical Representative*, as identified described in Section 2.1.3.2, excluded off-site subcontracting work. This was a missed opportunity to ensure ISM principles were implemented in off-site subcontracted operations, which ultimately allowed INIS to perform the work as they saw fit.

Identified Causal Factors:

Expected DOE processes not implemented or overseen (CF-C14)

Operations were not analyzed, controlled, or implemented as would be expected for a typical DOE operation (CF-C16)

2.1.3.1.3 Office of Safety, Infrastructure, and Operations (NA-50)

NA-51, Office of the Deputy Associate Administrator for Safety, within NA-50, is responsible for effective development and consistent implementation of safety programs and requirements across the Nuclear Security Enterprise. This includes governance initiatives to partner with M&O contractor staff to ensure safety oversight is efficient and effective. In addition, NA-50 is responsible for safety oversight policy for NNSA. No oversight policy exists for off-site work where NNSA has responsibility for the consequences of an accident.

NA-50 organizations are in place to address environment, safety, and health requests from NNSA organizations. NA-50 has the subject matter expertise to assist NA-21 in ensuring that proper Environment, Safety and Health (ES&H) requirements are flowed down to the appropriate organizations conducting high-activity source recovery work.

ANALYSIS

NA-50 has not promulgated policy or requirements for oversight of work conducted outside of DOE-owned facilities; in particular, when that work is performed by a subcontractor where no direct contracting relationship exists with the Government. This contributed to the lack of proper flow-down of safety requirements to INIS, and confusion as to who had oversight responsibility for NRC/Agreement State-licensed source recovery operations as implemented by NA-21.

Identified Causal Factors:

Operations were not analyzed, controlled, or implemented as would be expected for a typical DOE operation (CF-C16)

Expected DOE processes not implemented or overseen (CF-C14)

Safety oversight was not effective due to unclear roles and responsibilities (CC-3)

2.1.3.2 Triad National Security, LLC (Triad) Oversight

As the LANL Prime Contractor, per the Prime Contract, effective November 1, 2019, Triad is responsible for all on- and off-site work performed by subcontractors. Triad has no procedure governing off-site subcontracted work. In the absence of a procedure, OSRP/NEN-3 partially implemented P850, *Subcontract Technical Representative*, for source recovery subcontracts. P850 states:

"Section 1.0, Purpose

> "First bullet – establishes the requirement for Technical Oversight of a subcontract by a Los Alamos National Security [Triad] subcontract technical representative of all on-site work at LANL performed by a subcontractor and encourages the appointment of a subcontract technical representative for off-site work when appropriate.

"Section 2.2, Applicability

> "This document applies to all Laboratory organizations procuring work to be performed by subcontractors on-site at LANL."

The mechanism for oversight of off-site subcontracted work is only through the contract. There is not an established process for training personnel to conduct oversight of off-site subcontracted work.

NEN assigns Administrative Subcontract Technical Representatives (AdSTR) to off-site source recovery subcontracts; although the Indefinite Delivery, Indefinite Quantity (IDIQ) and Task Order subcontracts reference the STR function. The differences between the roles/responsibilities/authorities/accountabilities between the AdSTR and STR function warrant discussion.

STR or AdSTR assignment is based on the hazard of the subcontracted work activity and/or volume of subcontract work managed by the individual. An STR is required for medium and high-hazard work. Low-hazard work may be managed by an AdSTR. P850 requires an STR assignment for high- and medium-hazard work, and encourages the appointment of a STR for off-site work, when appropriate.

The procedure states:

"P850 is based on the 5-step ISM core functions and includes requirements to identify hazards, analyze hazards, and ensure hazards are controlled through a technical evaluation of the bid proposal, as follows:

"Section 3.4, Initial Determination of Hazard Level by Requesting Organization

> "When a requesting organization has need for work to be performed on-site at LANL, the requesting organization must:
>
> - Prepare a detailed Statement of Work (SOW) that describes the work in sufficient detail to identify the hazards and the circumstances in which they could cause harm;
> - Identify and analyze all hazards (i.e., any source of environmental, safety, or health danger or any safeguards or security threats or vulnerabilities) in the SOW, with assistance from LANL Subject Matter Experts (SMEs), as needed;
> - Determine hazard level…; and
> - Convey the hazard level determination together with the SOW… if the hazard level for the SOW has been determined to be moderate or high. The SOW will be reviewed by the institutional Designating Authorities."

The Exhibit F, *Environment, Safety, and Health Requirements for Subcontractors*, is the mechanism used to identify hazards and hazard controls for on-site subcontracted work. The OSRP IDIQ and Task Order subcontracts included the following Exhibits:

- Exhibit C, *Forms*;
- Exhibit D, Scope of Work;
- Exhibit G, Physical Security Requirements for Subcontractors; and
- Exhibit H, Quality Assurance Requirements.

The flow-down of the regulatory framework into the contract for this work includes several NRC and DOE regulatory requirements, some of which are duplicative. For example, both 10 CFR 20 and 10 CFR 835 are cited for radiation protection. Additionally, Price Anderson Amendments Act (PAAA) indemnification is included in the IDIQ and task order. Inclusion of DOE indemnification in a subcontract intended to fall under NRC regulation is inconsistent with requirements for NRC subcontracts within the Prime Contract (I-17, k). Inclusion of PAAA indemnification invokes a number of DOE-related CFRs and DEAR Clauses as requirements.

The NEN AdSTR performed general observations of INIS sub-contracted work during at least one source recovery in the field, and had been to the INIS facility in Idaho Falls. The AdSTR did not identify general safety issues associated with the INIS Field Services teams' work. The general observations were not documented.

The AdSTR did not conduct a review of INIS's procedures. NEN staff communicated a perception that reviewing OSRP subcontractor procedures would result in Triad assuming legal responsibility for the subcontractor procedures, or might be considered as giving direction to the subcontractor. NEN staff did not recognize that the subcontract allowed for the review of INIS Field Services procedures.

ANALYSIS

In accordance with the Prime Contract, Triad is responsible for the actions of their own work, and the work of sub-contractors, both on and off-site. Triad does not have a procedure for managing off-site subcontracted work. P850 was partially implemented by OSRP/NEN-3, in the absence of a procedure for managing off-site subcontracted work.

Triad considers oversight as any actions to ensure that work is being accomplished safely, and within the cost, scope, and schedule set by the subcontract. NEN has no formal oversight program for source recovery observations, although they have occasionally observed field operations. There is no formal training or qualification for personnel performing oversight, nor a requirement for an operational safety background. For example, NEN did not request or review work package documents or procedures for this operation. The JIT notes that even if the INIS over encapsulation procedure had been reviewed, it did not identify the use of an electric cut-off saw and cutting wheel to cut the source holder or perform the circumferential cut. Therefore, the JIT determined that an AdSTR review of the INIS procedure would not have sufficiently identified the risk of the over encapsulation process. Review by a SME with an operational radiation protection background, as required by P300, would have increased the potential of identifying uncontrolled hazards inherent in the operation.

Identified Causal Factors:

It was unclear who was responsible for safety oversight of the work (CF-BZZ)

Triad did not provide oversight of technical aspects of the contract (CF-C23)

The INIS work package was not reviewed or approved by Triad (CF-CZZ)

Safety oversight was not effective due to unclear roles and responsibilities (CC-3)

Safety requirements not flowed down by Triad (CC-2)

2.1.3.3 NRC Oversight

NRC has statutory responsibility under the AEA to license the possession and use of byproduct source, and special nuclear materials in the U.S. NRC's authority does not extend to DOE and its prime contractors. The AEA also authorizes the NRC to enter in Agreements with State to relinquish the NRC's regulatory authority and allow individual states to assume regulatory authority to license and inspect byproduct, source and certain quantities of special nuclear materials within their borders. Licenses issued by the NRC are legally binding. The NRC has an inspection program that periodically reviews a licensee's use of radioactive material at their facility or at temporary job sites, if so authorized on their license, based on the risk of the licensee's activities. NRC inspectors can cite violations of NRC regulations or license conditions and through its enforcement program, the NRC has a number of tools to require the licensee to correct the violations or in cases where significant safety and security violations occur, issues civil penalties or modification or revocation of the license. Agreement States have similar licensing and inspection programs to the NRC that are routinely audited. Licensees that use their NRC or Agreement State license to operate in other jurisdictions under reciprocity could be inspected by the regulatory agency that approves the reciprocity request. This frequency of reciprocity inspections is also commensurate with the risk of the licensee's activities. NRC and Agreement States will typically inspect a license such as the one issued to INIS every two years.

ANALYSIS

NRC's approach to oversight is different from DOE's. It was clear to the JIT that DOE/NNSA and Triad personnel were unaware of the differences in Federal oversight between the NRC and DOE. Particularly, the DOE evaluates activities before granting approval, whereas the NRC grants licenses to conduct work with the expectation that the rules will be complied with.

Identified Causal Factors:

It was unclear who was responsible for safety oversight of the work (CF-BZZ)

Safety oversight was not effective due to unclear roles and responsibilities (CC-3)

DOE is managing work regulated by the NRC or an Agreement State without clearly defined roles and responsibilities (RC-2)

2.1.3.4 NRC Agreement State Oversight

The State of Washington is an NRC agreement state and is the regulator for the byproduct materials license held by UW. The DOH Office of Radiation Protection granted INIS Reciprocity to conduct radiological work in the State of Washington for up to 180 days in one year. Per the agreement, INIS provided the DOH a proposed timeline, which described logistics for irradiator removal at UW. The timeline did not include specifics of the source recovery work activity (e.g., cutting activities on the source holder).

DOH had two Health Physicists (HP) on-site to observe the source recovery at HRT, monitor radiation fields associated with the work using State-provided equipment, and verify security requirements. They were there as a DOH presence for the operation, rather than conducting inspection. DOH planned on conducting an NRC license inspection during the packaging and transportation activities on the following Sunday (May 5, 2019).

The DOH HPs observing activities at the HRT were not involved in the INIS pre-job briefing. Without having reviewed the INIS operational procedure, they were not aware of the details of the work activity, including cutting the source holder with power tools to remove the special form sealed source capsule, and subsequent over encapsulation and welding in the MHC.

ANALYSIS

A dynamic observed by the JIT was a reliance on the "Appeal to Authority" logic fallacy. Individuals and groups assumed that, since INIS was selected by Triad, and Triad was managing the OSRP for DOE, that Triad had evaluated INIS as well qualified to do the work safely, their procedures were sound and mature, and that Triad knew what INIS was doing.

The JIT believes this led to a false sense of security by the DOH, and resulted in reduced oversight. The planned NRC license inspection by DOH was to focus on the packaging and transportation aspects of the source retrieval operation and not on the safety of the conduct of the work. The DOH HPs were not fully aware of the source holder disassembly operation and associated risks. In addition, they were actively conducting radiation surveys. These factors combined to minimize the actual oversight conducted.

Identified Causal Factors:

It was unclear who was responsible for safety oversight of the work (CF-BZZ)

Assessments not conducted by DOH (CF-BYY)

The INIS work package was not reviewed or approved by DOH (CF-CZZ)

INIS conducted operations without independent review of their processes (CF-C27)

INIS was allowed to conduct operations without technical or safety oversight from stakeholders (CF-B1)

Safety oversight was not effective due to unclear roles and responsibilities (CC-3)

2.1.3.5 University of Washington/Harborview Medical Center Oversight

UW requested source recovery from OSRP. UW was the licensee of the radioactive materials that OSRP was recovering and the owner of the facility where the work was conducted. UW had oversight responsibility for work conducted in their facilities. UW did not have authority or a mechanism to evaluate INIS as a vendor for the source recovery activity. The UW Radiation Safety Officer (RSO) was observing and monitoring radiation levels in areas adjacent to the work activity on the evening of the recovery. He became aware of cutting on the source holder during the work evolution.

ANALYSIS

UW, as the licensee and ultimate bearer of the risk and public safety related to the sources, did not have an opportunity to provide any input nor understand that lesser risk options were available during the OSRP vendor evaluation and selection process. In this case, the two vendors each had different approaches to removing the radioactive material, to include: 1) direct source transfer to shipping cask, and 2) removal of source from source holder and over encapsulation. These two approaches represent increasing degrees of risk.

The JIT believes that UW proceeded with a false sense of security, based on past experience with source transfers, and relied on the "Appeal to Authority" logical fallacy. Individuals and groups assumed that since INIS was selected by Triad, and Triad was managing the OSRP for DOE; that Triad had determined that INIS was well qualified to do the work safely and their procedures were sound and mature, and that Triad knew what INIS was doing.

Identified Causal Factors:

It was unclear who was responsible for safety oversight of the work (CF-BZZ)

The INIS work package was not reviewed, or approved by UW (CF-CZZ)

INIS conducted operations without independent review of their processes (CF-C27)

INIS was allowed to conduct operations without technical or safety oversight from stakeholders (CF-B1)

Safety oversight was not effective due to unclear roles and responsibilities (CC-3)

2.1.4 Triad OSRP Subcontracting Processes

The source recovery subcontracting process is initiated by the organization requesting the subcontract. For the UW source recovery subcontract, the AdSTR was responsible for preparing and submitting a RFQ to a Triad Subcontract Specialist. The Subcontract Specialist was responsible for identifying the subcontracting mechanism. The contracting mechanism chosen was Least Price Technically Acceptable (LPTA), which is the ASM-preferred method. Other contracting mechanisms were available (e.g., sole source or best value) that directly included risk evaluation in the selection process, and which had been utilized in the past. The ASM Subcontract Specialist issued the RFQ, received the responses, and submitted the responses, without the bid cost, to the AdSTR. The AdSTR completed a technical evaluation to determine if the bid submittal met the technical requirements of the RFQ.

The technical evaluation is an administrative review of the Exhibit C – Form J, *Technical Approach*, submitted by the subcontractor. The evaluation ensures the subcontractor is able to recover the source(s) listed in the RFQ and that the 'Technical Scenario/Site Specific' and 'Technical Approach' description is reasonable. Form J also requests specific information on the proposed shipping container, packaging method, and DOT special arrangements/permits (if required). The technical evaluation did not include a review of Exhibit G or H, which are a part of the IDIQ rather than the Task Order process.

In their response/submittal to the RFQ, INIS indicated that source re-encapsulation would be required. The AdSTR understood that source re-encapsulation required grinding on the source holder roll pin to unthread the tungsten rod and remove the source from the holder. The other technically acceptable proposal included direct source transfer, transferring the entire source holder directly from the irradiator into the transportation cask. The AdSTR was not trained to evaluate the significance of this information, nor was there a required process to engage SMEs to review ES&H safety and hazard analysis for off-site work. The AdSTR identified two technically acceptable bids, and submitted the results to ASM. The ASM Subcontract Specialist made the final selection based on lowest cost, per the LPTA process.

ANALYSIS

The JIT determined that Triad did not apply the ISM-based STR process to the subcontracted off-site work. The IDIQ omitted Exhibit F, *Environment, Safety, and Health Requirements for Subcontractors,* because Triad does not flow down ISM principles to off-site work. This resulted in the omission of the ES&H evaluation, and therefore hazards associated with OSRP and corresponding mitigation factors were not evaluated by Triad ES&H SMEs. The assigned

AdSTR demonstrated SME-level expertise in packaging and transportation of sources; however, the individual was not an ES&H or radiation protection SME. No one with the relevant ES&H skill sets evaluated the IDIQ subcontractor bid proposals for safety impacts.

Triad contracting mechanisms for off-site subcontracts do not require the inclusion of environmental, safety, health, quality, security, or oversight submittals. However, these submittals could be required through the RFQ process without a requirements driver if the risk of the work activity and method was clearly understood. Thus, the successful use of LPTA for high hazard OSRP subcontracts is reliant on people rather than process.

Because the subcontracted work would be performed off-site, Triad did not conduct a hazards analysis for the work or review procedures under which the work would be performed in accordance with ISM as implemented by P300. RFQ's developed for OSRP subcontracts do not include requirements that subcontractors submit a hazard analysis for the work or procedures under which the work will be performed. This resulted in an inaccurate understanding of risk by Triad associated with the high-activity sealed source recovery. It was not recognized that any operations removing a 2900 curie source from the source holder in the field was a higher relative risk than a direct source holder transfer.

NEN staff indicated they did not review subcontractor's work processes as they were concerned about directing subcontractor work. Triad General Counsel confirmed that review of work processes and procedures under the subcontracted scope of work was specifically authorized. The JIT determined there is an inconsistent interpretation within Triad regarding the ability to review and provide comment on off-site subcontractor work processes.

The Triad off-site subcontracting process does not implement the required ISM Guiding Principles and Core Functions for high-activity source recovery work.

<u>Identified Causal Factors:</u>

Triad subcontracting process incentivized contractors to use a least conservative approach to conduct work for cost savings (CF-BAA)

Triad did not provide oversight of technical aspects of the contract (CF-C23)

NRC licensing used as basis of Triad contract approval, and to allow work to begin (CF-CYY)

Safety requirements not flowed down by Triad (CC-2)

Triad contracting process does not effectively implement safety requirements for off-site work (RC-1)

2.1.5 INIS Experience in OSRP

INIS began performing work for field service source recoveries using the MHC in 2014. INIS has conducted 10 OSRP and 10 non-OSRP source recoveries in the past 4.5 years. The MHC was utilized in all of the OSRP source recoveries and five of the non-OSRP recoveries. INIS has conducted two previous over encapsulation (OE) recoveries. One did not involve cutting to over-encapsulate. The other was a source recovery from a JLS Mark 1-68 that involved side loading into the MHC, by successfully cutting the source holder and over-encapsulating the source. The HRT recovery was the first that INIS had performed using the bottom-loading configuration for a

JLS Mark 1-68 irradiator to the MHC. Additionally, INIS had no experience in recovering the other two irradiators in Seattle. All three Seattle recoveries were first-of-a-kind operations for INIS.

ANALYSIS

The JIT determined that INIS's lack of experience in high-activity beta/gamma recoveries utilizing over encapsulation is inconsistent with the expertise that UW, DOH, and NEN attributed to INIS.

The JIT also determined that INIS's confidence, based on a single, successful JLS Mark 1-68 irradiator source recovery, provided INIS with a false sense of security that cutting into the source holder was an acceptable approach to recovering the high-activity beta/gamma source.

Identified Causal Factors:

NRC licensing used as basis of Triad contract approval, and to allow work to begin (CF-CYY)

Questioning attitude was not present (CF-B7)

INIS conduct operations without independent review of their processes (C27)

INIS work planning and control processes were not effectively implemented (CF-1A)

Immature safety culture led to completion of work activities taking priority over safe conduct of the work (CF-1E)

2.2 Description of Work Activity

The scope of the work for the subcontracted source recovery work was identified in Exhibit D, *OSRP Recovery of Three Devices from University of Washington*, of Task Order 531650 between Triad and INIS. Section 1.0 of Exhibit D stated that the subcontractor (INIS) "*shall be responsible for full removal and transportation of the sources/device listed in Table 1 in Appendix D-1…*" It also stated that it was INIS's responsibility to "*remove all extraneous pieces and parts of the device in Table 1 of Appendix D-1 from the site…*" The devices in Table 1 were:

- JLS device Mark 1-68 [irradiator] with a single Cs-137 source with an estimated decayed activity of 2837 Ci;
- JLS device model 143-50A with two Cs-137 sources with an estimated decayed activity of 592 Ci; and
- AECL device model GC-40 with two Cs-137 sources with an estimated decayed activity of 1,689 Ci.

The Mark 1-68 irradiator was located at the HRT, while the others devices were located at the Magnuson Health Sciences Building located several miles away from the HRT, and were not involved in this incident.

Specifically, the work to be conducted was to:

- Assess the source/device details;
- Assess the facility conditions;
- Develop a work plan;

- Assemble a qualified team to perform the task; and
- Execute the task.

2.3 Event Chronology

2.3.1 Pre-contract Award Activities

In February 2016, a LANL IDIQ Subcontract Form of Agreement was established with qualified vendors. The initial term of the work was for one year beginning March 16, 2016, with LANL having the option to extend the subcontract up to 48 months past the initial term, but for no longer than 60 months total for the subcontract.

In January 2017, LANL issued a RFQ for a high-activity source recovery, to be conducted in Cleveland, Ohio. INIS was awarded the contract for the work, which was successfully conducted in May 2017. This was the only experience that INIS personnel had with recovering a source from a JLS Mark 1-68 irradiator utilizing the MHC and source over-encapsulation method.

In late summer/early fall of 2018, UW requested the recovery of three devices containing five sources to OSRP.

In November 2018, Triad issued the UW source recovery RFQ.

On January 9, 2019, INIS submitted a response to the RFQ. The Exhibit C Form J identified the shipping container and indicated the removal of the JLS Mark 1-68 irradiator in the HRT would occur first. The response did not include removal of the IDD features attached to all three devices.

Also in January, the INIS Regulatory Compliance Officer (RCO) contacted the UW RSO and informed him that INIS would be awarded the contract by LANL for the source recovery and shipping work. The UW RSO then contacted the LANL AdSTR to verify this information. The LANL AdSTR confirmed that INIS would be awarded the subcontract for the source recovery at UW.

LANL personnel reviewed the submittal for contractual requirements as described in Section 2.1.4. The AdSTR stated that based on the reviews and on past experience working with INIS on other tasks, INIS met the technical and procurement requirements.

On February 4, 2019, subcontract 531650, *OSRP Recovery of Three Devices from UW*, was awarded to INIS. It was signed by INIS on the same day. Triad signed the subcontract on February 7. The need to remove the IDDs, and INIS's lack of experience to do that work, was still not recognized by Triad.

<u>ANALYSIS</u>

The analysis for the contract selection process can be found in 2.1.4.

Triad had access to the database that identifies all irradiators that have IDDs installed. This omission resulted in an insufficient RFQ and need for later contract modification.

In addition, the JIT determined that safety evaluation criteria associated with the hazard grading and method of recovery were not adequately developed to support contract award. This resulted in award of the contract to the company proposing a substantially greater-risk method of source recovery.

Identified Causal Factors:
Triad did not provide oversight of technical aspects of the contract (CF-C23)

Work not performed under formality of operations requirements (CF-C13)

INIS was allowed to conduct operations without technical or safety oversight from stakeholders (CF-B1)

Safety requirements not flowed down by Triad (CC-2)

Triad contracting process does not effectively implement safety requirements for off-site work (RC-1)

2.3.2 Work Planning and Control

On January 4, INIS approved the INIS Field Services Radiological Work Permit (RWP). The RWP applies to all INIS field service activities over a one-year period, and is referred to as a Standing RWP. The document specified personal protective equipment (PPE) and timing for performing contamination surveys, but was not specific to the UW work activity or working with cesium.

The Triad Task Order RFQ did not identify a scope of work for IDD kit removal. The presence of IDD kits on all three irradiators was available to LANL via the IDD registry database. The resulting subcontract awarded to INIS did not include IDD kit removal in the work scope. Subsequently, a subcontract amendment was required. Evaluation and negotiation of the amendment occurred as follows:

- IDD kits were present on all three devices and a contract amendment would be needed to remove them.
- The AdSTR agreed to amend the contract to cover the additional cost, without re-competing the bid.
- INIS contacted JLS to request a quote for removal of IDD kits.
- JLS provided a bid for IDD kit removal, which included JLS special form certificates for the JLS irradiators (2).
- INIS then responded in an email to JLS to remove the cost for the special form certificates (less than 5% of the total contract value), as INIS could over-encapsulate for less. Note: The final cost for the INIS recovery was more than the competitive bid.
- INIS communicated the JLS bid to the AdSTR and stated it appeared to be excessive.
- The AdSTR responded that the cost was acceptable.
- Ultimately, INIS subcontracted with the Southwest Research Institute (SwRI) for IDD kit removal.

On February 22, the UW RSO held an initial meeting with UW facility management and INIS personnel to discuss the proposed INIS work activity. Walk-downs of the work areas were conducted. Discussion was focused on after-hours work activity, affected areas, vehicle logistics, and expected duration. The work activity was estimated at two hours after initial equipment set-up. The HRT Facility Manager (FM) posed general questions about hazards analysis for the work that were not addressed at this time.

At the end of February, as planning for the source removal work continued, the RCO and AdSTR communicated via telephone and identified that all three irradiators had IDDs installed and that INIS would need to subcontract for this activity. Based on this information, the AdSTR requested for INIS to identify an organization that could conduct the IDD removal work, to facilitate a subcontract modification. INIS initially contacted JLS for this service.

The INIS RCO completed negotiations for subcontracting the IDD removal, culminating in the selection of SwRI to perform the work.

On March 4, the NRC approved License Amendment 35 to the INIS License.

On April 2, a second walk-down of the planned work activities occurred, as requested by the HRT FM. The UW RSO, INIS RCO, INIS Employee 1 (E1) (who had the most experience setting up and working within the MHC), the HRT FM, and the HMC Engineering Maintenance Lead were included in the walk-down. Outcomes included that, due to space and weight restrictions, the MHC would be set up on the HRT building North loading dock, and the HRT FM would only need to be directly involved on May 5 for loading and shipping activities. The HRT FM raised a number of questions regarding the planned activity, to include:

- Was there a Job Task Analysis or Job Hazard Analysis (JHA)?
- Where were their [INIS's] procedures?
- Were the [INIS] workers adequately trained for this task?
- Was there a contingency plan if something went wrong? and
- Who would pay if something went wrong?

The UW RSO was unaware of the extent or methods to dissemble the source holder. The UW RSO's response to the questions noted that:

- His office would take care of radiation level monitoring, and securing areas as needed;
- He would work with the contractor to understand the expected radiation levels, develop a plan and respond back to the HRT FM;
- That all work would be performed with sealed sources, and that the risk of contamination was extremely low; and
- There were no operations planned with the potential to breach the source, and if the source was breached the contamination would remain in the MHC.

Additional discussion included radiation monitoring, access control, establishing a security boundary, hot work permitting, and a hazard analysis. Resulting documentation included a proposed timeline (communicated on April 29 to DOH), a completed INIS Hot Work Permit for welding inside the MHC (approved on May 2), and an HMC Risk Assessment (completed on April 19). The UW RSO communicated that this was a low-hazard activity, that INIS was experienced, and that hazards were adequately controlled. A JHA was not available, and accident responsibility was not addressed. Additionally, questions regarding contamination, or spread of contamination, were addressed with the assurance that it was highly unlikely that there could be a breach of the source, and if there was a breach, contamination would remain within the MHC.

Through these discussions, the HRT Building Facility Manager found out about the potential for grinding (for IDD kit removal) and welding (for over encapsulation in the MHC). The HRT Building Facility Manager required a "Hot Work Permit" for these operations.

On April 3, INIS submitted a request of reciprocity to the DOH for approval. DOH reviewed the reciprocity request and did not identify any "red flags". The reviewer had additional confidence in INIS's capabilities because this was a DOE program. On April 10, the DOH granted reciprocity to INIS for the UW source recovery. Additionally, a couple of days before starting, INIS provided DOH with a "work plan" that discussed in general what was going to take place. The work plan stated, *"Some grinding may be required on the irradiator shielding while it is on the loading dock to get a good mating surface to connect it to the hot cell. Additionally, welding will occur in the hot cell. Neither of these operations involve a risk of breaching the sources."*

The work plan failed to make any note of the planned cutting of the source holders at both HRT and Magnuson that could involve a risk of breaching the sources (and ultimately *did* involve a breach of a source).

Subsequent to the negotiation with JLS, INIS successfully negotiated a subcontract with SwRI to remove the IDDs from the three UW irradiator sources. On April 22, the INIS RCO submitted a contract modification request to Triad, which was approved by Triad procurement on April 24.

On April 22, the DOH received an email from INIS that provided work planning information for the UW irradiator removals and source recoveries. The information did not include the potential for cutting on the source holder and specifically stated that there was no risk of breaching the sources from grinding the IDD or welding in the MHC. DOH personnel stated that more time was usually available for these types of reviews. The DOH reviewer(s) did not identify any concerns.

On April 24, the UW RSO notified the DOH of the planned source recovery activities scheduled to begin on May 1.

On April 29, the INIS Procedure OP-SRC-040 Rev. B, *JL Shepherd Model Mark 1 and 143 Series Irradiator Source Unloading* (Procedure), was approved. The change was to accommodate the unloading of the JL Shepard Model Mark 143 Series Irradiator. This procedure was used for the source recovery at the HRT. The procedure did not identify the use of an electric cut-off saw and cutting wheel to cut the source holder either for pin removal or "cutting the aluminum tube below the pin." Additionally, INIS created and approved the procedure OP-SRC-046, *Gamma Cell 40 Exactor (GC-40) Irradiator Handling and Source Unloading*, for use with the UW irradiator source recoveries at the Magnuson Health Sciences Building. INIS was the only reviewer of the revisions. DOH and UW did not review these procedures because the procedures were not provided to them, and they considered INIS authorized to modify and approve their own procedures, per License Condition 23 of their NRC License (reference Section 2.1.2.1).

Also on April 29, the INIS Audio Visual Technician and INIS Employee 3 (E3) left Idaho in route to the UW work site in Seattle with the heavy equipment.

On April 30, INIS workers arrived at the HRT and started preparations for commencing work the next day.

ANALYSIS

During pre-job planning, the HRT FM repeatedly inquired about a variety of safety planning and operations issues. The HRT FM's previous employment experience had conditioned him to be cognizant of work planning and control elements that mirror the DOE ISM principles. Throughout the planning process, the HRT FM was not provided the requested documents, and was not satisfied with the answers he was getting. The bulleted questions relevant to the April 2nd walk-down were never addressed to the HRT FM's satisfaction. The UW RSO communicated that this was a low-hazard activity because it was a routine sealed source recovery. He was not cognizant that INIS planned to cut on the source holder in order to remove the source capsule. The JIT determined that, regardless of the cutting operation, recoveries of high-activity beta/gamma sources should never be considered low-hazard or routine.

The UW RSO's response that the risk of contamination was unlikely, and that any contamination would be contained within the INIS MHC, was based on previous direct-transfer irradiator removals, and the assumption that the INIS MHC had engineered containment features. The HRT FM told the JIT that if he thought he had stop work authority, he would have exercised it until the work planning process could have been formally documented.

The JIT determined that UW was not provided adequate information by INIS to sufficiently answer the work planning questions raised by the HRT FM.

The INIS irradiator unloading procedure had provisions for grinding or cutting IDD remnants, to facilitate proper alignment with the MHC; however, INIS did not conduct these steps due to the lack of a Hot Work Permit for operations conducted outside the MHC.

The proposed work plan provided to UW and DOH did not mention cutting or grinding operations inside the MHC to remove the source capsule from the source holder. The JIT determined that the proposed work plan provided to UW and DOH by INIS did not clearly state the full scope of the planned activities. As a result, UW and DOH could not evaluate the increased risk of breaching the source due to the use of power tools to remove the source capsule.

Condition 23 of INIS's NRC License addresses INIS's authorization to make program changes and changes to procedures, as specified, and with conditions (reference Section 2.1.2.1 for quote). This License Condition affected the DOH review of INIS. The NRC provided the JIT with supporting documentation that addressed this NRC License Condition. That documentation indicated that INIS's authorization to make program and procedure changes was limited to their institutional radiation protection program, their institutional QA program, and Product and Equipment Development and Design Control procedure. Field operations procedures were not included. The fact that this was a DOE operation, that INIS had approval to modify their procedures, and that the procedures were not provided by INIS resulted in DOH not reviewing the procedures prior to the conduct of work.

INIS did not approve Revision B of the Procedure until April 30, 2019; two days before commencing operations.

The JIT determined that the lack of procedure reviews by oversight organizations is a missed opportunity to evaluate INIS work planning and control prior to conduct of the work activity.

Identified Causal Factors:

It was unclear who was responsible for safety oversight of the work (CF-BZZ)

The INIS work package was not reviewed, or approved by UW or DOH (CF-CZZ)

INIS work planning and control processes not effectively implemented (CF-1A)

Safety oversight was not effective due to unclear roles and responsibilities (CC-3)

2.3.3 Conduct of Work

In April 2019, the HRT management notified residents via email that work activities would be performed on the North loading dock, and access would be restricted. As the work area was restricted and work was scheduled to occur after normal business hours, it was believed that there would be minimal impact to any remaining building activities, including custodial work.

In preparation for the source recovery activity, HMC Security established a security boundary using yellow caution tape around the portion of the HRT parking lot. Radiation tape was not used throughout the source removal activities, in order to avoid advertising that radiation work was being conducted.

On May 1, at approximately 08:00 hrs., INIS workers arrived at the HRT North loading dock to set up their MHC. The MHC set-up took several hours. Staff from SwRI completed removal of the IDD kit on the irradiator located in the basement of the HRT. The IDD removal process left a portion of the threaded studs on the top of the irradiator housing after removal. Upon completion of the IDD removal, INIS workers performed contamination surveys across the top of the irradiator. No contamination was detected.

On the morning of Thursday, May 2, 2019, INIS staff assisted SwRI with IDD removal on the remaining two irradiators located at the UW Magnuson Health Sciences building. No issues were identified in the conduct of this activity.

At approximately 16:00 hrs. on May 2, INIS workers began preparations for relocating the irradiator from its location in the basement of the HRT to the MHC located in the North loading dock.

During this source recovery:

- INIS was conducting on-the-job training (OJT) for field services work for three employees. Two INIS Employees (E2 and E3) were in training for field services as MHC Operators. E2 had regular work experience in the use of manipulators and cutting sources in the permanent hot cell at the INIS facility in Idaho Falls. A Radiological Control Technician (RCT) was completing qualification for field services. There were no operations or training conducted on the cutting activities within the MHC prior to May 2 for these individuals;

- Four observers were present during the work evolution, including two DOH Health Physicists, and two Federal Bureau of Investigation (FBI) representatives; and
- The UW RSO was monitoring radiation levels in surrounding areas.

At 16:55 hrs., INIS workers prepared the irradiator for movement from its secure location in the HRT basement radiography room to the North loading dock by securing it to a Rol-A-Lift® set. At 17:00 hrs., INIS workers rolled the irradiator via the HRT freight elevator from the basement to the South loading dock on the second floor of the building. Utilizing a forklift with a lifting device attached to the tines, INIS workers rigged the irradiator from the top and transferred it to the North loading dock apron. A pallet jack was then used to complete the move of the irradiator to its position next to the MHC (Figure 8).

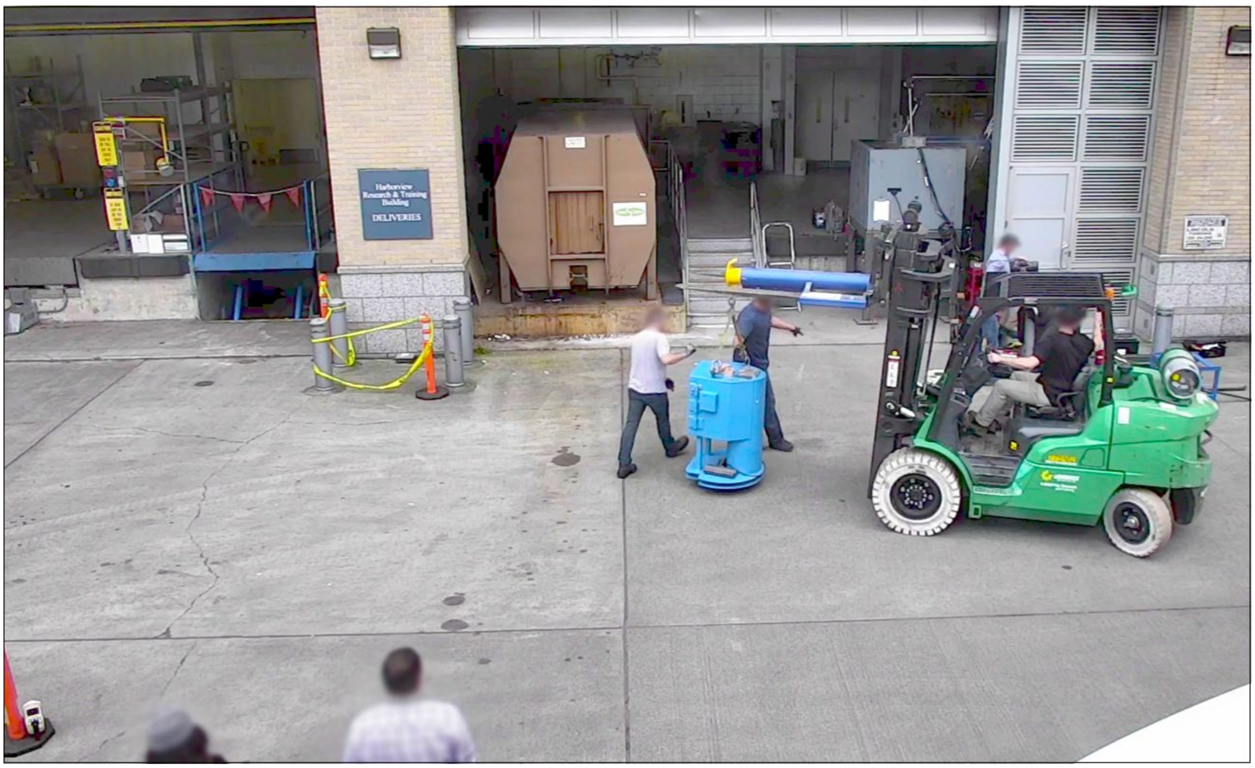


Figure 8: Movement of the Irradiator to the North Loading Dock

At 17:15 hrs., INIS workers made preparations to mate the irradiator to the MHC. The MHC was configured for bottom loading, and the irradiator was aligned with the MHC from below in order to fit to the MHC (mating). Note: This was the first use of the MHC in the bottom-loading configuration for the JLS Mark 1-68 irradiator. INIS workers determined that the lifting rod was too long to allow entry of the source holder through the port on the bottom of the MHC and needed to be shortened.

The initial attempt to mate the irradiator with the MHC was unsuccessful at obtaining a flush fit, as IDD kit remnants were interfering with the expected alignment. The Procedure identified a step to remove IDD kit remnants. This step was not performed because a Hot Work Permit was not prepared for grinding outside of the MHC. In addition, physical alignment was inhibited due to the orientation of the irradiator and placement of the MHC. This required several physical adjustments to fit the irradiator under the MHC. Due to the alignment of the irradiator under the MHC and also due to IDD kit remnants, the donut shield was not used. The donut shield is an integral part of the MHC bottom shielding configuration. Its absence left a void in the MHC bottom shielding (Figures 9 and 10).

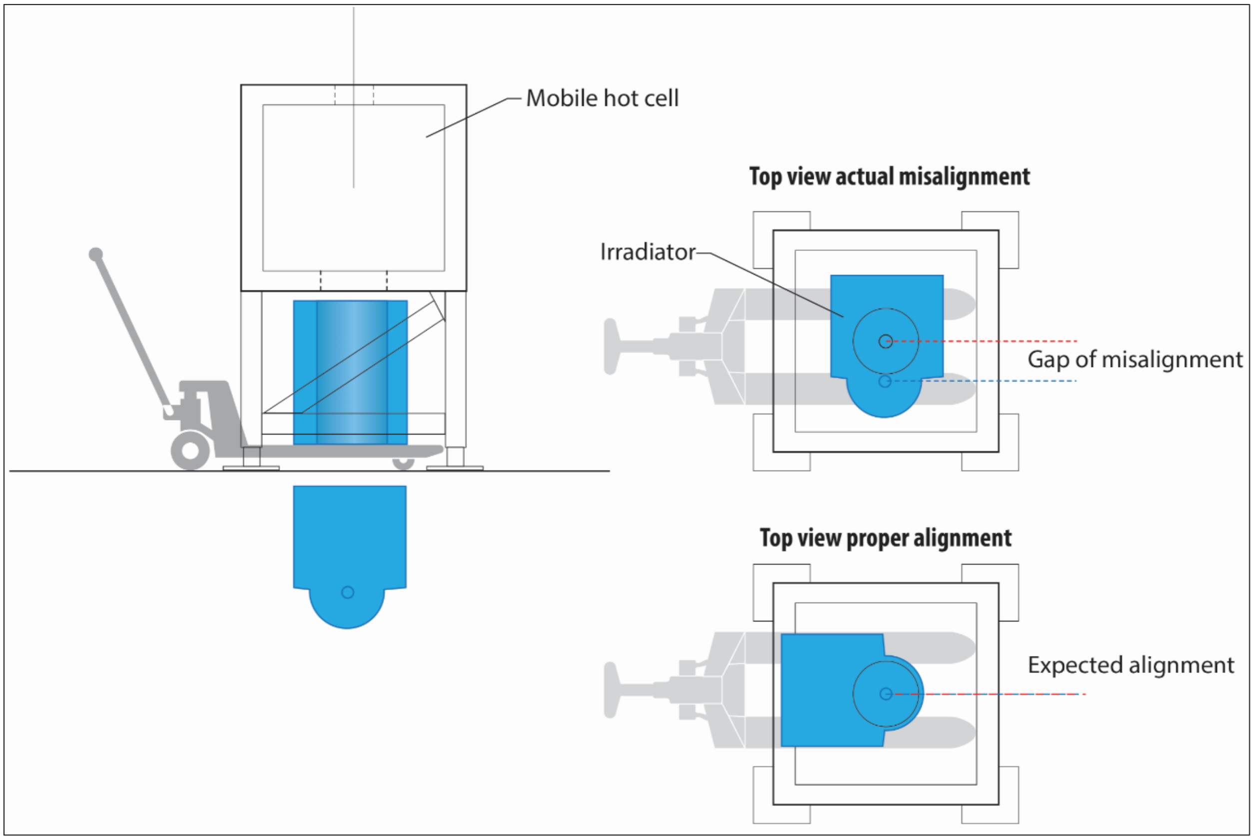


Figure 9: Notional Drawing of Irradiator (blue) Alignment Beneath the MHC

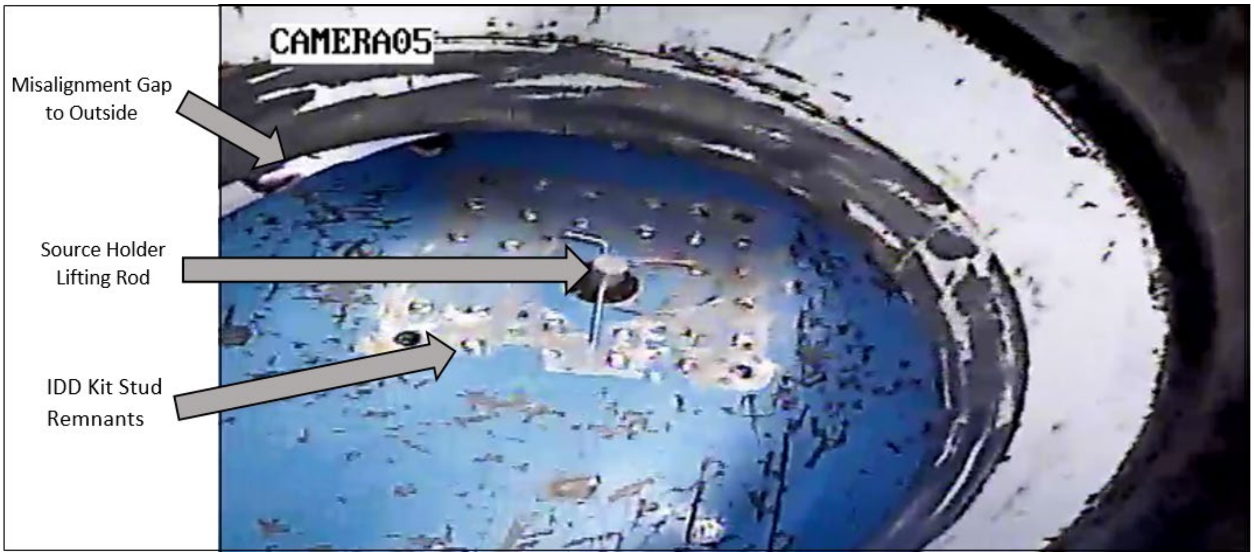


Figure 10: Image of Irradiator (blue) Beneath the MHC

At 17:23 hrs., INIS SMEs removed a portion of the exposed section of the lifting rod using a hacksaw. At 17:47 hrs., INIS SMEs raised a section of the lifting rod above the top of the irradiator and a hole was drilled through the rod to allow the insertion of a pin. This prevented the source holder from dropping back into the irradiator. The lifting rod was then cut a second time above the pin using a portable band saw. These actions were contrary to the Procedure, which states "Clamp the rod in place using a pipe clamp or vice grips and punch out the roll pin and replace it with a lifting eye or wire bail." At approximately 17:55 hrs., INIS workers completed the activities to shorten the lifting rod.

INIS workers then positioned, removed, and repositioned the irradiator under the MHC to facilitate a final mating. The INIS RCO concluded that the less-than-ideal configuration due to the IDD kit remnants and lack of donut shield use was acceptable and the work proceeded. Final mating of the irradiator to the MHC was completed at approximately 18:25 hrs.

At 18:29 hrs., E1, supported by the RCO, held a pre-job briefing for the INIS workers. Topics included Procedure and RWP review, industrial safety hazards, and worker responsibilities. The potential for a contamination event was not discussed. Observers of the work evolution and the UW RSO were not participants in the pre-job briefing. The RWP and pre-job briefing documents were not recovered in the printed material retrieved from HRT.

All observers had unencumbered access to areas with elevated radiation fields. The FBI Observers were not monitored with dosimeters. Some observers periodically viewed operations within the MHC via a video screen located on the MHC.

At 18:42 hrs., an INIS worker lowered the North loading dock roll-up door to approximately seven feet off the ground, in order to improve viewing of the video monitors on the MHC. At this time, work commenced to bring the source holder into the MHC.

At approximately 18:45 hrs., E1 and E2 pulled the source holder into the MHC using the manipulators, in accordance with Step 7.3.9 of the Procedure. Step 7.3.16 which states, "Perform a contamination wipe survey of the source tube and rod," was not performed. E1 and E2 proceeded to perform work configuration set-up activities inside the MHC (e.g., setting up the clamp, cutting equipment, etc.), in accordance with the Procedure.

Concurrent with the work configuration set-up activities, the RCT and RCO conducted routine radiation monitoring. High radiation fields were expected during this operation. Due to the lack of the donut shield use, higher-than-expected readings were identified exiting from below the MHC. A radiation stream projected a wedge from the bottom of the MHC onto the apron in front of the loading dock, where observers could stand and INIS workers could pass through (Figure 11). The reading was 400 milliroengten per hour (mR/hr) @ 1 meter (m) from the bottom of the MHC.

At 19:08 hrs., to partially mitigate the unexpected radiation stream coming from the bottom of the MHC, the decision was made to use a half-moon-shaped lead shield under the source assembly. The half-moon-shaped shield was used previously on top of a source assembly to mitigate the radiation effect on the cameras in the MHC.

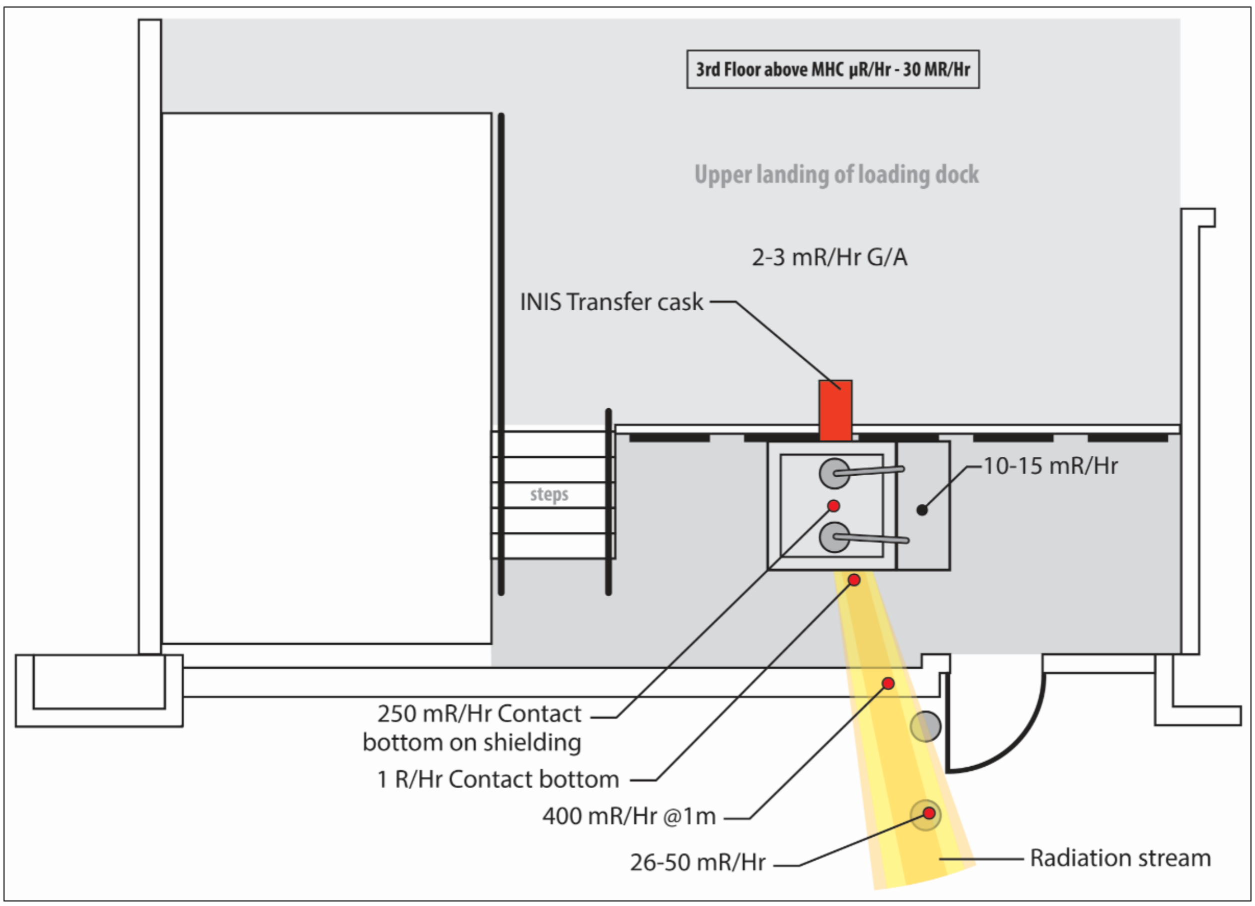


Figure 11: Radiation Fields During Source Removal Operation

The RCO also identified a high radiation stream coming out of the top of the MHC. The UW RSO, conducting confirmatory radiation surveys in the third floor laboratory directly above the loading dock and MHC, observed readings of 30 mR/hr rather than the pre-job expected dose rate of 3 mR/hr. Based on these readings, the UW RSO posted the laboratory above the MHC as a "Radiation Area."

During set-up activities, the following were noted:

- Radiation and high radiation areas were identified based on higher-than-expected radiological measurements; work was allowed to continue.
- Radiation conditions were constantly changing in response to the work activity; work was allowed to continue.
- Personnel without required dosimetry transited areas that were known to be under radiological control.
- The airborne radioactivity hold point of 1.0 Derived Air Concentration (DAC), specified in the RWP could not be complied with, as INIS had not deployed airborne radioactivity detection capability in the work area.
- Contamination surveys were not consistently performed during the work activity, as required by the RWP and Procedure.

ANALYSIS

If the IDD studs had been removed and the irradiator had been lifted onto the pallet jack in the originally planned configuration, this would allowed use of the donut shield. This would also have prevented the subsequent radiation stream in the direction of INIS Employees and observers. The utilized setup omitted the use of airborne radioactive contamination equipment required by the RWP. It is unknown whether the source holder was already contaminated or leaking when first removed from the irradiator because the required contamination wipe survey was not performed. The JIT determined that the MHC was not used as planned or designed to control the penetrating gamma radiation, and that the lack of contamination survey and airborne monitoring equipment increased the consequence of the event.

The pre-job briefing should have included observers who were allowed access into the radiological controlled area. This omission left observers unaware of the radiological hazards and personal monitoring requirements while accessing the work areas. In addition, source removal activities required frequent repositioning of the source holder inside the MHC, resulting in variable radiological conditions outside the MHC. The number of observers present during this evolution and varying dose rates made it difficult to control personnel exposures without defined controlled areas, as required by the RWP. The JIT determined that observers were not adequately informed of the hazards involved and their responsibilities to ensure their safety during the work activity.

INIS did not adequately restrict access to high dose rate areas, as required by their RWP and described in section 2.1.2.1: "*Rope barriers with signage will be established to identify radiation area boundaries (dose rate in excess of 5 mr/hr.) and at least two International Isotopes Inc. employees will be present during transfer operations to visually monitor the area.*" Lack of compliance with procedure-required contamination surveys, lack of equipment to detect the airborne radioactivity, failure to identify and control radiation area boundaries, and allowing personnel without required dosimetry into radiological control areas increased the radiological risk of the operation. The JIT determined that radiation protection program requirements were not adequately implemented for the HRT irradiator recovery, and that the conduct of this operation was not consistent with ALARA principles.

The JIT determined that this work activity and setup was not adequately planned, important steps and details were not adequately thought through or executed, and when unexpected conditions were encountered work was not paused to address the situation or consider alternate actions.

Identified Causal Factors:

INIS did not consistently follow their procedures (CF-1C)
Controls for spread of contamination were not identified or implemented (CF-BXX)
Safety requirements were not effectively implemented by INIS (CF-1D)
Hazard analysis did not include consideration of potential contamination (CF-B4/C2, CFx1)
INIS work planning and control processes not effectively implemented (CF-1A)
Questioning attitude was not present (CF-B7)
Lack of formality of operations delayed recognition of a contamination event (CF-C4, CFx3)
INIS conducted work inconsistent with a robust safety culture (CC-1)

3.0 The Accident

After INIS completed initial set-up operations and loaded the source holder into the MHC, they prepared to remove the source from the source holder (Figure 12). At 19:29 hrs., after approximately 12 minutes of manipulation, INIS positioned the source holder in the modified cut-off saw clamp and aligned the pin with the cut-off saw cutting blade.

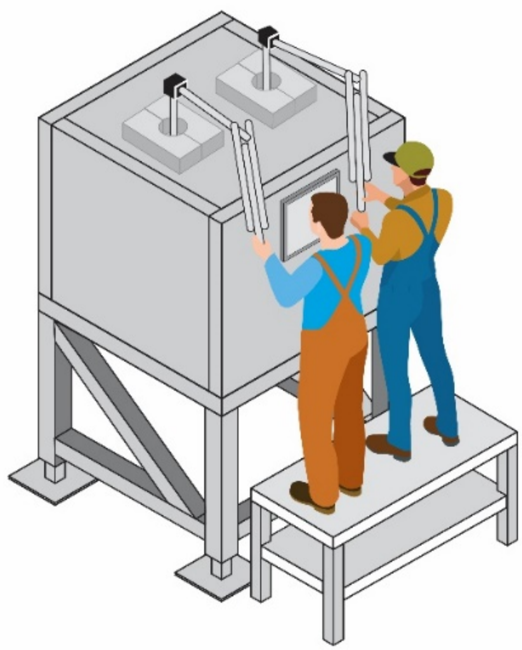


Figure 12: Notional MHC Working Configuration

Using the set of five cameras and a video screen, the MHC operators used the Left Manipulator (LM) to rotate and position the source assembly beneath the cut-off wheel. The saw was operated with the Right Manipulator (RM). The lack of manual dexterity inherent in manipulator use reduced fine motor control and extended the time required for even simple tasks (Figure 13).

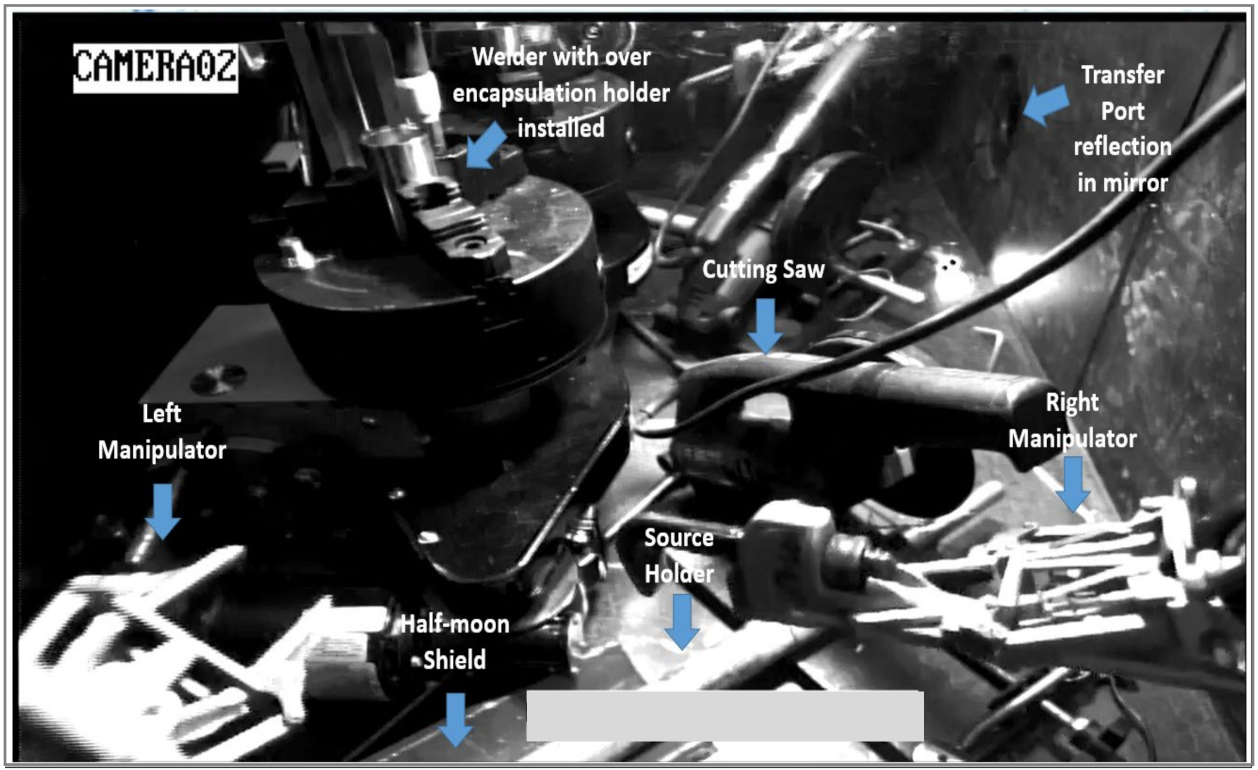


Figure 13: Operational Environment Inside MHC

At approximately 19:31 hrs., E1, E2, and E3 began work on the source holder and made the first cut on the roll pin to reduce the roll pin's length, in order to allow the unthreading of the aluminum source tube from the tungsten rod (Figure 14). Sparks were clearly visible in the MHC video, indicating the cut occurred on steel or tungsten. At this point FBI Observer 2 left the scene.

E1 provided OJT to E2 and E3, who were performing the activity for the first time on a 2900 Ci source in the MHC. The source holder was rotated to cut the other side of the roll pin. Although the cut-off wheel was in line with the plane of the roll pin, the pin itself was rotated forward towards the camera and was not in a vertical alignment. Fewer sparks were observed during cutting at this time, indicating that aluminum was the dominant metal being cut. E1 was observing and directing E2 to make the cuts as E3 positioned the source holder. After each cut, it took several minutes to re-position the source holder in preparation for the next cut. It became a tedious process of starting and stopping the cuts, repositioning the source holder, and attempting to hold on with the Clamp and manipulator.

At 19:50 hrs., they attempted to unthread the source holder using two pipe wrenches. Both the source tube and rod rotated together and did not separate as expected. Section 7.4.3 of the Procedure states "If the pin cannot be removed, then carefully cut the aluminum tube just below the pin." The RCO reported to the NRC on May 5, 2019 that there was 1" of threading with the roll pin located approximately ¼" from the top of the aluminum tube, leaving ¾" to make a 360-degree circumference cut around the source tube. However, INIS had no design drawings or specific information on the internal configuration of this particular source. According to forensics[1] information and as-built drawings, the threaded portion of the tungsten rod for this source holder is ½", and an additional ¼" aluminum spacer is between the rod and the source. Cuts on the aluminum tube extended to approximately 1¼" from the top of the aluminum tube (Figure 14).

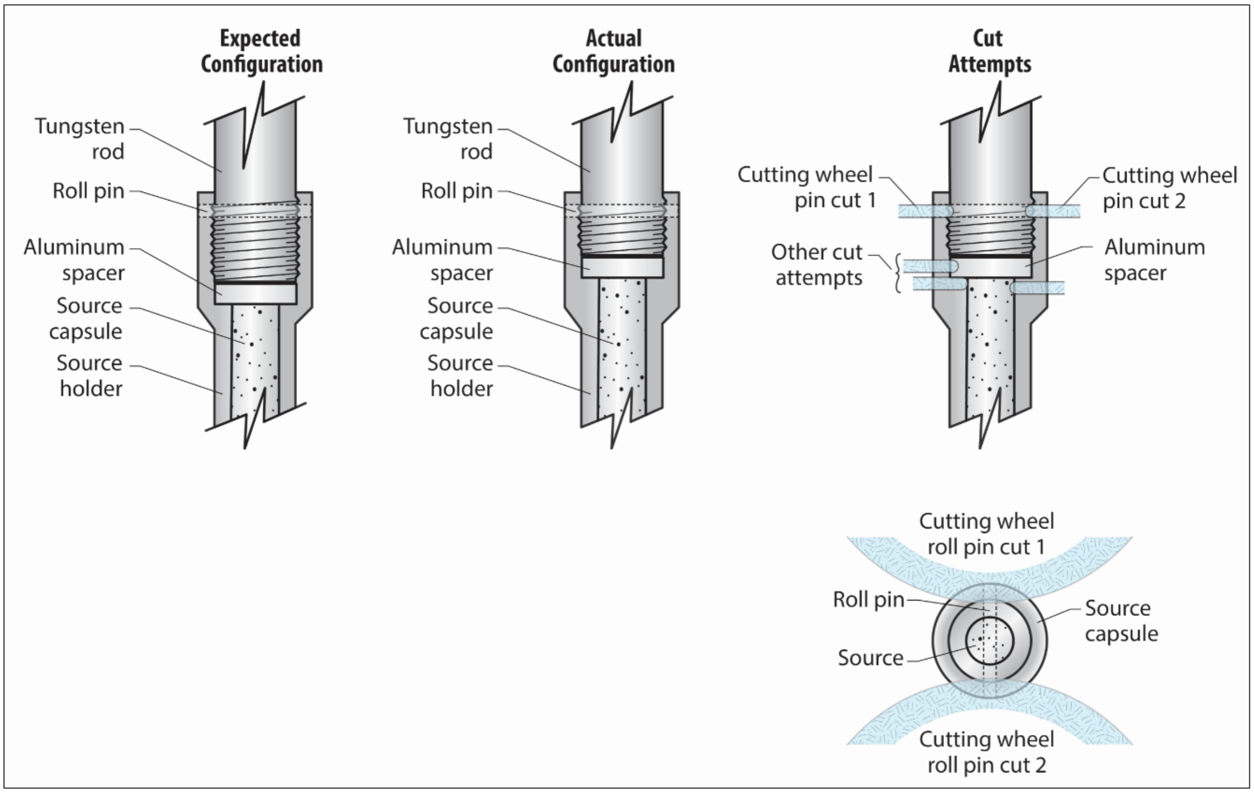


Figure 14: Notional Drawings of Source Holder Configuration

At 20:05 hrs., the RCO replaced E3 with E1 as MHC operator to speed up the cutting process, as he was concerned that the continued elevated radiation exposure was not ALARA. Ultimately, a decision was made to perform a circumferential (radial) cut on the source holder. E1 and E2 continued making the circumferential cuts and attempted to unthread the source holder (aluminum tube from the tungsten rod). These attempts continued to be unsuccessful. E1 believed this was due to oxidation between the aluminum and tungsten threads. Forensics visual examination did not identify evidence of corrosion on the source holder. E1 stated that this activity produced a lot of aluminum and other metal dust, which made the equipment and the source holder harder to grab with the manipulators.

At 20:12 hrs., increased "Bright Spots" were noted on the HRT security video (exterior to the MHC), and continued to the end of the feed. Bright Spots are random noise in a video feed that

[1] When identified in this report, forensics refers to analysis conducted at the Pacific Northwest National Laboratory of the damaged Cs-137 source and source assembly.

can be used as a surrogate radiation detector, as radiation interacting with solid-state video devices can cause an instant overloading of pixels that is manifest by random Bright Spots or a mild snow-like effect.

Around this time, the MHC video indicated that the clamp ceased being tightened between cuts, and cutting was less deliberate.

The JIT identified that the contamination event occurred between 20:00 hrs. and 21:00 hrs. Based on the HRT video bright spots, and MHC videos reviewed that show the location of cuts on the source, the cuts that most likely breached the source capsule occurred between 20:05 hrs. and 20:20 hrs. The JIT therefore used 20:15 hrs. as the approximate source breach time in this report.

At approximately 20:39 hrs., E1 observed that the cut-off wheel grabbed the source holder, which then twisted and rolled. E1 observed an angular cut on the source holder further away from the rod. E1 did not believe the source capsule was damaged. Work was not paused or stopped to perform contamination swipes after this cut.

From 20:45 hrs. to 20:48 hrs., DOH Health Physicist 2 (DOH 2) and an FBI observer approached the MHC to observe operations. At 20:51 hrs., the RCT left the work area to buy batteries for the AMP-100 extended survey meter (and returned at 21:14 hrs.), and radiation monitoring was performed by the FS Tech/Rigger. By 21:07 hrs., DOH 1, DOH 2, and the FBI observer had left the site. These individuals would later be found to be contaminated. Surveys were not performed before they left the work location because contamination was not expected or considered as part of the work planning.

At 21:13 hrs., INIS operators made their final cut and last attempt to unthread the source holder and the tungsten rod. Based on MHC video review, a total of 27 cuts were made. The circumferential cuts did not result in a continuous cut around the source holder. The source holder still would not unthread from the rod or separate. At this point, E1 considered pausing work to give the employees a break, as they were four hours into an expected two-hour operation. E1 planned to place the source holder into the transfer cask for temporary shielding while they considered other options.

At 21:22 hrs., the source holder was removed from the cut-off saw.

At 21:27 hrs., E1 lifted the source holder to place it in the transfer drawer and noticed movement between the source tube and tungsten rod. E1 worked the tube back and forth, and, at 21:28 hrs., the source tube separated at the cutting area (Figure 15). E1 used a hand-held video camera, held with the MHC manipulator, to inspect the capsule in the source holder and observed damage on the source capsule. At 21:29 hrs., E1 informed the RCO that the source may have been breached (Figures 15, 16, 17, and 18).

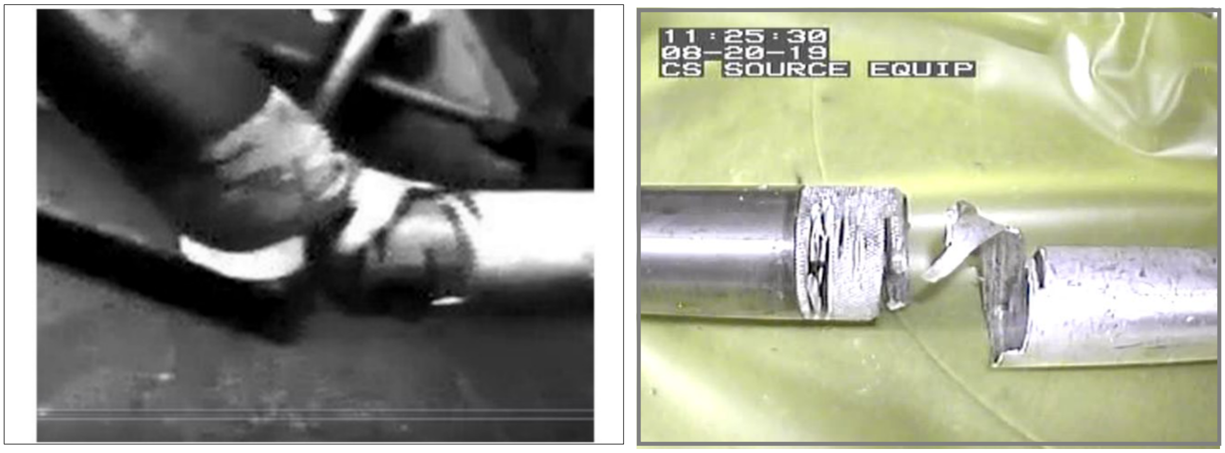


Figure 15: Source Holder Final Disassembly
Left View: MHC video. Right View: Forensic video.

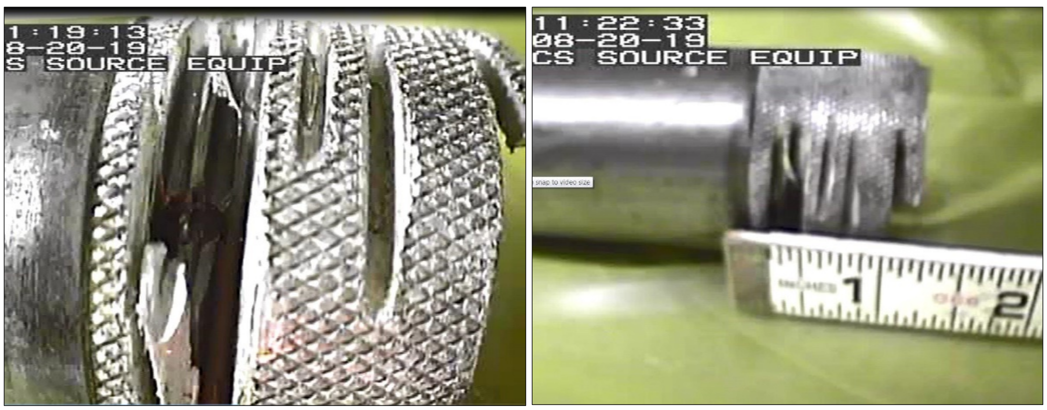


Figure 16: Cuts in the Vicinity of the Roll Pin – View 1 (left) and View 2 (right)

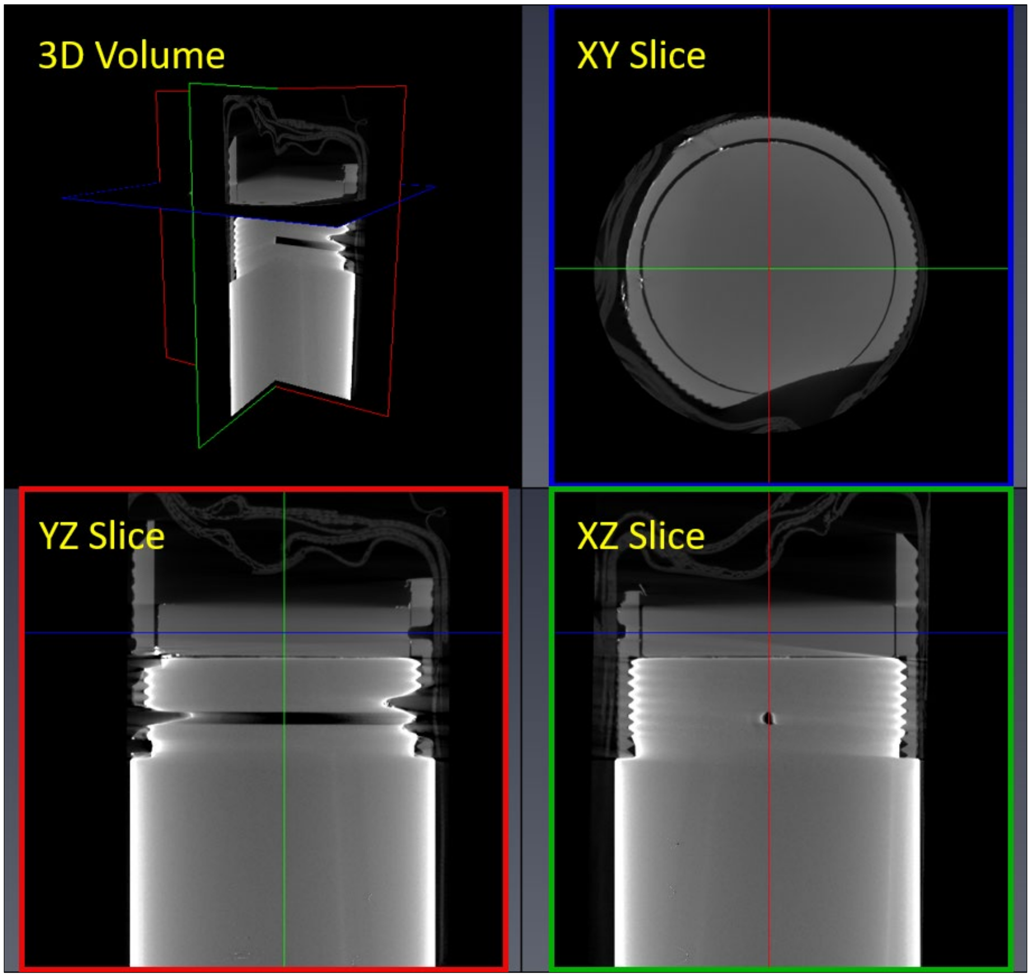


Figure 17: Tomographic Image of the Tungsten Rod

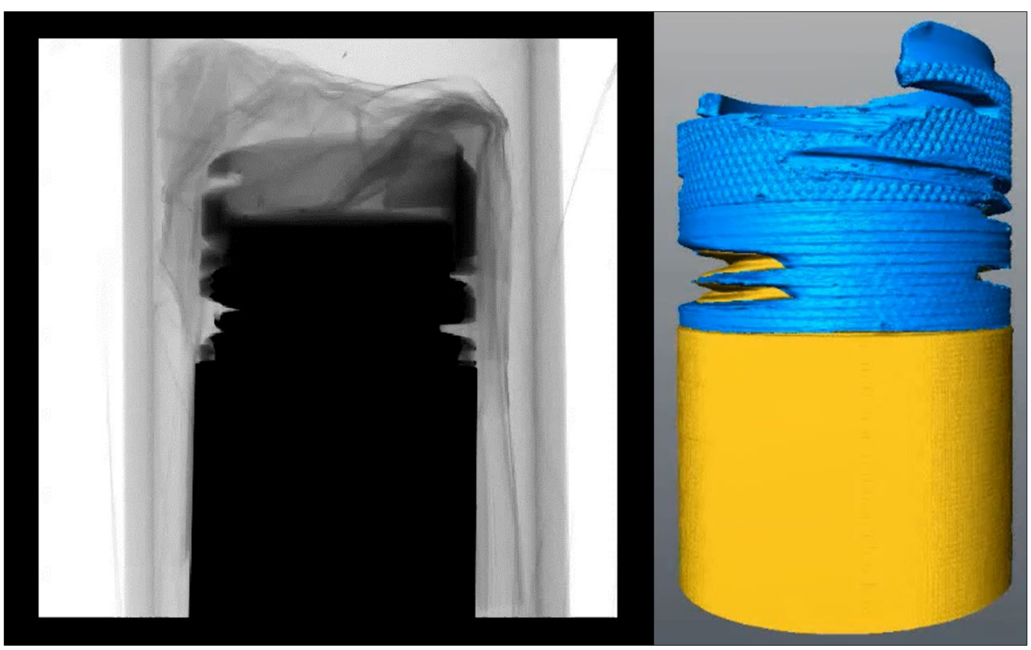


Figure 18: Tomographic Image (left) and False Color Image (right) of Tungsten Rod

ANALYSIS

INIS conducted the work without specific source holder configuration information for the Model 6810 sealed source. The INIS NRC license modification application to add the JLS Model 6810 sources to their license only included the grainy NRC source registry document (reference Figure 5 in Section 1.5.1.2), in which dimensions are illegible. INIS conducted the work based on only the previous Cleveland source recovery from a JLS Mark 1-68 irradiator, which was configured differently. Significantly, the source holder surrounding the JLS Model 6810 source at HRT was manufactured with only 0.5" of threading on the tungsten rod and a single 0.25" spacer, versus the configuration of approximately 1" of threading and two spacers for the Cleveland job. As INIS was cutting through the knurled aluminum portion of the source holder, they believed it was backed by the tungsten rod. In actuality, some of those cuts went through the aluminum and penetrated the stainless-steel-sealed source capsule, nearly creating a completed circular cut of the capsule, which would have resulted in an unconstrained release of cesium.

The JIT determined that INIS did not have any specific design information for the JLS Model 6810 sealed source at HRT and used a power tool to cut significantly below the roll pin and into the source holder.

The JIT determined that cutting the source holder by any method within the MHC without containment capabilities should not have been attempted.

The JIT determined that the source breach occurred about 75 minutes before it was recognized, as determined by video examination of the operation and "Bright Spots" observed on the HRT security video. Lack of airborne contamination monitoring equipment allowed for the undetected spread of radioactive contamination to INIS Employees, observers, HRT personnel, the facility, and the environment.

Identified Causal Factors:

INIS was allowed to conduct operations without technical or safety oversight from stakeholders (CF-B1)

INIS did not consistently follow their procedures (CF-1C)

Lack of formality of operations delayed recognition of a contamination event (CF-C4, CFx3)

INIS work planning and control processes were not effectively implemented (CF-1A)

Immature safety culture led to completion of work activities taking priority over safe conduct of the work (CF-1E)

INIS conducted work inconsistent with a robust safety culture (CC-1)

4.0 Accident Response and Follow-up

4.1 Accident Response

The accident response is defined as the time of discovery of the contamination until the INIS employees were released from the HMC around 09:00 hrs. on May 3. This involved the immediate response conducted by INIS to address and control the breached source, and the immediate emergency response conducted by the Seattle Fire Department (SFD), with support from UW, DOH, and Radiation Emergency Assistance Center/Training Site (REAC/TS).

4.1.1 Immediate Response

At 21:29 hrs., the RCO took a large area swipe on the MHC along the manipulator opening. The MHC was open to the environment and had no contamination control or containment capability. When the RCO turned on the contamination survey meter (which had been staged near the MHC) it pegged on the highest scale, >500,000 counts per minute (cpm). Believing the meter to either be showing a high ambient background reading or broken, the RCO moved to the back of the loading dock; however, the meter indication did not drop. Note: Subsequent survey results from INIS survey instruments conveyed in this report are not accurate, due to contamination.

At 21:31 hrs., E1 removed the source capsule from the source tube, and performed a visual inspection of the source capsule. E1 confirmed "*scratches and one cut that appeared to breach the source capsule wall*" (Figures 19, 20, and 21). E1 continued evaluation of the situation at the controls.

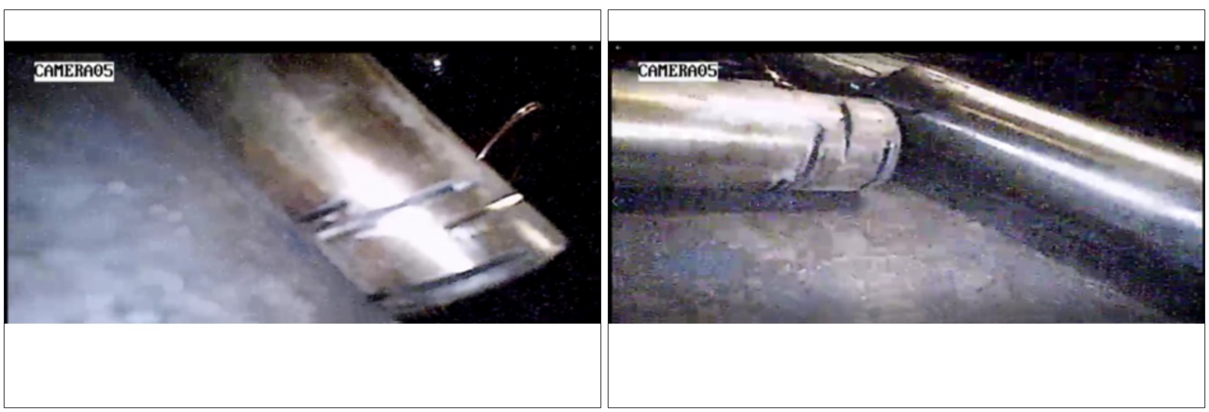


Figure 19: Damage to Cesium-137 Outer Source Capsule
(screen captures from the MHC video)

Figure 20: Damage to Cesium-137 Outer Source Capsule
(Forensic images – counterclockwise rotation views.)
(Numbers are references to identify the cuts into the outer source capsule)

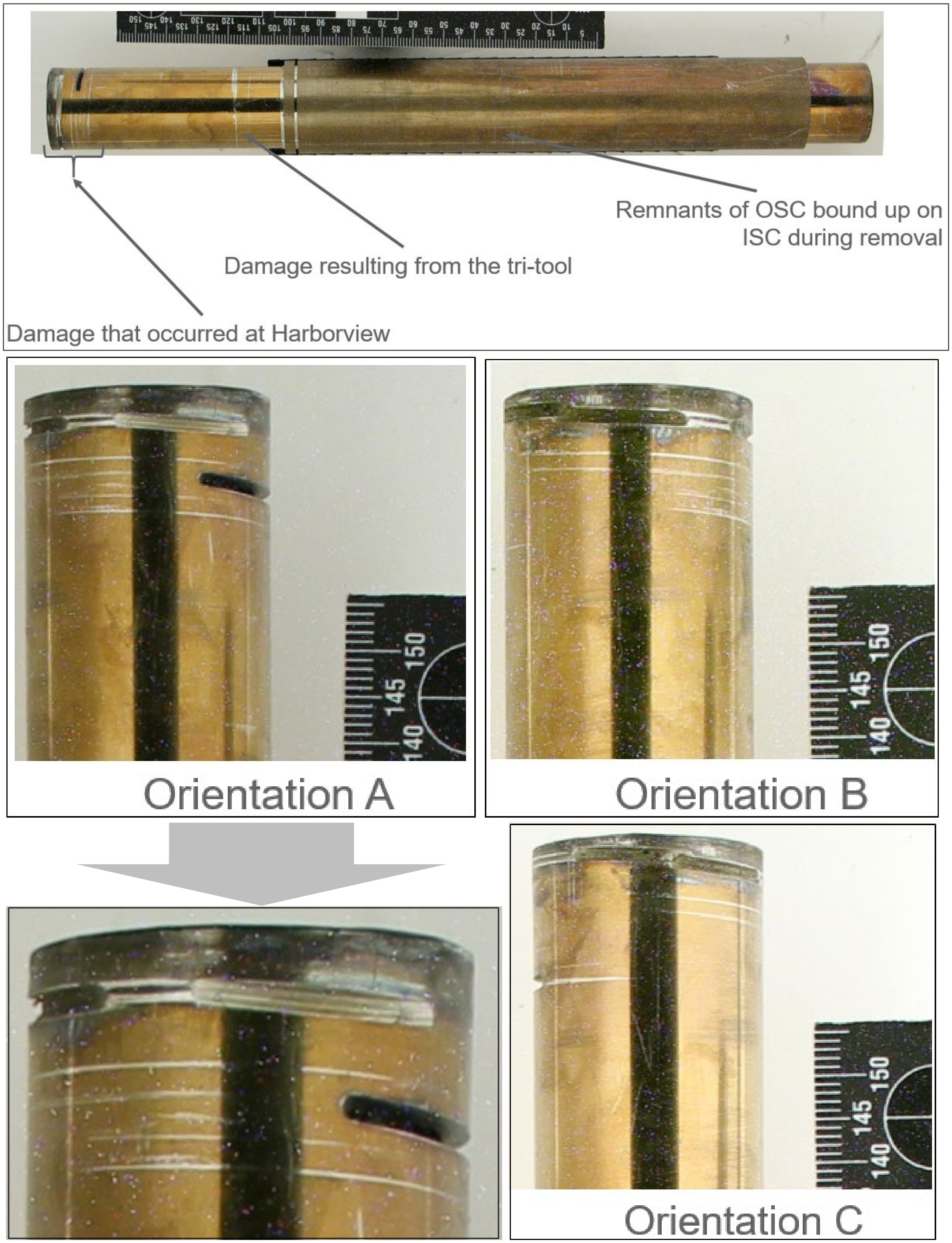


Figure 21: Damage to Cesium-137 Inner Source Capsule

(Forensic images – Close ups show damage during source recovery operations.)

(OSC: Outer Source Capsule; ISC: Inner Source Capsule)

Concurrently, the RCO left the loading dock and entered the parking area within the work boundary in an effort to get a lower background reading on the contamination survey meter.

At 21:32 hrs., the RCO contacted the UW RSO to request a contamination survey instrument, to perform confirmatory measurements. At 21:33 hrs., the RCO and UW RSO exited the loading dock into the interior HRT corridor to determine whether the instrument readings would drop.

The RCO attempted to decontaminate his contamination survey meter, and the meter indication dropped below the maximum and leveled off at 200,000 cpm. The RCO contacted the UW RSO, who informed the RCO that he had obtained a survey meter from the third floor and had confirmed contamination on his shoes.

At 21:34 hrs., the RCT, who was conducting monitoring outside of the loading dock, was directed to come back inside the loading dock. The roll-up door was closed.

During initial response activities, INIS workers remained in a known contaminated area without PPE, rather than exiting to a clean area for response planning.

Starting at 21:46 hrs., INIS personnel performed large area swipes for contamination around the loading dock area. INIS had insufficient contamination control supplies in the work area (i.e., respirators, gloves, anti-contamination clothing (Anti-C's), Masslinn®, etc.). They found and used nitrile gloves, which were stored on the loading dock.

The RCO left voice messages for the INIS President and the LANL AdSTR.

During this time, the damaged source was placed into the steel OE capsule in the welding fixture with the lid resting on top.

The RCO discussed the situation with the rest of the work crew, and, according to his statement, the work crew was to consider everything contaminated, and minimize movement as much as possible. There was also discussion with the UW RSO at the open interior hallway door regarding turning off the building ventilation. At this time, INIS personnel knew that their only contamination survey meter was contaminated, and widespread contamination was identified throughout the loading dock area. The loading dock Heating, Ventilation, and Air Conditioning (HVAC) systems remained operable. The UW RSO contacted the HRT FM to report the event and request the building ventilation be turned off. UW then started their emergency notifications.

At 21:53 hrs., the UW RSO called for assistance from the UW Associate RSO (ARSO) and made additional notifications.

At 21:53 hrs., INIS personnel closed the double doors leading from the loading dock to the interior hallway and the RCO contacted the UW RSO to request that the loading dock freezer compressors be turned off, to eliminate circulation of the contamination on the loading dock. Due to the contents of the freezers, UW identified that this was not possible.

At 22:02 hrs., the RCO called the NRC HQ Operations Center to establish initial notification, and report the incident. The length of the call increased as additional organizations were brought onto the bridge line, and therefore the call took all of the RCO's attention for more than 30 minutes. During the call, no significant activities took place on the loading dock.

The primary building ventilation was turned off sometime between 22:00 hrs. and 22:30 hrs. (30-60 minutes after the spread of contamination was identified by INIS, and 1 hour 45 minutes after the suspected source capsule breach). Two auxiliary ventilation systems servicing the North loading dock (for a trash compactor and a freezer) remained operational.

At 22:25 hrs., after conversing with the UW RSO, the Seattle Police Department Officer on security detail for the work evolution called 911 to contact the SFD. This notification occurred approximately 60 minutes after the spread of contamination was identified. The SFD was notified and dispatched for a hazardous materials (HAZMAT) response at the HRT. They arrived on-scene at 22:30 hrs.

At 22:26 hrs., a custodian, potentially unaware of that evening's work activities, was seen walking down the interior hallway, adjacent to the loading dock. The RCO stopped the custodian near the loading dock interior hallway doors and the RCT took surveys of the bottom of the custodian's shoes with a contaminated meter. No contamination was identified. However, inaccurate readings caused by contaminated monitoring equipment did not allow INIS personnel to make an accurate determination on the spread of the contamination, including on the shoes of the custodian. Consequently, the custodian was allowed to leave the area, but was later identified as having contaminated shoes.

At 22:34 hrs., the INIS crew gathered to evaluate options to further secure the area. Neither the INIS procedures nor the RWP addressed the spread of contamination and the INIS Emergency Plan was not tailored for Field Services. The INIS crew had to develop an emergency response on the fly.

Options discussed were:

- Seal the open manipulator ports on the MHC with plastic and tape.
- Over-encapsulate the breached source. This would limit additional release of cesium from the breached source. Concern was expressed that the welding process could increase the spread of contamination.
- Place metal tape over the source capsule to cover the breach.

INIS decided to over-encapsulate the breached source.

The UW RSO remained outside the loading dock, but within the caution tape boundary for the duration of the event response. The RCO and UW RSO maintained communication via a man door common to the exterior of the loading dock. The information exchanges included the INIS plan to secure and stabilize the situation and the status of the exterior initial response.

At 22:54 hrs., E1 and E2 prepared for over encapsulation of the breached source.

At 23:06 hrs., E1 wetted a Kimwipe® with acetone. The RCO moved a lead shield brick from the RM on top of the MHC to create an opening and dropped the Kimwipe® into the MHC for cleaning the welding surface. Without measuring the radiation field, the RCO then looked directly down into the MHC. E1 and E2 cleaned the top of the OE capsule with the Kimwipe®.

At 23:18 hrs., E1 and E2 completed over encapsulation by welding the lid onto the INIS special form cylinder. The weld was visually inspected with the manipulator-held video camera.

At 23:28 hrs., the OE capsule was placed into a source drawer and loaded into the INIS shielded transfer cask. The cask was unmated from the side of the MHC. The cask was slowly backed away from the MHC, and preliminary contamination swipes were taken while E3 started work to seal the MHC cask port.

At 23:38 hrs., the RCO performed a large area swipe of the transfer port mating surface on the cask, which was found to be contaminated. During this time, a number of INIS workers were standing in close proximity to the MHC opening. Cardboard was placed over the MHC transfer port covering and secured with duct tape. The open ends of the cask were sealed with duct tape, and the end plates were attached. The cask was moved to the side of the loading dock, and positioned such that a higher dose rate stream was directed towards the trash compactor and away from the workers on the loading dock at 23:52 hrs.

INIS workers remained in the loading dock awaiting further instructions until 00:48 hrs., approximately one hour after completing over encapsulation, when the UW RSO and RCO decided that it was time to leave the contaminated loading dock. While waiting, the interior hallway doors were sealed.

In total, INIS workers remained in the airborne-contaminated loading dock for approximately 4.5 hours. By 00:51 hrs., all INIS personnel had exited the loading dock and stood outside the loading dock roll-up door. While waiting for the SFD decontamination process to begin, the RCO and UW RSO worked to identify the extent of contamination levels on the INIS workers, based on work activities and locations of the individuals.

ANALYSIS

The INIS Emergency Response Procedure and training for this activity did not address the required actions in the event of an emergency during field services work. Required actions are specific, in most cases, to the Idaho Falls, Idaho facility.

The JIT determined that INIS did not have clearly defined emergency response guidance for an event of this type.

The JIT determined that INIS's lack of controls and preparedness for this type of event increased the spread of contamination to the facility, consequence to personnel, and material release to the environment.

The JIT also determined that personnel involved in the accidental release were subjected to an unanalyzed contamination hazard, in order to plan and conduct response activities, and while waiting for decontamination. The proper response was to vacate the contaminated area and make re-entry to the contaminated area on a volunteer basis to conduct response activities. In addition, after over encapsulation was completed, INIS personnel remained in contaminated clothing in a contaminated environment for an excessive period of time. When they exited the loading dock, they were directed to stand in the highest dose area of the exterior of the HRT.

Identified Causal Factors:

INIS work planning and control processes were not effectively implemented (CF-1A)

INIS did not have an emergency response process to cover Field Services work (CF-1F)

INIS training program did not prepare INIS personnel to conduct off normal work activities and to address emergency response during Field Services work (CF-1G)

4.1.2 Initial Incident Response and Decontamination

The organizations involved in the initial response involved the SFD, National Guard (NG), and Civil Support Team (CST), DOH, REAC/TS, DOE RAP 8, and UW.

At 22:00 hrs., while in route home, DOH 1 and 2 were informed of potential contamination by the DOH emergency response hotline. Prior to this notification, they had visited a local restaurant. Upon arriving at an off-site location, DOH 1 and 2 assessed contamination, and performed dry decontamination. Additional activities performed included:

- Making notification to supervisors;
- Returning their vehicle to headquarters;
- Loading supplies into a second vehicle to assist with the HRT response; and
- Returning to the HRT with an additional three DOH personnel.

DOH personnel arrived at HRT during wet decontamination operations and integrated into the SFD response.

Later in the evening, the FBI Observer received notification of the contamination event. The FBI Observer returned to the HRT, and was surveyed. Minor contamination was found, and the FBI Observer was successfully decontaminated by SFD. FBI surveyed and cleared the FBI Observer's residence.

At 22:30 hrs., SFD HAZMAT response arrived outside the HRT and established Incident Command (IC) – designated "Terry Command" and started initial set-up (Figure 22). SFD HAZMAT had not received formal notification of source recovery activities. The initial HAZMAT response did not include mass radiological decontamination capability.

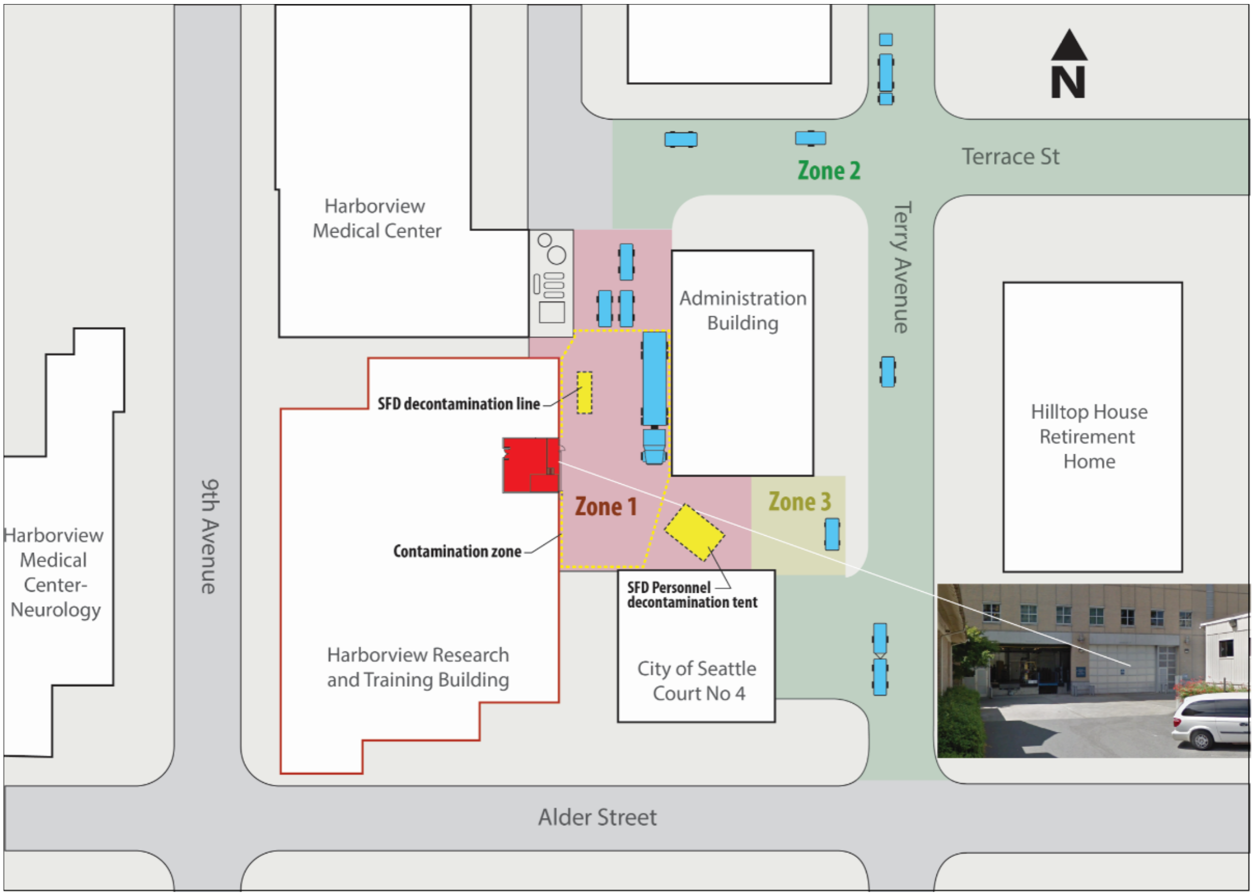


Figure 22: Notional Diagram of "Terry Command"

At 23:12 hrs., the SFD made a request for a decontamination team (DECON 1), which arrived at 23:59 hrs. SFD determined there were no life-threatening emergent medical issues with contaminated individuals. The SFD HAZMAT response team focused on identification of contamination exterior of the building in the lot. The SFD DECON 1 focused on the decontamination of personnel involved.

At 23:20 hrs., the SFD contacted the REAC/TS. A teleconference call occurred between the REAC/TS, SFD, and DOE RAP. The event was described during the call and the REAC/TS group made recommendations to the SFD on how to provide decontamination and triage services to the affected personnel. REAC/TS and RAP 8 continued to provide advice to incident command and HMC throughout the initial response.

At 23:50 hrs., UW RCTs arrived carrying more monitoring equipment and donning Anti-C's. The UW RCTs conducted radiological surveys of the area and personnel outside the HRT loading dock. The UW ARSO ascertained that individuals were contaminated and significantly expanded the caution tape boundaries. The UW RCTs then assisted the SFD with personnel contamination surveys.

Around midnight on May 3, the SFD began to establish personnel decontamination protocol (Figure 23). The UW ARSO recommended to the SFD to decontaminate the highest-contaminated individuals first to mitigate their accumulating dose. However, the SFD decontaminated individuals with the least contamination first, and the highest-contaminated individuals last, in order to limit the transfer of accumulated contamination in the decontamination pools.

Figure 23: "Terry Command" Decontamination Tent

Decontamination activities were performed, as follows:

- 00:06 hrs., "cold," "warm," and "hot" personnel decontamination zones were established.
- 00:31 hrs., SFD HAZMAT performed identification and characterization surveys of the external cordoned-off area in Level B PPE, with Self-Contained Breathing Apparatus (SCBA) and HAZMAT suits. Contamination areas were recorded and those ≥100 cpm were marked.
- 00:56 hrs., HAZMAT Team concluded surveys.
- 00:57 hrs., HAZMAT Team surveyed INIS workers.
- 00:59 hrs., DECON 1 begins decontamination activities for lesser-contaminated personnel.
- 01:09 hrs., a transportation corridor for ambulances and path to decontamination tents was established, and additional resources were requested.
- 01:32 hrs., decontamination of lesser-contaminated personnel concluded.
- 01:45 hrs., decontamination of heavily contaminated personnel (INIS workers and UW RSO) commenced.
- 04:00 hrs., transportation to HMC was completed for affected personnel.
- 04:17 hrs., personnel decontamination activities were concluded.
- 05:23 hrs., SFD demobilization was completed and Terry Command concluded. SFD left behind the contaminated decontamination tent, equipment, contaminated decontamination water, and all the bagged, contaminated personal items.
- 06:00 hrs., DOH, NG and CST SMEs returned to the restaurant before its opening. Surveys were conducted throughout the restaurant and no contamination was found.

ANALYSIS

The SFD had never performed this type of response before. They followed their protocol and worked well with DOH and UW; however, they had some problems. Initially, the SFD used the dry decontamination method. SFD determined this was ineffective and they switched to the wet decontamination method. The SFD had equipment difficulties that resulted in cool water being used for decontamination vs. the preferred warm water use. Eventually, warm water became available and was used on a few individuals. Initial decontamination efforts did not alleviate all fixed contamination.

Response activities were somewhat delayed due to the unique nature of the event, lack of knowledge of the existing work activity, and incomplete initial event details. The JIT determined that initial response activities from SFD, UW, DOH, and other organizations were performed adequately, given the unique nature of the event.

The JIT determined that DOE reach-back capabilities, RAP 8 and REAC/TS, supported field response as expected.

The JIT reviewed the SFD after-action report and agrees with their determinations on path-forward corrective actions.

Identified Causal Factors:

Local response agencies were unaware of the work activity and were unprepared for the contamination event which delayed their response (CF-BCCC)

4.2 Follow-up Response

The follow-up response covers the period from Friday morning (May 3) to the establishment of Unified Command on May 15.

4.2.1 Friday, May 3, through Sunday, May 5, 2019

4.2.1.1 Friday, May 3, 2019

4.2.1.1.1 UW Pre-Entry Assessment Team

UW used their Pre-Entry Assessment Team to assess the vivarium. The Team provided animal care and monitored vivarium entry routes within the HRT.

4.2.1.1.2 Notifications

At 12:07 hrs., the NRC provided notification to various governmental agencies, including DOE, of the event. This was recognized as a notable event that required monitoring by the NA-80 watch officer.

That morning, NA-21 personnel received initial notification about the event via a mutual colleague from the National Institutes of Health, who had received the NRC notification of the event, and forwarded it to NA-21.

Also that morning, following release from the HMC, the RCO made contact with the LANL AdSTR and provided a status update on the event. The AdSTR made additional management notification, to include the LANL Chief Operating Officer for Associate-Level Directorate for Global Security. LANL reviewed the subcontract, determined that responsibility was solely on the subcontractor, and decided to monitor the situation.

Upon notification that morning, the INIS President contacted their insurance company, initiated communications with and contracted Chase for clean-up activities, and traveled to Seattle. Upon arrival that evening, the INIS President and a few of the INIS workers went to the scene, where they began efforts to isolate the HVAC to the loading dock and reduce the spread of contamination.

UW personnel were unsure whom to contact for assistance. DOE RAP was recommended by DOH. The DOE RAP assistance request was made by the UW EH&S Interim Senior Director. Once requested and mobilized, DOE RAP 8 arrived to the scene on the evening of May 3, 2019.

At 12:21 hrs., the NA-LA Manager informed DOE Headquarters that work conducted by a Triad subcontractor had resulted in a contamination event in Seattle. The significance of the event was still being characterized. The notification was distributed via email to NA-1, -3, -20, and -80.

4.2.1.1.3 RAP Deployment

RAP 8, stationed in Richland, WA, was notified of the event at the HRT in Seattle through a conference call that occurred with Oak Ridge Operations Center (OROC), RAP 2, REAC/TS, and SFD. There was no official request for assistance at that time. The RAP 8 Team Captain received an update of the event at 01:45 hrs. They were not requested to deploy, but the RAP 8 Federal Team Leader (FTL) determined that it would be prudent to be prepared for a response. Seven members were identified for possible deployment, and the team proceeded to gather pertinent information on the event and developed deployment logistics.

As identified above, UW personnel were unsure whom to contact for assistance the morning of May 3. DOH recommended DOE RAP. At 13:10 hrs., the UW EH&S Interim Senior Director formally requested RAP 8 support. At 14:05 hrs., NA-80 authorized deployment of RAP 8 for immediate assessment of health, safety, and habitability; and specified they would not be involved in recovery activities.

At 19:07 hrs., the RAP 8 team arrived in Seattle. Upon arrival, they observed that a State Patrol Officer was present at the event site, and there was no apparent IC structure in place. The decontamination tent was still present (to include decontamination supplies and wastewater), with one end open to the environment. Red biohazard bags containing potentially contaminated items were on-scene, and the event location was marked with yellow caution tape. RAP 8 set up their trailer, zipped up the decontamination tent, and performed general characterization surveys of the cordoned-off area. This resulted in downsizing the cordoned-off area and marking some contamination spots. At 21:30 hrs., RAP 8 concluded their activities for the evening.

4.2.1.2 Saturday, May 4, 2019

At approximately 08:00 hrs. on Saturday, May 4, INIS personnel returned to the HRT to retrieve personal effects and begin recovery efforts. At 08:50 hrs., a meeting occurred between RAP 8, INIS, and UW. UW was focused on immediate needs such as feeding animals in the vivarium and researcher access, and stated they were depending on RAP 8 for guidance. RAP 8 accepted tasking to support entry into the HRT vivarium and continued assessment activities.

INIS continued planning to control the air flow through the loading dock. Workers placed plastic over the vents on the louvers exterior to the loading dock and second floor hallways. They conducted characterization activities on the seventh floor. The INIS President established contact with the NRC, as license amendments were needed for decontamination and recovery.

RAP 8 performed habitability evaluations of the HRT. For most of the surveys, the RAP 8 team wore protective booties and gloves. For surveys on the second floor, they donned Anti-C's and respirators. RAP 8 leadership observed that there was a lack of radiological notification postings within and outside of the HRT. Room access constraints and incomplete floor plans slowed survey progress. Surveys continued to identify contamination.

RAP 8 identified multiple, independent HVAC systems in the HRT, but only the main building HVAC system had been shut down. Consequently, they set up air monitoring stations at locations throughout the HRT. The initial air samples did not identify airborne contamination.

INIS requested that RAP 8 identify isotopes found through their surveys. RAP 8 confirmed the presence of Cs-137. RAP 8 surveyed the exterior louvers for the battery room exhaust system and contamination was identified.

Additional RAP 8 activities and interactions included notification that a clean-up contractor (Chase) would be arriving that night, a conversation with the FBI Observer, and status inquiries from DOE HQ of when they would demobilize.

At 20:00 hrs., multiple surveys of the research freezer condenser coils located on different floors in the HRT identified cesium contamination, indicating that contamination had spread throughout the building and was not isolated to the second floor.

4.2.1.3 Sunday, May 5, 2019

In the morning, the RAP 8 team continued performing habitability surveys in the HRT. This included air monitoring. They also observed that air was pushing out through the glass doors at the front of the building, and concluded that a HVAC system was still operating in the building.

At 09:55 hrs., a Chase project manager arrived, who was largely unaware of the conditions in the HRT. INIS directed Chase to do what DOH and UW requested. INIS activities concentrated on securing loading dock ventilation.

At 11:50 hrs., the RAP 8 Program Manager called the RAP 8 team and discussed the response status. With the arrival of the recovery subcontractor (Chase), the RAP 8 FTL was informed that they would demobilize that day.

At 13:00 hrs., a conference call took place for RAP 8 to turn over their assessment results to UW. DOH, INIS, and Chase were also present. Discussion included:

- HRT survey results by floor;
- Recommendation to cover the battery room louvers;

- Recommendation to continue air monitoring on each floor;
- DOH request to review and approve INIS/Chase cleanup plans;
- Disposition of decontamination supplies and water from decontamination tent;
- Isolation of the loading dock and first and second floors; and
- RAP 8's demobilization that day.

At 13:30 hrs., once it was confirmed that the Chase representative had arrived, there was a final situational report meeting conducted, and the scene was turned over from RAP 8 to UW, INIS, and Chase. RAP 8 leadership indicated that their presence was still highly desired by the UW leadership.

At 14:30 hrs., the RAP 8 team demobilized and returned to Richland, WA.

DOH did not object to RAP 8 departure. UW requested they remain onsite, but was informed that RAP 8 was not authorized to stay. UW personnel acknowledged that the lack of support from DOH and DOE was demoralizing.

ANALYSIS

DOE RAP involvement at the onset of the contamination event was limited at first. DOE RAP was connected to the initial calls from SFD to OROC and REAC/TS on the night of May 2, 2019. There was no formal request for assistance until early in the afternoon of May 3, 2019.

Once on-site, they performed their initial assessments and reduced the cordoned-off area for the event. RAP 8 expertise was recognized by UW leadership, who relied on them as a de facto incidence command. RAP 8 response scope was limited to assessment of contamination and habitability of the building. NA-80 leadership was concerned that RAP 8 would be utilized as a decontamination and consequence management asset. They wanted to ensure that RAP 8 was strictly utilized for immediate assessment of health and safety habitability. RAP 8 team members acknowledged pressure from headquarters to convey that message to UW.

The demobilization of RAP 8 on May 5 left UW leadership demoralized and unsure on how to deal with the long-term recovery of the scene. UW leadership had neither the technical expertise nor experience to address an incident of this magnitude and INIS and Chase did not fill that gap.

The JIT recognizes that DOE RAP and NA-80 do not have established capabilities to provide continuing support or advice to UW response leadership at the conclusion of RAP assessment operations.

The JIT determined that the lack of a formalized IC structure inhibited effective recovery operations during the first weekend.

The JIT determined that DOE does not have an established process to bridge long-term response and consequence management to non-DOE organizations.

The JIT determined that Triad's initial response focused on the subcontract and corporate responsibility and therefore they decided to monitor the situation. This inhibited a thorough understanding of the event by NA-212 leadership. The JIT notes that there was no clear guidance in OSRP documentation regarding management of emergency response during source recovery operations.

<u>Identified Causal Factors:</u>

Triad did not have clear guidance from NA-21 on their role for an offsite emergency response (CF-4D)

DOE RAP and NA-80 did not have a mechanism to provide continuing support or advice to UW response leads (CF-4B)

DOE does not have a capability to bridge long term response and consequence management (CF-4A)

No formal command structure was developed in response to the event (CC-4/CF-C33)

DOE is managing work regulated by the NRC or an Agreement State without clearly defined roles and responsibilities (RC-2)

4.2.2 Monday, May 6, through Sunday, May 12, 2019

UW had no experience responding to a broad radiological contamination event. They had to contend with requests by HRT residents to access the building, DOH requests for re-entry and decontamination plans, INIS's goal to control the spread of contamination, and an understaffed Chase decontamination team.

UW was focused on returning the HRT to full research operations and was getting pressure from the HRT resident principal investigators (PIs). Building temperatures reached approximately 100°F. Research freezers normally kept at -80°C were alarming and in threat of failure, due to the lack of operational HVAC. Several eventually did fail, and mitigative action was taken. This put extensive and expensive research at risk.

INIS and Chase workers conducted some building recovery operations from May 6 to 12. Chase workers began building surveys, spot decontamination, and conducted air sampling, often using INIS workers as augmented staff. Chase and INIS continued efforts to characterize the extent of contamination, focusing on floors 4-7 of the HRT. Chase surveys of roof exhaust of two uncontrolled and unfiltered ventilation systems serving the North loading dock identified cesium contamination. These were then secured.

Decontamination activities were constrained by several factors. One was the review and approval of a re-entry and decontamination plan by the DOH, in their regulatory role, prior to work commencing. Another was the high demand for escort of PIs and HRT staff to check on research, animals in the vivarium, and access to offices for a variety of reasons. Entry required escort by trained radiological workers. Chase and INIS workers filled this need, pulling them away from decontamination efforts.

Following RAP 8's departure, there was minimal communication from the event scene to DOE. While at a conference that week, DOH staff informally discussed with NA-212 leadership that this was a minor event and that UW was in control. This generated an under-appreciation by DOE of the scale of contamination and the location of the event in a dense urban setting.

Nevertheless, recognizing the risk of cutting activities, NA-21 paused all source recovery operations involving source transfer.

UW's confidence in Chase's and INIS's ability to decontaminate the facility diminished throughout the week. UW attempted to seek DOE assistance through several channels, including the Washington Governor's office, Washington State Senate and House of Representative Offices, and colleagues in the University of California system.

On Friday, May 10, a conference call was held between UW, Triad, and several senior officials from NA-20. UW requested that DOE assume the lead of the event recovery and provide oversight of INIS activities, as UW personnel lacked confidence that INIS could adequately handle the job. No evidence of overt action from NNSA Senior Management occurred until the following Monday, May 13.

4.2.3 Monday, May 13, through Wednesday, May 15, 2019

On May 13, the Triad Director and Senior NNSA leadership provided clear guidance that DOE would provide direct support and leadership to HRT recovery efforts. The NA-LA Contracting Officer provided direction to Triad, authorizing these activities.

On Tuesday, May 14, Triad, and NNSA leadership arrived in Seattle. This was the first recognition by both Triad and NNSA of the scale of the incident.

With the arrival of DOE assets, there was significant discussion regarding response leadership, management, regulatory framework, and oversight.

In parallel, NA-80 activated the National Incident Team (NIT) at DOE HQ and re-deployed the RAP 8 team to Seattle. The NIT immediately began planning for a modified RAP/Consequence Management response deployment. NA-80 also provided assets with augmented Consequence Management advisors for the Senior Energy Official (SEO) and Senior Response Official.

On Wednesday, May 15, DOE continued deploying assets to Seattle and engaged in IC planning activities. Unified Command was established and implemented, with the NA-21 manager as the SEO on Friday, May 17.

ANALYSIS

The JIT determined that the response to the event by DOE was delayed due to regulatory jurisdiction questions, event responsibility concerns, and unclear communications.

UW personnel were inexperienced in IC structure, specifically for a broad radiological contamination event. UW had to contend with requests by HRT residents to access the building, DOH requests for re-entry and decontamination plans, and INIS's desire to immediately mitigate continuing spread of contamination, all with an understaffed Chase. Per INIS's direction, Chase focused on UW requests to provide escort for the researchers that work in the HRT.

NA-21 management indicated that there was an under-appreciation of the scale of contamination and the location of the HRT being in a dense urban setting. The under-appreciation was exacerbated when NA-21 representatives went to a radiation control conference, during which DOH communicated the extent of the event was of manageable scale.

UW continued to seek more DOE assistance through several channels, including the University of California system, the State of Washington Governor's Office, and other political channels. The JIT determined that substantial DOE involvement was delayed because of poor communication between UW, Triad, and DOE HQ, resulting in an under-appreciation of the scale of the event.

The JIT determined that response coordination between DOE, Triad, DOH, and UW was not well-implemented until the Unified Command Structure was established, 15 days after the event.

Identified Causal Factors:

Triad did not have clear guidance from NA-21 on their role for an offsite emergency response (CF-4D)

Lack of communication between stakeholders inhibited response (CF-2A)

Response coordination was not well implemented until the Unified Command was established (CF-4C)

No formal leadership mechanism developed in response to the event (CC-4/C33)

DOE is managing work regulated by the NRC or an Agreement State without clearly defined roles and responsibilities (RC-2)

4.2.4 Medical Response

SFD inquired about medical issues when they arrived on-scene. There were no emergent life-threatening issues reported with this event for individuals identified as contaminated; therefore, SFD focused on decontamination activities.

DOE REAC/TS physicians provided guidance and assistance to SFD, DOH, and HMC medical personnel throughout the night to discuss how to treat the contaminated personnel.

SFD's decontamination process did not remove all contamination from personnel. HMC medical staff were concerned about contaminating their emergency room. Consequently, affected personnel waited in ambulances for an extended period. REAC/TS and DOH advised HMC medical staff, which resulted in affected personnel evaluation at the HMC at about 04:00 hrs. on May 3.

Urine samples were collected at the hospital, but never analyzed. DOH personnel conducted post-decontamination surveys, including qualitative nasal swabs from all INIS personnel. Four of the swabs were identified as positive, which indicated that radioactive material was inhaled into the body. Workers were released from the hospital by 09:00 hrs.

Bioassay sample collection for INIS personnel was completed approximately 48 hours after the event. They were analyzed by GEL Laboratories and validated by Triad. The results confirmed internal uptake of Cs-137.

In August, DOE, through Triad, reached out to involved organizations to offer confirmatory in vivo whole body counts conducted on affected individuals. The offer was declined by all parties.

ANALYSIS

The JIT determined that although there was a significant discussion needed in order for contaminated personnel to be admitted and issues with initial bioassay collection and analysis at the HMC, the medical response was acceptable.

Identified Causal Factors:

None

5.0 Safety Programs

5.1 Integrated Safety Management Systems

The objective of an organizations work planning process is to assure that safety is considered and practiced at all phases of the work. This planning process provides a structure for any work activity that could potentially affect the public, the workers, and the environment. The ISM process is designed to ensure that safety is effectively considered in all phases of work activities. The failure of any one of the core functions could result in the failure to effectively accomplish subsequent work. ISM is required at LANL through the incorporation of the DOE Acquisition Regulation (DEAR) clauses in the Prime Contract, as a proven and effective process for safely planning and executing work. The DEAR clauses are incorporated into the INIS subcontract for this work. The ISM process is analogous to the work processes element within the NRC *Traits of a Positive Safety Culture*. The core functions of ISM are to:

1. **Define the Scope**- identify boundaries, determine priorities, and expectations. The level of detail is determined by the importance, complexity and potential risk of the activity.
2. **Identify the Hazards**- identify hazards tailored to the work performance. Do a "what-if" analysis to determine what hazards involved with this activity could potentially affect the worker, public or the environment.
3. **Develop and Implement Hazard Controls-** Controls identified and tailored as appropriate to adequately address the hazards identified in performing this activity.
4. **Perform Work within the Established Controls-** work is performed per work documents that incorporate the hazard controls. All personnel associated with performance of this activity are sufficiently trained to understand the hazards and controls.
5. **Feedback and Improvement-** post-job review, discussion, or formal meeting that is an open forum, and lessons learned are incorporated to improve future work for continuous improvement.

ANALYSIS

INIS was doing work under a NRC license. In consideration of the INIS work planning and execution process, INIS mirrored a process that, in concept, followed the DOE ISM process in that they did define a scope of the work, determine associated hazards, develop hazard controls, and execute the work. However, the INIS work planning and control processes were not effectively implemented.

5.1.1 Define the Scope

Effective work execution begins with the development of a well-defined scope of work, which translates mission and requirements into terms that those who are to accomplish the work can clearly understand. The definition of work scope must provide sufficient detail to support hazard analysis and subsequent development and implementation of controls at the task level. Line management must determine the work to be accomplished and be accountable for completely understanding the scope through every phase of the work.

The OSRP currently resides in the NNSA Office of Radiological Security, NA-212, within the NA-21 Global Material Security organization. NA-212 engages Triad through the LANL M&O contract. The OSRP mission is to remove excess, unwanted, or disused radioactive sealed sources that pose a potential risk to national security, health, and safety.

Triad subcontracts with NRC-licensed vendors for high-activity beta/gamma source recovery operations. The INIS scope of work was defined in Subcontract No. 531850 between INIS and Triad, signed February 4, 2019. Exhibit D, *Scope of Work and Technical Specifications*, subtitle, *OSRP Recovery of Three Devices from UW* included recovery of five sources from three devices at two locations.

Scope of Work

Exhibit D Excerpts:

> *SUBCONTRACTOR shall furnish qualified personnel, equipment, materials and facilities in perform, as detailed in this Exhibit D, all services necessary to safely and compliantly package and transport high-activity beta/gamma emitting sealed sources/devices from domestic and international locations to a site identified on a Task Order basis by the CONTRACTOR.*
>
> *SUBCONTRACTOR shall be responsible for full removal and transportation of the sources/device listed in Table 1 in Appendix D-1…*
>
> *SUBCONTRACTOR shall also remove all extraneous pieces and part of the device in Table 1 of Appendix D-1 for the site … CONTRACTOR will accept the device shield(s) if shielding is required for transport of the device sources to the receiving facility or there is no other destination option for the shield, otherwise CONTRACTOR does not want the device shield.*

Although subcontract exhibits incorporated several DOE requirements, including radiation control, indemnification, and ISM, the scope of work in the subcontract was specific to NRC-licensed operations.

ANALYSIS

The scope of this activity, as defined in the contract, gave the subcontractor flexibility in how source retrieval and shipment would be performed. The contract language should have a clear definition of expected outcomes and safety boundaries within the work scope definition, to ensure hazards can be identified and addressed.

INIS believed, incorrectly, that the characteristics of the source were the same as a previously removed JLS source, as performed in Cleveland. INIS also did not understand this specific source design. This led INIS to plan the work without detailed information of the source.

INIS decided early in the scoping process to over-encapsulate the source. This pre-disposed planning activities to a higher-risk profile. INIS scoping also constrained the operation to a single shipment.

The JIT determined that INIS scoping activities pre-selected higher-risk methods that increased the potential for a widespread contamination event.

<u>Identified Causal Factors:</u>

INIS decided to over encapsulate the source rather than buying the design information from JL Shepherd (CF-1H)

Operations were planned without detailed information about the source (CF-1B)

INIS work planning and control processes were not effectively implemented (CF-1A)

5.1.2 Identify the Hazards

Hazard controls are established to protect the worker, the public, and the environment, and to anticipate human errors and put defenses in place.

There is no formal guidance for the conduct of subcontracted work off-site. Triad has no procedure governing off-site subcontracted work. In the absence of a procedure, NEN-3 partially implemented the contracting aspects of P850. To integrate ISM, P850 references P300, *Integrated Work Management,* as guidance for determining the hazard class of the work activity. This aspect of P850 was not implemented. Specifically, hazard grading was not performed in accordance with P300.

P300 suggests the use of an SME for assistance in determining hazard classes, and references LANL procedure P121, *LANL Radiation Protection*, in determining hazard classification for work involving radiological hazards. The radiation levels involved in this source recovery would have resulted in a high or moderate hazard categorization.

INIS relied on past experience and skill of the craft to identify hazards. INIS did not follow a step-by-step analysis of the work activity to evaluate the potential impacts of unanticipated machine or human performance. Based on a previous similar source recovery, and the fact that it was a special form sealed source, contamination was not considered a potential hazard associated with this activity. When employing powered tooling on hazardous devices, device-specific information is critical for understanding potential hazards. JLS-manufactured sources are fabricated to hold specific source configurations. INIS did not have JLS as-built information on the device configuration, thus assumed the internal design of the source holder assembly. They could not identify hazards associated with cutting operations.

The INIS procedure OP-SRC-040 Revision B, *JL Shepard Model Mark 1 and 143 Series Irradiator Source Unloading*, is applicable to four types of Model Mark 1 Irradiators and provides instructions for unloading the Cs-137 sources from the irradiators utilizing the INIS MHC. The procedure identifies four potential hazards, to include: 1) extremely high radiation levels associated with unshielded sources, 2) industrial hazards associated with handling of heavy pieces of equipment, 3) cart or roller lifts associated with moving the irradiator, and 4) electrical hazards associated with inadvertent energizing of the irradiator during disassembly. It was noted that the hazards associated with this INIS Field Services activity were not fully evaluated, including potential spread of contamination.

ANALYSIS

INIS did not follow a step-by-step hazard analysis of what could go wrong in each step of the process, with a subsequent determination of how to prevent and/or mitigate the failure. Instead, INIS relied on limited past experience to identify hazards. Based on a previous similar source recovery, contamination was not considered a potential hazard associated with this activity.

For high-risk activities, such as the source recovery work conducted by INIS, a documented "what if", or similar, analysis technique should always be used, and work should be performed by individuals with appropriate depth and breadth of expertise to identify and analyze the hazards thoroughly. Appropriate SME involvement is also required to ensure that the analysis is complete and effective.

The JIT determined that the INIS team did not consider contamination as a potential hazard to control. The hazards created as a result of grinding on the source holder assembly were also not adequately considered, analyzed, or understood by INIS.

Identified Causal Factors:

Hazard analysis was not conducted on potential contamination (CFx1)

Expected DOE processes not implemented or overseen (CF-C14)

5.1.3 Develop and Implement Hazard Controls

The objective of developing and implementing hazard controls is to identity and provide all engineering, administrative, and personal protective equipment requirements consistent with the hazards to be encountered. Hazard controls are identified and tailored to adequately address the hazards identified in performing the activity.

INIS identified radiological controls for high radiation fields and minor source contamination, and industrial hazards for this work.

Radiological controls included both engineered and administrative controls. Engineered controls included shielding provided by the MHC, transfer cask shielding, irradiator body shielding, and remote handling of the source. Administrative controls were incorporated into operating procedures and the RWP, for example, radiation and contamination surveys, alarming dosimetry, airborne monitoring equipment, area control, training requirements, and hold points.

Industrial controls included administrative controls, such as PPE requirements, physical hazards (e.g., hoisting and rigging, pinch points, and confined space), and electrical.

Unevaluated hazards controls included: broad contamination controls; work location; alternate tooling; seismic event; and confined space.

ANALYSIS

To adequately develop and implement hazard controls, the work scope must first be well defined and the hazards thoroughly analyzed. Since a broad spread of contamination was not identified as a credible hazard by INIS, the JIT determined that this was a missed opportunity to develop controls to prevent or mitigate a contamination event.

The JIT also determined that several controls should have been considered, as follows:

Preventive:

- Use of an alternative method for shipping the source that did not require cutting the source holder. Options included:
  - Shipping the entire irradiator.
  - Purchasing the source certification.
  - Over encapsulation of the entire source holder instead of removing the source capsule.
- Triad selection of a vendor that only required direct source transfer.

Mitigative:

- Selection of a cutting method that did not involve power tool use, such as a pipe cutter, for disassembly of the source holder.
- Incorporating contamination controls into the MHC.
- Use of the prescribed contamination monitoring equipment and associated response actions needed to prevent the spread of contamination.

The JIT determined that because all hazards were not evaluated, effective preventative or mitigating controls could not be developed.

Two key steps in the MHC operation were identified as irreversible and potentially irrecoverable from an upset condition:

- Cutting on the source holder with power tools renders the source unable to be returned to the irradiator for a safe configuration in the event of an upset condition.
- Using electrical tape to secure the electric saw on/off switch allows a failure mode where if the tape comes unwound, the saw will not be able to be turned on, and if occurring before the completion of cutting operations, renders the saw inoperable, and the source potentially unrecoverable and marooned in the MHC.

The JIT determined that the above conditions were not recognized or addressed in the procedures, and resulting work controls were not implemented.

<u>Identified Causal Factors:</u>

Safety requirements were not effectively implemented by INIS (CF-1D)

Operations were planned without detailed information about the source (CF-1B)

Work planning did not develop controls to mitigate a contamination event on the loading dock (CF-B12)

INIS developed their work package without necessary ISM considerations (CF-C15)

5.1.4 Perform Work within the Established Controls

Work is supposed to be performed in accordance with work documents that incorporate the hazard controls. All personnel associated with performance of this activity should be sufficiently trained to understand the hazards and controls.

The cutting operation relied on skill of the craft to perform precision cuts on a high-hazard radiological source.

The designated Person in Charge (PIC) is responsible for the safety and approval of the work, by reviewing and evaluating the work documents to ensure they were properly prepared. The PIC is to ensure equipment is available, the work area is prepared, and all personnel involved are trained to safely perform their assigned functions. The PIC of this activity was the RCO for the overall operation.

INIS failed to work within established controls. Workers involved with the movement and lifting of the loaded irradiator were not wearing proper PPE. Prior to mating the irradiator to the MHC, an individual stood on a toolbox under the MHC. He placed his head inside the assembled box and subjected himself to confined space hazards.

INIS conducted a pre-job briefing after the irradiator had been mated to the MHC. Therefore, the pre-job briefing focused on the source recovery inside the MHC and associated high radiation fields. The pre-job briefing was not documented.

Factual issues identified with procedure compliance included:

- *Emergency Response Plan* states, "*In any emergency, PERSONNEL PROTECTION IS THE NUMBER ONE PRIORITY followed by confinement, containment and shielding of the radioactive material or containment and containment [sic] of the of the chemical release.*" This procedure was not followed. INIS workers remained in an airborne contamination environment for four hours.
- WI-RWP-013, *Field Service-Source loading/unloading Utilizing MHC*, established an Airborne Radioactivity hold point of 1.0 DAC. A quantitative instrument for determining airborne radioactive materials was not at the site of the accident.
- The RWP was not briefed to observers who entered the work area several times, without knowledge of radiological controls or dosimetry requirements.
- PD-RSP-001, *Radiation Safety Manual*, states, "*In any radiation emergency, personnel safety is the priority followed by confinement, containment and shielding of the radioactive material*" and "*It is the responsibility of the each supervisor [PIC] to ensure that all supervised personnel are properly instructed with respect to the nature of the hazards and the necessary safety procedures are in the work area and that they possess the necessary skills and disposition to cope with radiation hazards. The supervisor is also responsible for ensuring necessary safety equipment is available and in working order.*" The necessary PPE to address the contamination hazards was not readily available on the loading dock. Personnel found a box of nitrile gloves on the loading dock, which were used to respond to the accident.

- PD-RSP-001, *Radiation Safety Manual*, states, "*INIS is committed to keeping all radiation exposures to staff, the public, and the environment As Low as Reasonably Achievable (ALARA)*". The RCO leaned on the MHC for an extended period, while the operators attempted to remove the source from the source holder. Additionally, Workers and Observers traversed the radiation field at the base of the MHC.

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INIS demonstrated relaxed safety practices while conducting work. This was evident as follows:

- Workers involved with the movement and lifting of the loaded irradiator were not all wearing standard PPE for his type of activity;
- While using the handsaw, sledgehammer and other hand tools, safety glasses were not worn; and
- The RCO stood on a toolbox under the MHC, placing his head and shoulders inside the 15" opening and exposing himself to unanalyzed hazards, such as confined space.

Additionally, INIS had a pre-job briefing prior to the start of the MHC operations. However, this occurred after the irradiator was moved and connected to the MHC. As a result, the pre-job briefing focused on the source recovery inside the MHC and associated high radiation fields, but did not include any of the industrial safety elements of the activity including a critical lift, or availability or use of PPE.

The JIT determined that the physical radiological boundaries established and maintained were not effective for controlling the radiological hazards. At the onset of the activity, working with UW, radiological boundaries were not established. Only caution tape was used to identify the work area. Radiation and high-radiation areas were not established and maintained around the loading dock area in accordance with the RWP, although dose rates would have warranted such action.

The MHC was not used as designed. The MHC was designed to use a donut shield to mitigate the release of radiation when the irradiator is mated to the MHC. Because this activity had not been appropriately walked down and mocked up prior to the evolution, the irradiator did not line up with the MHC and the donut shield was not used. Because the donut shield was not used, there was a high radiation stream (26-50 mR/hr) emanating from the bottom of the MHC, to approximately 10 feet outside of the dock area. The JIT determined that the absence of the donut shield allowed the work to be conducted outside of acceptable ALARA practices.

The JIT determined that INIS did not consistently follow their procedures, which significantly contributed to the event.

Issues identified by the JIT with procedure compliance included:

- *Emergency Response Plan* states, "*In any emergency, PERSONNEL PROTECTION IS THE NUMBER ONE PRIORITY followed by confinement, containment and shielding of the radioactive material or containment and containment [sic] of the of the chemical release.*" This procedure was not followed. INIS workers remained in an airborne contamination environment for approximately four hours.

- WI-RWP-013, *Field Service-Source loading/unloading Utilizing MHC*, established an Airborne Radioactivity hold point of 1.0 DAC. A quantitative instrument for determining airborne radioactive materials was not at the site of the accident. In addition, the RWP was not briefed to observers who entered the work area several times, without knowledge of radiological controls or dosimetry requirements.
- PD-RSP-001, *Radiation Safety Manual*, states, "*In any radiation emergency, personnel safety is the priority followed by confinement, containment and shielding of the radioactive material.*" and "*It is the responsibility of the each supervisor [PIC] to ensure that all supervised personnel are properly instructed with respect to the nature of the hazards and the necessary safety procedures are in the work area and that they possess the necessary skills and disposition to cope with radiation hazards. The supervisor is also responsible for ensuring necessary safety equipment is available and in working order.*" The necessary PPE to address the contamination hazards was not readily available on the loading dock. Personnel found a box of nitrile gloves on the loading dock, which were used to respond to the accident.
- PD-RSP-001, *Radiation Safety Manual*, states, "*INIS is committed to keeping all radiation exposures to staff, the public, and the environment As Low as Reasonably Achievable (ALARA)*". The RCO leaned on the MHC for an extended period, while the operators attempted to remove the source from the source holder. Additionally, Workers and Observers traversed the radiation field at the base of the MHC. Additionally, after the roll-up door was closed and prior to encapsulating the source in the MHC, personnel crossed in front of the MHC through the high radiation area to exit through the man door on the North side of the dock.
- OP-SRC-040, Step 7.2.12 states, "*Clamp the rod in place using a pipe clamp or vice grips and punch out the roll pin and replace it with a lifting eye or wire bail.*" Step 7.3.16 states, "*Perform a contamination wipe survey of the source tube and rod.*" Neither of these steps were performed.

INIS did not adequately control the work:

- Workers remained in the area after the known material release;
- Correct radiation protection equipment (e.g., airborne contamination meter) was not available;
- PPE was not readily available and was not used; observer movements were not controlled;
- ALARA practices were not observed, and emergency response actions were inadequate.

The JIT determined that INIS failed to work within established controls.

<u>Identified Causal Factors:</u>

INIS training program did not prepare INIS personnel to conduct off normal work activities and to address emergency response during Field Services work (CF-1G)

INIS did not have an emergency response process to cover Field Services work (CF-1F)

INIS work planning and control processes were not effectively implemented (CF-1A)

INIS work planning and control deficiencies were not identified or corrected prior to performing work (CF-C21)

Immature safety culture led to completion of work activities taking priority over safe conduct of the work (CF-1E)

INIS conducted work inconsistent with a robust safety culture (CC-1)

5.1.5 Feedback and Improvement

Feedback and improvement processes are designed and implemented to provide information on the adequacy of the work controls, to identify and implement opportunities for improving the definition and planning of work, and to utilize line and independent oversight processes to provide information on the status of safety. The feedback and improvement function is intended to identify and correct processes or conditions that lead to unsafe or undesired work outcomes, confirm that desired work outcomes were arrived at in a safe manner, and provide managers and workers with information to improve the quality and safety of subsequent, similar work.

The INIS QA Manual outlines a process for Improvement through Corrective and Preventive Actions. The plan addresses the facility or activity elements that potentially have an adverse effect on quality or safety. Past corrective actions indicate that INIS does follow their established procedure for this process. However, line management does not conduct independent oversight because they are involved in work planning and execution. For example, a senior line manager was the PIC for this operation.

The Completion Report for the Cleveland Source Recovery Activity, dated May 17, 2017, was provided to LANL as a requirement of Exhibit D of Subcontract 430773. In addition to the specifics of the activity, a number of lessons learned identified and documented in the report included:

- Improving communication with the landlord in the pre-planning of the activity;
- Evaluating the irradiator mating to the MHC; and
- The use of radiation hardened cameras, the use of mock up in the welding process.

Additionally, INIS identified that instead of punching the roll pin that is used to keep the aluminum source tube from backing off the threaded tungsten plug, they used a cutting wheel to cut through the aluminum; as recommended by SwRI. This resulted in having metal filings in the cell, so they would evaluate an alternative method of removing the roll pin.

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Based on the after-action report from the Cleveland work evolution, the JIT determined that the INIS lessons-learned process is immature, as it continues to focus solely on operations rather than safety. This is contrary to ISM and NRC principles of positive safety culture.

The JIT identified the following feedback and improvement items:

The unique nature of this contract involving work across regulatory boundaries (i.e., DOE managing work that was regulated by an Agreement State) resulted in undefined roles and responsibilities related to safety oversight of the operation in the field.

While interviewees agreed that the DOH was the regulator for the activity, there were questions as to field oversight responsibilities. NEN-3 considers their oversight responsibility to be in a general safety capacity, to preclude any appearance of directing work and thereby incurring responsibility. Since an AdSTR was assigned to the contract, oversight responsibilities in accordance with P850 were limited to monitoring compliance with terms and conditions of the contract, not technical and safety performance.

DOH personnel saw their oversight role as verifying compliance with the subcontractor's reciprocity license and monitoring area dose rates during the activity, but considered their presence to be for "observation" rather than "inspection". Their reciprocity inspection was scheduled for Sunday, May 5, after all of the sources were retrieved. When DOH regulatory personnel were informed that cutting and grinding would have to be performed on the source tube, it did not raise any significant concerns with the regulators because they believed the subcontractor was experienced with the source tube and their processes to perform the cuts safely.

The UW RSO was also present for the source retrieval but believed he had no official oversight role since this was a DOE contract job (no UW personnel involved) and was regulated by DOH. The UW RSO assisted with radiation monitoring, particularly on the third floor where he posted a radiation area in the lab above the MHC during the source retrieval activity, but did no oversight on the subcontractor activities.

As identified in Section 2.1.3.2, LANL procedure P850 establishes LANL institutional STR program requirements and is primarily applicable to conducting on-site work. Because this activity was performed off-site by a subcontractor, many formal work review and oversight practices required for on-site subcontract work were not employed by Triad, including:

- Triad safety SMEs were not required for the oversight process or technical review of contract submittals.
- Subcontractor procedure or process reviews were not conducted or required by Triad or the DOH regulators.
- NEN personnel had the perception that evaluating procedures or safety plans was discouraged as part of the technical review, so as not to appear to be directing subcontractor work.

The basis of these items are:

Exhibit H, Section IV, Nuclear or Radiological Work, was checked as "YES", indicating that failure of the items and/or services to be furnished under this subcontract may affect nuclear or radiological safety. In addition to triggering the inclusion of the PAAA clause, this is typically an indication that the process should be evaluated by a radiological SME for on-site work. Because AdSTRs are not required to have technical expertise for the contracts they oversee, it is unlikely that an AdSTR would have identified those hazards even if they had thoroughly reviewed the proposal.

Because the subcontract was performed off-site with no hazard grading or analysis, oversight was assigned to a Triad AdSTR instead of an STR. STRs are Triad personnel who provide technical oversight of moderate and high-risk subcontracts. AdSTRs are responsible for oversight of the subcontractor's compliance with the established terms and conditions of low-hazard subcontracts. Training requirements are significantly different between the two designations. STRs are specifically trained for their duties, while AdSTRs do not have a formal training requirement.

DOH was responsible for review and approval of the NRC license reciprocity application for the subcontractor to perform work in the state. Documentation reviewed included the subcontractor's NRC license, regulatory compliance record, training records, emergency procedures, and the project overview, as provided by the UW RSO. DOH did not review INIS operations procedures for the planned work activity because none were provided. DOH personnel stated that consideration was given to the fact that this was a DOE-contracted activity.

NEN-3 indicated that they were discouraged from reviewing procedures, processes, and safety plans of the bidders during the technical review, so as not to appear to be "*directing work*", which could have incurred responsibility to Triad. ASM stated that they relied on the requesting organization and their SMEs to determine safety, regulatory, and quality controls relevant to the contract work requirements. Because the AdSTR felt that procedure reviews were outside the scope of their technical review, they were not aware of the techniques that would be employed to remove the source from the source tube and could not make an informed determination as to the technical soundness of the subcontractor's methodology. This was considered a low-hazard operation, and therefore additional SMEs, who could have identified the inherent hazards associated with the subcontractor's planned process to separate the source holder with a cutting wheel, were not employed to review the procedures.

<u>Identified Causal Factors:</u>

Expected DOE processes not implemented or overseen (CF-C14)

Operations were not analyzed, controlled, or implemented as would be expected for a typical DOE operation (CF-C16)

Work was authorized and conducted without addressing potential contamination concerns (CF-C18)

INIS work planning and control deficiencies were not identified or corrected prior to performing work (CF-C21)

INIS was allowed to conduct operations without technical or safety oversight from stakeholders (CF-B1)

INIS developed their work package without necessary ISM considerations (CF-C15)

Work planning and control oversight was not conducted on INIS (CF-C25)

Triad did not providing oversight of technical aspects of the contract (CF-C23)

The INIS work package was not reviewed, or approved, by either Triad, UW, or DOH (CF-CZZ)

INIS conducted operations without independent review of their processes (CF-C27)

Safety oversight was not effective due to unclear roles and responsibilities (CC-3)

5.2 Safety Culture

An established safety culture, as defined by the NRC, is distinguished by both attitudes and accepted practices. It governs the actions and interactions of all individuals and organizations engaged in hazardous activities. Elements of the NRC Safety Conscious Work Environment include: Communication, Training, Procedures, Stop Work, and Planning. An immature safety culture led to the completion of work activities taking priority over safe conduct of the work.

5.2.1 Communication

It was apparent that the stakeholders were not fully aware of INIS's contracted and planned activity. While INIS thought they shared all relevant information, INIS was not transparent in communicating to DOH or UW that cutting on the source holder was to be conducted during the source recovery operation, and there was not a clear understanding of the scope of the work prior to the start of the project. DOH and UW understood the work to be consistent with other source removals that did not include cutting the source holder. INIS may not have recognized how sharing the intricacies of the work in the planning process might have influenced stakeholders to consider the consequences of performing a high-consequence activity in an uncontained environment.

5.2.2 Training

INIS has established and implemented processes to train personnel in field service activities. Two individuals associated with the HRT operations were in training at the time of the accident. The fact that these people were involved did not contribute to the accident, as is documented in the interviews. There was interaction between the trainees and lead operator that demonstrated positive mentoring. The fact that this was the first time the operator-in-training had attempted to grind the pins on a source holder is an indication of a less-than-adequate safety culture that is threaded throughout the INIS organization. A high-risk activity such as this should have been practiced and perfected in a mock-up situation prior to working with nuclear materials. While the JIT does not endorse the methods used, training for any high-risk activity should not be conducted in a live environment, until it has been practiced in a mock-up situation. The INIS training program did not prepare INIS personnel to conduct off-normal work activities and to address emergency response.

Training records for INIS did not indicate any vendor-specific training for the JLS Mark 1-68 irradiator. Information available to the JIT indicated that the basis for the SwRI training does not include vendor or irradiator-specific instructions on disassembly or removal of source capsules from source holders, etc.

The Triad STR training does not include elements for conducting oversight of off-site subcontracted work.

5.2.3 Procedures

The INIS QA processes did not ensure adequate procedures for personnel conducting hazardous operations. The INIS QA Manual, QP-QMS-001, Rev L, considers a graded approach to risk management. The graded approach assigns QA requirements based on:

- Risk significance;
- Relative importance to safety, safeguards, and security;
- Applicable regulations, industry codes, and standards;
- Complexity or uniqueness of the item/activity, and the environment in which it has to function; and
- Quality or safety history of the item in service or activity recovery.

The INIS Procedure did not include controls or barriers equivalent to the risk significance of this activity, or the complexity or uniqueness of the activity and the environment in which it had to function. Given the location and the consequences associated with a source breach, associated procedures should not have considered the use of a cutting saw without specific engineered controls to ensure a safe and compliant work evolution. The procedures should have been practiced in a mock-up environment, including simulated upset conditions to ensure that operators were trained to respond to off-normal events.

Triad does not have a procedure for subcontracting work activities conducted off-site that is analogous to P850. This resulted in a lack of ISM implementation for off-site subcontracted work.

5.2.4 Stop/Pause Work

The JIT determined that individuals did not demonstrate a questioning attitude. This complacency was derived from past successes in doing similar work. It is also due to a "group-think" mentality, derived from shared assumptions and beliefs that contamination was not a hazard associated with this activity. While this is particularly relevant to the INIS personnel conducting the work, pre-disposed notions from observers contributed to the same mindset.

Personnel observing the work activity were not sufficiently familiar with the expected evolution to recognize deviations from planned operations. They were preoccupied with conducting independent work activities, such as radiation monitoring and source security. They were also predisposed to consider this work evolution as routine because of the expected INIS expertise, due to the NRC license and DOE selection as the recovery lead.

The JIT determined that several opportunities were missed to pause or stop operations.

5.2.5 Planning

INIS relied on past experience to plan the work, as demonstrated in equipment design and procedure development. Delayed completion of operating procedures inhibited review by stakeholders. On-site planning activities focused on security, transportation, and logistics, with little or no discussion about the specifics or hazards associated with source recovery operations using the MHC.

Overall, planning for this work activity did not address the high-hazard nature of the operation, and minimized development of ISM core functions and review by stakeholders.

5.2.6 Evolution

The evolution did not proceed as planned or expected. Issues were identified with procedural compliance, PPE utilization, radiation protection, industrial safety, immediate response to the contamination event. These deficiencies are detailed Section 5.1.4. The JIT determined that it was apparent that work was conducted without operational rigor or a questioning attitude.

5.3 Human Performance Review

The Human Performance considerations of this accident investigation were undertaken per DOE Handbook 1028-2009, *Human Performance Improvement Handbook*, Volume 1, Section 1-14, *Anatomy of an Event*.

None of the stakeholders involved in this source recovery had a fully accurate understanding of the work activity, i.e., that the source capsule would be removed from the source holder, and that this would be accomplished using a cutting saw. Stakeholder focus was restricted to their respective involvement (e.g., contractual, regulatory, security, facility, etc.) and historical experience. This resulted in incomplete information availability (imprecise communication habits), suppositions regarding the work activity that were not verified (assumptions), and an inaccurate understanding of potential consequences (inaccurate risk perception). These human performance error precursors represent a skill-based performance model, in that the stakeholders were very familiar with their respective roles related to the work activity, but did not recognize the potential risk for a broad contamination event.

When the source holder was transferred into the MHC, INIS was in a position where the work activity had to proceed to completion, i.e., over encapsulation of the source and placement into the transfer cask (irrecoverable act). At this point in the work evolution, INIS was working in a skill-based performance mode. INIS relied heavily on a single, previously successful job for the execution of this work activity, and believed their projected understanding of the work steps were accurate (assumptions). INIS encountered an unfamiliar situation when the source holder did not unthread as expected (unexpected equipment condition). Continued cutting on the roll pin revealed a trial-and-error approach, in that there was not conclusive information (based on fact or experience) by which to proceed (indistinct problem-solving skills).

When the attempts to separate the tungsten rod from the aluminum tube were unsuccessful, INIS proceeded to the next procedural step to cut on the source tube directly below the roll pin. This step had never been performed and there was, again, a heavy reliance on the unverified configuration of the source holder (assumptions, lack of knowledge, interpretation requirements). Additionally, there was a sense of urgency to complete the operation as soon as possible, due to ALARA concerns (time pressure).

Ultimately, INIS workers quickly transitioned to a knowledge-based performance mode, in that their problem-solving and decisions were based on limited information and assumptions. The work evolution was predominantly reliant on inaccurate information. For the majority of the work evolution, including the immediate response to the contamination event, they were operating in the riskiest performance mode most likely to result in errors.

6.0 Analyses

The JIT used different analytical techniques to determine the causal factors of the accident, including event and causal factor, change, and barrier analysis. Causal factors are the events or conditions that produced or contributed to the occurrence of the accident. The JIT then assessed the causal factors, using them to develop direct, contributing, and root causes. The direct, contributing, and root causes as identified by the JIT are included at the end of this section.

In turn, the JIT developed CONs and JONs from these identified causes. Table I, in Section 7.0, presents the JONs developed by the JIT.

6.1 Barrier Analysis

Barrier analysis considers hazards that result in an accident or event. For an accident/event to occur there must be an exposure of the hazard to the target (worker) because the barriers or controls were not in place, not used, or failed. A hazard is the potential for unwanted energy flow to result in an accident or other adverse consequence(s). A target is a person or object that a hazard may damage, injure, or fatally harm. A barrier is any means used to control, prevent, or impede the hazard from reaching the target, thereby reducing the severity of the resultant accident or adverse consequence(s). Barriers are a part of a system or work process to protect personnel and equipment from hazards.

The JIT reviewed multiple potential barriers, which may have kept this accident and its subsequent results from occurring. Appendix B contains a summary of those barriers and their effectiveness. As examples, this analysis identified potential barriers such as using a closed MHC to contain potential contamination, effective hazard analysis and work planning, a questioning attitude, and safety reviews of the task-level activities being conducted.

6.2 Change Analysis

Change is anything that disturbs the "balance" of a system from operating as planned. Change is often the source of deviations in system operations. Change can be planned, anticipated, and desired, or it can be unintentional and unwanted. Change analysis examines planned or unplanned changes that caused undesired results or outcomes related to the event. The process analyzes the difference between what is normal (or "ideal") and what actually occurred.

The JIT analyzed multiple changes identified during the investigation. Appendix C provides a summary of those changes the JIT felt were applicable to this accident. The analysis identified several factors involving the ability of the MHC to contain contamination, the difference between typical DOE work and work conducted under NRC requirements, identification and implementation of radiological controls, oversight, and identifying safer methods to conduct the activity. In this analysis, the JIT considered both the change from normal and ideal practices, because the JIT felt that even though source removal activities had been conducted by INIS without incident in the past, the techniques used in this situation were not ideal, and represented a series of deviations from preferred practices.

6.3 Events and Causal Factors Analysis

An events and causal factors analysis was performed in accordance with the DOE *Workbook for Conducting Accident Investigations*. The events and causal factors analysis begins with identifying the facts that are identified as events or conditions in place at the time of the accident. This analysis requires deductive reasoning to determine which events and/or conditions contributed to the accident. The analyses conducted by the JIT are based on the events and conditions identified and the causal factors are then included on the Events and Causal Factor chart. A summary of the chart is located in Appendix D. Causal factors determined as direct, contributing, and root causes (as determined by the JIT) are identified on the chart.

Please note the Events and Causal Factors Chart is meant to be a comprehensive reflection of the timeline. Not all of the items reflected on the Events and Causal Factors Chart are developed in the narrative in this report. However, the narrative developed was sufficient to fully support the causes, conclusions, and judgments of need.

6.4 Causes

Based on the analysis of the facts conducted by the JIT, the JIT determined the following causes of the accident.

- DC – the immediate events or conditions that caused the accident.
  DC: Cesium was released as a result of cutting operations on the source holder assembly.
- RC – Causal factors that, if corrected, would prevent recurrence of the same or similar accidents.

  RC-1: Triad contracting process does not effectively implement safety requirements for off-site work.

  RC-2: DOE is managing work regulated by the NRC or an Agreement State without clearly defined roles and responsibilities.
- CC – Events or conditions that, collectively with other causes, increased the likelihood or severity of an accident, but that individually did not cause the accident.

  CC-1: INIS conducted work inconsistent with a robust safety culture.

  CC-2: Safety requirements not flowed down by Triad.

  CC-3: Safety oversight was not effective, due to unclear roles and responsibilities.

  CC-4: No formal leadership mechanism was developed in response to the event.

7.0 Conclusions and Judgments of Need

Table I links the Conclusions (CONs) to Causal Factors (CFs). The CFs are the analytical results performed during this investigation for determining what happened and why it happened utilizing the Barrier Analysis, Change Analysis, and Events and Causal Factors Chart tools (reference Appendices B, C, and D).

Table I: Conclusions to Causal Factors Cross Reference

Conclusion	Causal Factors
DOE is responsible for operations conducted by subcontractors operating under a NRC license without corresponding oversight [CON-1]	RC-2, CF-13, CF-C14, CF-C15, CF-C16, CF-B1
DOE is managing work outside of its regulatory authority, and relying on the NRC licensing process to ensure safety of high-activity beta/gamma source recovery operations [CON-2]	RC-2, CC-3, CF-BZZ, CF-CYY
Application of DOE DEAR requirements is not understood by NA-21 for subcontracted NRC regulated work [CON-3]	RC-2, CC-1, CC-3, CF-13, CF-C14, CF-C15, CF-C16, CF-CYY, CF-1E, CF-B1
DOE has not evaluated how work is to be conducted when another agency has regulatory authority [CON-4]	CC-3, CF-16, CF-CYY, CF-BZZ
DOE and NRC roles and responsibilities for gamma source recovery is not clearly defined or documented when DOE is conducting the work [CON-5]	CC-3, CF-16, CF-CYY, CF-BZZ
DOT regulation allowance for self-certification inadvertently and negatively impacted operational safety [CON-6]	CF-CAAA
DOE responsibilities, authorities, and accountability for NRC/Agreement State-licensed source recovery were not clearly communicated to the stakeholders involved [CON-7]	CF-CYY
Having a NRC license was viewed by LANL and DOH as evidence of technical competency and assurance the work would be conducted safely. This led Triad, DOH, and UW to incorrectly assume that INIS would perform the work safely, which resulted in a complacency of oversight [CON-8]	CF-BYY, CF-BZZ, CF-C13, CF-C14, CF-C15, CF-C16, CF-CYY, CF-B1
DOE does not have a mechanism to provide oversight of Triad off-site subcontracted activities [CON-9]	CF-C16, CF-C18, CF-C21, CF-C25, CF-C27
Triad does not have formal processes in place to train personnel to oversee off-site work performed by sub-contractors [CON-10]	CC-2, CF-B1
Triad did not meet requirements for developing, awarding, and management of off-site subcontracts as identified in the prime contract [CON-11]	RC-1, CC-2, CC-3, CF-B1, CF-BAA, CF-C16, CF-C21, CF-C23, CF-C25, CF-C27, CF-CYY

Table I: Conclusions to Causal Factors Cross Reference

Conclusion	Causal Factors
Triad did not evaluate work practices and procedures due to concerns over directing subcontractor work and incurring corporate responsibility [CON-12]	CF-C16, CF-C21, CF-C23, CF-C25, CF-C27, CF-CZZ
Triad does not have established requirements for STR responsibilities for off-site work [CON-13]	CF-B4/C2/CFx1, CF-C18, CF-C21, CF-C23, CF-C25, CF-C27
Application of DEAR ISM requirements was not consistently applied during contract processing or conduct of the work [CON-14]	CF-C13, CF-C14, CF-C15, CF-C16
Contracting processes/practices did not include evaluation of environment, safety, health, and quality assurance for RFQ development, or technical evaluation of contract submittals for offsite work [CON-15]	CF-C14, CF-C15, CF-C16
The elements of integrated safety management, as required by the DEAR Clause in the contract for a rigorous and credible safety program, were not implemented by INIS for the source recovery work [CON-16]	CF-C13, CF-C14, CF-C15, CF-C16
Analysis of the work hazards (including potential contamination events), developing controls, incorporating controls into procedures, and performing work in accordance with procedures was not conducted or communicated to stakeholders [CON-17]	CF-B1, CF-C18, CF-C21, CF-BCCC
A lack of separation between safety leadership and corporate responsibilities within INIS resulted in prioritization of mission completion over safe conduct of work [CON-18]	CC-1, CF-1A, CF-1C, CF-1D, CF-1E, CF-1H
INIS has not implemented a robust safety culture in accordance with the NRC licensing guidance. [CON-19]	CF-1A, CF-1D, CF-1E
INIS's quality assurance processes do not ensure adequate procedures for personnel conducting hazardous operations [CON-20]	CF-C18
Lack of proper radiological controls resulted in radiation exposure to unmonitored individuals and lack of identification of the spread of contamination [CON-21]	CF-B4/C2/CFx1, CF-C4/CFx3, CF-1G, CF-B12, CF-BXX, CF-C18
INIS's lack of preparedness for consequence mitigation increased the spread of contamination to the facility and personnel [CON-22]	CF-B4/C2/CFx1, CF-C4/CFx3, CF-B12, CF-BXX, CF-BCCC, CF-C18
Spread of contamination occurred because the potential for breaching the source was not considered or reevaluated when power tools were used, or when additional cutting operations that increased the chance	CF-B4/C2/CFx1, CF-B12, CF-BXX, CF-C21, CF-1B

Table I: Conclusions to Causal Factors Cross Reference

Conclusion	Causal Factors
of breaching the source (e.g., the radial cutting) were performed [CON-23]	
Opportunities to stop and pause operations were missed, and changes in process conditions were not evaluated, which could have prevented or limited the spread of contamination [CON-24]	CF- B7, CF-1B, CF-1D, CF-1F
The breach was not immediately identified because contamination controls, such as swipes, and instrumentation were not utilized [CON-25]	CF-1C
After RAP departure, recovery activities were fragmented and ineffective until establishment of a Unified Command due to lack of emergency response pre-planning and ineffective communications [CON-26]	CC-4, CF-2A, CF-4A, CF-4B, CF-4C, CF-4D

In summary, the JIT concluded that the likelihood of this accident would have been greatly reduced if:

- The choice to cut into the source tube had not been made;
- Proper oversight and training was conducted prior to the work being conducted; and
- Hazards were properly identified and controlled.

Table II provides the JONs identified by the JIT to its corresponding CONs.

Table II: Conclusions and Judgments of Need as determined by the JIT

Conclusions	Judgments of Need
• DOE is responsible for operations conducted by subcontractors operating under a NRC license without corresponding oversight. [CON-1] • DOE is managing work outside of its regulatory authority, and relying on the NRC licensing process to ensure safety of high-activity beta/gamma source recovery operations. [CON-2] • Application of DOE DEAR requirements is not understood by NA-21 for subcontracted NRC-regulated work. [CON-3] • DOE has not evaluated how work is to be conducted when another agency has regulatory authority. [CON-4] • DOE and NRC roles and responsibilities for gamma source recovery are not clearly defined or documented when DOE is conducting the work. [CON-5]	• NA-21 needs to work with NRC to clarify roles, responsibilities, authorities, and accountabilities for requirements and methods for conducting source recovery work, and oversight of NRC/Agreement State-licensed recovery work. [JON-1]

Table II: Conclusions and Judgments of Need as determined by the JIT

Conclusions	Judgments of Need
• DOT regulation allowance for self-certification inadvertently and negatively impacted operational safety. [CON-6]	• NA-21, with support from NA-50, needs to work with DOT to evaluate the feasibility of a publically-accessible domestic special form registry to support shipments of special form sealed sources (similar to the requirements for the international CoCAs). [JON-2]
• DOE responsibilities, authorities, and accountability for NRC/Agreement State-licensed source recovery were not clearly communicated to the stakeholders involved. [CON-7] • Having a NRC license was viewed by Triad, DOH, and UW as evidence of technical competency and assurance the work would be conducted safely. This led Triad, DOH, and UW to incorrectly assume that INIS would perform the work safely, which resulted in complacency of oversight. [CON-8]	• NA-21 needs to establish a policy to ensure stakeholders are informed of, and agree to, responsibilities, authorities, and accountability for retrieval of NRC-licensed sources. [JON-3]
• DOE does not have a mechanism to provide oversight of Triad off-site subcontracted activities. [CON-9] • Triad does not have formal processes in place to train personnel to oversee off-site work performed by subcontractors. [CON-10] • Triad did not meet requirements for developing, awarding, and management of off-site subcontracts, as identified in the prime contract. [CON-11] • Triad did not evaluate work practices and procedures, due to concerns over directing subcontractor work and incurring corporate responsibility. [CON-12] • Triad does not have established requirements for STR responsibilities for off-site work. [CON-13] • Application of the DEAR ISM requirements was not consistently applied during contract processing or conduct of the work. [CON-14] • Contracting processes/practices did not include evaluation of environment, safety, health, and quality assurance for RFQ development, or technical evaluation of contract submittals for off-site work. [CON-15]	• NA-21 prime contractors managing OSRP source recovery operations need to develop a strategy to ensure source recovery work plans and procedures are within the scope of the applicable NRC License prior to approval to commence work. [JON-4] • NNSA needs to evaluate oversight requirements for off-site work conducted by M&Os and their subcontractors. [JON-5] • Triad needs to assure that prime contract safety requirements are identified, developed and implemented for off-site subcontracted work. [JON-6] • Triad needs to establish a process to assure that off-site subcontracted work is accurately characterized and ensures that subcontractors have effectively implemented ISMS. [JON-7]

Table II: Conclusions and Judgments of Need as determined by the JIT

Conclusions	Judgments of Need
• The elements of integrated safety management, as required by the DEAR Clause in the contract for a rigorous and credible safety program, were not implemented by INIS for the source recovery work. [CON-16] • Analysis of the work hazards (including potential contamination events), developing controls, incorporating controls into procedures, and performing work in accordance with procedures was not conducted or communicated to stakeholders. [CON-17] • A lack of separation between safety leadership and corporate responsibilities within INIS resulted in prioritization of mission completion over safe conduct of work. [CON-18] • INIS has not implemented a robust safety culture in accordance with the NRC licensing guidance. [CON-19] • INIS' quality assurance processes do not ensure adequate procedures for personnel conducting hazardous operations. [CON-20] • Lack of proper radiological controls resulted in radiation exposure to unmonitored individuals and lack of identification of the spread of contamination. [CON-21] • INIS' lack of preparedness for consequence mitigation increased the spread of contamination to the facility and personnel. [CON-22] • Spread of contamination occurred because the potential for breaching the source was not considered or reevaluated when power tools were used, or when additional cutting operations that increased the chance of breaching the source (e.g., radial cutting) were performed. [CON-23] • Opportunities to stop and pause operations were missed, and changes in process conditions were not evaluated which could have prevented or limited the spread of contamination. [CON-24] • The breach was not immediately identified because contamination controls, such as	NA-21 needs to collaborate with prime contractors managing OSRP source recovery operations to ensure selection of subcontractors that: – Implement a formal and rigorous hazard analysis and work planning and control program in accordance with ISMS principles; – Have a robust safety culture in accordance with the NRC Safety Culture requirements; – Have and maintain emergency response plans for off-site recoveries that ensure integration with local response assets. – Communicates the full scope of work to ensure all stakeholders understand the work method, including key steps, hazards, and controls. [JON-8]

Table II: Conclusions and Judgments of Need as determined by the JIT

Conclusions	Judgments of Need
swipes, and instrumentation were not utilized. [CON-25]	
• After RAP departure, recovery activities were fragmented and ineffective until establishment of Unified Command due to lack of emergency response pre-planning and ineffective communications [CON-26]	• NA-80 needs to develop a process to provide advice and assistance to local response leads at the conclusion of RAP assessment operations, based on RAP FTL recommendations. [JON-9]

8.0 Team Signatures

Patrick S. Moss
Team Co-Chair
National Nuclear Security Administration
Los Alamos Field Office

Audrey Hakonson-Hayes
Team Co-Chair
Triad National Security, LLC

Nathan A. Morley
Team Member/Trained Accident Investigator
National Nuclear Security Administration
Office of Safety, Infrastructure and Operations

James A. Mumma
Team Member
National Nuclear Security Administration
Office of Safety, Infrastructure and Operations

Kerry N. Smith
Team Member
Triad National Security, LLC

Robert M. Boyko
Team Member
Triad National Security, LLC

8.1 Joint Investigation Team Member Biographies

Patrick S. Moss

Patrick Moss serves as Assistant Manager for Field Operations at the NNSA's Los Alamos Field office, where he is responsible for facility representatives, safety system oversight, nuclear safety implementation, and safety & health.

Prior to becoming the Assistant Manager, Moss worked as the Deputy Manager for Field Operations and has served as a criticality safety subject matter expert.

Mr. Moss holds Bachelors and Masters Degrees in Physics from Creighton University. Mr. Moss was the Los Alamos Site Office Criticality Safety Program Manager from September 2006 until February 2019. He was the lead technical interface at the Field Office for Nuclear Nonproliferation, Science, Emergency Response, and Intelligence programmatic activities from 2002 until 2006. He began his carrier with DOE in 2000 as a participant of the Technical Leadership Development Program in 2000.

Prior to joining the federal government, Mr. Moss worked as a design engineer with LAB-InterLink, Inc. in the areas of optical engineering, systems analysis and optimization, and robotics. He was a team member in the latest revision of ANSI/ANS 8.23, Nuclear Criticality Accident Emergency Planning and Response. He is co-author on the National Committee for Clinical Laboratory Standardization standard, AUTO2-A, Laboratory Automation: Bar Codes for Specimen Container Identification; Approved Standard. He is listed as inventor on the U.S. Patent for a scanning system for reading bar codes affixed to an item regardless of angular orientation. He has participated in numerous Nuclear Safety Assessments and Emergency Response activities within the NNSA complex as both a team member and team lead.

Audrey Hakonson-Hayes

Audrey completed a Master's of Science in Radioecology from Colorado State University in 2000 and joined the Nuclear Regulatory Commission (NRC) that same year. While at the NRC she worked as a Technical Staff Member in the Office of Nuclear Reactor Regulation (NRR) and as a Nuclear Materials Safety and Safeguards (NMSS) Enforcement Specialist in the NRC Office of Enforcement. She joined Los Alamos National Laboratory in 2005, as an Occurrence Investigator where she became a qualified Human Performance Improvement Practitioner and successfully completed DOE Accident Investigation training. In 2013, Audrey transitioned to the Price Anderson Amendments Act Office where she supported 10 CFR 830, Nuclear Safety Management, compliance reporting. In 2014, she became the Group Leader for the Standards and Calibration Laboratory where she leads continuous environmental, safety, health and operational improvements.

Nathan A. Morley

Nathan A. Morley, CQA, CQMOE, is currently in the Office of Nuclear Safety Services (NA-512) within the Office of the Associate Administrator for Safety, Infrastructure and Operations (NA-50). He received a Bachelor of Science degree in Nuclear Engineering from the University of New Mexico in 1986, has been certified by the American Society for Quality, as a Quality Auditor since 1999, and as a Manager of Quality/Organizational Excellence since 2006. He is also a Senior Member in the American Society for Quality. Mr. Morley has completed the Operational Readiness Review for Team Members class and the Operational Readiness Review for Team Leaders class. He has also completed the Technical Review Team Leader technical qualification standard. Mr. Morley has also achieved the Quality Assurance and Senior Technical Safety Manager qualifications within the Department of Energy's Technical Qualification Program.

Mr. Morley has experience as a team member and team leader on various assessment teams from 1990 to the present including numerous readiness verification reviews, project reviews and subject matter reviews in areas such as quality assurance, formality of operations and training. Mr. Morley has served on six accident investigation boards.

Mr. Morley also led a group of DOE and contractor personnel conducting a review of quality assurance programs and implementation plans as required by Title 10 Code of Federal Regulations (10 CFR) Part 830, Subpart A; and has participated on assessments of Radiation Protection Programs and other assessments related to the review of the implementation of 10 CFR 835 requirements. Mr. Morley was detailed to the Amarillo Area Office in 1995 to write the Quality Assurance Plan for Area Office. Mr. Morley continues to serve as a recognized non-weapons QA SME and continues to provide guidance and assistance on QA issues to the National Nuclear Security Administration (NNSA) community. Mr. Morley has also served as the Vice Chair of the Department of Energy Quality Council.

James A. Mumma

James Mumma is a Packaging Certification Engineer with the NNSA Office of Packaging and Transportation (NA-531). In this capacity, Mr. Mumma leads and conducts reviews of Packaging and Transportation (P&T) safety bases of offsite authorizations, certificates, and determinations as defined by DOE Order 461.1C for transport of materials of national security interest. Mr. Mumma joined the NNSA in 2005 as a member of the Nevada Field Office through the Future Leader's Career Intern Program. Mr. Mumma was stationed in Mercury, NV as a Facility Representative (FR) for the Nevada Field Office. Mr. Mumma was also a FR for the Los Alamos Field Office.

Mr. Mumma has conducted a number of assessments of varying depth and breadth. This includes operational awareness activities to Operational Readiness Reviews (ORR). He has assessed areas within P&T, P&T Quality Assurance, Conduct of Operations, ISMS, work control, emergency management, occurrence reporting, nuclear maintenance, and contractor and federal T&Q.

Mr. Mumma is a graduate of the Sandia National Laboratories' Weapon Intern Program. Mr. Mumma holds a Bachelor's of Science degree in Mechanical Engineering from the University of New Mexico.

Kerry N. Smith

Kerry Smith has over 30 years of experience working in Government-Owned, Contractor-Operated facilities within the Department of Energy, in supervising and managing nuclear facilities and activities and in ensuring safety and regulatory compliance. During the accelerated closing of Rocky Flats Environmental Technology Site (RFETS), as an Operations Manager Mr. Smith ensured safe and compliant operations in a number of nuclear waste facilities and authorized all activities conducted in these facilities, including two TRU waste shipping facilities. As the Group Leader for Readiness and Technical Support at LANL, Mr. Smith was responsible for the development and institutional implementation of P315, Conduct of Operations, and the administration of the LANL Readiness Review process. He has participated in, and/or coordinated a number of Readiness Reviews, Directors Assessments, and Effectiveness Assessments throughout LANL. Mr. Smith has served as acting Deputy FOD at Weapons Facility Operations and the acting Deputy FOD at Science and Technology Operations, and as a Facility Project Manager responsible for the facility operations in a number of technical areas. Currently he is the LANL Conduct of Operations Program Manager reporting to the Operations Support Division Leader. Mr. Smith completed a Master's of Science in Environmental Management from the University of Denver.

Robert M. Boyko

Mr. Boyko has 37-plus years of experience in radiological protection/health physics in capacities ranging from RCT to program management. His experience includes work in nuclear power plants, DOE facilities, fuel fabrication, facility D&D, and environmental remediation. At LANL, he is a Health Physicist with HP III Certifications. Additionally, he is a National Registry of Radiation Protection Technologists (NRRPT) DOE certified ASME NQA-1 Lead Auditor. Mr. Boyko He is currently pursuing his Master's of Science degree in Nuclear Energy Technology Management.

Appendix A: Appointment of a Joint Investigation Team

Federal Appointment Letter

Department of Energy
National Nuclear Security Administration
Washington, DC 20585

May 30, 2019

MEMORANDUM FOR PATRICK MOSS
BOARD CO-CHAIRPERSON
NNSA OFFICE OF SAFETY, INFRASTRUCTURE, AND OPERATIONS

FROM: THEODORE A. WYKA
COGNIZANT SECRETARIAL OFFICER FOR SAFETY
APPOINTING OFFICIAL
FOR SAFETY, INFRASTRUCTURE, AND OPERATIONS

SUBJECT: Joint Federal and M&O Investigation into the Breach of Sealed Radioactive Cesium 137 Source at the University of Washington Harborview Training and Research Building on May 2, 2019

Based on the currently known facts about the incident referenced in the subject line, I am establishing a joint Department of Energy/National Nuclear Security Administration (DOE/NNSA) investigation team. Though the incident has not yet met the criteria of DOE O 225.1B, *Accident Investigations*, I believe the seriousness of the incident warrants an investigation to identify lessons learned. Also, based on potential cleanup costs, this incident is likely to exceed the threshold of greater than $2.5 million dollars in property damage or decontaminating the property.

You are appointed as the Investigation Team Co-Chairperson and Audrey Hakonson-Hayes of TRIAD will be the other co-chairperson. The Federal personnel on the team will include the following members:

- Nathan Morley, Office of Safety, Infrastructure, and Operations - Trained Accident Investigator
- James Mumma, Office of Safety, Infrastructure, and Operations
- David Hall, Office of Safety, Infrastructure, and Operations

Mark Henry and Kristen Schwab, of the Washington State Department of Health, will participate as they need in the investigation team activities.

Silas DeRoma, of the NA-LA General Counsel's Office, will support the team as an advisor.

The NNSA Office of Defense Nuclear Nonproliferation, NA-20, will support the team with advisors.

TRIAD will be responsible for assigning personnel to be part of the investigation team within three business days. All members of this investigation team are released from their normal regular duty assignments to serve on the joint investigation team, while the team is convened.

The scope of the joint investigation is to include, but not be limited to, identifying all relevant facts, determining direct, contributing, and root causes of the event. This includes an analysis of the source, management and organizational systems, policies, and line management oversight processes in accordance with DOE Integrated Safety Management core functions and guiding principles, and developing conclusions, and determining the judgments of need to prevent recurrence.

The scope of the investigation includes, but is not limited to, interviewing individuals as appropriate, reviewing documentation related to the accident, as well as applicable DOE's programs and oversight activities, and conducting an analysis of the radioactive source itself, including associated materials such as the source tube, the tungsten plug, spacers as well as the source/device diagram and the video taken during the field transfer. Furthermore, I expect the outcome of the investigation to include the following:

- A comprehensive articulation of the facts including timeline, involved organizations, actions, and outcomes;
- An assessment of the accident facts and circumstances, and recommendations regarding identified judgments of need;
- An assessment of the emergency response, and recommendations regarding any necessary judgments of need; and,
- Human Performance Improvement (HPI) and causal analysis supporting the identified judgments of need.

The investigation shall address the core analytical techniques discussed in DOE O 225.1B, *Accident Investigations*, (i.e., events and casual factors, change analysis, and barrier analysis) and subsequently develop judgments of need that lead to corrective actions that will prevent recurrence. Lessons learned shall also be disseminated from the event as required by the Order. The team shall provide my office with periodic reports on the status of the investigation.

Please submit draft copies of the factual portion of the investigation report to me, the Los Alamos Field Office, and TRIAD for factual accuracy review prior to finalization. The Co-Chairs should provide the draft report to the Office of the Associate Under Secretary for Environment, Health, Safety and Security for quality review prior to public release.

The final report should be provided to me within 45 days of the convening of the team. If additional time is needed, the Team co-chair should notify me and request it. Discussion of the investigation and copies of the draft report will be controlled until I authorize release of the final report.

The Office of Management and Budget, NA-MB, has allocated funds to the Office of Safety, Infrastructure, and Operations, NA-50, for expenses and costs associated with this Investigation from appropriation 089-19/20-0313, Federal Salaries and Expenses Primary Fund, fund code 01657. Coordination for all funding needs, including allocations to travel and necessary purchase requisitions for support services shall be coordinated with Shari Crandell, NA-50, at (505) 845-4708 or email Shari.Crandell@nnsa.doe.gov, prior to expenses incurred.

If you have any further questions, please contact Daniel Sigg, Deputy Associate Administrator for Safety, at (505) 845-4404.

cc:
Douglas Fremont, NA-1
William White, NA-3
David G. Huizenga, NA-20
Eleanor Melamed, NA-21
Kristin J. Hirsch, NA-212
James McConnell, NA-50
Shari Crandell, NA-50
Frank J. Lowery, NA-MB-1
William S. Goodrum, NA-LA
Rick Verhaagen, NA-LA
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Silas DeRoma, NA-LA
Daniel Sigg, NA-51
Jeff Roberson, NA-51
Greg Hatchett, NA-51
Carl R. Sykes, NA-511
David J. Adair, NA-512
Nathan Morley, NA-512
Lynn Maestas, NA-513
David Hall, NA-513
Ahmad Al-Daouk, NA-53
James Mumma, NA-531
Matthew Moury, AU-1
Todd Lapointe, AU-1
Gary Staffo, AU-23
Thom Mason, TRIAD
Audrey Hakonson-Hayes, TRIAD

M&O Appointment Letter

Los Alamos
NATIONAL LABORATORY
EST. 1943
memorandum
Deputy Laboratory Director
for Science, Technology and Engineering

To: Distribution
From: John Sarrao, DDSTE, A127
Phone: 505-667-8597
Symbol: DDSTE: 19-015
Date: June 4, 2019

SUBJECT: JOINT FEDERAL AND M&O INVESTIGATION INTO THE BREACH OF SEALED RADIOACTIVE CESIUM 137 SOURCE AT THE UNIVERSITY OF WASHINGTON HARBORVIEW TRAINING AND RESEARCH BUILDING ON MAY 2, 2019

The Cognizant Secretarial Officer for Safety Appointing Official and the Los Alamos National Laboratory (LANL) Director have directed Patrick Moss, NNSA Office of Safety, Infrastructure, and Operations and Audrey Hakonson-Hayes to co-chair a joint Federal and Management and Operating (M&O) Partner Investigation Board (IB). The LANL Investigation Board membership is:

Audrey Hakonson-Hayes, OS-SCL, Co-Chair
Kerry Smith, OS-DO, Conduct of Operations
Kimberli Tanner, OS-SCL, Support
Bob Boyko, RP-PROG, Health Physics
Mike Petrowski, IQPA-IPA, HPI
David Mccumber, GC-BL, Contracting

As a member of the IB, you are released from your normal regular duty assignments to serve on the IB during the period that the board is convened. The scope of the joint investigation is to include, but not be limited to, identifying all relevant facts, and determining direct, contributing, and root causes of the event. This includes an analysis of the source, management and organizational systems, policies, and line management oversight processes in accordance with DOE Integrated Safety Management core functions and guiding principles, and developing conclusions, and determining the judgments of need to prevent recurrence.

The scope of the investigation includes, but is not limited to, interviewing individuals as appropriate, reviewing documentation related to the accident, as well as applicable DOE programs and oversight activities, and conducting an analysis of the radioactive source itself, including associated materials such as the source tube, the tungsten plug, spacers, as well as the source/device diagram and the video taken during the field transfer.

Furthermore, I expect the outcome of the investigation to include the following:

- A comprehensive articulation of the facts including timeline, involved organizations, actions, and outcomes;
- An assessment of the accident facts and circumstances, and recommendations regarding identified judgments of need;
- An assessment of the emergency response, and recommendations regarding any necessary judgments of need; and,
- Human Performance Improvement (HPI) and causal analysis supporting the identified judgments of need.

The investigation shall address the core analytical techniques discussed in DOE O 225.1B, *Accident Investigations,* (i.e., events and casual factors, change analysis, and barrier analysis) and subsequently develop judgments of need that lead to corrective actions that will prevent recurrence. Lessons learned shall also be disseminated from the event as required by the Order.

The Co-Chairs should provide the draft report to the Office of the Associate Under Secretary for Environment, Health, Safety and Security for quality review prior to public release. Please submit draft copies of the factual portion of the investigation report to the Cognizant Appointing Official, the Los Alamos Field Office, and TRIAD for factual accuracy review prior to finalization.

The final report should be provided within 45 days of the convening of the team. If additional time is needed, the Team Co-chairs should notify the Cognizant Appointing Official. Discussion of the investigation and copies of the draft report will be controlled until the Cognizant Appointing Official authorizes release of the final report.

All charges for time, travel and expenses should be charged to the code established for this purpose: W137 0000 0000.

If you have any further questions, please contact Evelyn Mullen, Chief Operating Officer for Global Security at emullen@lanl.gov or (505) 665-7576.

Distribution:
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Appendix B: Barrier Analysis

Appendix B – Barrier Analysis Worksheet Summary

Hazard: Contamination		Target: Workers, the Public, the Environment, and the Facilities		
What were the barriers?	**How did each barrier perform?**	**Why did the barrier fail?**	**How did the barrier affect the incident?**	**Context: ISM/HPI**
Mobile Hot Cell (MHC) containment barrier	MHC did not contain contamination	• Primary hazard control purpose of MHC was to provide radiation shielding • MHC not designed or constructed to contain contamination • MHC at neutral atmospheric pressure to the loading dock	• Contamination was able to spread • Contamination was allowed to be transported outside of the MHC and the loading dock CF-C12 • People, facilities, equipment and the environment were contaminated	• Hazard analysis did not include consideration of potential contamination CF-B4/C2, CFx1
Negative pressure ventilation/HEPA filtration	Contamination was not contained	• This barrier was not present in either the MHC or loading dock	• MHC not designed or constructed to contain contamination • MHC at neutral atmospheric pressure to the loading dock • HRT Building ventilation system was not considered during work planning/pre-job walk down • HRT Building ventilation system remained operational during source disassembly work activity • Limited understanding of HRT Building ventilation system by personnel on the scene • Contamination controls considering the work area environment were not identified or implemented events • Contamination was able to spread from the MHC, throughout the HRT	• Other areas to conduct the work were not considered to address radiation dose and contamination control • Hazard analysis did not include consideration of potential contamination CF-B4/C2, CFx1

Hazard: Contamination		Target: Workers, the Public, the Environment, and the Facilities		
What were the barriers?	**How did each barrier perform?**	**Why did the barrier fail?**	**How did the barrier affect the incident?**	**Context: ISM/HPI**
			Building, and ultimately to the environment • People, facilities, equipment and the environment were contaminated	
Hazard analysis/control	Hazard analysis/control did not address spread of contamination event	• Spread of contamination hazard was not evaluated during hazard analysis for source disassembly field service work activity • Controls for spread of contamination event were not identified or established	• The need for periodic contamination surveys during the source assembly disassembly did not get identified • Periodic surveys did not get performed • The contamination event was not identified because contamination swipes were not taken during the source assembly disassembly activity • Adequate contamination monitoring equipment was not available (e.g. CAM) • Contamination was able to spread • Contamination was allowed to be transported outside of the MHC and loading dock • People, facilities, equipment and the environment were contaminated • Operations were planned without detailed information about the source CF-1B	• Hazard analysis did not include consideration of potential contamination CF-B4/C2, CFx1 • Operations were not analyzed, controlled or implemented as would be expected for a typical DOE operation CF-C16

Hazard: Contamination		**Target: Workers, the Public, the Environment, and the Facilities**		
What were the barriers?	**How did each barrier perform?**	**Why did the barrier fail?**	**How did the barrier affect the incident?**	**Context: ISM/HPI**
Work procedures	• Contamination was not identified as a potential hazard in OP-SRP-040, *JL Shepherd Model Mark 1 and 143 Irradiator Source unloading* or OP-SPR-024, *Utilizing the INIS Mobile Hot Cell* • Contamination surveys were required at the beginning and end of source retrieval activity in OP-SRP-040, *JL Shepherd Model Mark 1 and 143 Irradiator Source Unloading* (Steps 7.3.16 and 7.4.6) and WI-RWP-013 Rev A, *Field Service – Source Loading and Unloading Using MHC Special* Instruction Step 2 and Step 7	• Procedure development/review process did not identify contamination hazard associated with cutting method of source assembly disassembly • Spread of contamination hazard was not evaluated during hazard analysis for source disassembly field service work activity • Spread of contamination controls did not get implemented (e.g. CAM, periodic contamination surveys) • Incidental contamination hazards were not fully analyzed • Incidental contamination controls were not adequately implemented	• The spread of contamination event was not identified because the contamination swipes were not taken • Dose to radiological workers not ALARA • Contamination able to spread outside of the MHC • People, facilities, equipment and the environment were contaminated	• Hazard analysis did not include consideration of potential contamination CF-B4/C2, CFx1 • Controls for spread of contamination were not identified or implemented CF-BXX • INIS did not consistently follow their procedures CF-1C
Pause/Stop work; questioning attitude	• RWP established pause/stop radiological work limits	• Non-radiological pause/stop work expectations/process were not proceduralized in OP-SRP-040, *JL Shepherd Model Mark 1 and 143 Irradiator Source unloading* or OP-SPR-024, *Utilizing the INIS Mobile Hot Cell*	• Unexpected irradiator mating configuration did not result in pause work to evaluate shielding options to mitigate higher than expected dose rate streaming from bottom of MHC (e.g. lead blanket) • Pause/Stop work did not occur after roll pin removal failed to release the tungsten plug	• Personnel were not trained to recognize unusual non-radiological work conditions • Personnel did not recognize the potential consequence of performing a radial cut on the source holder tube • Safety culture not fully matured

Hazard: Contamination		Target: Workers, the Public, the Environment, and the Facilities		
What were the barriers?	**How did each barrier perform?**	**Why did the barrier fail?**	**How did the barrier affect the incident?**	**Context: ISM/HPI**
		• Training not provided on non-radiological pause/stop work expectations/process	• Angular cut not recognized as an abnormal event/condition and work was not paused • Contamination able to spread outside of the MHC • People, facilities, equipment and the environment were contaminated	• INIS conducted work inconsistent with a robust safety culture CC-1 • Questioning attitude was not present CF-B7
RFQ/ Subcontract	• RFQ did not establish criteria that would have allowed vendor selection based on manufacturer self-certification • Least Price Technically Acceptable method used	• INIS over-encapsulation process identified in technical evaluation but risk associated with over-encapsulation hazards (e.g. cutting) not identified • Contract method requires an 'acceptable' or 'not acceptable' determination which does not allow for grading/rating acceptability	• LPTA preferred subcontract method at Triad • LPTA based on standard LANL OSRP RFQ • INIS awarded subcontract as low bidder • Risks associated with requirement for INIS to create an INIS certified special form for transportation were not evaluated or understood • People, facilities, equipment and the environment were contaminated	• Importance of manufacturer self-certification not recognize during RFQ/Subcontracting process • Competitive subcontract method used without incorporating criteria to select vendor with the lowest risk approach • Technical criteria and evaluation was not sufficient to ensure appropriate environment, safety, health and quality assurance were addressed in the contract submittal • Triad subcontracting process incentivized contractors to use a least conservative approach to conduct work for cost savings CF-BAA

Hazard: Contamination		Target: Workers, the Public, the Environment, and the Facilities		
What were the barriers?	**How did each barrier perform?**	**Why did the barrier fail?**	**How did the barrier affect the incident?**	**Context: ISM/HPI**
Oversight (INIS, Triad, DOE, UW, DOH, NRC)	Oversight was not conducted on the irradiator activity	• No one was looking to see how the activity was conducted • Everyone relying on everyone else to do a credible review of the INIS process • INIS left to do the work as they saw fit • It is unclear to DOE who had responsibility for oversight of the operation	• Work control not assessed • Need for contamination controls were not identified and implemented • Assessments not conducted by DOH CF-BYY • It was unclear to DOE who was responsible for safety oversight of the work CF-BZZ • INIS left to do the work as they saw fit	• Hazard analysis did not include consideration of potential contamination CF-B4/C2, CFx1 • Work planning did not develop controls to mitigate a contamination event on the loading dock CF-B12 • Feedback and improvement not effectively implemented
Triad oversight of INIS Subcontract	• Work procedures not reviewed prior to INIS being awarded the contract • Implementation of work procedures conducted	• Triad personnel have a belief that the Laboratory would incur responsibility if they commented on any of INIS's procedures or processes • Not looking at the best interest of the government	• Activities conducted by INIS were not reviewed as would by typical for straight DOE work • INIS allowed to conduct work as they saw fit	• Operations were not analyzed, controlled, or implemented as would be expected for a typical DOE operation CF-C16 • Feedback and improvement was not conducted
NRC License	• Condition 16 of the NRC license with INIS states that the sealed source cannot be removed from the source holder by the licensee - except as specifically authorized by the license • There are no specific authorizations to remove the source from the source holder in the license	• INIS's source recovery procedure allowed them to remove the source from the source holder in contrast Condition 16 of the license • INIS successfully used the same process for a 2017 source recovery and were confident it would work for this source recovery as well	• License conditions on not removing the source from the source holder were not met • Stakeholders assumed that NRC license equates to the work being done safely • Due to the cutting/grinding operations the source was breached and contamination was released • It was unclear who was responsible for safety oversight of the work CF-BZZ	• Identified controls were violated • Feedback and improvement activities were not conducted

Hazard: Contamination		**Target: Workers, the Public, the Environment, and the Facilities**		
What were the barriers?	**How did each barrier perform?**	**Why did the barrier fail?**	**How did the barrier affect the incident?**	**Context: ISM/HPI**
	• Condition 23 provides conditions for changes to procedures without NRC approval when approved by the INIS Radiation Safety Committee, and when the INIS staff is trained in the procedures prior to implementation	• Use of cutting/ grinding for the 2017 work was not identified as an issue against the NRC INIS license with INIS • Modifications to OP-SRC-040.B did not meet NRC procedure change requirements • There was no coordination between LANL, UW, and DOH on oversight responsibilities • LANL and DOH reviews did not identify INIS's procedures violated Condition 16 • INIS personnel were able to remove the source from the source tube	• DOE is managing work regulated by the NRC or an Agreement State without clearly defined roles and responsibilities RC-2	
Independent review of processes	People reviewed documents that felt they did not have the proper background to question activities	• No questioning attitude • People were relying on others believed to have more experience	• INIS was allowed to conduct operations without technical or safety oversight from stakeholders CF-B1 • Stakeholders assumed that NRC license equates to the work being done safely • Questioning attitude was not present CF-B7	• Hazard analysis did not include consideration of potential contamination CF-B4/C2, CFx1 • Work planning did not develop controls to mitigate a contamination event on the loading dock CF-B12

Hazard: Contamination		Target: Workers, the Public, the Environment, and the Facilities		
What were the barriers?	**How did each barrier perform?**	**Why did the barrier fail?**	**How did the barrier affect the incident?**	**Context: ISM/HPI**
Pursuing least risk option	INIS decided not to ship the entire unit	• Source taken up into the hot cell to disassemble Al/W assembly	• Allowed work to be made on the Aluminum tube	• Hazard analysis did not include consideration of potential contamination CF-B4/C2, CFx1 • Work planning did not develop controls to mitigate a contamination event on the loading dock CF-B12
Emergency procedures Hazard analysis for potential contamination resulting from source disassembly	Procedures did not consider a contamination event Planned for potential contamination on source Communication to local emergency and medical response agencies was not planned	• Procedures not written for Field Services work • Facility walk down concentrated on location of the MHC and radiation dose concerns • Need for appropriate monitors not identified or used to identify a potential contamination event • Did not identify a place to immediately evacuate • Decontamination equipment not identified • Facility walk down did not consider a contamination event • Need for ventilation control was not understood • Analysis of cutting source not conducted • Analysis of wide spread contamination not conducted	• Contamination control equipment was not readily available to INIS personnel • Could not identify when the contamination event occurred • Ventilation could not be controlled immediately after the discovery of contamination • INIS personnel remained in the highest contaminated area • Self-rescue equipment not available for immediate decontamination • Contaminated personal continue to receive dose • Contamination was spread outside of the loading dock • INIS personnel not prepared for wide spread contamination event • Contamination was spread from the source to the facility and personnel • Local response agencies were unaware of the work activity and were unprepared for the contamination event which delayed their response CF-BCCC	• Hazard analysis did not include consideration of potential contamination CF-B4/C2, CFx1 • Work planning did not develop controls to mitigate a contamination event on the loading dock CF-B12 • INIS personnel not prepared for wide spread contamination event • Hazard analysis was not conducted on cutting the source • Controls for spread of contamination were not identified or implemented CF-BXX

Hazard: Contamination		**Target: Workers, the Public, the Environment, and the Facilities**		
What were the barriers?	**How did each barrier perform?**	**Why did the barrier fail?**	**How did the barrier affect the incident?**	**Context: ISM/HPI**
		• Local emergency and medical response agencies were not informed of the planned activity		
PPE (Anti-C's, respirators, gloves, etc.)	WI-RWP-013 Rev A, *Field Service – Source Loading and Unloading Using MHC Special*, did not require contamination protective PPE with the exception of gloves	• Workers did not use gloves during radiological work activities • Spread of contamination hazard was not evaluated during hazard analysis for source disassembly field service work activity • Contamination PPE was not available in the loading dock	• Personnel were contaminated • Personnel needed to be decontaminated	• Hazard analysis did not include consideration of potential contamination CF-B4/C2, CFx1
Radiation and Contamination Instrumentation (redundancy)	Instrumentation availability limited	• Major concern was on radiation protection • Focused on radiation exposure (dose) controls • Did not plan for contamination event	• Unable to determine the extent of contamination with equipment available • Needed to ask UW RSO to find meter • Took longer to confirm contamination event • Had shine outside of the loading dock area	• Hazard analysis did not include consideration of potential contamination CF-B4/C2, CFx1 • Other areas to conduct the work were not considered to address radiation dose and contamination control
Personnel contamination identification Emergency procedures	• Observers and normal building occupants not informed of contamination potential • Procedures did not consider a contamination event	• Contamination was not considered when planning the job • Observers and normal building occupants were unaware that they may have been contaminated	• Observers and normal building occupants were initially allowed to move freely inside and outside of the loading dock and HRT Building • Personnel spread contamination outside of the loading dock	• Hazard analysis did not include consideration of potential contamination CF-B4/C2, CFx1 • Work planning did not develop controls to mitigate a

Hazard: Contamination		**Target: Workers, the Public, the Environment, and the Facilities**		
What were the barriers?	**How did each barrier perform?**	**Why did the barrier fail?**	**How did the barrier affect the incident?**	**Context: ISM/HPI**
		• Need for appropriate monitors not identified or used to identify a potential contamination event • Ventilation control was not understood • Procedures not written for Field Services work • Facility walk down concentrated on location of the MHC and radiation dose concerns • Need for appropriate monitors not identified or used to identify a potential contamination event • Did not identify a place to immediately evacuate • Decontamination equipment not identified • Facility walk down did not consider a contamination event • Need for ventilation control was not understood	• Ventilation could not be controlled immediately after the discovery of contamination • Contamination control equipment was not readily available to INIS personnel • Could not identify when the contamination event occurred • INIS personnel remained in the highest contaminated area • Self-rescue equipment not available for immediate decontamination • Contaminated personal continue to receive dose • Contamination was spread outside of the loading dock	contamination event on the loading dock CF-B12 • All personnel were not aware of what to do to minimize the spread of contamination • Safety requirements were not effectively implemented by INIS CF-1D
Radiation Work Permit Personnel contamination identification	• Permit was developed • Observers and normal building occupants not informed of contamination potential	• RWP did not address source breach • RWP did not address the need for a continuous air monitor	• INIS personnel not prepared for contamination event • Contamination control equipment was not readily available to INIS personnel • Could not identify when the contamination event occurred	• Hazard analysis did not include consideration of potential contamination CF-B4/C2, CFx1 • Work planning did not develop controls to mitigate a

Hazard: Contamination		**Target: Workers, the Public, the Environment, and the Facilities**		
What were the barriers?	**How did each barrier perform?**	**Why did the barrier fail?**	**How did the barrier affect the incident?**	**Context: ISM/HPI**
		• RWP did not address potential contamination event • Contamination was not considered when planning the job • Observers and normal building occupants were unaware that they may have been contaminated • Need for appropriate monitors not identified or used to identify a potential contamination event • Ventilation control was not understood	• Ventilation could not be controlled immediately after the discovery of contamination • INIS personnel remained in the highest contaminated area • Self-rescue equipment not available for immediate decontamination • Contaminated personal continue to receive dose • Contamination was spread outside of the loading dock • Observers and normal building occupants were initially allowed to move freely inside and outside of the loading dock and HRT Building • Personnel spread contamination outside of the loading dock	contamination event on the loading dock CF-B12 • All personnel were not aware of what to do to minimize the spread of contamination • Work was authorized and conducted without addressing potential contamination concerns CF-C18
Subcontract Pre-job briefing Radiation Work Permit	Briefing was given	• Did not address source breach • Did not address the need for a continuous air monitor • Did not address potential contamination event	• INIS personnel not prepared for contamination event • Contamination control equipment was not readily available to INIS personnel • Could not identify when the contamination event occurred • Ventilation could not be controlled immediately after the discovery of contamination • INIS personnel remained in the highest contaminated area • Self-rescue equipment not available for immediate decontamination • Contaminated personal continue to receive dose	• Work planning did not develop controls to mitigate a contamination event on the loading dock CF-B12

Hazard: Contamination		**Target: Workers, the Public, the Environment, and the Facilities**		
What were the barriers?	**How did each barrier perform?**	**Why did the barrier fail?**	**How did the barrier affect the incident?**	**Context: ISM/HPI**
			• Contamination was spread outside of the loading dock	
Contamination Surveys	• Surveys did not get performed throughout the source disassembly work activity	• Contamination survey required by OP-SRP-040, *JL Shepherd Model Mark 1 and 143 Irradiator Source Unloading* (Step 7.3.16) did not get performed • Spread of contamination hazard was not evaluated during hazard analysis for source disassembly field service work activity • Controls for spread of contamination event were not identified or established • Radiation protection focus was on incidental contamination and high radiation fields	• Breach of the sealed source was not detected until source was removed from source holder • Work continued until potential breach was identified • Additional radial cuts on the source holder were made after angular cut on aluminum source holder • Contamination not identified during work activity • Contamination was able to spread • People, facilities, equipment and the environment were contaminated	• Questioning attitude was not present CF-B7 • Evaluation of as-found source assembly condition not conducted • Analysis/Evaluation of off normal condition (angular cut) not conducted • Potential new hazard not recognized following angular cut

Appendix C: Change Analysis

Appendix C – Change Analysis Worksheet Summary

Factors	Accident Situation	Prior, Ideal or Accident-Free-Situation	Difference	Evaluation of Effects
WHAT Conditions, occurrences, activities, equipment	Mobile Hot Cell (MHC) not designed for contamination control	Contamination control considered in the design of the MHC	• Contamination was not a consideration for this activity • Enclosure would have been ready to control the contamination event • Contamination would have been enclosed within the MHC • Misunderstanding of the capabilities of the MHC • MHC actually a hot box • Assumption was made by UW that the MHC would contain a contamination release	• MHC design allowed contamination to escape to the loading dock, other areas of the HRT building and the environment • Personnel and facilities contaminated • Personnel received unplanned dose • UW believed that contamination was not able to go beyond the MHC • MHC allowed contamination to be transmitted to the loading dock
	NRC regulated work is at the compliance level	DOE contractual safety requirements be implemented	• Subcontractor personnel doing work under Agreement State reciprocity rather than personnel doing work under DOE requirements • Assumed NRC license accounts for all requirements needed to get the job done rather than a joint listing of NRC and DOE requirements • Acceptance that NRC licensing equates to being able to do the work safely	• NRC licensing used as basis of Triad contract approval, and to allow work to begin CF-CYY • Work not performed under formality of operations requirements CF-C13 • No indication on how DOE SMPs and all DOE expected safety and health management protection items addressed

Factors	Accident Situation	Prior, Ideal or Accident-Free-Situation	Difference	Evaluation of Effects
			• NRC does not regulate work activity the way DOE does • DOE personnel have limited knowledge of NRC compliance and oversight requirements • NNSA and Triad not used to the work being conducted under NRC requirements and how NRC operates and oversight requirements • LTA ISM integrated into high activity source recovery program • It is unclear in the subcontract whether the work falls under PAAA • DEAR clauses still applicable to Triad • Triad needs to flow down DEAR requirements • DOE is managing work regulated by the NRC or an Agreement State without clearly defined roles and responsibilities RC-2	• Expected DOE processes not implemented or overseen CF-C14 • Triad did not provide oversight of technical aspects of contract CF-C23 • Work activities and ISM element implementation are not evaluated • Work planning and control oversight was not conducted on INIS CF-C25 • INIS conducted operations without independent review of their processes CF-C27 • Safety requirements not flowed down by Triad CC-2 • ISM not implemented for source recovery work
	No domestic special form registry available from DOT to Triad or INIS	DOT makes a domestic special form registry available to NRC and Agreement State licensees that can be accessed by organizations such as Triad and INIS	• Triad or INIS access to a registry would allow compliant shipment without over encapsulation • INIS could have a better understanding of source holder	• Domestic self-certified special form certificates are a commodity that resulted in a cost determination over safety CF-CAAA • INIS decided to over encapsulate the source rather

Factors	Accident Situation	Prior, Ideal or Accident-Free-Situation	Difference	Evaluation of Effects
			design for work control purposes • INIS left to trying to purchase a certification from the manufacturer or over encapsulation	than buying the design information from JL Shepherd CF-1H
	Triad ORSP visits INIS to conduct general observation activities	Formal safety management program assessment of the work conducted	• Triad reviews not structured or recorded • Work documents not reviewed • Potential for inadequate work process documents missed • Potential for grinding on the source tube not identified • Need for contamination control not identified • Did not identify that MHC was not designed for contamination control • Work observations not conducted	• INIS work planning and control deficiencies were not identified or corrected prior to performing work CF-C21 • INIS conducted operations without independent review of their processes CF-C27 • INIS allowed to conduct work as they saw fit • Contamination control not identified • Contamination spread to facility and personnel
	INIS did not have specific source configuration information	INIS had specific source configuration information	• Was unsure of configuration of the items within the source tube • Not sure how source was kept within the source tube • INIS was aware that each JL Shepherd items are different • INIS did not know there were no spacers at the W end of the source tube • Should not have cut in Cs-137 where they were grinding	• Formality of operations and work planning and control were not developed or implemented for the source recovery work • INIS work planning and control deficiencies were not identified or corrected prior to performing work CF-C21 • Cut into Cs-137 source • Contamination released from sealed source

Factors	Accident Situation	Prior, Ideal or Accident-Free-Situation	Difference	Evaluation of Effects
			• Would have knowledge of the area to safely cut the source tube or whether they could safely cut the source tube at all • Would have known if there was a spacer in the source tube or whether the source could slide to the end of the source tube	
	Not knowing QLs for the work activity	Quality levels for the Project and identified and appropriate requirements are implemented	• Proper requirements for flow down of controls not identified • Oversight of requirements not conducted • Project was identified as a LANL Management Level-3 activity	• Triad did not assure that applicable requirements were flowed down to INIS • Safety requirements not flowed down by Triad CC-2 • INIS developed their work package without necessary ISM considerations CF-C15
WHEN Occurred, identified, facility status, schedule	Contamination not detected when the source was initially breached	Contamination event determined in real time	• Swipes not taken when angular cut was made in the Al tube • Need for response would have been identified earlier • Contamination locations would have been minimized	• Contamination allowed to be released to the MHC, loading dock, HMC, and environment without being detected
	Deployment of DOE related resources delayed	DOE related resources provided quickly to support UW and Washington State	• State of Washington DOH initially thought they could handle the situation • UW management did not have confidence in INIS handling the cleanup efforts	• DOE resources that could have been useful for the initial recovery efforts did not arrive for almost two weeks following the incident • DOE does not have a capability to bridge long term response and

Factors	Accident Situation	Prior, Ideal or Accident-Free-Situation	Difference	Evaluation of Effects
			• UW management was looking for DOE to lead recovery efforts • UW was not aware of the process to request RAP support • Personnel responsible for deploying RAP resources did not have the knowledge of the extent of the problem • Triad did not believe they had responsibility for the incident	consequence management CF-4A • DOE RAP and NA-80 did not have a mechanism to provide continuing support or advice to UW response leads CF-4B • Response coordination was not well implemented until the Unified Command was established CF-4C • Lack of communication between stakeholders inhibited response CF-2A
WHERE Physical location, environmental conditions	INIS and UW personnel not aware of HRT building ventilation configuration	Ventilation configuration is known in order to limit spread of contamination outside of the loading dock	• HRT Building ventilation controls were not known by INIS personnel, and UW personnel on the scene • Did not know how to isolate the ventilation from the loading dock • Ventilation for the building was not totally shut down for several days • UW personnel needed to keep freezers running to maintain research materials • Fume hoods without scrubbers kept running throughout the recovery	• Ventilation could not be controlled immediately after the discovery of the contamination • Contamination was not limited to the loading dock • Freezers began to fail • HRT building contaminated from loading dock to the top of the building • Contamination reached buildings around the HRT Building
	Contamination spread by personnel to locations	Contamination limited to loading dock	• Extent of spread of contamination not limited to the smallest area possible	• Personnel tracked contamination throughout the HRT Building, the

Factors	Accident Situation	Prior, Ideal or Accident-Free-Situation	Difference	Evaluation of Effects
	outside of the immediate work area		• Janitorial staff not informed of job by UW • INIS and other individuals not aware that they have been contaminated • Contamination allowed to be transferred to multiple locations	parking lot outside the HRT building and to several offsite locations
WHO Staff involved, training, qualification, supervision	INIS personnel did not receive the applicable training for source recovery work	INIS personnel trained and qualified for source recovery work	• SwRI training identified for the Seattle work is not applicable to INIS personnel for source recovery work • SwRI device shipping preparation training is not applicable to taking the source a part • Scope of INIS training program not focused on Field Service's facility work • INIS training program did not prepare INIS personnel to conduct off normal work activities and to address emergency response during Field Services work CF-1G • INIS's QAP does not provide specific training requirements relevant to Field Service's source recovery work	• INIS operators not trained to respond to off-normal events • Contamination was released from the sealed source • Contamination surveys not taken to determine potential cesium release following the angular cut CF-CXX • Contamination allowed to spread while additional cuts were conducted
	AdSTR assigned to the activity	STR assigned to the activity	• There is no Triad STR for assigned for offsite work • Triad STR has more training requirements	• Triad oversight of contract activities was not conducted

Factors	Accident Situation	Prior, Ideal or Accident-Free-Situation	Difference	Evaluation of Effects
			• ADSTR has limited oversight expectations • STR has highly integrated oversight expectations • STR is required in the contract • ADSTR primary occupation is not for technical oversight of subcontracts • STR primary occupation is for technical oversight of subcontracts • STRs have more training	• INIS conducted operations without independent review of their processes CF-C27 • Work planning and control oversight was not conducted on INIS CF-C25 • Source holder disassembly hazards not addressed • Hazard analysis did not include consideration of potential contamination CF-B4/C2, CFx1 • Work was authorized and conducted without addressing potential contamination concerns CF-C18
	RAP directed home and was redeployed	RAP remained on scene until the full scope of the event was determined	• Limited information available during first RAP deployment • Directions being given from Washington DC, and Richland, WA • Local leadership were not provided assistance necessary to manage event response to the incident • DOE assets were not on scene to provide guidance to local personnel as the extent of the contamination evolved during RAP absence from the scene	• DOE does not have a capability to bridge long term response and consequence management CF-4A • DOE RAP and NA-80 did not have a mechanism to provide continuing support or advice to UW response leads CF-4B

Factors	Accident Situation	Prior, Ideal or Accident-Free-Situation	Difference	Evaluation of Effects
	Unified Command was established 13 days after the event	Unified command set up immediately to take charge of the event	• Local leadership were not provided assistance necessary to manage event response to the incident • Triad did not have clear guidance from NA-21 on their role for an off-site emergency response CF-4D • Roles and responsibilities between UW, DOH, Triad, and DOE were not clearly identified in responding to the incident • No formal command structure was developed in response to the event CC-4/CF-C33	• Response coordination was not well implemented until the Unified Command was established CF-4C • Unified command was not established for almost two weeks • UW personnel were placed in roles of leadership for which they were not prepared
HOW Control chain, hazard analysis monitoring	No Field Service experience with widespread contamination event	Field Services personnel able to handle widespread contamination event	• INIS personnel were not expecting a widespread contamination event • Hazard analysis and job planning did not consider a widespread contamination event • OP-SRC-040.B did not address contamination as a potential hazard • Field Services personnel had not been trained for a widespread contamination event • INIS personnel did not plan for emergency activities to conduct in the event of a	• Potential source breach and spread of contamination hazards did not get evaluated • INIS personnel were not able to limit the spread of the cesium contamination • Contamination was allowed to be transported outside of the loading dock • Personnel and facilities contaminated

Factors	Accident Situation	Prior, Ideal or Accident-Free-Situation	Difference	Evaluation of Effects
			widespread contamination event	
	Work conducted not the same as work identified to stakeholders outside of INIS	Stakeholders aware of, and agree with, INIS planned operation	• INIS did not present the specific work activities to, nor were the specific work activities requested by, Triad, UW, or DOH to remove the source from the source holder for review • Information on use of cutting and grinding on the source holder were not requested by, provided to, Triad, UW, or DOH • Triad, UW, and DOH were unaware of the actual actions to be conducted	• The INIS work package was not reviewed, or approved, by either Triad, UW, or DOH CF-CZZ • Operations allowed the source to be placed in a configuration where it could be breached • Cesium was released as a result of cutting operations on the source holder assembly DC
	Extent of contamination potential not anticipated or addressed	Potential widespread contamination planned for and addressed in work planning and control	• Contamination hazards not analyzed, addressed, and controlled by any entity • OP-SRC-040.B did not address contamination as a potential hazard • Typical DOE processes for contamination monitoring, identification, and control not considered • UW incorrectly assumed that contamination could not escape from the MHC • Contracts only identify that "*work be conducted safely*"	• Operations were not analyzed, controlled, or implemented as would be expected for a typical DOE operation CF-C16 • INIS personnel not prepared for wide spread contamination event • Contamination surveys not taken to determine potential cesium release following the angular cut CF-CXX • Lack of formality of operations delayed recognition of a

Factors	Accident Situation	Prior, Ideal or Accident-Free-Situation	Difference	Evaluation of Effects
			• Training for widespread contamination not conducted • Pre-job did not address wide spread contamination hazards • No need identified for contamination swipes to be taken in the MHC until tube/plug separation • Hold point swipe on source tube when removed from the irradiator were not conducted • Work not stopped or paused to conduct swipe of source tube following angular cut • INIS and HRT building personnel did not have the knowledge to limit the spread of the contamination • No anti-C's or respirators available to protect personnel, or contamination supplies available for self-rescue	contamination event CF-C4, CFx3 • Contamination allowed to spread while additional cuts were conducted • Contamination escaped to the building • Personnel and facilities contaminated • Personnel received unplanned dose
	No consideration for emergency response/procedures	Emergency response and procedures were developed and implemented	• Procedures did not address abnormal conditions/normalizing deviations (e.g. doughnut shield, IDD posts, half-moon shield first time unique use, battery change of AMP 100 meter while operations continued	• INIS personnel not prepared for wide spread contamination event • INIS did not have an emergency response process to cover Field Services work CF-1F • Contamination escaped to the building

Factors	Accident Situation	Prior, Ideal or Accident-Free-Situation	Difference	Evaluation of Effects
				• Personnel and facilities contaminated • Personnel received unplanned dose
	Used greatest risk option to recover the source	Use lower risk option to recover the source	• Least risk option to package and transport irradiator as a unit not used • Direct transfer of the source holder from the irradiator to the transfer cask not used • Over-encapsulation of intact source holder in the MHC and place in the transfer cask not used • Source needed to be removed from the irradiator • Cutting and grinding was performed on the source tube	• Cutting and grinding on the source tube was conducted outside of a sealed hot cell • Operations allowed the source to be placed in a configuration where it could be breached • Cesium was released as a result of cutting operations on the source holder assembly DC • INIS work planning and control processes were not effectively implemented CF-1A • Contamination released into the MHC • Contamination was allowed to be transported outside of the loading dock • Contamination escaped to the building • Personnel and facilities contaminated • Personnel received unplanned dose

Factors	Accident Situation	Prior, Ideal or Accident-Free-Situation	Difference	Evaluation of Effects
	Cutting the tube holder to verify the source	Moving source intact within the tube holder	• Risk change from cutting increases significantly • Inadequate hazard analyses of cutting operations conducted • Cutting the source becomes a possibility • Contamination from cutting the source becomes a possibility	• Cutting and grinding on the source tube was conducted outside of a sealed hot cell • Cesium was released as a result of cutting operations on the source holder assembly DC • Contamination released into the MHC • Contamination was allowed to be transported outside of the loading dock • Immature safety culture led to completion of work activities taking priority over safe conduct of the work CF-1E • INIS conducted work inconsistent with a robust safety culture CC-1 • Contamination escaped to the building • Personnel and facilities contaminated • Personnel received unplanned dose • Disruption to research activities in the HRT Building
	Lack of oversight of Field Services activities • Program Fed	Oversight activities assure that Field Service processes are conducted in accordance with stated requirements	• Field Service activities are not being assessed to determine they meet established requirements	• Stakeholders assumed that NRC license equates to the work being done

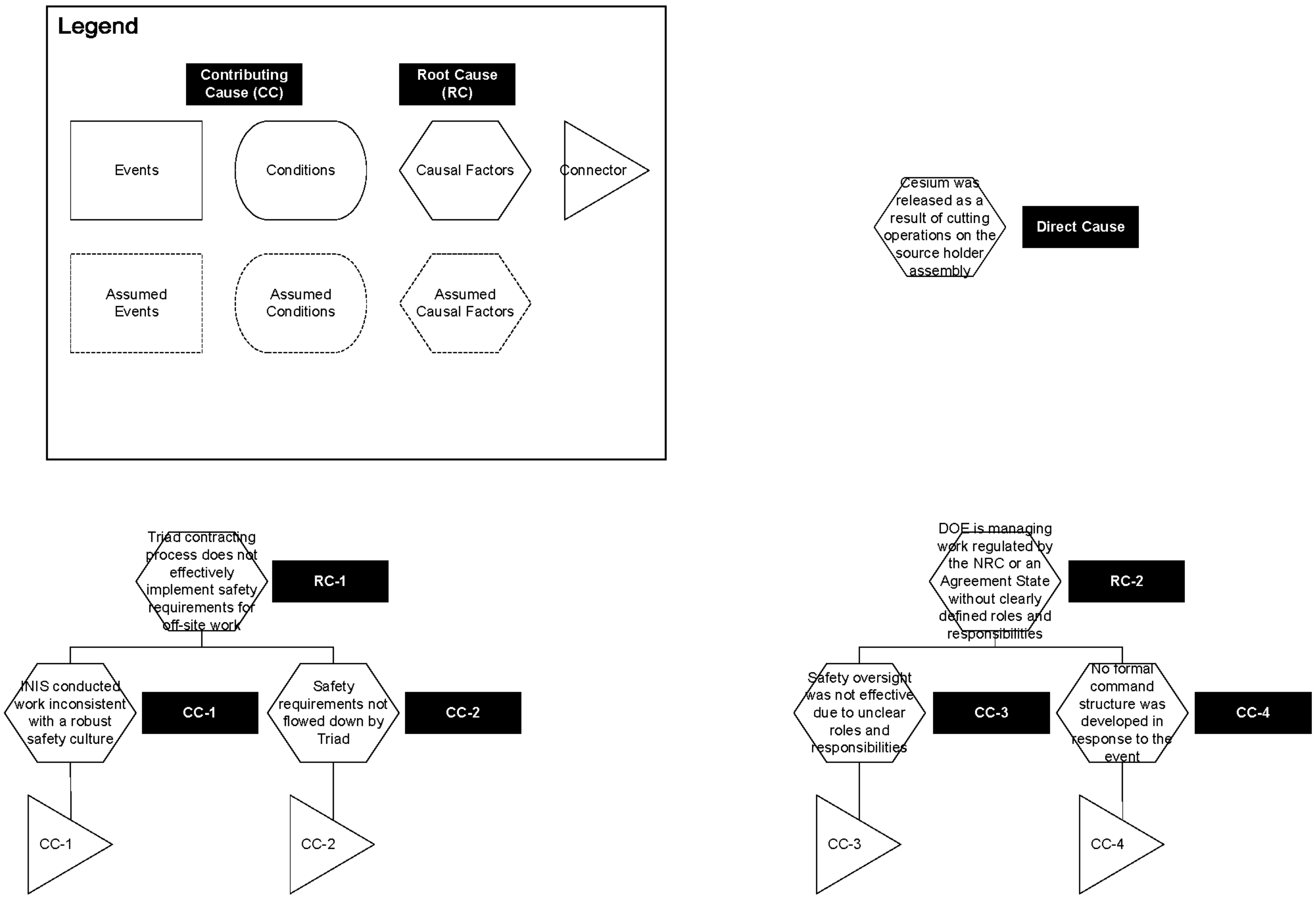
Factors	Accident Situation	Prior, Ideal or Accident-Free-Situation	Difference	Evaluation of Effects
	• Program Triad • Corporate INIS • Washington State DOH		• Work processes and controls are allowed to deviate from established requirements • Skill of the craft operations become prevalent • Issues with conducting planning, conducting, and implementing work are not identified • INIS QA personnel concentrate on oversight home office processes rather than on Field Services work • INIS working under Agreement State reciprocity	• Cutting and grinding on the source tube was conducted outside of a sealed hot cell • Cesium was released as a result of cutting operations on the source holder assembly DC • Contamination was allowed to be transported outside of the MHC and loading dock • Contamination escaped to the building • Personnel and facilities contaminated • Personnel received unplanned dose • It was unclear who was responsible for safety oversight of the work CF-BZZ • The INIS work package was not reviewed, or approved, by either Triad, UW, or DOH CF-CZZ • Safety oversight was not effective due to unclear roles and responsibilities CC-3
	Hazard analysis for activity was neither complete nor formal	Work is effectively planned and hazards adequately analyzed	• Inadequate knowledge of source holder and source design and configuration	• Cutting and grinding on the source tube was conducted outside of a sealed hot cell • Cesium was released as a result of cutting operations

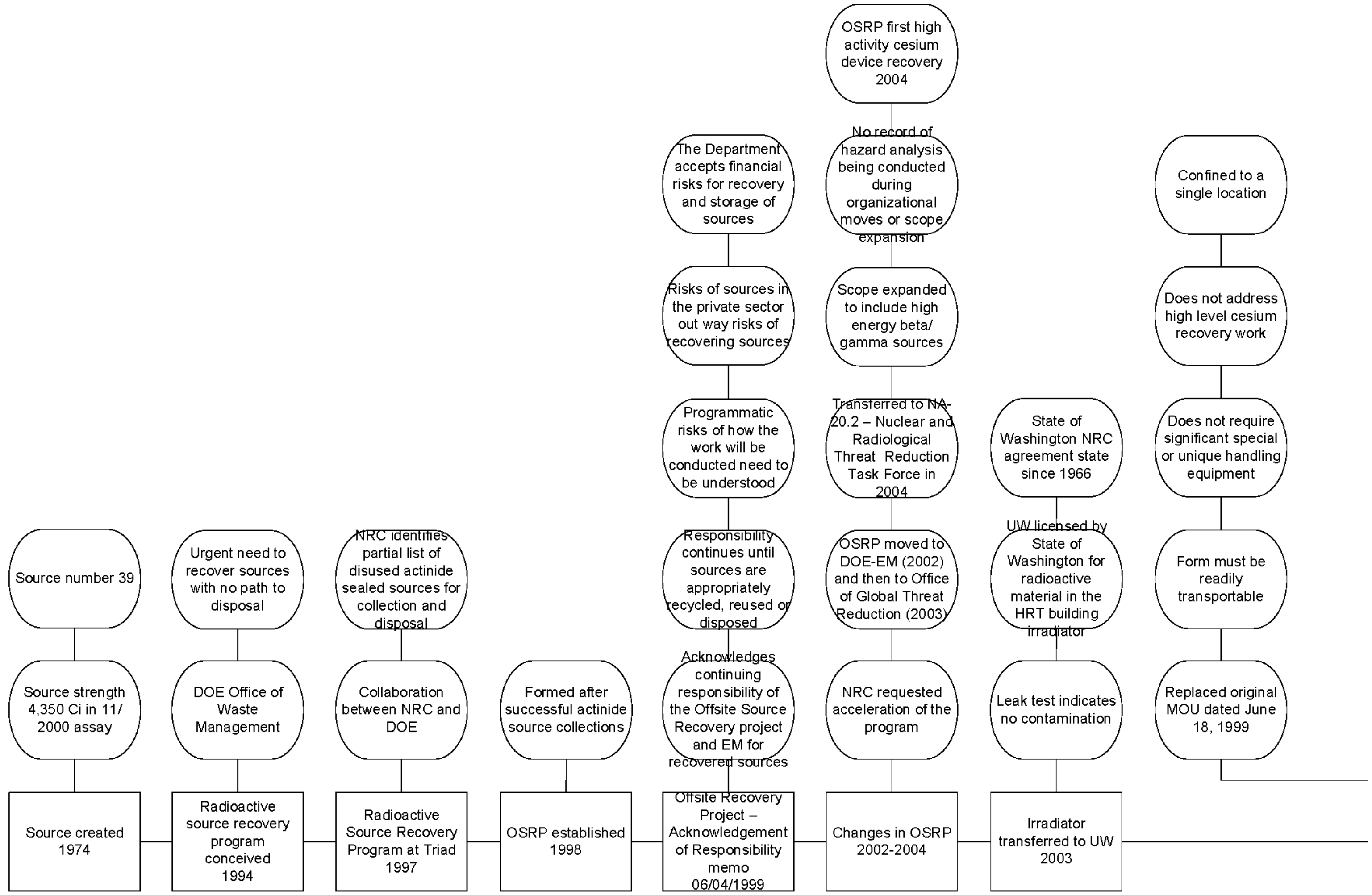
Factors	Accident Situation	Prior, Ideal or Accident-Free-Situation	Difference	Evaluation of Effects
			• Hazard analysis did not address significant contamination events • Controls addressed the hazards analyzed, namely radiation exposure • Controls did not address significant contamination events • Insufficient engineered controls for ensuring cuts are done safely as planned • Work processes leave a lot of room for interpretation • Insufficient engineering contamination controls for the MHC • Lack of questioning attitude demonstrated by INIS and oversight organizations • Did not stop work to analyze changes in expected conditions	on the source holder assembly DC • Operations were planned without detailed information about the source CF-1B • Pause/stop work did not occur after roll pin removal failed to release tungsten plug • Hazard analysis did not include consideration of potential contamination CF-B4/C2, CFx1 • Contamination escaped to the building • Did not stop work to analyze changes in expected conditions • Questioning attitude was not present CF-B7 • Personnel and facilities contaminated • Personnel received unplanned dose • Work was authorized and conducted without addressing potential contamination concerns CF-C18
	Half-moon shield used below the source tube in the MHC for radiation control	Half-moon shield used above the source tube in the MHC for radiation control	• First time the half-moon shield was used under the source holder rather than above the source	• Did not stop work to analyze changes in expected conditions

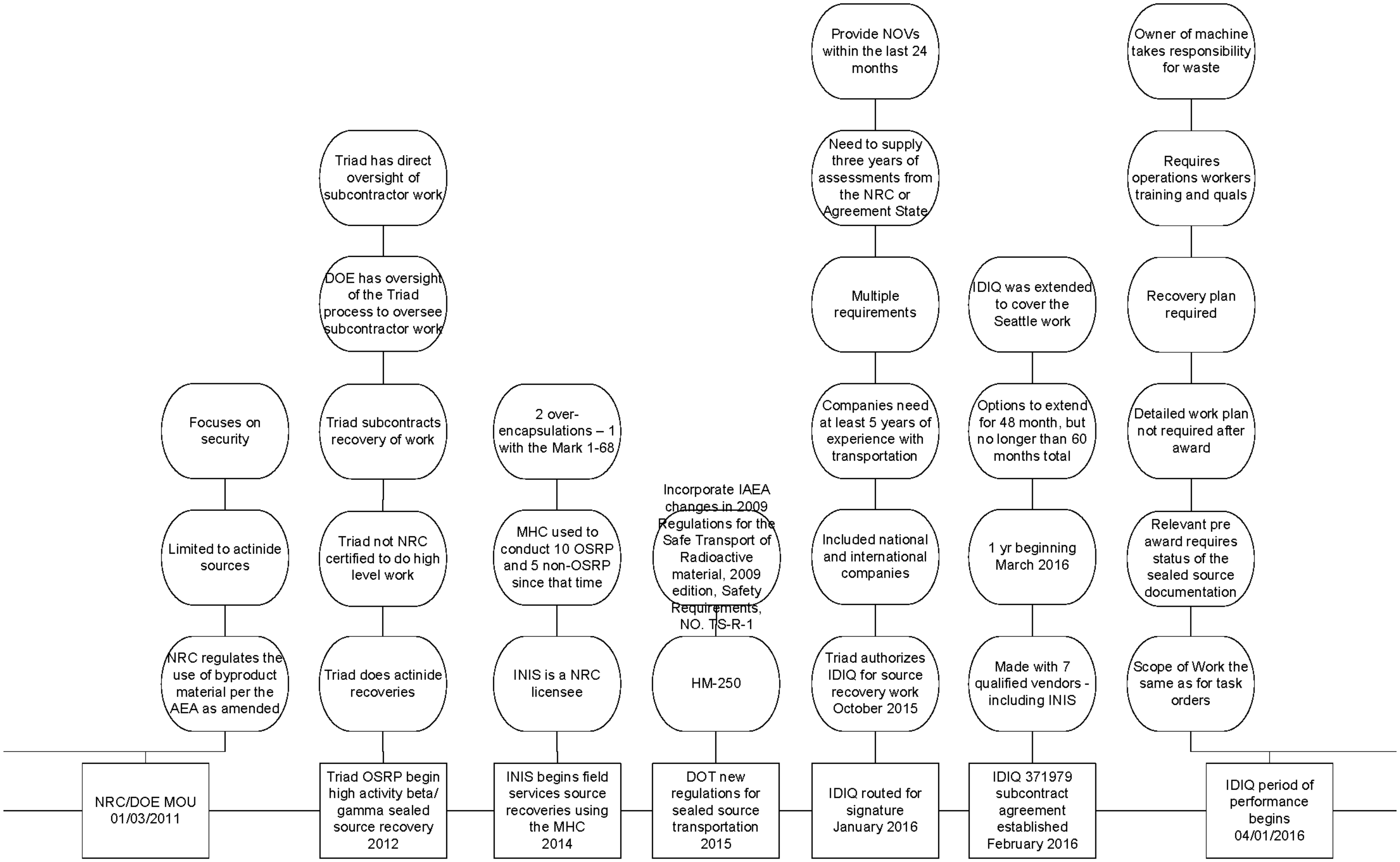
Factors	Accident Situation	Prior, Ideal or Accident-Free-Situation	Difference	Evaluation of Effects
			• Needed to use half-moon shield used under source for first time as a compensatory measure • Procedures did not address the unique first time half-moon shield first time use as an abnormal conditions/normalizing deviation • Change in documented procedure not analyzed • Higher radiation (streamers) allowed to exit out of the openings on the top of the MHC • Source tube not oriented and secured in the MHC as in the 2017 operation • Instability of the source tube during cutting/grinding operations within the MHC	• Questioning attitude was not present CF-B7 • ALARA concerns created • Operations allowed the source to be placed in a configuration where it could be breached • Cesium was released as a result of cutting operations on the source holder assembly DC • Operations were planned without detailed information about the source CF-1B • Contamination surveys not taken to determine potential cesium release following the angular cut CF-CXX • INIS could not identify when the contamination event began • Contamination allowed to spread while additional cuts were conducted • Contamination released into the MHC • Contamination was allowed to be transported outside of the loading dock • Contamination escaped to the building • Personnel and facilities contaminated

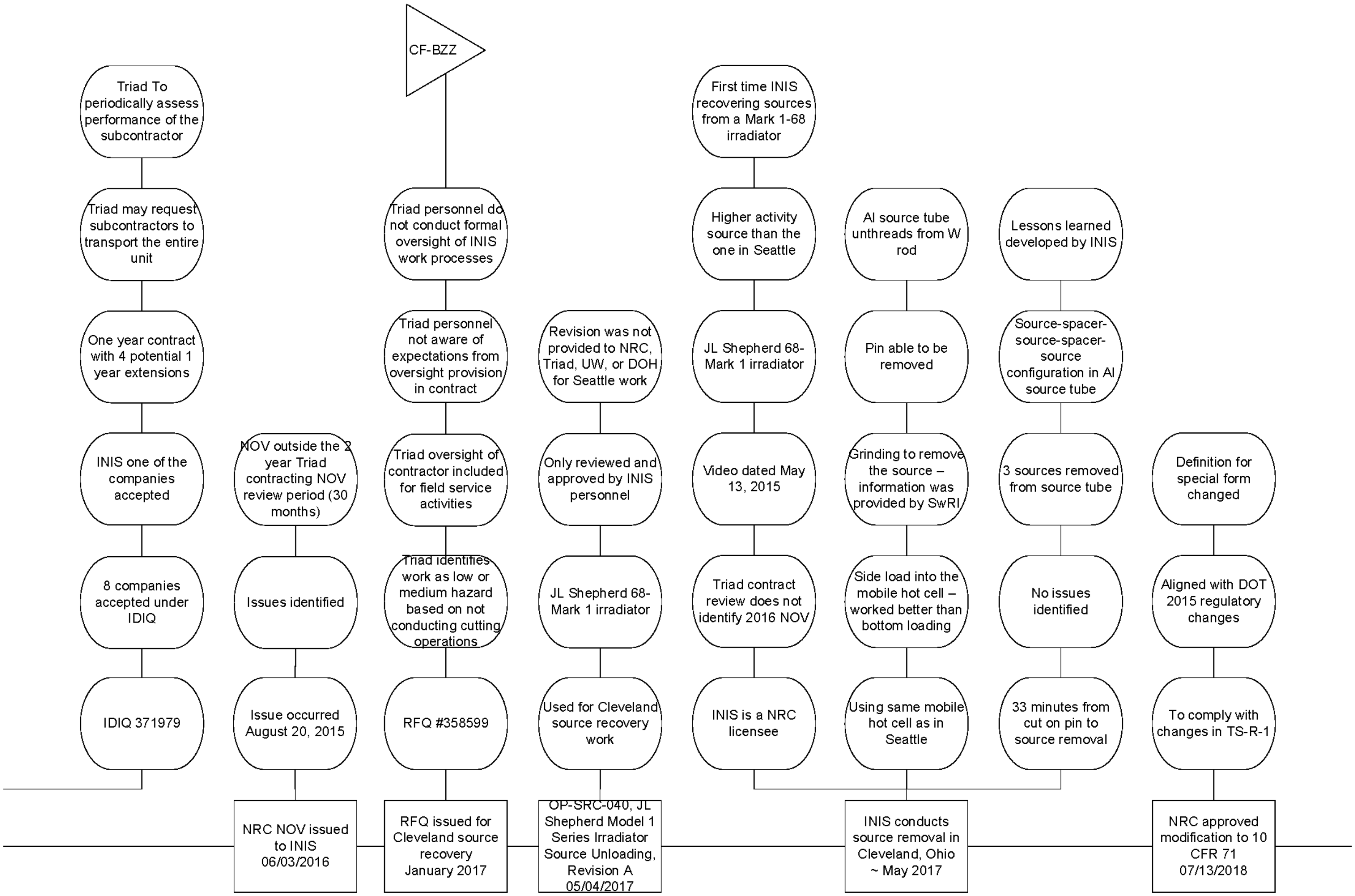
Factors	Accident Situation	Prior, Ideal or Accident-Free-Situation	Difference	Evaluation of Effects
				• Personnel received unplanned dose
	Procedure OP-SRC-040.B did not receive approval by the INIS ALARA Committee and training was not conducted on the revision	Procedure changes allowed without NRC approval with approval by the INIS Radiation Safety Committee and INIS staff is trained in the procedures prior to implementation per referenced correspondence as identified in License Condition 23	• Modifications to OP-SRC-040.B did not meet NRC procedure change requirements • INIS internal procedures allowed the change to be conducted without the ALARA Committee approval or training to the revised procedure • NRC license does not specify references to applicable procedures	• Apparent conflict between INIS change procedure and the NRC license • Operations allowed the source to be placed in a configuration where it could be breached
	Location of the source within the source tube was not known by INIS personnel	INIS positively knows the location of the source within the source tube	• JL Shepherd sources are not constructed consistently • Critical that INIS has access to the actual source drawings • INIS did not know the actual position of the source within the source holder	• Operations allowed the source to be placed in a configuration where it could be breached • Cesium was released as a result of cutting operations on the source holder assembly DC • Operations were planned without detailed information about the source CF-1B
OTHER	None			

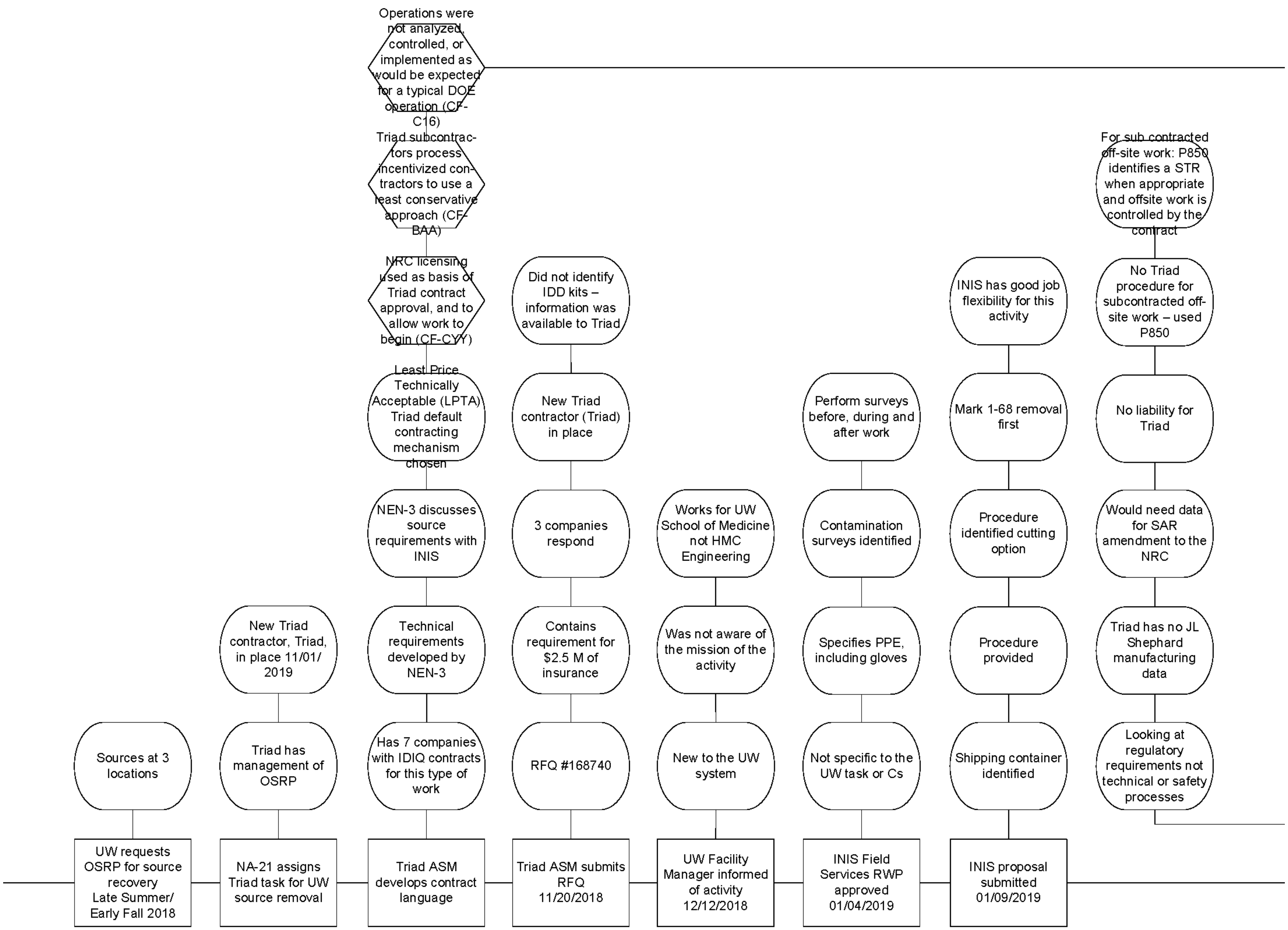
Appendix D: Events and Causal Factor Analysis

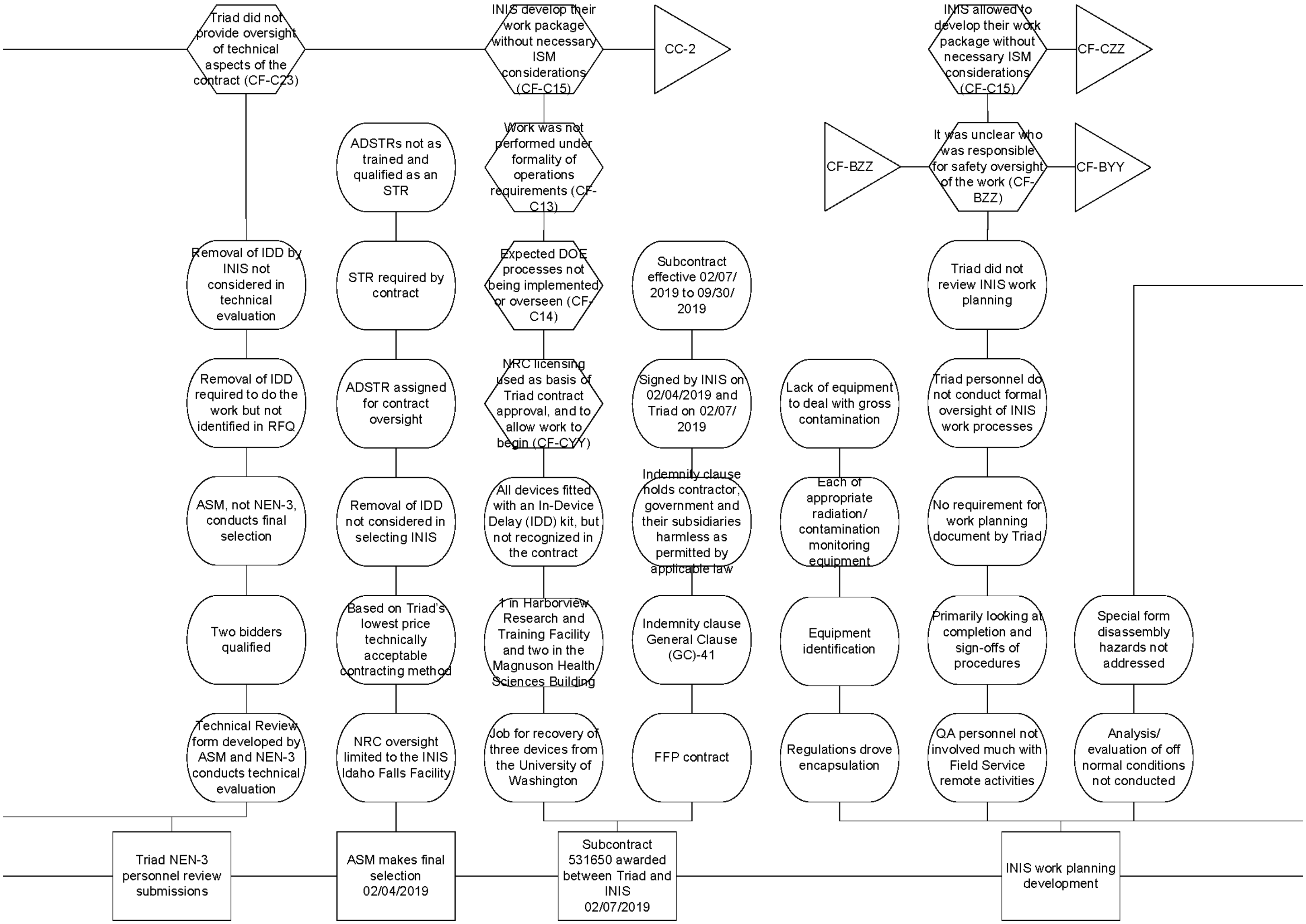


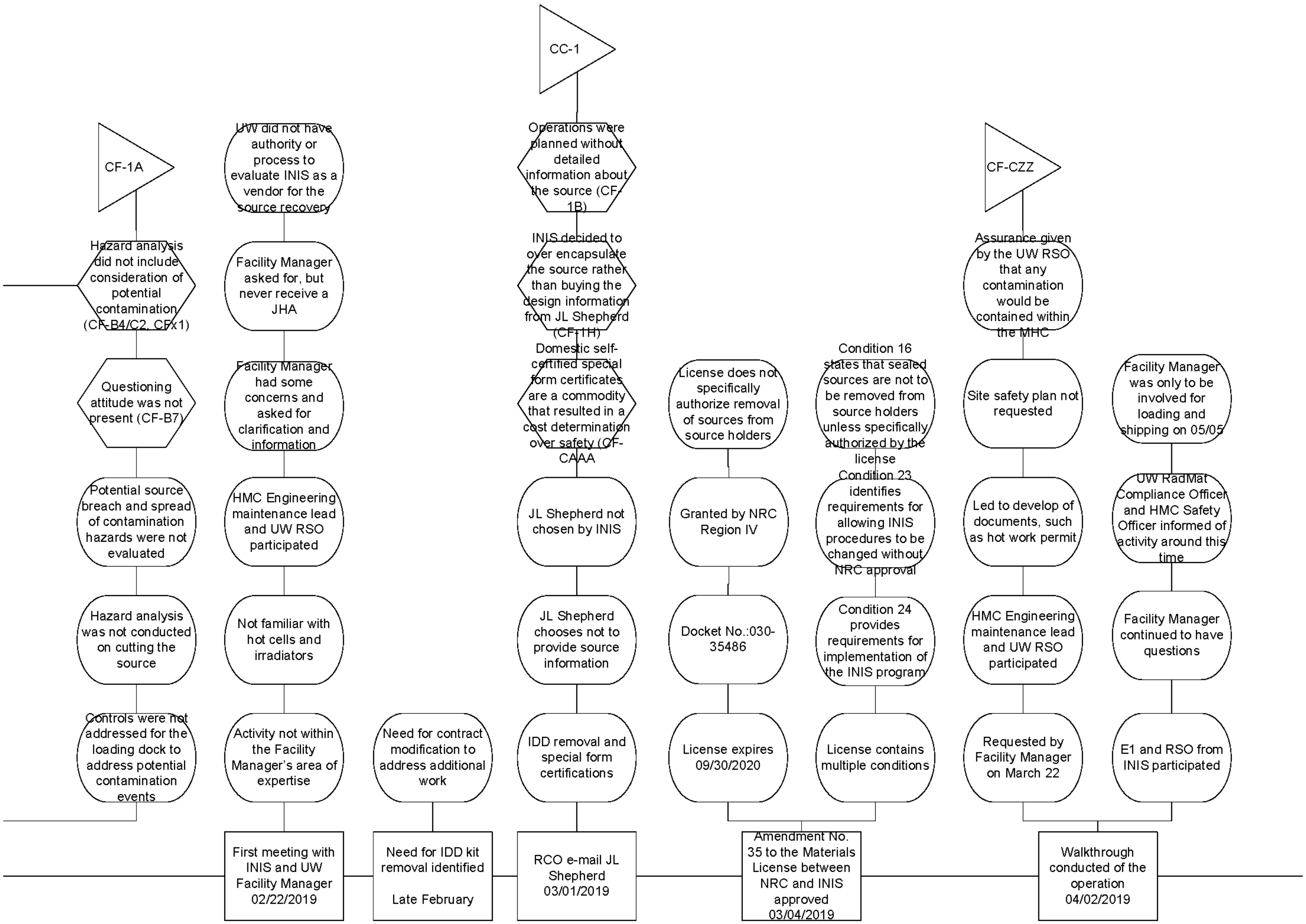

Source created 1974
Source strength 4,350 Ci in 11/ 2000 assay
Source number 39
Radioactive source recovery program conceived 1994
DOE Office of Waste Management
Urgent need to recover sources with no path to disposal
Radioactive Source Recovery Program at Triad 1997
Collaboration between NRC and DOE
NRC identifies partial list of disused actinide sealed sources for collection and disposal
OSRP established 1998
Formed after successful actinide source collections
Offsite Recovery Project – Acknowledgement of Responsibility memo 06/04/1999
Acknowledges continuing responsibility of the Offsite Source Recovery project and EM for recovered sources
Responsibility continues until sources are appropriately recycled, reused or disposed
Programmatic risks of how the work will be conducted need to be understood
Risks of sources in the private sector out way risks of recovering sources
The Department accepts financial risks for recovery and storage of sources
Changes in OSRP 2002-2004
NRC requested acceleration of the program
OSRP moved to DOE-EM (2002) and then to Office of Global Threat Reduction (2003)
Transferred to NA-20.2 – Nuclear and Radiological Threat Reduction Task Force in 2004
Scope expanded to include high energy beta/ gamma sources
No record of hazard analysis being conducted during organizational moves or scope expansion
OSRP first high activity cesium device recovery 2004
Irradiator transferred to UW 2003
Leak test indicates no contamination
UW licensed by State of Washington for radioactive material in the HRT building irradiator
State of Washington NRC agreement state since 1966
Replaced original MOU dated June 18, 1999
Form must be readily transportable
Does not require significant special or unique handling equipment
Does not address high level cesium recovery work
Confined to a single location

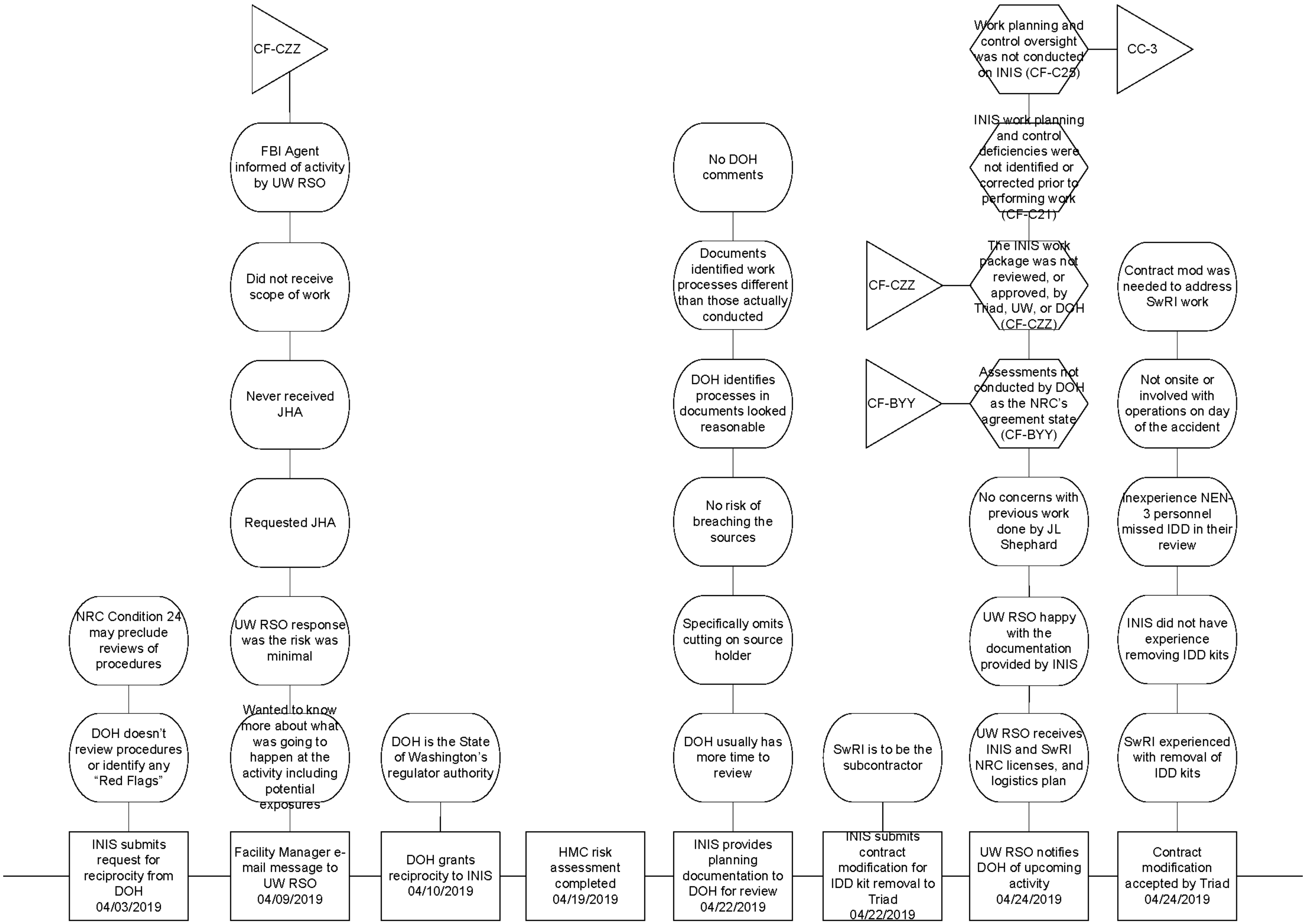

Focuses on security
Limited to actinide sources
NRC regulates the use of byproduct material per the AEA as amended
NRC/DOE MOU 01/03/2011
Triad has direct oversight of subcontractor work
DOE has oversight of the Triad process to oversee subcontractor work
Triad subcontracts recovery of work
Triad not NRC certified to do high level work
Triad does actinide recoveries
Triad OSRP begin high activity beta/ gamma sealed source recovery 2012
2 over-encapsulations – 1 with the Mark 1-68
MHC used to conduct 10 OSRP and 5 non-OSRP since that time
INIS is a NRC licensee
INIS begins field services source recoveries using the MHC 2014
Incorporate IAEA changes in 2009 Regulations for the Safe Transport of Radioactive material, 2009 edition, Safety Requirements, NO. TS-R-1
HM-250
DOT new regulations for sealed source transportation 2015
Provide NOVs within the last 24 months
Need to supply three years of assessments from the NRC or Agreement State
Multiple requirements
Companies need at least 5 years of experience with transportation
Included national and international companies
Triad authorizes IDIQ for source recovery work October 2015
IDIQ routed for signature January 2016
IDIQ was extended to cover the Seattle work
Options to extend for 48 month, but no longer than 60 months total
1 yr beginning March 2016
Made with 7 qualified vendors - including INIS
IDIQ 371979 subcontract agreement established February 2016
Owner of machine takes responsibility for waste
Requires operations workers training and quals
Recovery plan required
Detailed work plan not required after award
Relevant pre award requires status of the sealed source documentation
Scope of Work the same as for task orders
IDIQ period of performance begins 04/01/2016

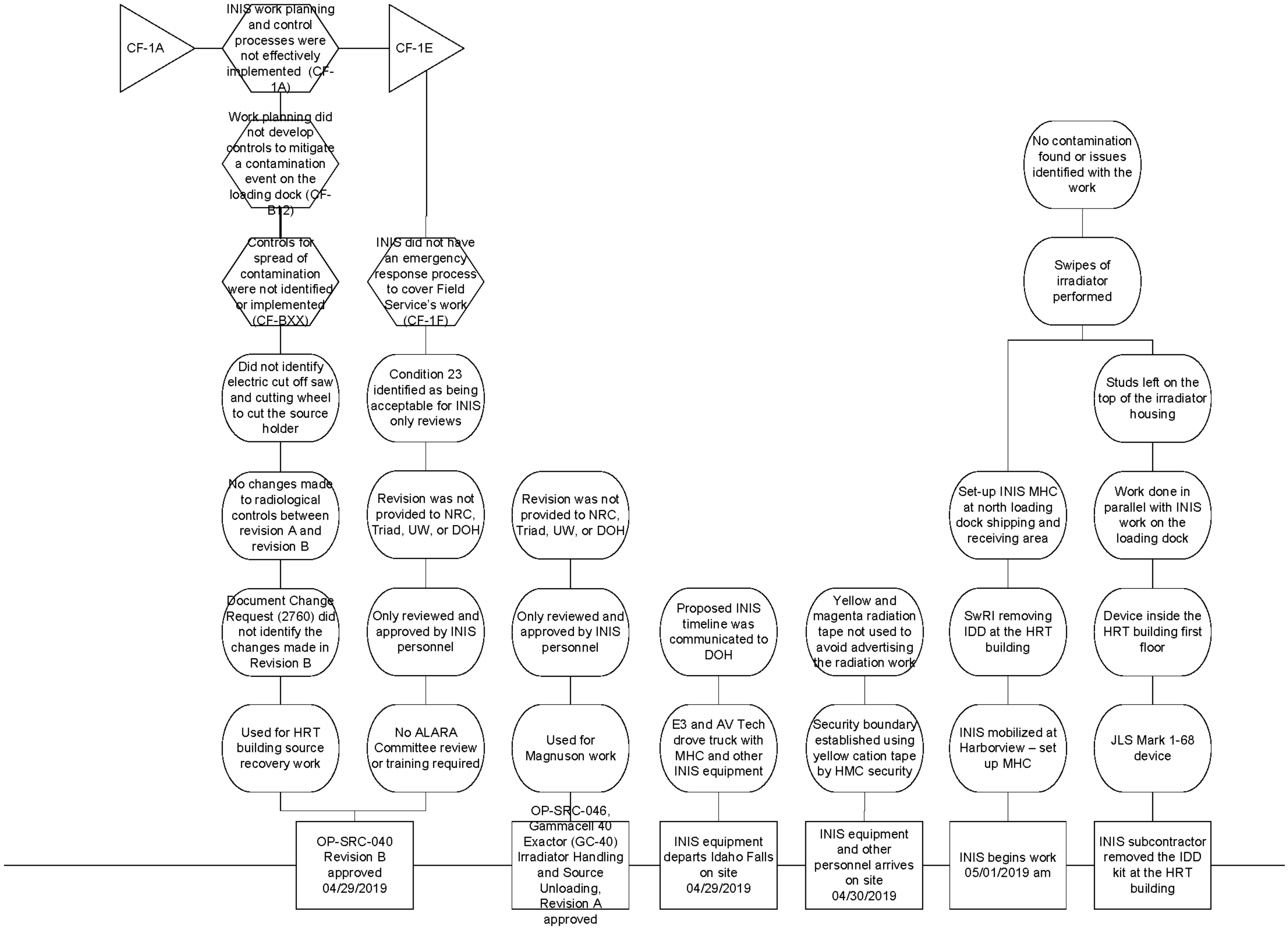

CF-BZZ
Triad To periodically assess performance of the subcontractor
Triad may request subcontractors to transport the entire unit
One year contract with 4 potential 1 year extensions
INIS one of the companies accepted
8 companies accepted under IDIQ
IDIQ 371979
NOV outside the 2 year Triad contracting NOV review period (30 months)
Issues identified
Issue occurred August 20, 2015
NRC NOV issued to INIS 06/03/2016
Triad personnel do not conduct formal oversight of INIS work processes
Triad personnel not aware of expectations from oversight provision in contract
Triad oversight of contractor included for field service activities
Triad identifies work as low or medium hazard based on not conducting cutting operations
RFQ #358599
RFQ issued for Cleveland source recovery January 2017
Revision was not provided to NRC, Triad, UW, or DOH for Seattle work
Only reviewed and approved by INIS personnel
JL Shepherd 68-Mark 1 irradiator
Used for Cleveland source recovery work
OP-SRC-040, JL Shepherd Model 1 Series Irradiator Source Unloading, Revision A 05/04/2017
First time INIS recovering sources from a Mark 1-68 irradiator
Higher activity source than the one in Seattle
JL Shepherd 68-Mark 1 irradiator
Video dated May 13, 2015
Triad contract review does not identify 2016 NOV
INIS is a NRC licensee
Al source tube unthreads from W rod
Pin able to be removed
Grinding to remove the source – information was provided by SwRI
Side load into the mobile hot cell – worked better than bottom loading
Using same mobile hot cell as in Seattle
INIS conducts source removal in Cleveland, Ohio ~ May 2017
Lessons learned developed by INIS
Source-spacer-source-spacer-source configuration in Al source tube
3 sources removed from source tube
No issues identified
33 minutes from cut on pin to source removal
Definition for special form changed
Aligned with DOT 2015 regulatory changes
To comply with changes in TS-R-1
NRC approved modification to 10 CFR 71 07/13/2018

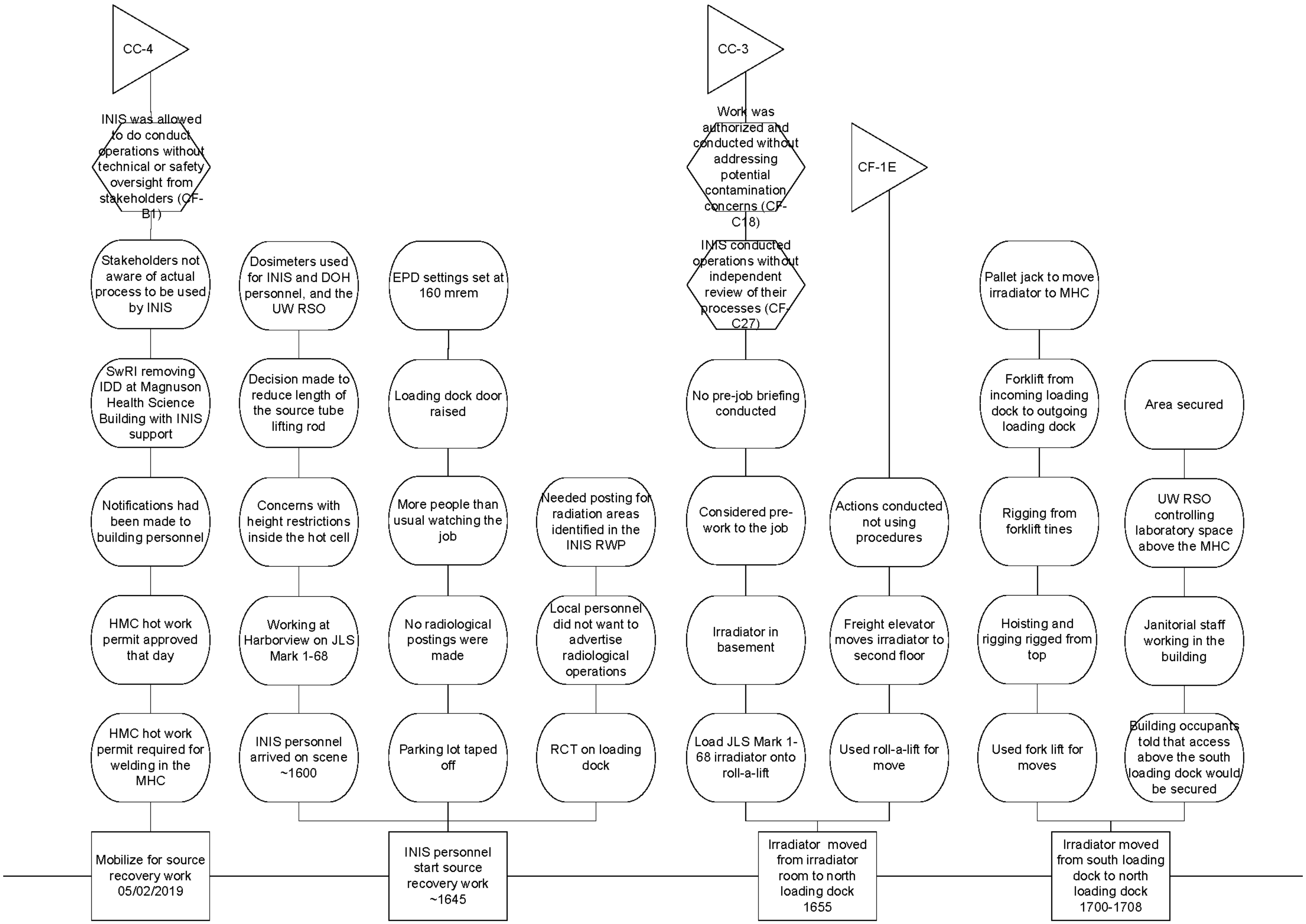

Operations were not analyzed, controlled, or implemented as would be expected for a typical DOE operation (CF-C16)
Triad subcontrac-tors process incentivized con-tractors to use a least conservative approach (CF-BAA)
NRC licensing used as basis of Triad contract approval, and to allow work to begin (CF-CYY)
Least Price Technically Acceptable (LPTA) Triad default contracting mechanism chosen
NEN-3 discusses source requirements with INIS
Technical requirements developed by NEN-3
Has 7 companies with IDIQ contracts for this type of work
Triad ASM develops contract language
Sources at 3 locations
UW requests OSRP for source recovery Late Summer/ Early Fall 2018
New Triad contractor, Triad, in place 11/01/ 2019
Triad has management of OSRP
NA-21 assigns Triad task for UW source removal
Did not identify IDD kits – information was available to Triad
New Triad contractor (Triad) in place
3 companies respond
Contains requirement for $2.5 M of insurance
RFQ #168740
Triad ASM submits RFQ 11/20/2018
Works for UW School of Medicine not HMC Engineering
Was not aware of the mission of the activity
New to the UW system
UW Facility Manager informed of activity 12/12/2018
Perform surveys before, during and after work
Contamination surveys identified
Specifies PPE, including gloves
Not specific to the UW task or Cs
INIS Field Services RWP approved 01/04/2019
INIS has good job flexibility for this activity
Mark 1-68 removal first
Procedure identified cutting option
Procedure provided
Shipping container identified
INIS proposal submitted 01/09/2019
For sub contracted off-site work: P850 identifies a STR when appropriate and offsite work is controlled by the contract
No Triad procedure for subcontracted off-site work – used P850
No liability for Triad
Would need data for SAR amendment to the NRC
Triad has no JL Shephard manufacturing data
Looking at regulatory requirements not technical or safety processes

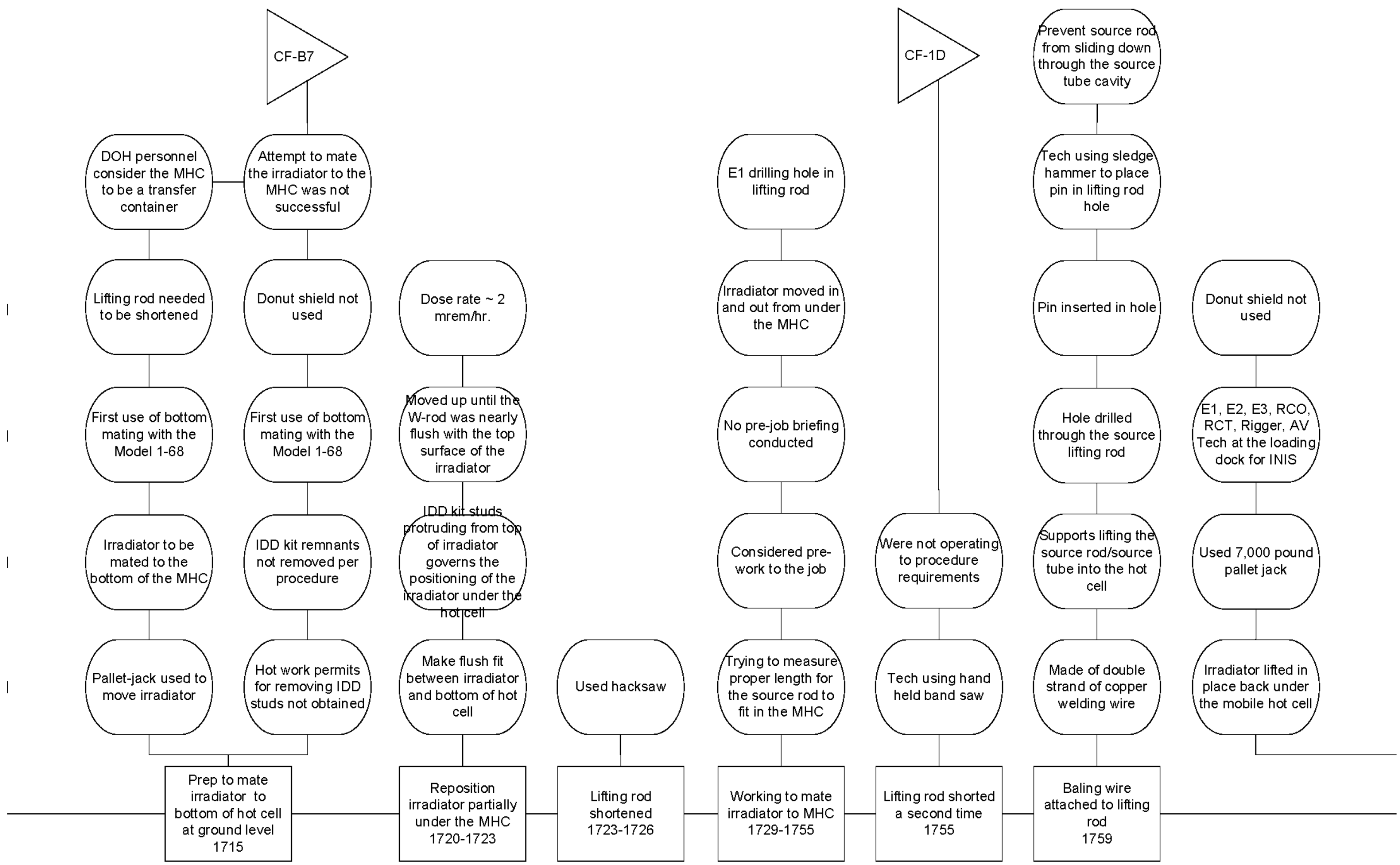

Triad did not provide oversight of technical aspects of the contract (CF-C23)
INIS develop their work package without necessary ISM considerations (CF-C15)
CC-2
INIS allowed to develop their work package without necessary ISM considerations (CF-C15)
CF-CZZ
ADSTRs not as trained and qualified as an STR
Work was not performed under formality of operations requirements (CF-C13)
CF-BZZ
It was unclear who was responsible for safety oversight of the work (CF-BZZ)
CF-BYY
Removal of IDD by INIS not considered in technical evaluation
STR required by contract
Expected DOE processes not being implemented or overseen (CF-C14)
Subcontract effective 02/07/2019 to 09/30/2019
Triad did not review INIS work planning
Removal of IDD required to do the work but not identified in RFQ
ADSTR assigned for contract oversight
NRC licensing used as basis of Triad contract approval, and to allow work to begin (CF-CYY)
Signed by INIS on 02/04/2019 and Triad on 02/07/2019
Lack of equipment to deal with gross contamination
Triad personnel do not conduct formal oversight of INIS work processes
ASM, not NEN-3, conducts final selection
Removal of IDD not considered in selecting INIS
All devices fitted with an In-Device Delay (IDD) kit, but not recognized in the contract
Indemnity clause holds contractor, government and their subsidiaries harmless as permitted by applicable law
Each of appropriate radiation/ contamination monitoring equipment
No requirement for work planning document by Triad
Two bidders qualified
Based on Triad's lowest price technically acceptable contracting method
1 in Harborview Research and Training Facility and two in the Magnuson Health Sciences Building
Indemnity clause General Clause (GC)-41
Equipment identification
Primarily looking at completion and sign-offs of procedures
Special form disassembly hazards not addressed
Technical Review form developed by ASM and NEN-3 conducts technical evaluation
NRC oversight limited to the INIS Idaho Falls Facility
Job for recovery of three devices from the University of Washington
FFP contract
Regulations drove encapsulation
QA personnel not involved much with Field Service remote activities
Analysis/ evaluation of off normal conditions not conducted
Triad NEN-3 personnel review submissions
ASM makes final selection 02/04/2019
Subcontract 531650 awarded between Triad and INIS 02/07/2019
INIS work planning development

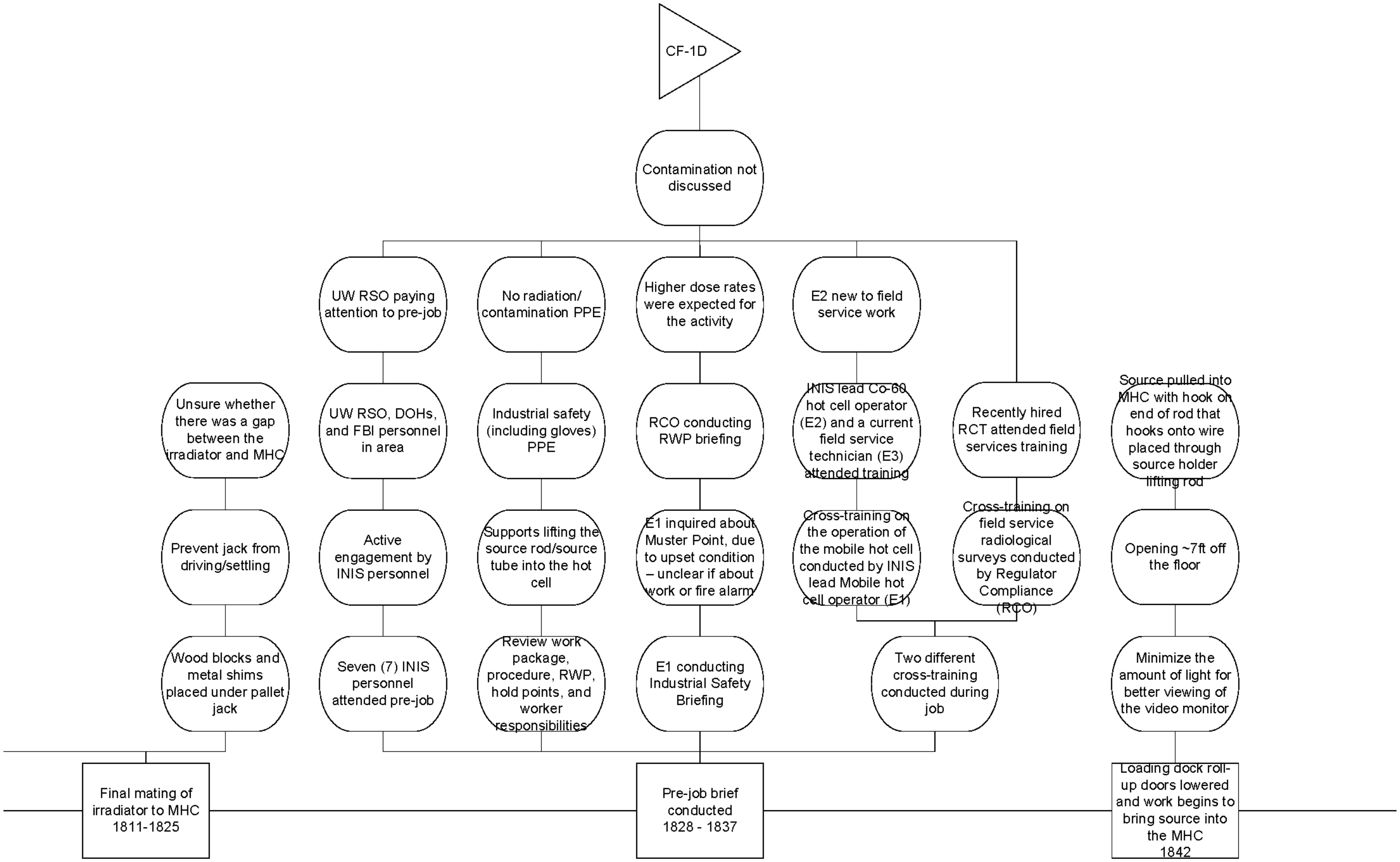

CF-1A
Hazard analysis did not include consideration of potential contamination (CF-B4/C2, CFx1)
Questioning attitude was not present (CF-B7)
Potential source breach and spread of contamination hazards were not evaluated
Hazard analysis was not conducted on cutting the source
Controls were not addressed for the loading dock to address potential contamination events
UW did not have authority or process to evaluate INIS as a vendor for the source recovery
Facility Manager asked for, but never receive a JHA
Facility Manager had some concerns and asked for clarification and information
HMC Engineering maintenance lead and UW RSO participated
Not familiar with hot cells and irradiators
Activity not within the Facility Manager's area of expertise
First meeting with INIS and UW Facility Manager 02/22/2019
Need for contract modification to address additional work
Need for IDD kit removal identified
Late February
CC-1
Operations were planned without detailed information about the source (CF-1B)
INIS decided to over encapsulate the source rather than buying the design information from JL Shepherd (CF-1H)
Domestic self-certified special form certificates are a commodity that resulted in a cost determination over safety (CF-CAAA
JL Shepherd not chosen by INIS
JL Shepherd chooses not to provide source information
IDD removal and special form certifications
RCO e-mail JL Shepherd 03/01/2019
License does not specifically authorize removal of sources from source holders
Granted by NRC Region IV
Docket No.:030-35486
License expires 09/30/2020
Condition 16 states that sealed sources are not to be removed from source holders unless specifically authorized by the license
Condition 23 identifies requirements for allowing INIS procedures to be changed without NRC approval
Condition 24 provides requirements for implementation of the INIS program
License contains multiple conditions
Amendment No. 35 to the Materials License between NRC and INIS approved 03/04/2019
CF-CZZ
Assurance given by the UW RSO that any contamination would be contained within the MHC
Site safety plan not requested
Led to develop of documents, such as hot work permit
HMC Engineering maintenance lead and UW RSO participated
Requested by Facility Manager on March 22
Facility Manager was only to be involved for loading and shipping on 05/05
UW RadMat Compliance Officer and HMC Safety Officer informed of activity around this time
Facility Manager continued to have questions
E1 and RSO from INIS participated
Walkthrough conducted of the operation 04/02/2019

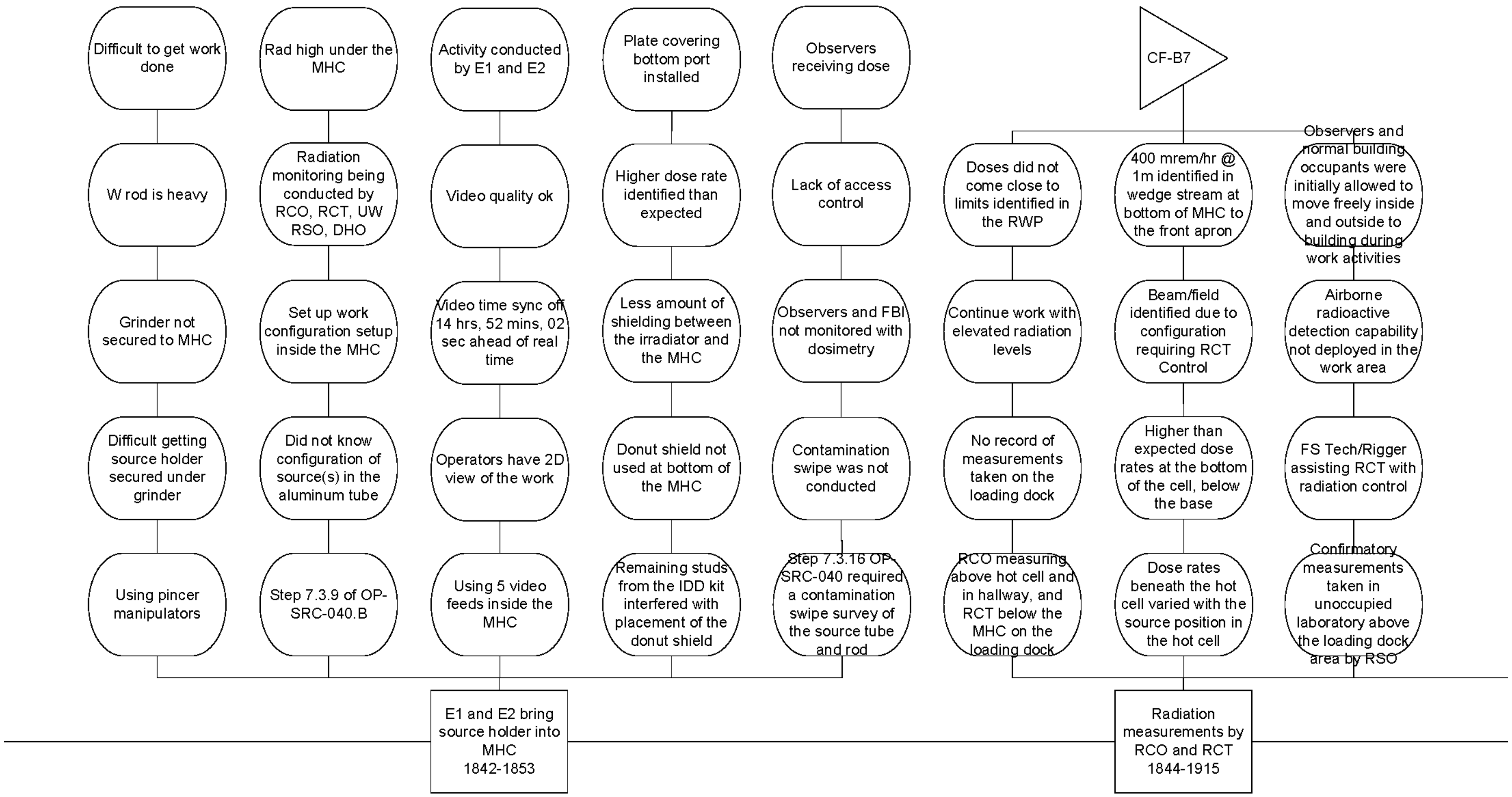

CF-CZZ
FBI Agent informed of activity by UW RSO
Did not receive scope of work
Never received JHA
Requested JHA
NRC Condition 24 may preclude reviews of procedures
UW RSO response was the risk was minimal
DOH doesn't review procedures or identify any "Red Flags"
Wanted to know more about what was going to happen at the activity including potential exposures
DOH is the State of Washington's regulator authority
No DOH comments
Documents identified work processes different than those actually conducted
DOH identifies processes in documents looked reasonable
No risk of breaching the sources
Specifically omits cutting on source holder
DOH usually has more time to review
SwRI is to be the subcontractor
Work planning and control oversight was not conducted on INIS (CF-C25)
CC-3
INIS work planning and control deficiencies were not identified or corrected prior to performing work (CF-C21)
CF-CZZ
The INIS work package was not reviewed, or approved, by Triad, UW, or DOH (CF-CZZ)
CF-BYY
Assessments not conducted by DOH as the NRC's agreement state (CF-BYY)
No concerns with previous work done by JL Shephard
UW RSO happy with the documentation provided by INIS
UW RSO receives INIS and SwRI NRC licenses, and logistics plan
Contract mod was needed to address SwRI work
Not onsite or involved with operations on day of the accident
Inexperience NEN-3 personnel missed IDD in their review
INIS did not have experience removing IDD kits
SwRI experienced with removal of IDD kits
INIS submits request for reciprocity from DOH 04/03/2019
Facility Manager e-mail message to UW RSO 04/09/2019
DOH grants reciprocity to INIS 04/10/2019
HMC risk assessment completed 04/19/2019
INIS provides planning documentation to DOH for review 04/22/2019
INIS submits contract modification for IDD kit removal to Triad 04/22/2019
UW RSO notifies DOH of upcoming activity 04/24/2019
Contract modification accepted by Triad 04/24/2019

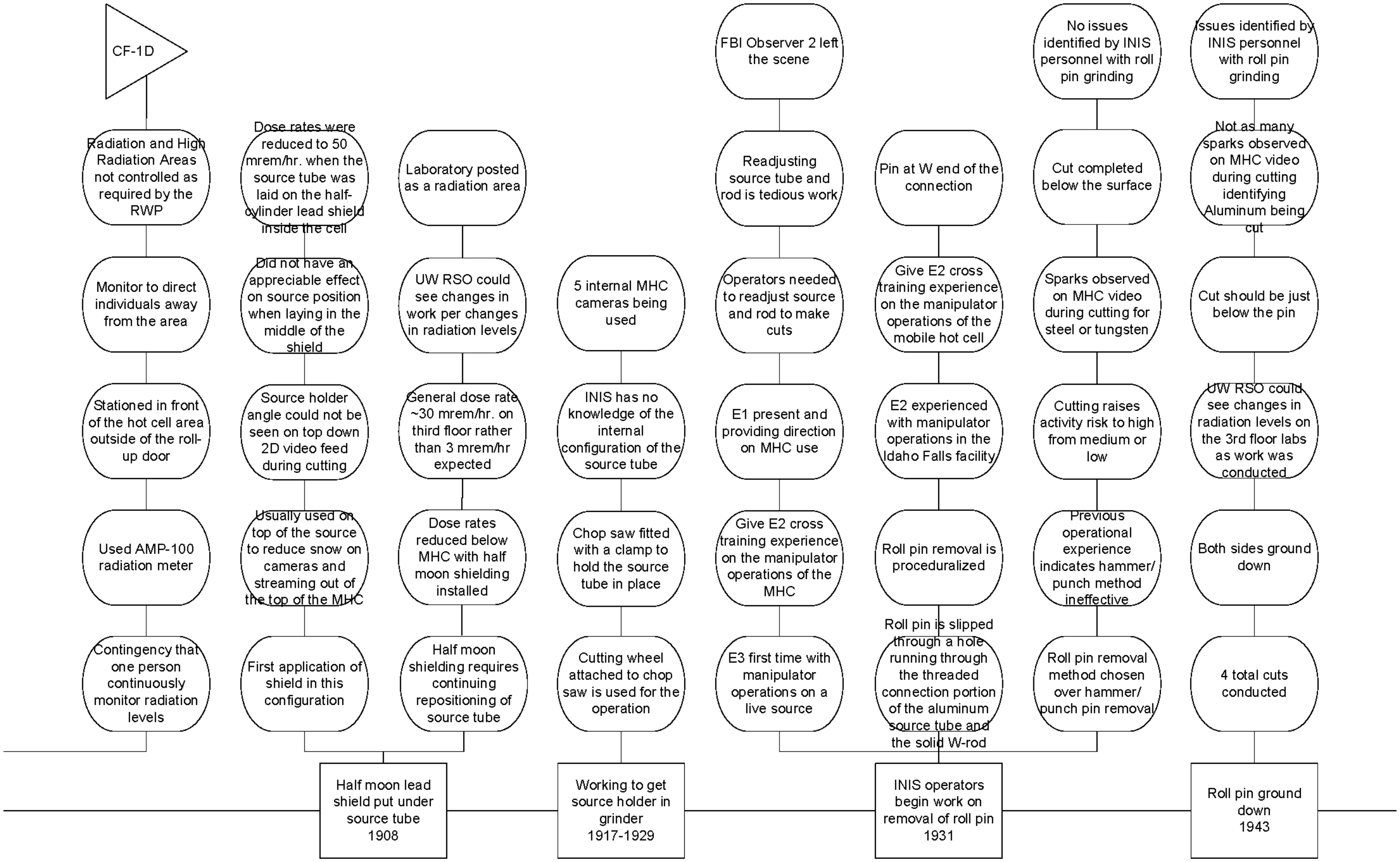

CF-1A
INIS work planning and control processes were not effectively implemented (CF-1A)
CF-1E
Work planning did not develop controls to mitigate a contamination event on the loading dock (CF-B12)
Controls for spread of contamination were not identified or implemented (CF-BXX)
INIS did not have an emergency response process to cover Field Service's work (CF-1F)
No contamination found or issues identified with the work
Swipes of irradiator performed
Did not identify electric cut off saw and cutting wheel to cut the source holder
Condition 23 identified as being acceptable for INIS only reviews
Studs left on the top of the irradiator housing
No changes made to radiological controls between revision A and revision B
Revision was not provided to NRC, Triad, UW, or DOH
Revision was not provided to NRC, Triad, UW, or DOH
Set-up INIS MHC at north loading dock shipping and receiving area
Work done in parallel with INIS work on the loading dock
Document Change Request (2760) did not identify the changes made in Revision B
Only reviewed and approved by INIS personnel
Only reviewed and approved by INIS personnel
Proposed INIS timeline was communicated to DOH
Yellow and magenta radiation tape not used to avoid advertising the radiation work
SwRI removing IDD at the HRT building
Device inside the HRT building first floor
Used for HRT building source recovery work
No ALARA Committee review or training required
Used for Magnuson work
E3 and AV Tech drove truck with MHC and other INIS equipment
Security boundary established using yellow cation tape by HMC security
INIS mobilized at Harborview – set up MHC
JLS Mark 1-68 device
OP-SRC-040 Revision B approved 04/29/2019
OP-SRC-046, Gammacell 40 Exactor (GC-40) Irradiator Handling and Source Unloading, Revision A approved
INIS equipment departs Idaho Falls on site 04/29/2019
INIS equipment and other personnel arrives on site 04/30/2019
INIS begins work 05/01/2019 am
INIS subcontractor removed the IDD kit at the HRT building

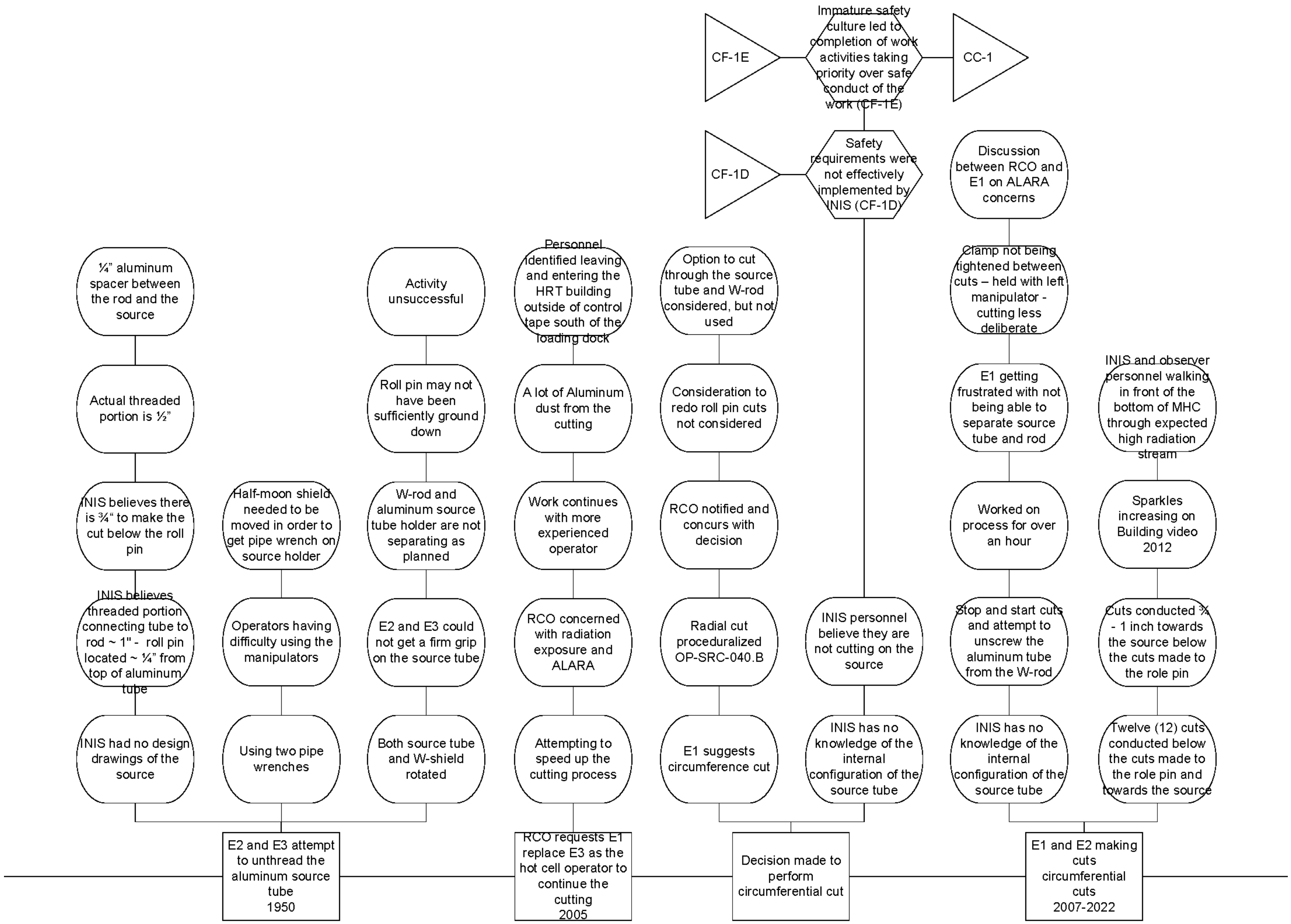

CC-4
INIS was allowed to do conduct operations without technical or safety oversight from stakeholders (CF-B1)
Stakeholders not aware of actual process to be used by INIS
SwRI removing IDD at Magnuson Health Science Building with INIS support
Notifications had been made to building personnel
HMC hot work permit approved that day
HMC hot work permit required for welding in the MHC
Mobilize for source recovery work 05/02/2019
Dosimeters used for INIS and DOH personnel, and the UW RSO
Decision made to reduce length of the source tube lifting rod
Concerns with height restrictions inside the hot cell
Working at Harborview on JLS Mark 1-68
INIS personnel arrived on scene ~1600
EPD settings set at 160 mrem
Loading dock door raised
More people than usual watching the job
No radiological postings were made
Parking lot taped off
Needed posting for radiation areas identified in the INIS RWP
Local personnel did not want to advertise radiological operations
RCT on loading dock
INIS personnel start source recovery work ~1645
CC-3
Work was authorized and conducted without addressing potential contamination concerns (CF-C18)
INIS conducted operations without independent review of their processes (CF-C27)
No pre-job briefing conducted
Considered pre-work to the job
Irradiator in basement
Load JLS Mark 1-68 irradiator onto roll-a-lift
CF-1E
Actions conducted not using procedures
Freight elevator moves irradiator to second floor
Used roll-a-lift for move
Irradiator moved from irradiator room to north loading dock 1655
Pallet jack to move irradiator to MHC
Forklift from incoming loading dock to outgoing loading dock
Rigging from forklift tines
Hoisting and rigging rigged from top
Used fork lift for moves
Area secured
UW RSO controlling laboratory space above the MHC
Janitorial staff working in the building
Building occupants told that access above the south loading dock would be secured
Irradiator moved from south loading dock to north loading dock 1700-1708

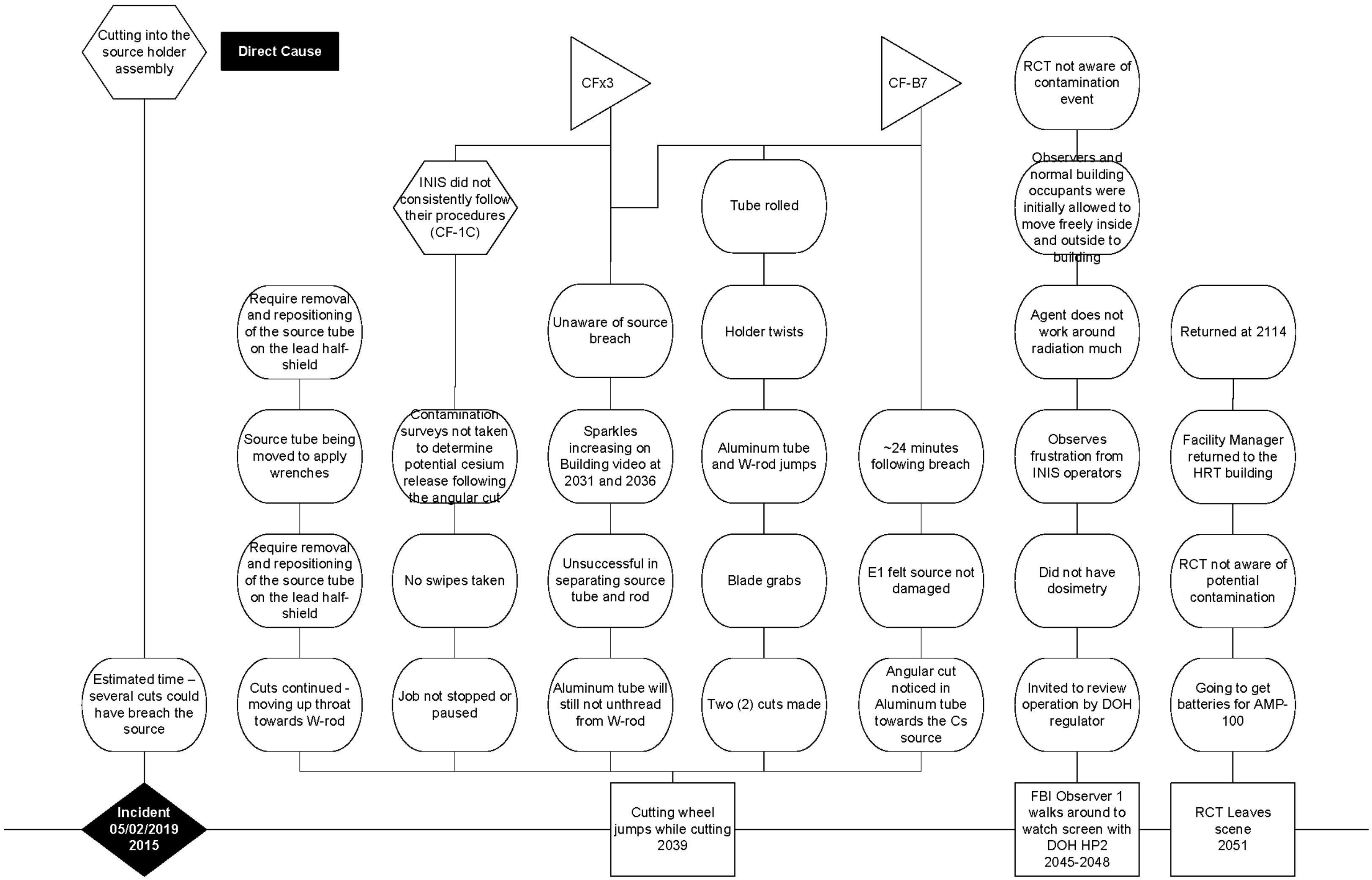

CF-B7
CF-1D
Prevent source rod from sliding down through the source tube cavity
DOH personnel consider the MHC to be a transfer container
Attempt to mate the irradiator to the MHC was not successful
E1 drilling hole in lifting rod
Tech using sledge hammer to place pin in lifting rod hole
Lifting rod needed to be shortened
Donut shield not used
Dose rate ~ 2 mrem/hr.
Irradiator moved in and out from under the MHC
Pin inserted in hole
Donut shield not used
First use of bottom mating with the Model 1-68
First use of bottom mating with the Model 1-68
Moved up until the W-rod was nearly flush with the top surface of the irradiator
No pre-job briefing conducted
Hole drilled through the source lifting rod
E1, E2, E3, RCO, RCT, Rigger, AV Tech at the loading dock for INIS
Irradiator to be mated to the bottom of the MHC
IDD kit remnants not removed per procedure
IDD kit studs protruding from top of irradiator governs the positioning of the irradiator under the hot cell
Considered pre-work to the job
Were not operating to procedure requirements
Supports lifting the source rod/source tube into the hot cell
Used 7,000 pound pallet jack
Pallet-jack used to move irradiator
Hot work permits for removing IDD studs not obtained
Make flush fit between irradiator and bottom of hot cell
Used hacksaw
Trying to measure proper length for the source rod to fit in the MHC
Tech using hand held band saw
Made of double strand of copper welding wire
Irradiator lifted in place back under the mobile hot cell
Prep to mate irradiator to bottom of hot cell at ground level 1715
Reposition irradiator partially under the MHC 1720-1723
Lifting rod shortened 1723-1726
Working to mate irradiator to MHC 1729-1755
Lifting rod shorted a second time 1755
Baling wire attached to lifting rod 1759

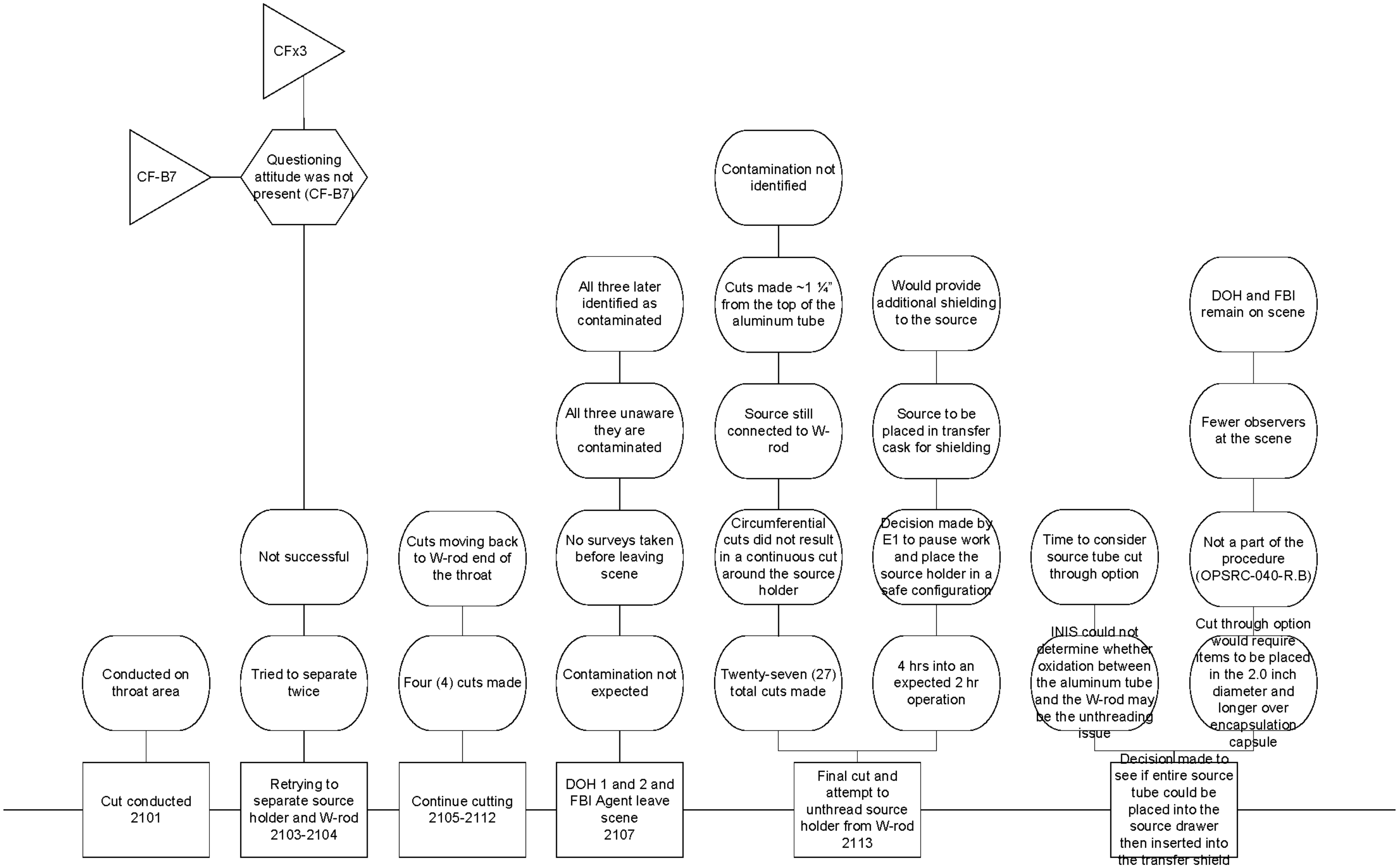

CF-1D
Contamination not discussed
UW RSO paying attention to pre-job
No radiation/ contamination PPE
Higher dose rates were expected for the activity
E2 new to field service work
Unsure whether there was a gap between the irradiator and MHC
UW RSO, DOHs, and FBI personnel in area
Industrial safety (including gloves) PPE
RCO conducting RWP briefing
INIS lead Co-60 hot cell operator (E2) and a current field service technician (E3) attended training
Recently hired RCT attended field services training
Source pulled into MHC with hook on end of rod that hooks onto wire placed through source holder lifting rod
Prevent jack from driving/settling
Active engagement by INIS personnel
Supports lifting the source rod/source tube into the hot cell
E1 inquired about Muster Point, due to upset condition – unclear if about work or fire alarm
Cross-training on the operation of the mobile hot cell conducted by INIS lead Mobile hot cell operator (E1)
Cross-training on field service radiological surveys conducted by Regulator Compliance (RCO)
Opening ~7ft off the floor
Wood blocks and metal shims placed under pallet jack
Seven (7) INIS personnel attended pre-job
Review work package, procedure, RWP, hold points, and worker responsibilities
E1 conducting Industrial Safety Briefing
Two different cross-training conducted during job
Minimize the amount of light for better viewing of the video monitor
Final mating of irradiator to MHC 1811-1825
Pre-job brief conducted 1828 - 1837
Loading dock roll-up doors lowered and work begins to bring source into the MHC 1842

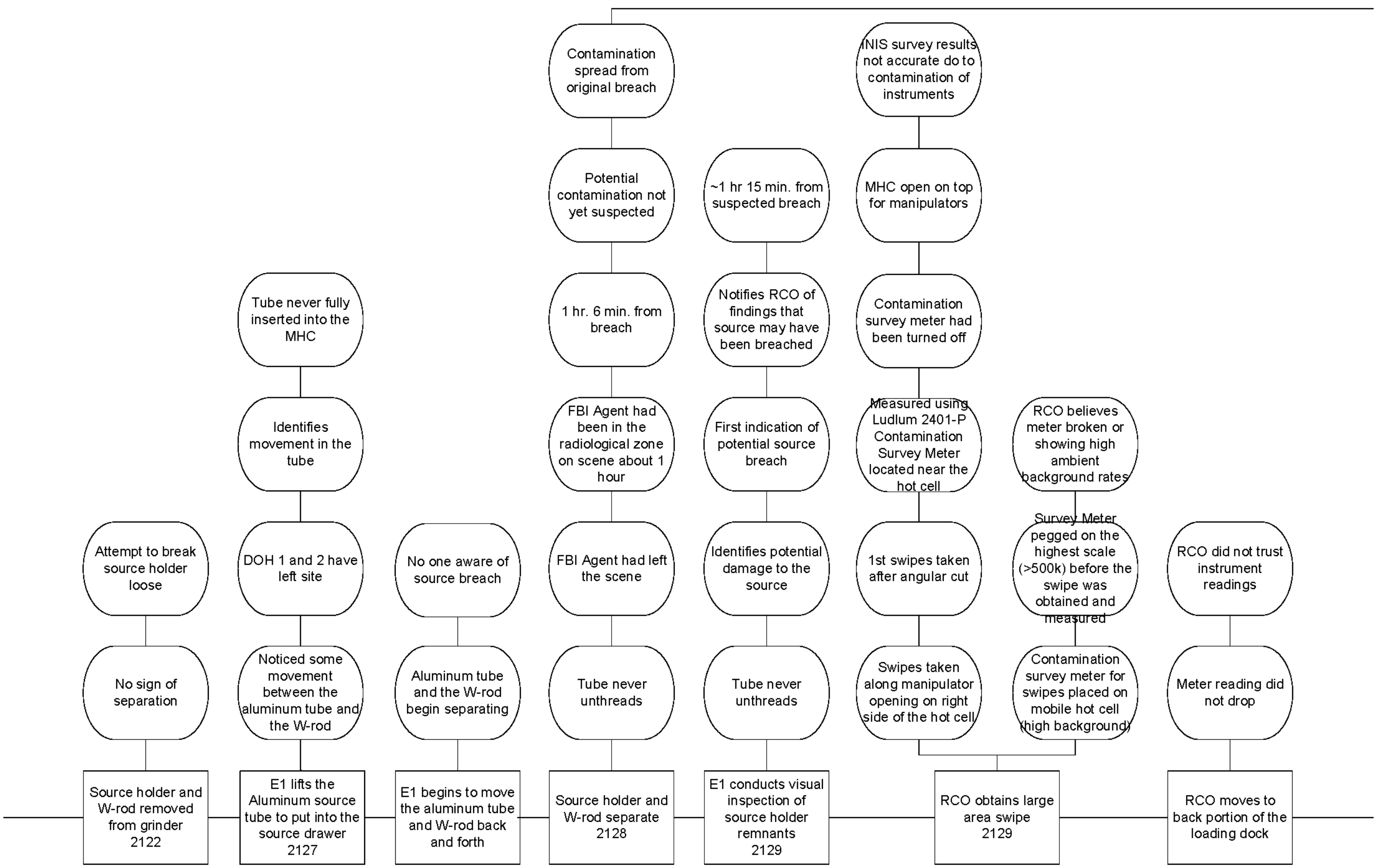

Difficult to get work done
W rod is heavy
Grinder not secured to MHC
Difficult getting source holder secured under grinder
Using pincer manipulators
Rad high under the MHC
Radiation monitoring being conducted by RCO, RCT, UW RSO, DHO
Set up work configuration setup inside the MHC
Did not know configuration of source(s) in the aluminum tube
Step 7.3.9 of OP-SRC-040.B
Activity conducted by E1 and E2
Video quality ok
Video time sync off 14 hrs, 52 mins, 02 sec ahead of real time
Operators have 2D view of the work
Using 5 video feeds inside the MHC
Plate covering bottom port installed
Higher dose rate identified than expected
Less amount of shielding between the irradiator and the MHC
Donut shield not used at bottom of the MHC
Remaining studs from the IDD kit interfered with placement of the donut shield
Observers receiving dose
Lack of access control
Observers and FBI not monitored with dosimetry
Contamination swipe was not conducted
Step 7.3.16 OP-SRC-040 required a contamination swipe survey of the source tube and rod
CF-B7
Doses did not come close to limits identified in the RWP
Continue work with elevated radiation levels
No record of measurements taken on the loading dock
RCO measuring above hot cell and in hallway, and RCT below the MHC on the loading dock
400 mrem/hr @ 1m identified in wedge stream at bottom of MHC to the front apron
Beam/field identified due to configuration requiring RCT Control
Higher than expected dose rates at the bottom of the cell, below the base
Dose rates beneath the hot cell varied with the source position in the hot cell
Observers and normal building occupants were initially allowed to move freely inside and outside to building during work activities
Airborne radioactive detection capability not deployed in the work area
FS Tech/Rigger assisting RCT with radiation control
Confirmatory measurements taken in unoccupied laboratory above the loading dock area by RSO
E1 and E2 bring source holder into MHC 1842-1853
Radiation measurements by RCO and RCT 1844-1915

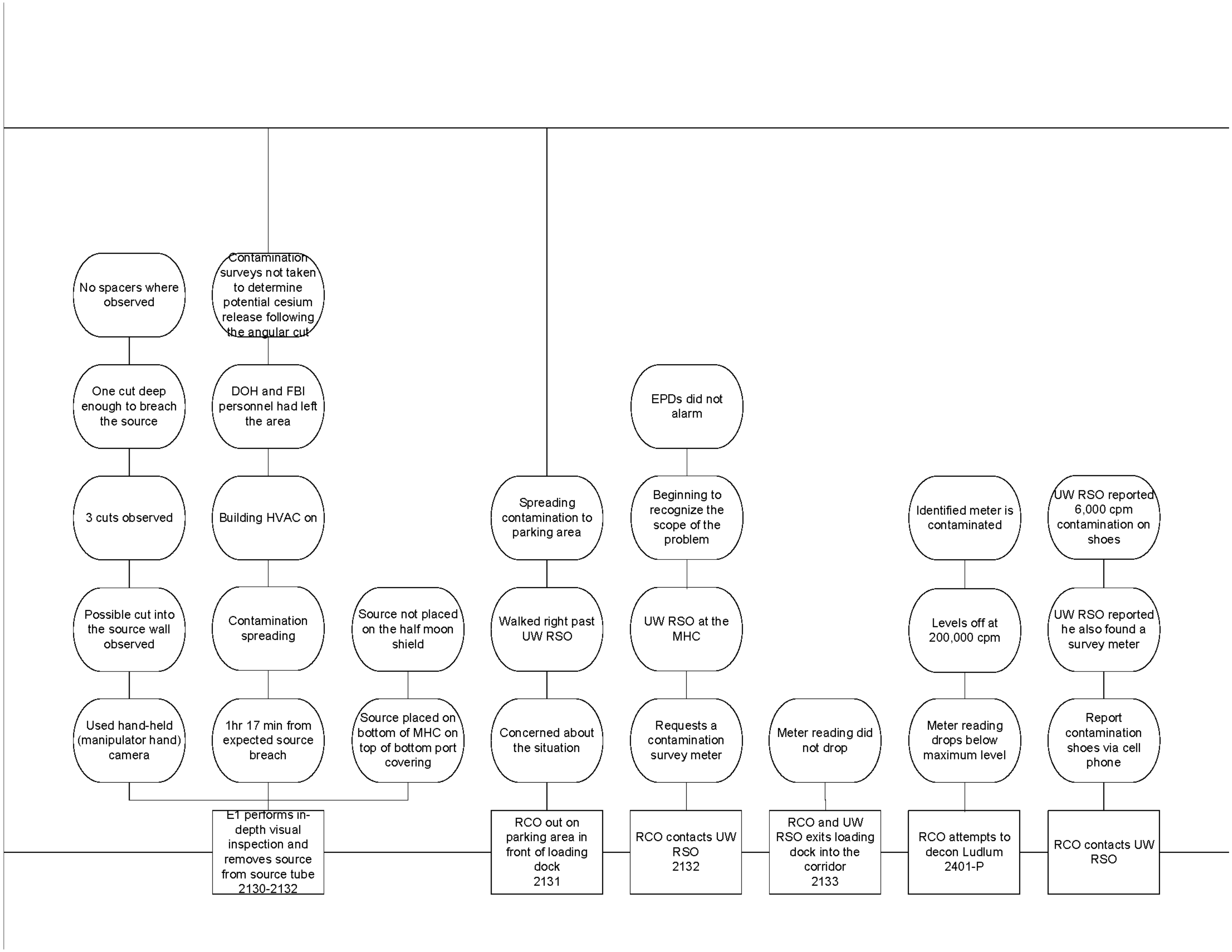

CF-1D
Radiation and High Radiation Areas not controlled as required by the RWP
Monitor to direct individuals away from the area
Stationed in front of the hot cell area outside of the roll-up door
Used AMP-100 radiation meter
Contingency that one person continuously monitor radiation levels
Dose rates were reduced to 50 mrem/hr. when the source tube was laid on the half-cylinder lead shield inside the cell
Did not have an appreciable effect on source position when laying in the middle of the shield
Source holder angle could not be seen on top down 2D video feed during cutting
Usually used on top of the source to reduce snow on cameras and streaming out of the top of the MHC
First application of shield in this configuration
Laboratory posted as a radiation area
UW RSO could see changes in work per changes in radiation levels
General dose rate ~30 mrem/hr. on third floor rather than 3 mrem/hr expected
Dose rates reduced below MHC with half moon shielding installed
Half moon shielding requires continuing repositioning of source tube
Half moon lead shield put under source tube
1908
5 internal MHC cameras being used
INIS has no knowledge of the internal configuration of the source tube
Chop saw fitted with a clamp to hold the source tube in place
Cutting wheel attached to chop saw is used for the operation
Working to get source holder in grinder
1917-1929
FBI Observer 2 left the scene
Readjusting source tube and rod is tedious work
Operators needed to readjust source and rod to make cuts
E1 present and providing direction on MHC use
Give E2 cross training experience on the manipulator operations of the MHC
E3 first time with manipulator operations on a live source
Pin at W end of the connection
Give E2 cross training experience on the manipulator operations of the mobile hot cell
E2 experienced with manipulator operations in the Idaho Falls facility
Roll pin removal is proceduralized
Roll pin is slipped through a hole running through the threaded connection portion of the aluminum source tube and the solid W-rod
INIS operators begin work on removal of roll pin
1931
No issues identified by INIS personnel with roll pin grinding
Cut completed below the surface
Sparks observed on MHC video during cutting for steel or tungsten
Cutting raises activity risk to high from medium or low
Previous operational experience indicates hammer/ punch method ineffective
Roll pin removal method chosen over hammer/ punch pin removal
Issues identified by INIS personnel with roll pin grinding
Not as many sparks observed on MHC video during cutting identifying Aluminum being cut
Cut should be just below the pin
UW RSO could see changes in radiation levels on the 3rd floor labs as work was conducted
Both sides ground down
4 total cuts conducted
Roll pin ground down
1943

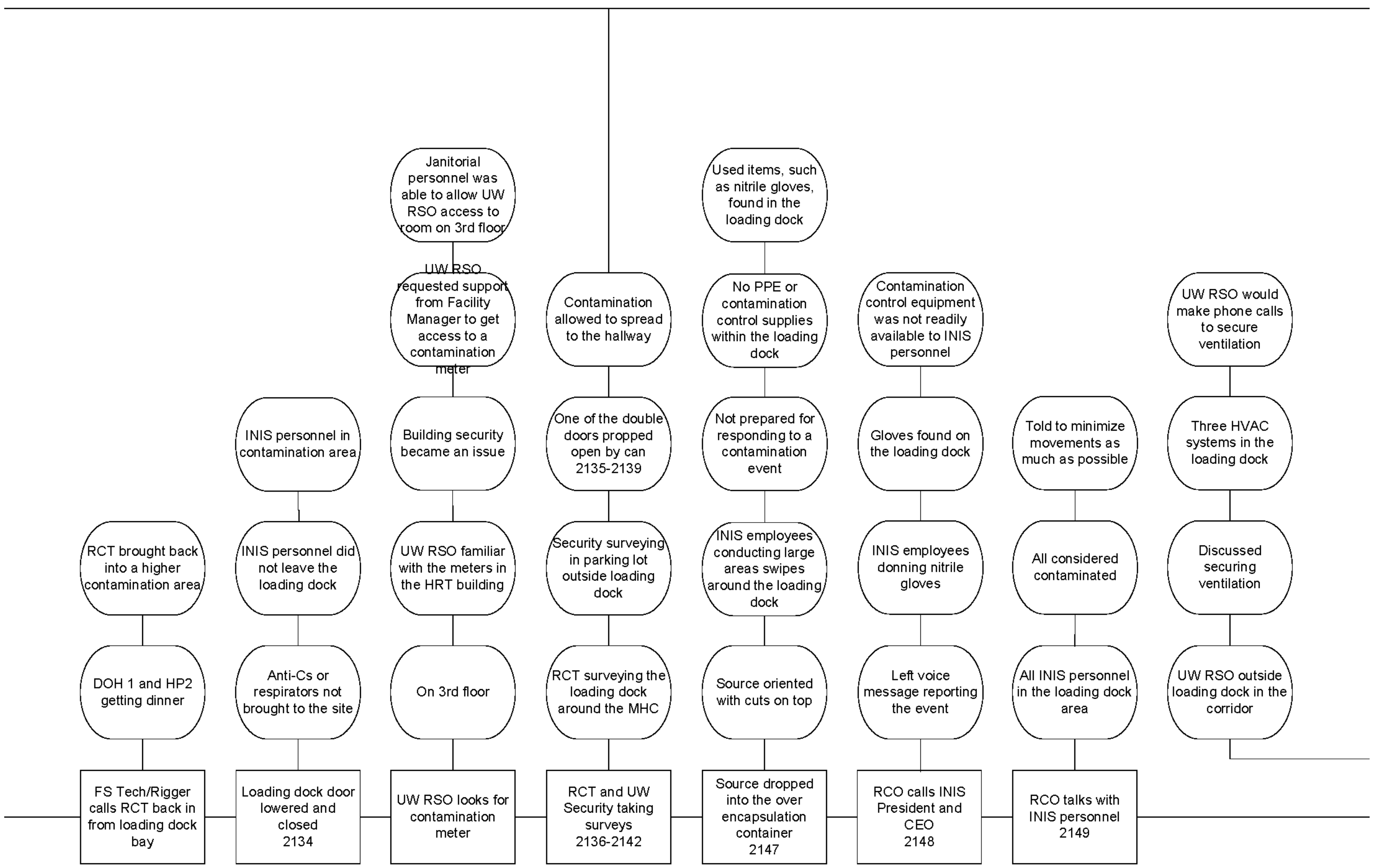

CF-1E
Immature safety culture led to completion of work activities taking priority over safe conduct of the work (CF-1E)
CC-1
CF-1D
Safety requirements were not effectively implemented by INIS (CF-1D)
Discussion between RCO and E1 on ALARA concerns
¼" aluminum spacer between the rod and the source
Actual threaded portion is ½"
INIS believes there is ¾" to make the cut below the roll pin
INIS believes threaded portion connecting tube to rod ~ 1" - roll pin located ~ ¼" from top of aluminum tube
INIS had no design drawings of the source
Half-moon shield needed to be moved in order to get pipe wrench on source holder
Operators having difficulty using the manipulators
Using two pipe wrenches
Activity unsuccessful
Roll pin may not have been sufficiently ground down
W-rod and aluminum source tube holder are not separating as planned
E2 and E3 could not get a firm grip on the source tube
Both source tube and W-shield rotated
E2 and E3 attempt to unthread the aluminum source tube
1950
Personnel identified leaving and entering the HRT building outside of control tape south of the loading dock
A lot of Aluminum dust from the cutting
Work continues with more experienced operator
RCO concerned with radiation exposure and ALARA
Attempting to speed up the cutting process
RCO requests E1 replace E3 as the hot cell operator to continue the cutting
2005
Option to cut through the source tube and W-rod considered, but not used
Consideration to redo roll pin cuts not considered
RCO notified and concurs with decision
Radial cut proceduralized OP-SRC-040.B
E1 suggests circumference cut
INIS personnel believe they are not cutting on the source
INIS has no knowledge of the internal configuration of the source tube
Decision made to perform circumferential cut
Clamp not being tightened between cuts – held with left manipulator - cutting less deliberate
E1 getting frustrated with not being able to separate source tube and rod
Worked on process for over an hour
Stop and start cuts and attempt to unscrew the aluminum tube from the W-rod
INIS has no knowledge of the internal configuration of the source tube
INIS and observer personnel walking in front of the bottom of MHC through expected high radiation stream
Sparkles increasing on Building video 2012
Cuts conducted ¾ - 1 inch towards the source below the cuts made to the role pin
Twelve (12) cuts conducted below the cuts made to the role pin and towards the source
E1 and E2 making cuts circumferential cuts
2007-2022

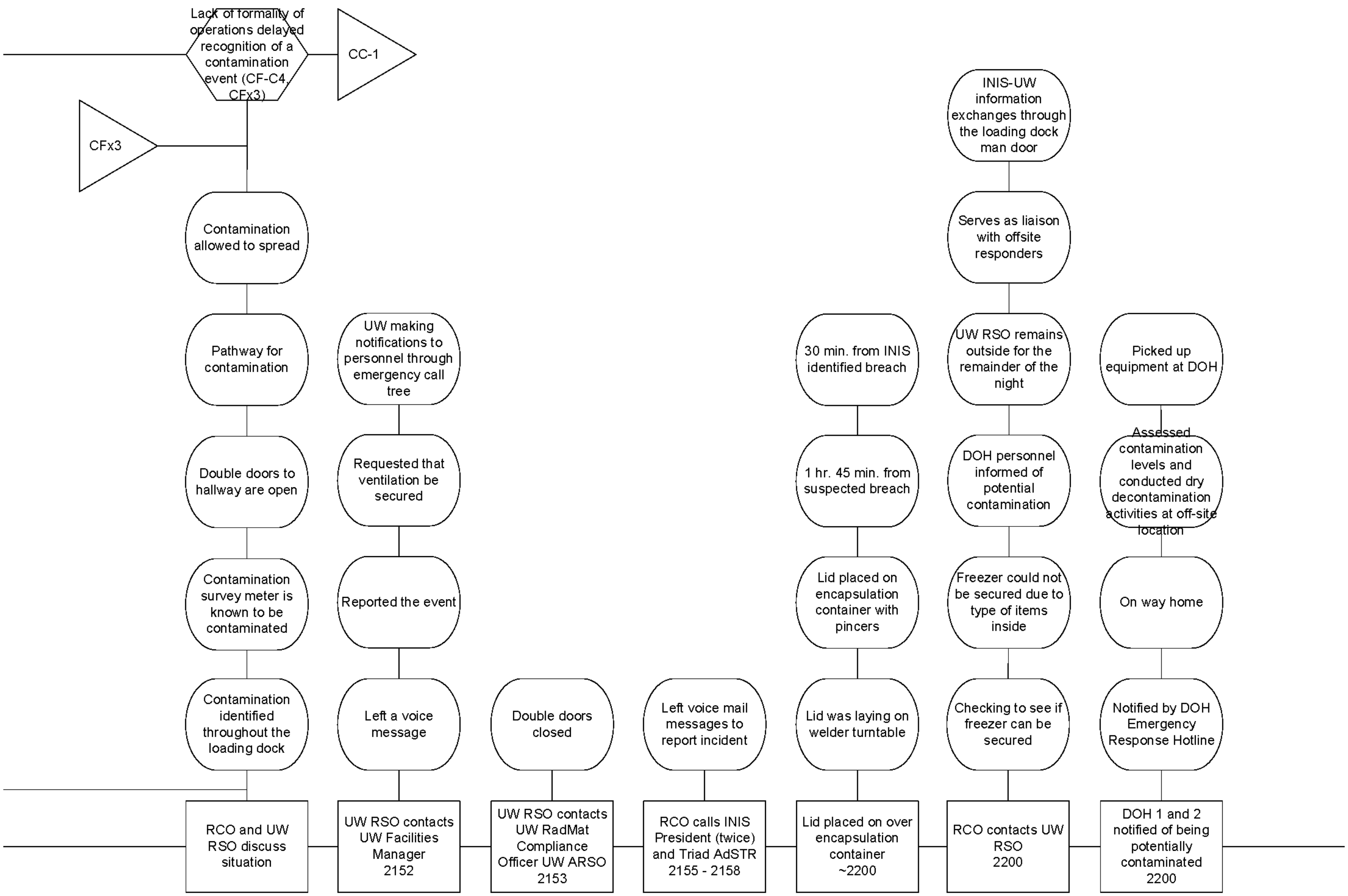

Cutting into the source holder assembly
Direct Cause
CFx3
CF-B7
RCT not aware of contamination event
INIS did not consistently follow their procedures (CF-1C)
Tube rolled
Observers and normal building occupants were initially allowed to move freely inside and outside to building
Require removal and repositioning of the source tube on the lead half-shield
Unaware of source breach
Holder twists
Agent does not work around radiation much
Returned at 2114
Source tube being moved to apply wrenches
Contamination surveys not taken to determine potential cesium release following the angular cut
Sparkles increasing on Building video at 2031 and 2036
Aluminum tube and W-rod jumps
~24 minutes following breach
Observes frustration from INIS operators
Facility Manager returned to the HRT building
Require removal and repositioning of the source tube on the lead half-shield
No swipes taken
Unsuccessful in separating source tube and rod
Blade grabs
E1 felt source not damaged
Did not have dosimetry
RCT not aware of potential contamination
Estimated time – several cuts could have breach the source
Cuts continued - moving up throat towards W-rod
Job not stopped or paused
Aluminum tube will still not unthread from W-rod
Two (2) cuts made
Angular cut noticed in Aluminum tube towards the Cs source
Invited to review operation by DOH regulator
Going to get batteries for AMP-100
Incident 05/02/2019 2015
Cutting wheel jumps while cutting 2039
FBI Observer 1 walks around to watch screen with DOH HP2 2045-2048
RCT Leaves scene 2051

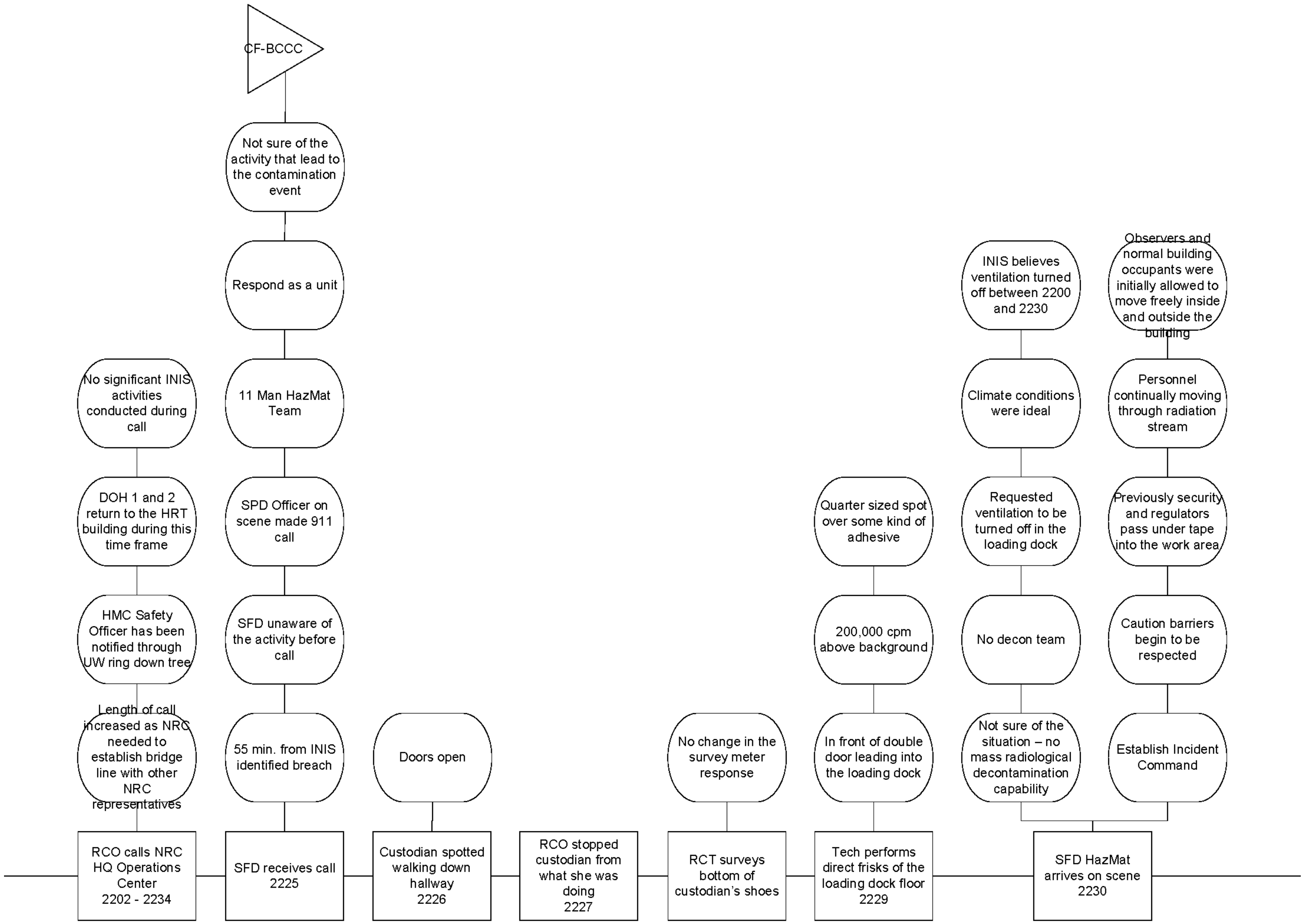

CFx3
CF-B7
Questioning attitude was not present (CF-B7)
Contamination not identified
All three later identified as contaminated
Cuts made ~1 ¼" from the top of the aluminum tube
Would provide additional shielding to the source
DOH and FBI remain on scene
All three unaware they are contaminated
Source still connected to W-rod
Source to be placed in transfer cask for shielding
Fewer observers at the scene
Not successful
Cuts moving back to W-rod end of the throat
No surveys taken before leaving scene
Circumferential cuts did not result in a continuous cut around the source holder
Decision made by E1 to pause work and place the source holder in a safe configuration
Time to consider source tube cut through option
Not a part of the procedure (OPSRC-040-R.B)
Conducted on throat area
Tried to separate twice
Four (4) cuts made
Contamination not expected
Twenty-seven (27) total cuts made
4 hrs into an expected 2 hr operation
INIS could not determine whether oxidation between the aluminum tube and the W-rod may be the unthreading issue
Cut through option would require items to be placed in the 2.0 inch diameter and longer over encapsulation capsule
Cut conducted 2101
Retrying to separate source holder and W-rod 2103-2104
Continue cutting 2105-2112
DOH 1 and 2 and FBI Agent leave scene 2107
Final cut and attempt to unthread source holder from W-rod 2113
Decision made to see if entire source tube could be placed into the source drawer then inserted into the transfer shield

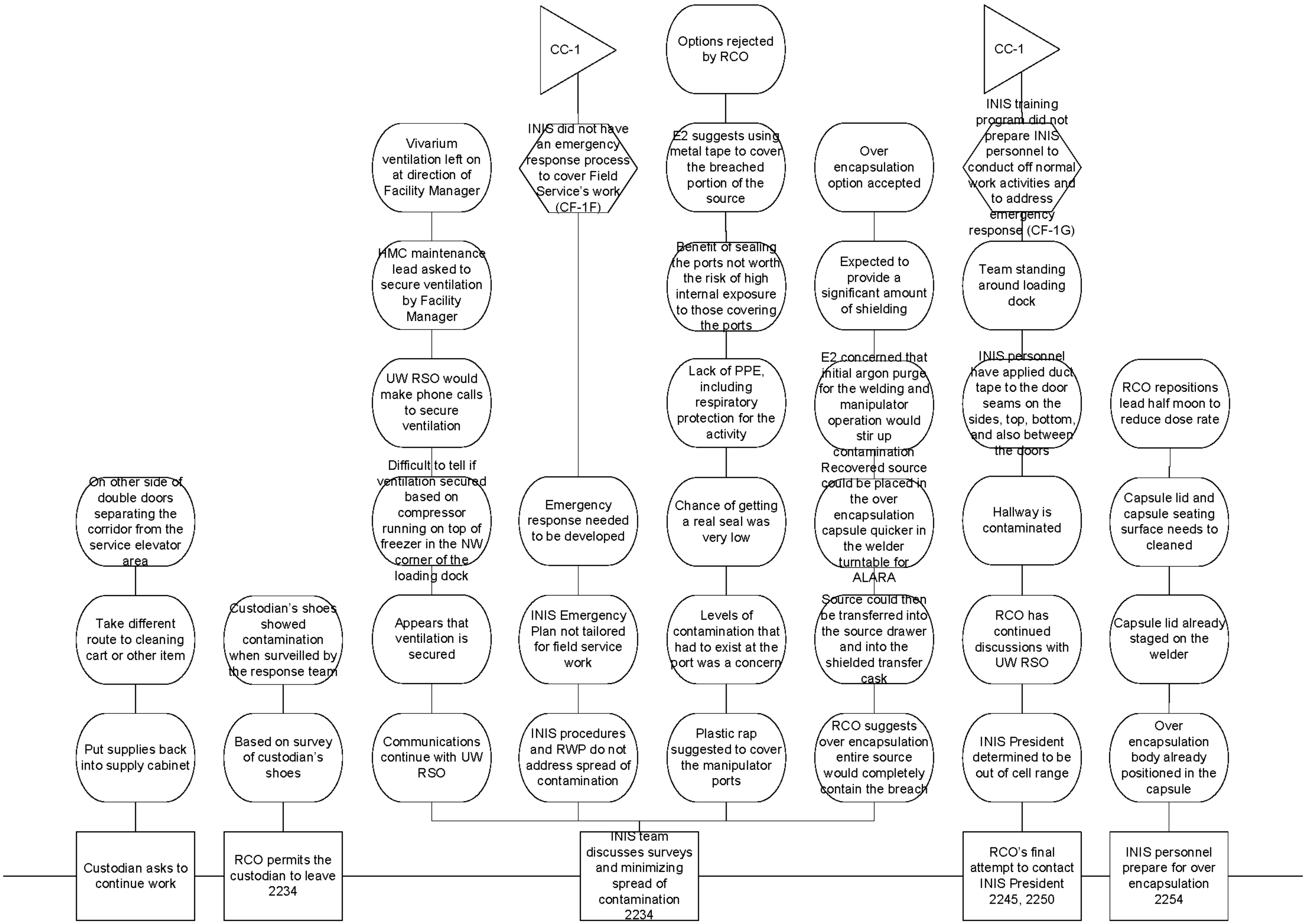

Contamination spread from original breach
NIS survey results not accurate do to contamination of instruments
Potential contamination not yet suspected
~1 hr 15 min. from suspected breach
MHC open on top for manipulators
Tube never fully inserted into the MHC
1 hr. 6 min. from breach
Notifies RCO of findings that source may have been breached
Contamination survey meter had been turned off
Identifies movement in the tube
FBI Agent had been in the radiological zone on scene about 1 hour
First indication of potential source breach
Measured using Ludlum 2401-P Contamination Survey Meter located near the hot cell
RCO believes meter broken or showing high ambient background rates
Attempt to break source holder loose
DOH 1 and 2 have left site
No one aware of source breach
FBI Agent had left the scene
Identifies potential damage to the source
1st swipes taken after angular cut
Survey Meter pegged on the highest scale (>500k) before the swipe was obtained and measured
RCO did not trust instrument readings
No sign of separation
Noticed some movement between the aluminum tube and the W-rod
Aluminum tube and the W-rod begin separating
Tube never unthreads
Tube never unthreads
Swipes taken along manipulator opening on right side of the hot cell
Contamination survey meter for swipes placed on mobile hot cell (high background)
Meter reading did not drop
Source holder and W-rod removed from grinder 2122
E1 lifts the Aluminum source tube to put into the source drawer 2127
E1 begins to move the aluminum tube and W-rod back and forth
Source holder and W-rod separate 2128
E1 conducts visual inspection of source holder remnants 2129
RCO obtains large area swipe 2129
RCO moves to back portion of the loading dock

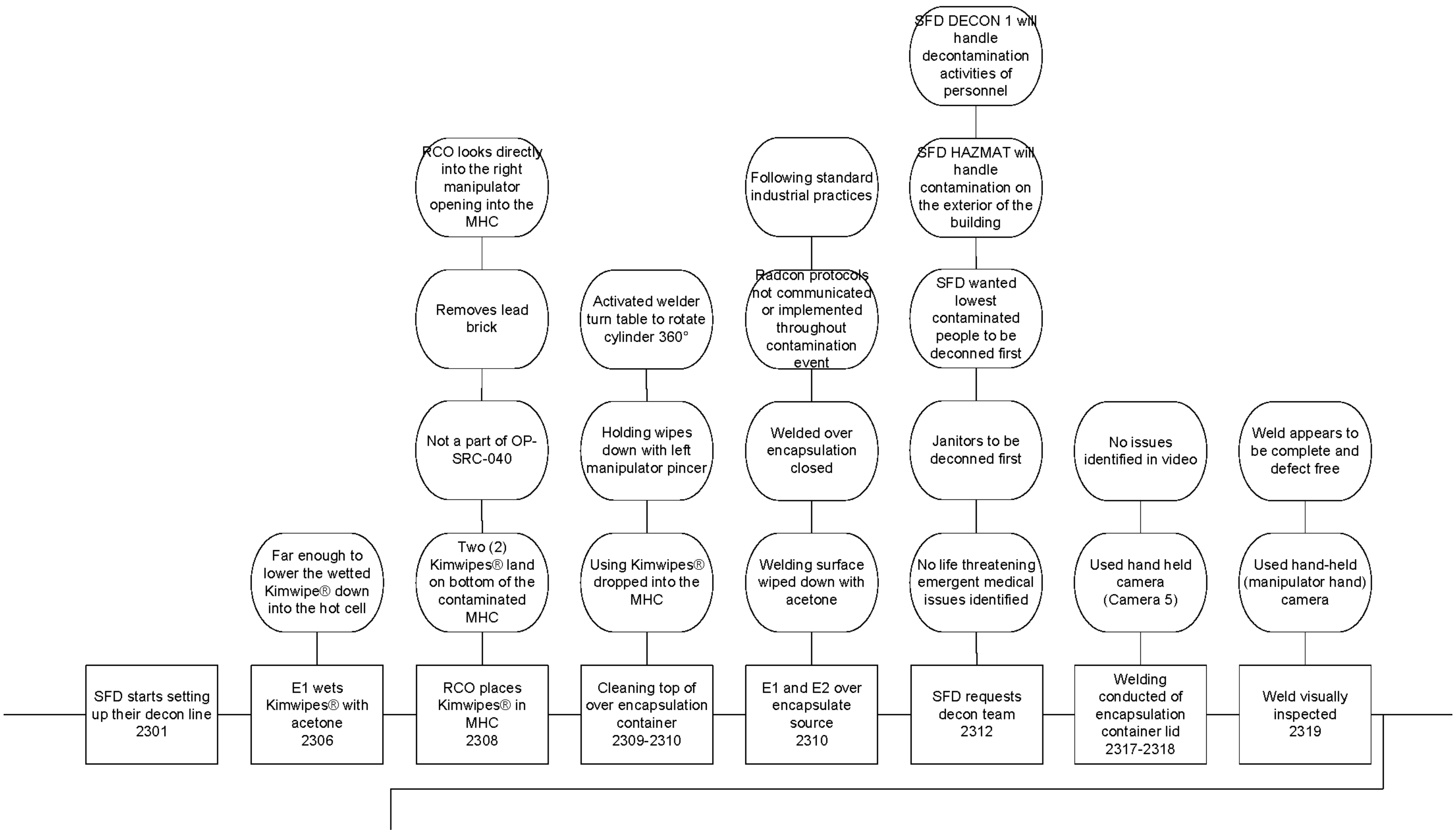

No spacers where observed
One cut deep enough to breach the source
3 cuts observed
Possible cut into the source wall observed
Used hand-held (manipulator hand) camera
Contamination surveys not taken to determine potential cesium release following the angular cut
DOH and FBI personnel had left the area
Building HVAC on
Contamination spreading
1hr 17 min from expected source breach
Source not placed on the half moon shield
Source placed on bottom of MHC on top of bottom port covering
E1 performs in-depth visual inspection and removes source from source tube 2130-2132
Spreading contamination to parking area
Walked right past UW RSO
Concerned about the situation
RCO out on parking area in front of loading dock 2131
EPDs did not alarm
Beginning to recognize the scope of the problem
UW RSO at the MHC
Requests a contamination survey meter
RCO contacts UW RSO 2132
Meter reading did not drop
RCO and UW RSO exits loading dock into the corridor 2133
Identified meter is contaminated
Levels off at 200,000 cpm
Meter reading drops below maximum level
RCO attempts to decon Ludlum 2401-P
UW RSO reported 6,000 cpm contamination on shoes
UW RSO reported he also found a survey meter
Report contamination shoes via cell phone
RCO contacts UW RSO

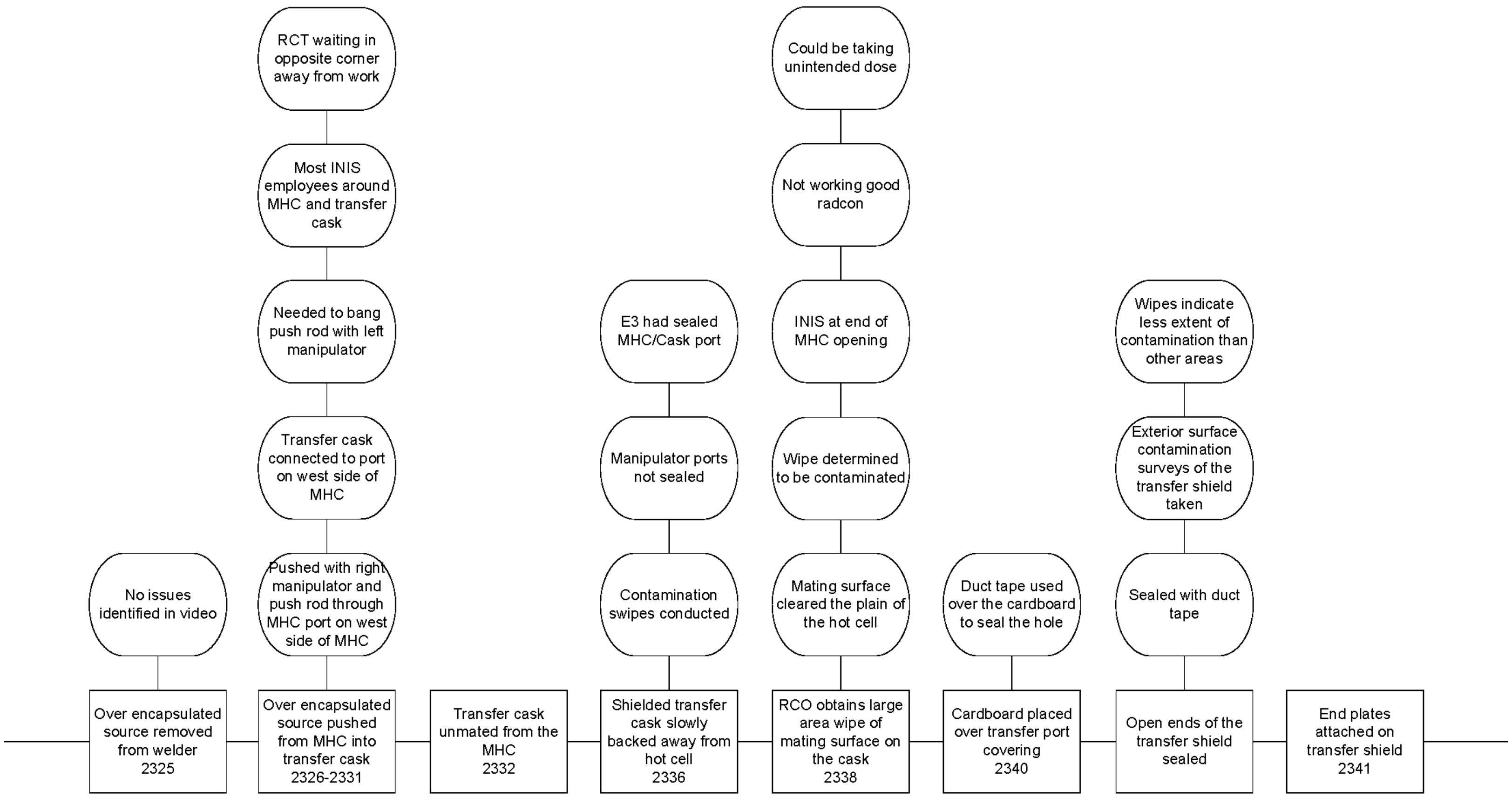

FS Tech/Rigger calls RCT back in from loading dock bay
DOH 1 and HP2 getting dinner
RCT brought back into a higher contamination area
Loading dock door lowered and closed 2134
Anti-Cs or respirators not brought to the site
INIS personnel did not leave the loading dock
INIS personnel in contamination area
UW RSO looks for contamination meter
On 3rd floor
UW RSO familiar with the meters in the HRT building
Building security became an issue
UW RSO requested support from Facility Manager to get access to a contamination meter
Janitorial personnel was able to allow UW RSO access to room on 3rd floor
RCT and UW Security taking surveys 2136-2142
RCT surveying the loading dock around the MHC
Security surveying in parking lot outside loading dock
One of the double doors propped open by can 2135-2139
Contamination allowed to spread to the hallway
Source dropped into the over encapsulation container 2147
Source oriented with cuts on top
INIS employees conducting large areas swipes around the loading dock
Not prepared for responding to a contamination event
No PPE or contamination control supplies within the loading dock
Used items, such as nitrile gloves, found in the loading dock
RCO calls INIS President and CEO 2148
Left voice message reporting the event
INIS employees donning nitrile gloves
Gloves found on the loading dock
Contamination control equipment was not readily available to INIS personnel
RCO talks with INIS personnel 2149
All INIS personnel in the loading dock area
All considered contaminated
Told to minimize movements as much as possible
UW RSO outside loading dock in the corridor
Discussed securing ventilation
Three HVAC systems in the loading dock
UW RSO would make phone calls to secure ventilation

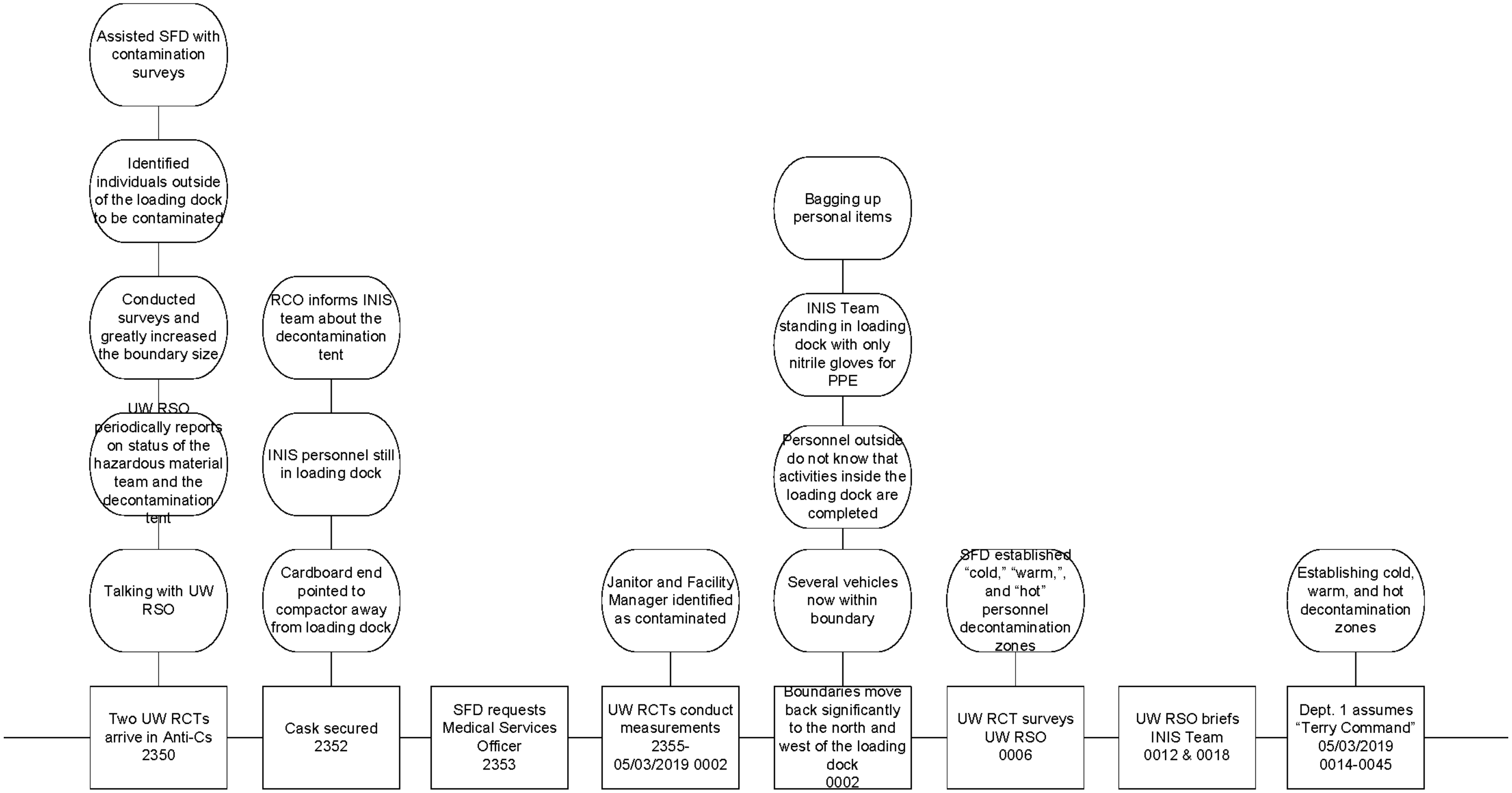

Lack of formality of operations delayed recognition of a contamination event (CF-C4, CFx3)
CC-1
CFx3
Contamination allowed to spread
Pathway for contamination
Double doors to hallway are open
Contamination survey meter is known to be contaminated
Contamination identified throughout the loading dock
RCO and UW RSO discuss situation
UW making notifications to personnel through emergency call tree
Requested that ventilation be secured
Reported the event
Left a voice message
UW RSO contacts UW Facilities Manager 2152
Double doors closed
UW RSO contacts UW RadMat Compliance Officer UW ARSO 2153
Left voice mail messages to report incident
RCO calls INIS President (twice) and Triad AdSTR 2155 - 2158
30 min. from INIS identified breach
1 hr. 45 min. from suspected breach
Lid placed on encapsulation container with pincers
Lid was laying on welder turntable
Lid placed on over encapsulation container ~2200
INIS-UW information exchanges through the loading dock man door
Serves as liaison with offsite responders
UW RSO remains outside for the remainder of the night
DOH personnel informed of potential contamination
Freezer could not be secured due to type of items inside
Checking to see if freezer can be secured
RCO contacts UW RSO 2200
Picked up equipment at DOH
Assessed contamination levels and conducted dry decontamination activities at off-site location
On way home
Notified by DOH Emergency Response Hotline
DOH 1 and 2 notified of being potentially contaminated 2200

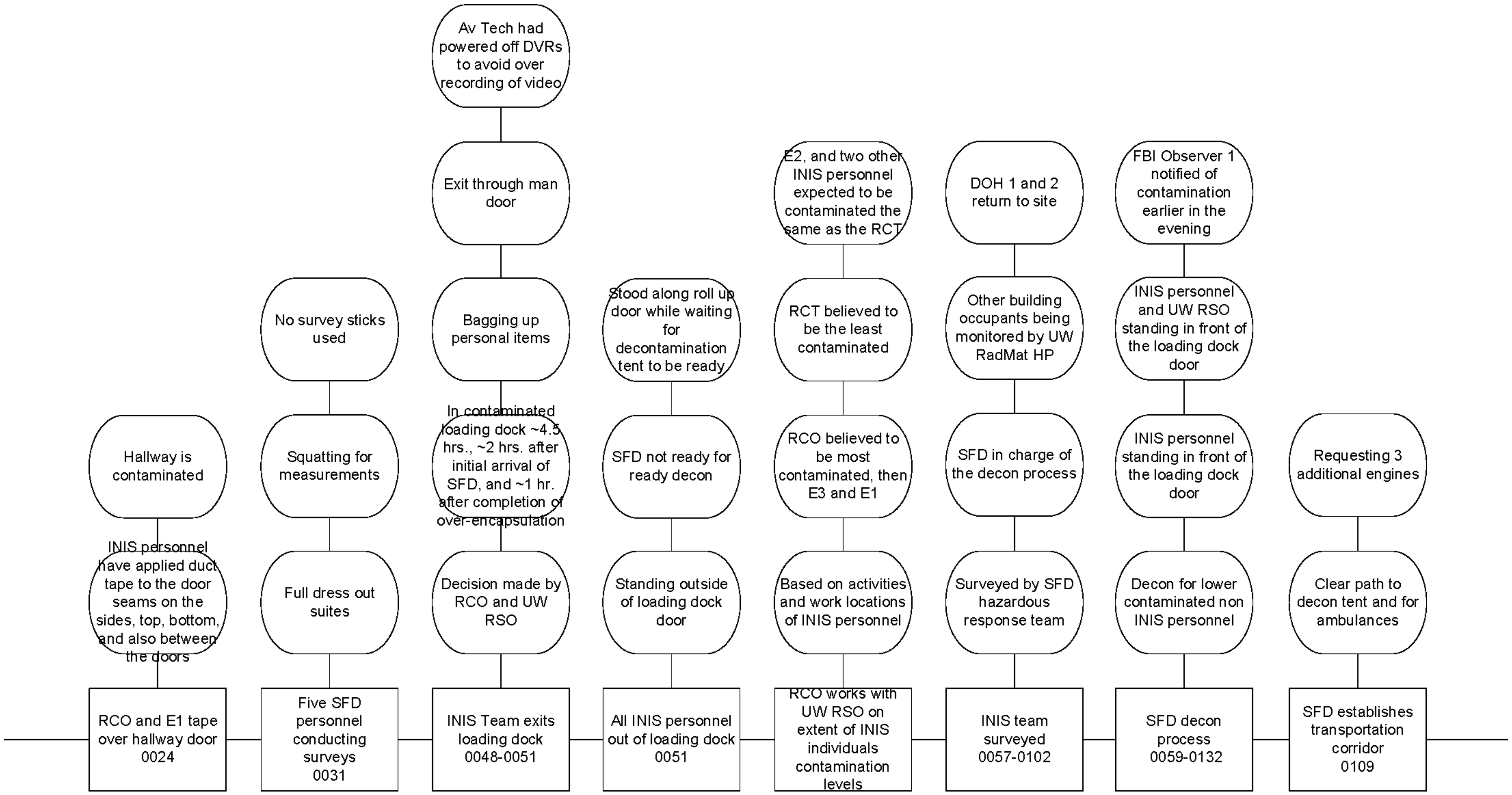

CF-BCCC
Not sure of the activity that lead to the contamination event
Respond as a unit
11 Man HazMat Team
SPD Officer on scene made 911 call
SFD unaware of the activity before call
55 min. from INIS identified breach
SFD receives call 2225
No significant INIS activities conducted during call
DOH 1 and 2 return to the HRT building during this time frame
HMC Safety Officer has been notified through UW ring down tree
Length of call increased as NRC needed to establish bridge line with other NRC representatives
RCO calls NRC HQ Operations Center 2202 - 2234
Doors open
Custodian spotted walking down hallway 2226
RCO stopped custodian from what she was doing 2227
No change in the survey meter response
RCT surveys bottom of custodian's shoes
Quarter sized spot over some kind of adhesive
200,000 cpm above background
In front of double door leading into the loading dock
Tech performs direct frisks of the loading dock floor 2229
INIS believes ventilation turned off between 2200 and 2230
Climate conditions were ideal
Requested ventilation to be turned off in the loading dock
No decon team
Not sure of the situation – no mass radiological decontamination capability
Observers and normal building occupants were initially allowed to move freely inside and outside the building
Personnel continually moving through radiation stream
Previously security and regulators pass under tape into the work area
Caution barriers begin to be respected
Establish Incident Command
SFD HazMat arrives on scene 2230

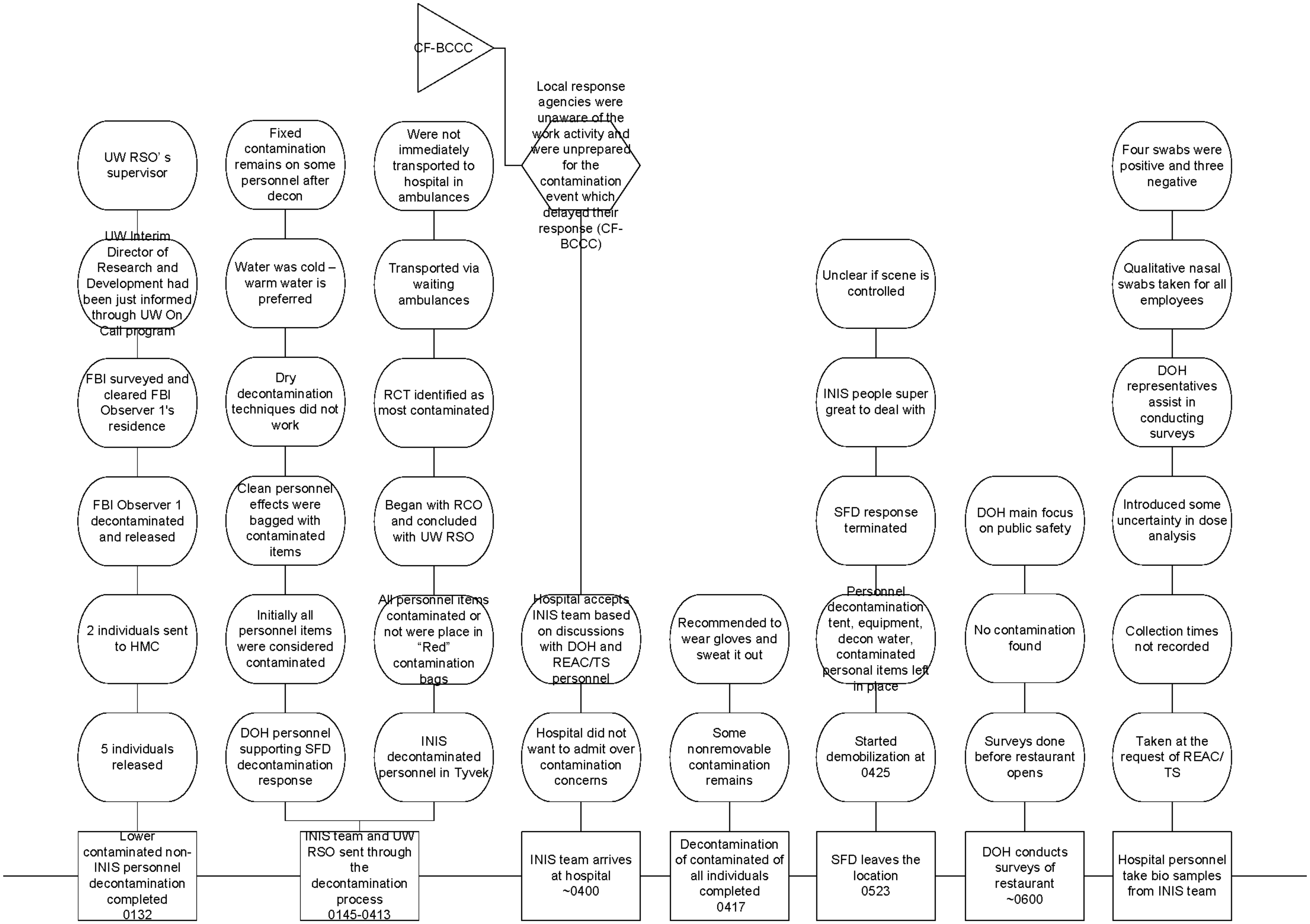

CC-1
Options rejected by RCO
CC-1
Vivarium ventilation left on at direction of Facility Manager
INIS did not have an emergency response process to cover Field Service's work (CF-1F)
E2 suggests using metal tape to cover the breached portion of the source
Over encapsulation option accepted
INIS training program did not prepare INIS personnel to conduct off normal work activities and to address emergency response (CF-1G)
HMC maintenance lead asked to secure ventilation by Facility Manager
Benefit of sealing the ports not worth the risk of high internal exposure to those covering the ports
Expected to provide a significant amount of shielding
Team standing around loading dock
UW RSO would make phone calls to secure ventilation
Lack of PPE, including respiratory protection for the activity
E2 concerned that initial argon purge for the welding and manipulator operation would stir up contamination
INIS personnel have applied duct tape to the door seams on the sides, top, bottom, and also between the doors
RCO repositions lead half moon to reduce dose rate
On other side of double doors separating the corridor from the service elevator area
Difficult to tell if ventilation secured based on compressor running on top of freezer in the NW corner of the loading dock
Emergency response needed to be developed
Chance of getting a real seal was very low
Recovered source could be placed in the over encapsulation capsule quicker in the welder turntable for ALARA
Hallway is contaminated
Capsule lid and capsule seating surface needs to cleaned
Take different route to cleaning cart or other item
Custodian's shoes showed contamination when surveilled by the response team
Appears that ventilation is secured
INIS Emergency Plan not tailored for field service work
Levels of contamination that had to exist at the port was a concern
Source could then be transferred into the source drawer and into the shielded transfer cask
RCO has continued discussions with UW RSO
Capsule lid already staged on the welder
Put supplies back into supply cabinet
Based on survey of custodian's shoes
Communications continue with UW RSO
INIS procedures and RWP do not address spread of contamination
Plastic rap suggested to cover the manipulator ports
RCO suggests over encapsulation entire source would completely contain the breach
INIS President determined to be out of cell range
Over encapsulation body already positioned in the capsule
Custodian asks to continue work
RCO permits the custodian to leave 2234
INIS team discusses surveys and minimizing spread of contamination 2234
RCO's final attempt to contact INIS President 2245, 2250
INIS personnel prepare for over encapsulation 2254

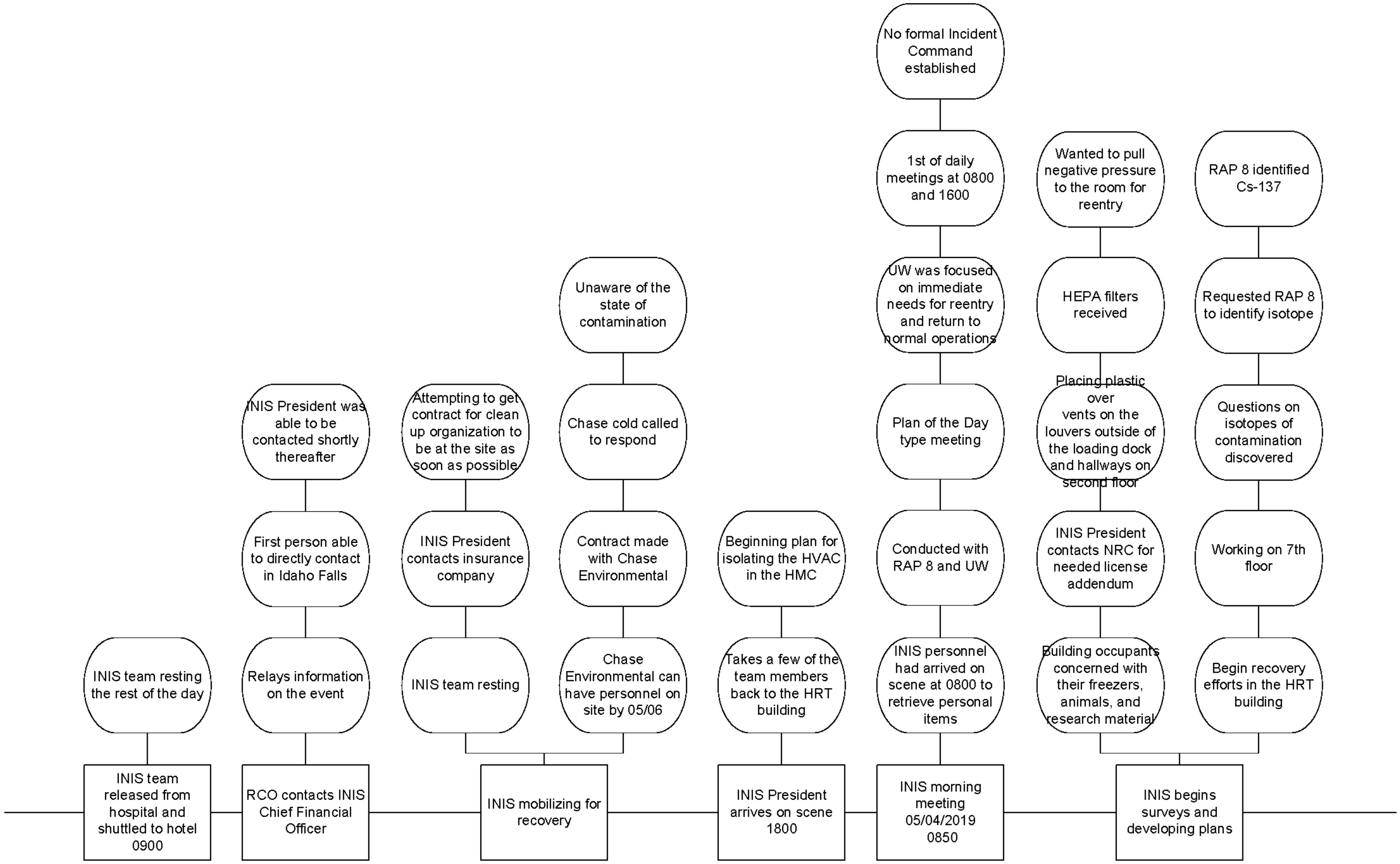

SFD starts setting up their decon line 2301
E1 wets Kimwipes® with acetone 2306
Far enough to lower the wetted Kimwipe® down into the hot cell
RCO places Kimwipes® in MHC 2308
Two (2) Kimwipes® land on bottom of the contaminated MHC
Not a part of OP-SRC-040
Removes lead brick
RCO looks directly into the right manipulator opening into the MHC
Cleaning top of over encapsulation container 2309-2310
Using Kimwipes® dropped into the MHC
Holding wipes down with left manipulator pincer
Activated welder turn table to rotate cylinder 360°
E1 and E2 over encapsulate source 2310
Welding surface wiped down with acetone
Welded over encapsulation closed
Radcon protocols not communicated or implemented throughout contamination event
Following standard industrial practices
SFD requests decon team 2312
No life threatening emergent medical issues identified
Janitors to be deconned first
SFD wanted lowest contaminated people to be deconned first
SFD HAZMAT will handle contamination on the exterior of the building
SFD DECON 1 will handle decontamination activities of personnel
Welding conducted of encapsulation container lid 2317-2318
Used hand held camera (Camera 5)
No issues identified in video
Weld visually inspected 2319
Used hand-held (manipulator hand) camera
Weld appears to be complete and defect free

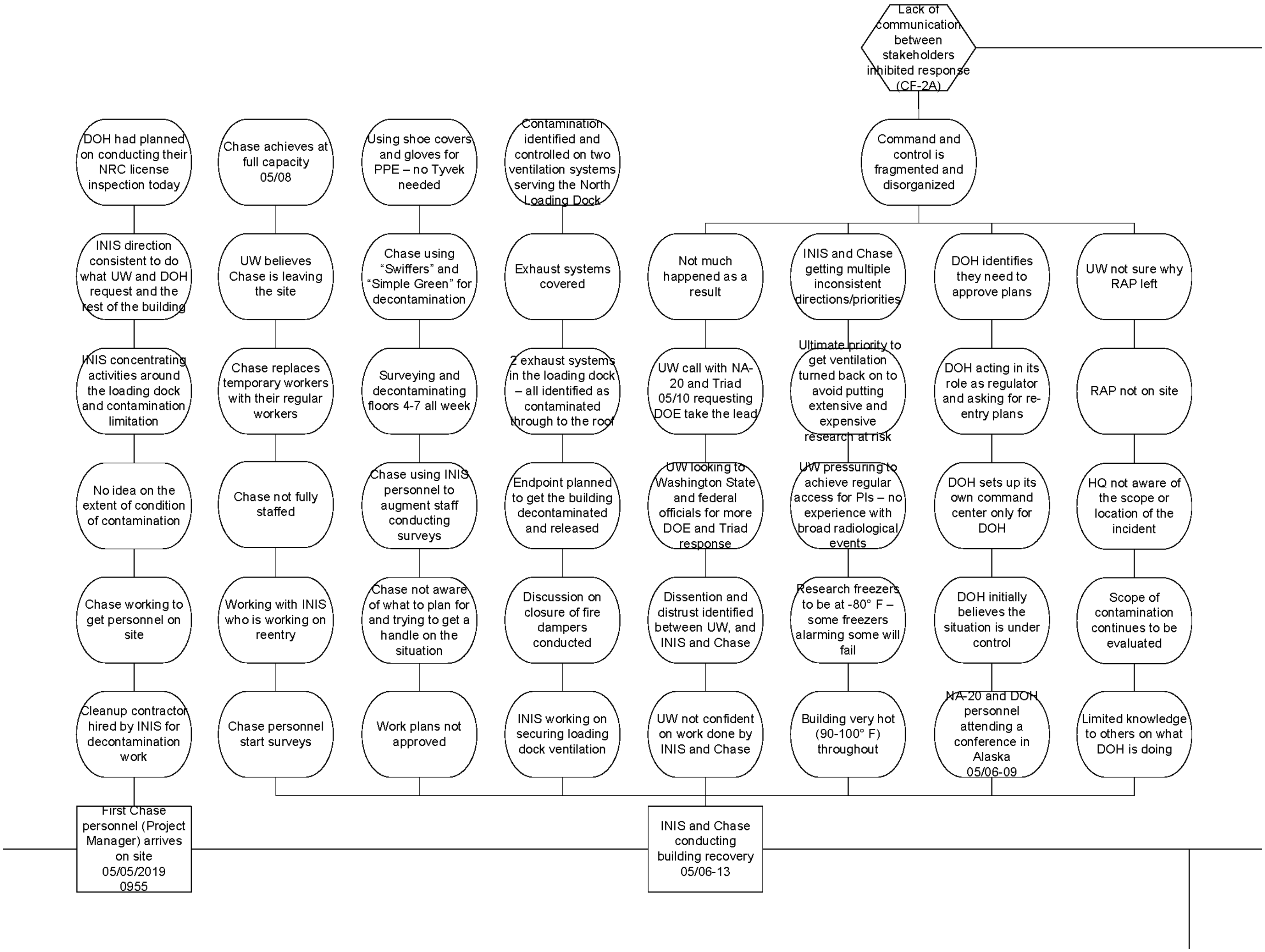

No issues identified in video
Over encapsulated source removed from welder 2325
RCT waiting in opposite corner away from work
Most INIS employees around MHC and transfer cask
Needed to bang push rod with left manipulator
Transfer cask connected to port on west side of MHC
Pushed with right manipulator and push rod through MHC port on west side of MHC
Over encapsulated source pushed from MHC into transfer cask 2326-2331
Transfer cask unmated from the MHC 2332
E3 had sealed MHC/Cask port
Manipulator ports not sealed
Contamination swipes conducted
Shielded transfer cask slowly backed away from hot cell 2336
Could be taking unintended dose
Not working good radcon
INIS at end of MHC opening
Wipe determined to be contaminated
Mating surface cleared the plain of the hot cell
RCO obtains large area wipe of mating surface on the cask 2338
Duct tape used over the cardboard to seal the hole
Cardboard placed over transfer port covering 2340
Wipes indicate less extent of contamination than other areas
Exterior surface contamination surveys of the transfer shield taken
Sealed with duct tape
Open ends of the transfer shield sealed
End plates attached on transfer shield 2341

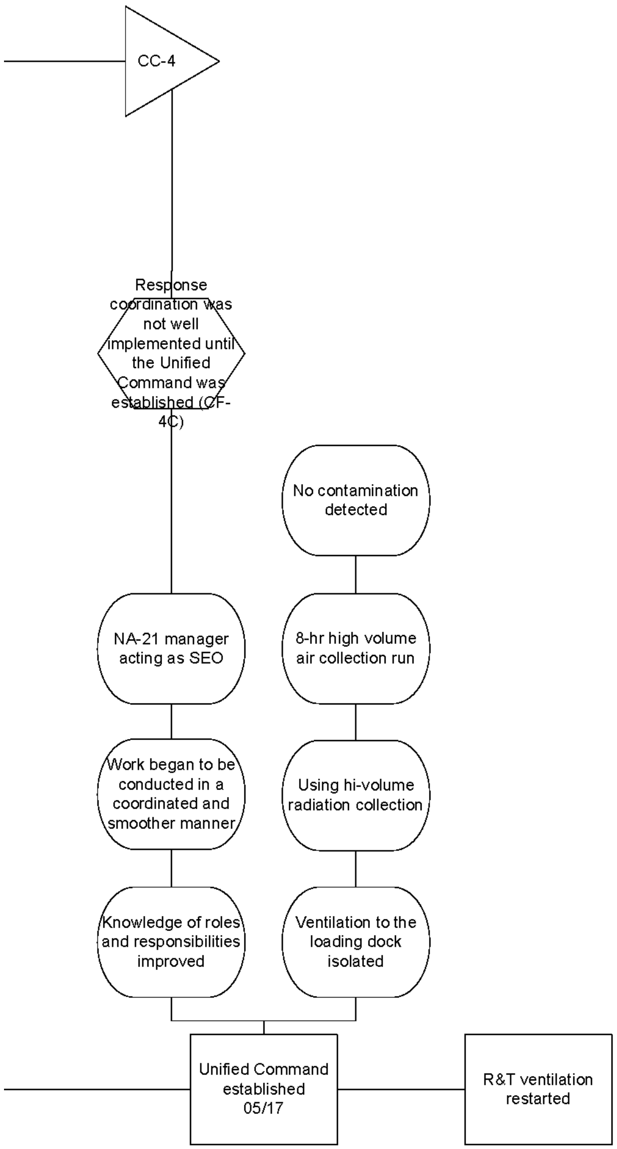

Assisted SFD with contamination surveys
Identified individuals outside of the loading dock to be contaminated
Conducted surveys and greatly increased the boundary size
UW RSO periodically reports on status of the hazardous material team and the decontamination tent
Talking with UW RSO
Two UW RCTs arrive in Anti-Cs 2350
RCO informs INIS team about the decontamination tent
INIS personnel still in loading dock
Cardboard end pointed to compactor away from loading dock
Cask secured 2352
SFD requests Medical Services Officer 2353
Janitor and Facility Manager identified as contaminated
UW RCTs conduct measurements 2355-05/03/2019 0002
Bagging up personal items
INIS Team standing in loading dock with only nitrile gloves for PPE
Personnel outside do not know that activities inside the loading dock are completed
Several vehicles now within boundary
Boundaries move back significantly to the north and west of the loading dock 0002
SFD established “cold,” “warm,”, and “hot” personnel decontamination zones
UW RCT surveys UW RSO 0006
UW RSO briefs INIS Team 0012 & 0018
Establishing cold, warm, and hot decontamination zones
Dept. 1 assumes “Terry Command” 05/03/2019 0014-0045

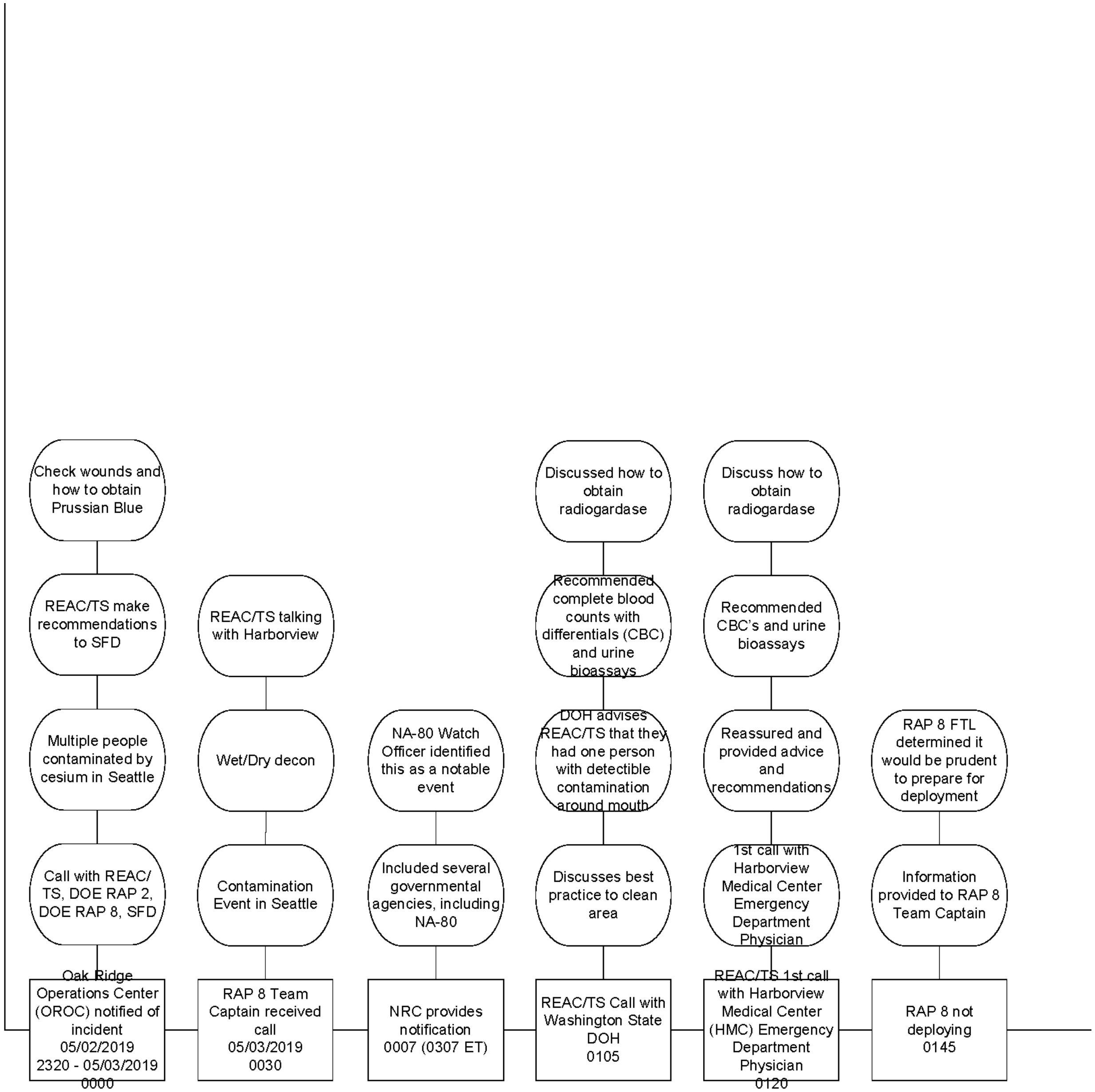

Av Tech had powered off DVRs to avoid over recording of video
Exit through man door
Bagging up personal items
In contaminated loading dock ~4.5 hrs., ~2 hrs. after initial arrival of SFD, and ~1 hr. after completion of over-encapsulation
Decision made by RCO and UW RSO
INIS Team exits loading dock 0048-0051
Hallway is contaminated
INIS personnel have applied duct tape to the door seams on the sides, top, bottom, and also between the doors
RCO and E1 tape over hallway door 0024
No survey sticks used
Squatting for measurements
Full dress out suites
Five SFD personnel conducting surveys 0031
Stood along roll up door while waiting for decontamination tent to be ready
SFD not ready for ready decon
Standing outside of loading dock door
All INIS personnel out of loading dock 0051
E2, and two other INIS personnel expected to be contaminated the same as the RCT
RCT believed to be the least contaminated
RCO believed to be most contaminated, then E3 and E1
Based on activities and work locations of INIS personnel
RCO works with UW RSO on extent of INIS individuals contamination levels
DOH 1 and 2 return to site
Other building occupants being monitored by UW RadMat HP
SFD in charge of the decon process
Surveyed by SFD hazardous response team
INIS team surveyed 0057-0102
FBI Observer 1 notified of contamination earlier in the evening
INIS personnel and UW RSO standing in front of the loading dock door
INIS personnel standing in front of the loading dock door
Decon for lower contaminated non INIS personnel
SFD decon process 0059-0132
Requesting 3 additional engines
Clear path to decon tent and for ambulances
SFD establishes transportation corridor 0109

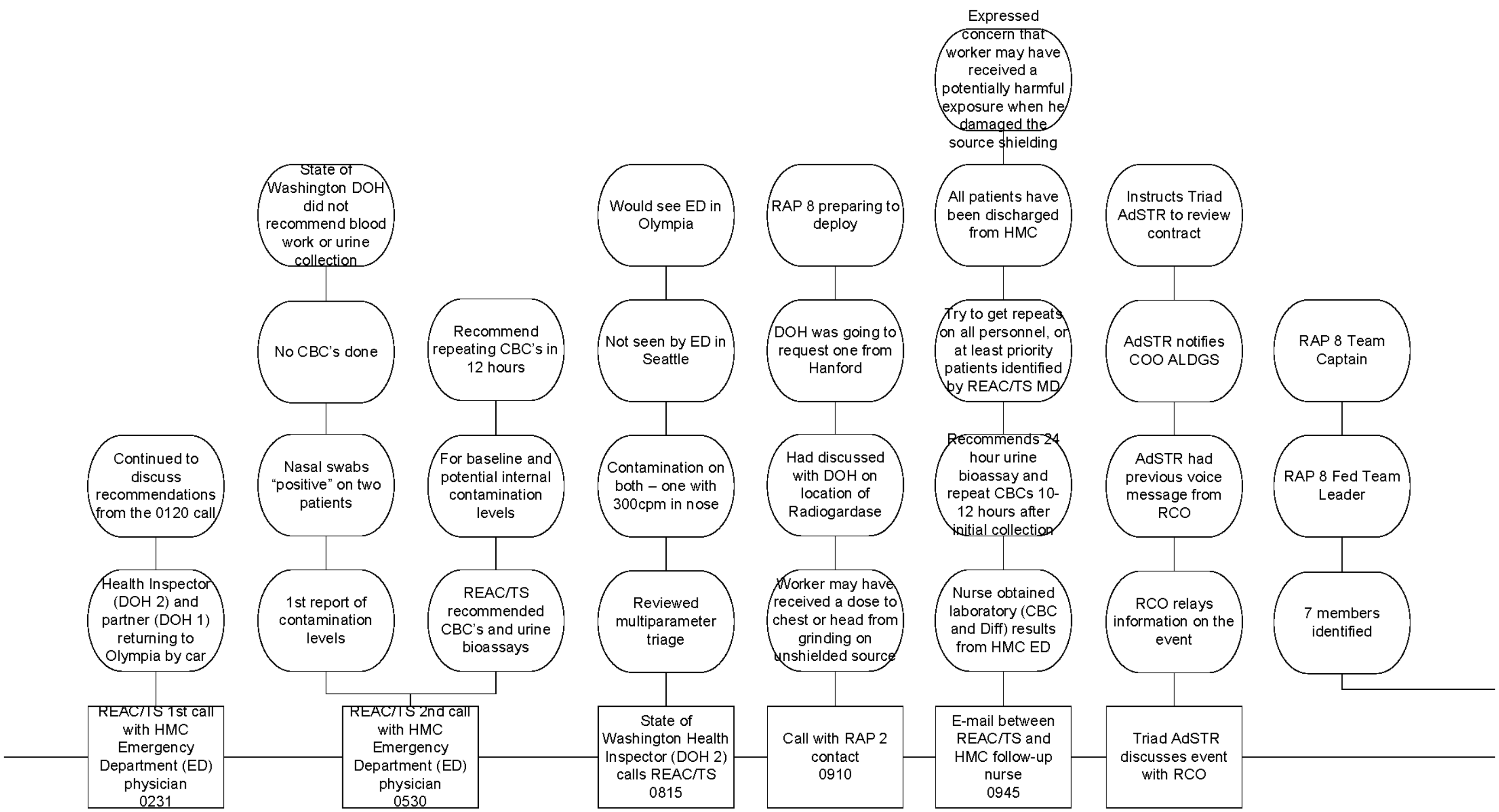

CF-BCCC
Local response agencies were unaware of the work activity and were unprepared for the contamination event which delayed their response (CF-BCCC)
UW RSO' s supervisor
UW Interim Director of Research and Development had been just informed through UW On Call program
FBI surveyed and cleared FBI Observer 1's residence
FBI Observer 1 decontaminated and released
2 individuals sent to HMC
5 individuals released
Lower contaminated non-INIS personnel decontamination completed 0132
Fixed contamination remains on some personnel after decon
Water was cold – warm water is preferred
Dry decontamination techniques did not work
Clean personnel effects were bagged with contaminated items
Initially all personnel items were considered contaminated
DOH personnel supporting SFD decontamination response
Were not immediately transported to hospital in ambulances
Transported via waiting ambulances
RCT identified as most contaminated
Began with RCO and concluded with UW RSO
All personnel items contaminated or not were place in "Red" contamination bags
INIS decontaminated personnel in Tyvek
INIS team and UW RSO sent through the decontamination process 0145-0413
Hospital accepts INIS team based on discussions with DOH and REAC/TS personnel
Hospital did not want to admit over contamination concerns
INIS team arrives at hospital ~0400
Recommended to wear gloves and sweat it out
Some nonremovable contamination remains
Decontamination of contaminated of all individuals completed 0417
Unclear if scene is controlled
INIS people super great to deal with
SFD response terminated
Personnel decontamination tent, equipment, decon water, contaminated personal items left in place
Started demobilization at 0425
SFD leaves the location 0523
DOH main focus on public safety
No contamination found
Surveys done before restaurant opens
DOH conducts surveys of restaurant ~0600
Four swabs were positive and three negative
Qualitative nasal swabs taken for all employees
DOH representatives assist in conducting surveys
Introduced some uncertainty in dose analysis
Collection times not recorded
Taken at the request of REAC/TS
Hospital personnel take bio samples from INIS team

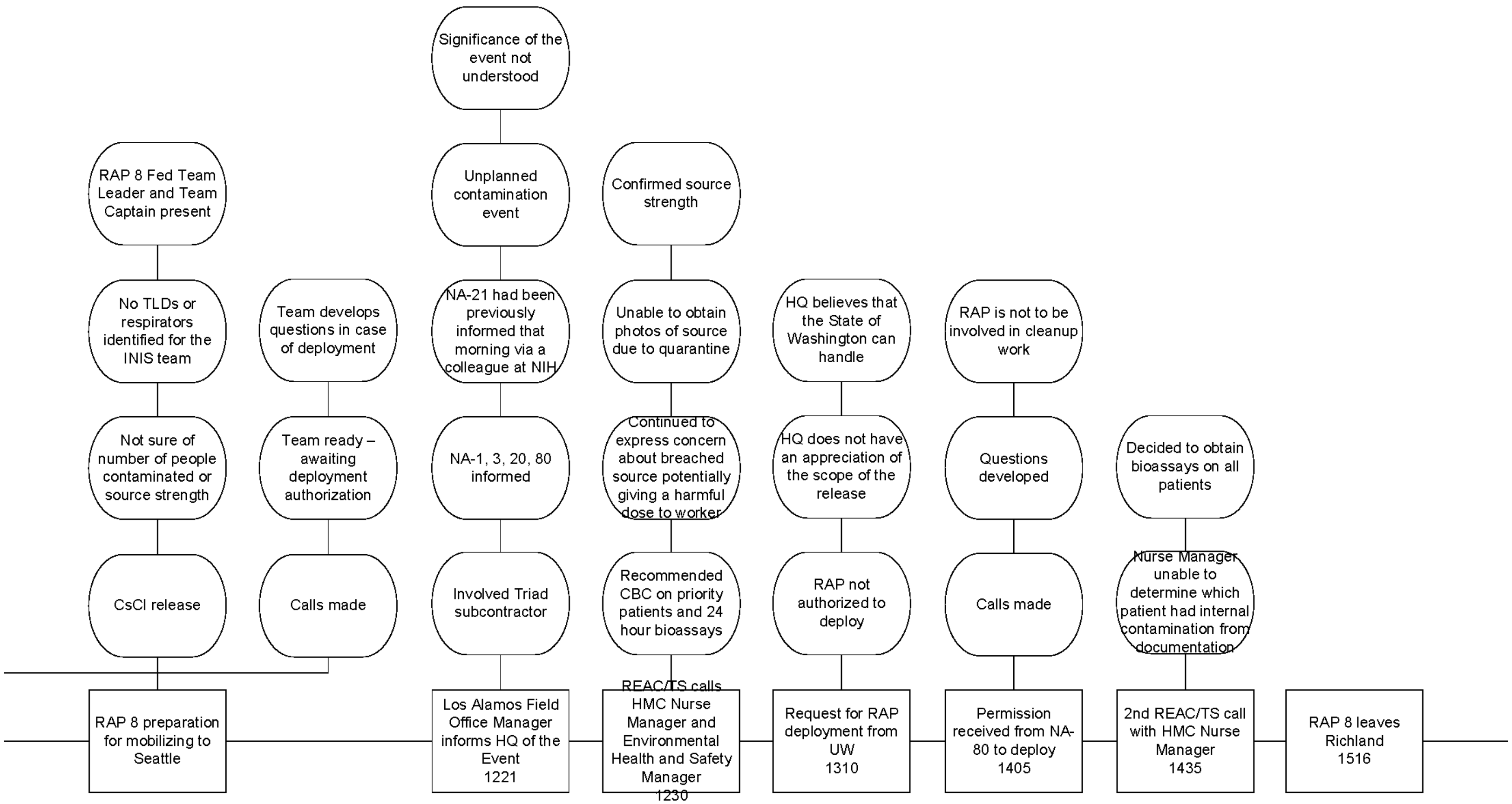

INIS team released from hospital and shuttled to hotel 0900
INIS team resting the rest of the day
RCO contacts INIS Chief Financial Officer
Relays information on the event
First person able to directly contact in Idaho Falls
INIS President was able to be contacted shortly thereafter
INIS mobilizing for recovery
INIS team resting
INIS President contacts insurance company
Attempting to get contract for clean up organization to be at the site as soon as possible
Chase Environmental can have personnel on site by 05/06
Contract made with Chase Environmental
Chase cold called to respond
Unaware of the state of contamination
INIS President arrives on scene 1800
Takes a few of the team members back to the HRT building
Beginning plan for isolating the HVAC in the HMC
INIS morning meeting 05/04/2019 0850
INIS personnel had arrived on scene at 0800 to retrieve personal items
Conducted with RAP 8 and UW
Plan of the Day type meeting
UW was focused on immediate needs for reentry and return to normal operations
1st of daily meetings at 0800 and 1600
No formal Incident Command established
INIS begins surveys and developing plans
Building occupants concerned with their freezers, animals, and research material
INIS President contacts NRC for needed license addendum
Placing plastic over vents on the louvers outside of the loading dock and hallways on second floor
HEPA filters received
Wanted to pull negative pressure to the room for reentry
Begin recovery efforts in the HRT building
Working on 7th floor
Questions on isotopes of contamination discovered
Requested RAP 8 to identify isotope
RAP 8 identified Cs-137

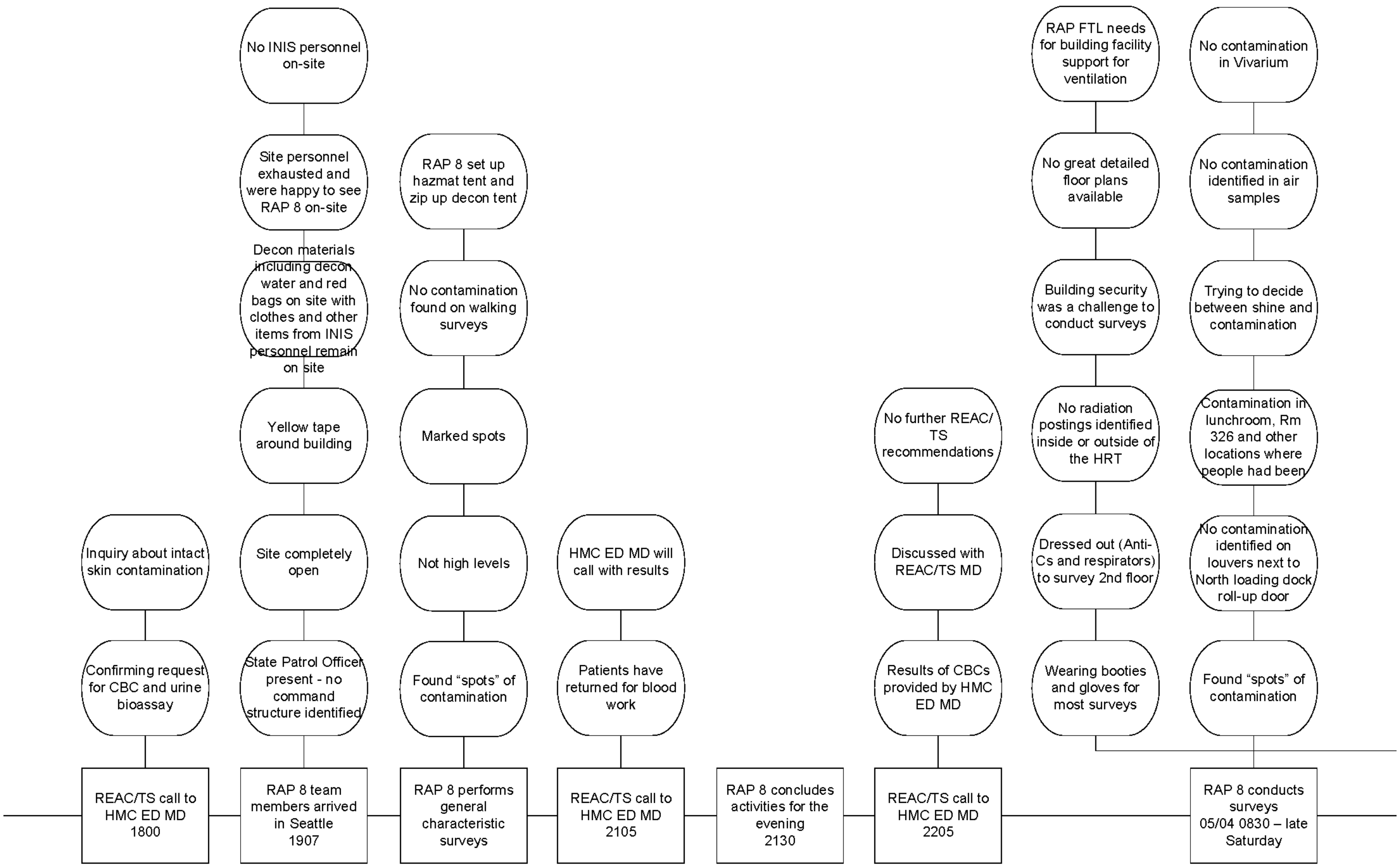

Lack of communication between stakeholders inhibited response (CF-2A)
Command and control is fragmented and disorganized
DOH had planned on conducting their NRC license inspection today
INIS direction consistent to do what UW and DOH request and the rest of the building
INIS concentrating activities around the loading dock and contamination limitation
No idea on the extent of condition of contamination
Chase working to get personnel on site
Cleanup contractor hired by INIS for decontamination work
First Chase personnel (Project Manager) arrives on site 05/05/2019 0955
Chase achieves at full capacity 05/08
UW believes Chase is leaving the site
Chase replaces temporary workers with their regular workers
Chase not fully staffed
Working with INIS who is working on reentry
Chase personnel start surveys
Using shoe covers and gloves for PPE – no Tyvek needed
Chase using “Swiffers” and “Simple Green” for decontamination
Surveying and decontaminating floors 4-7 all week
Chase using INIS personnel to augment staff conducting surveys
Chase not aware of what to plan for and trying to get a handle on the situation
Work plans not approved
Contamination identified and controlled on two ventilation systems serving the North Loading Dock
Exhaust systems covered
2 exhaust systems in the loading dock – all identified as contaminated through to the roof
Endpoint planned to get the building decontaminated and released
Discussion on closure of fire dampers conducted
INIS working on securing loading dock ventilation
Not much happened as a result
UW call with NA-20 and Triad 05/10 requesting DOE take the lead
UW looking to Washington State and federal officials for more DOE and Triad response
Dissention and distrust identified between UW, and INIS and Chase
UW not confident on work done by INIS and Chase
INIS and Chase conducting building recovery 05/06-13
INIS and Chase getting multiple inconsistent directions/priorities
Ultimate priority to get ventilation turned back on to avoid putting extensive and expensive research at risk
UW pressuring to achieve regular access for PIs – no experience with broad radiological events
Research freezers to be at -80° F – some freezers alarming some will fail
Building very hot (90-100° F) throughout
DOH identifies they need to approve plans
DOH acting in its role as regulator and asking for re-entry plans
DOH sets up its own command center only for DOH
DOH initially believes the situation is under control
NA-20 and DOH personnel attending a conference in Alaska 05/06-09
UW not sure why RAP left
RAP not on site
HQ not aware of the scope or location of the incident
Scope of contamination continues to be evaluated
Limited knowledge to others on what DOH is doing

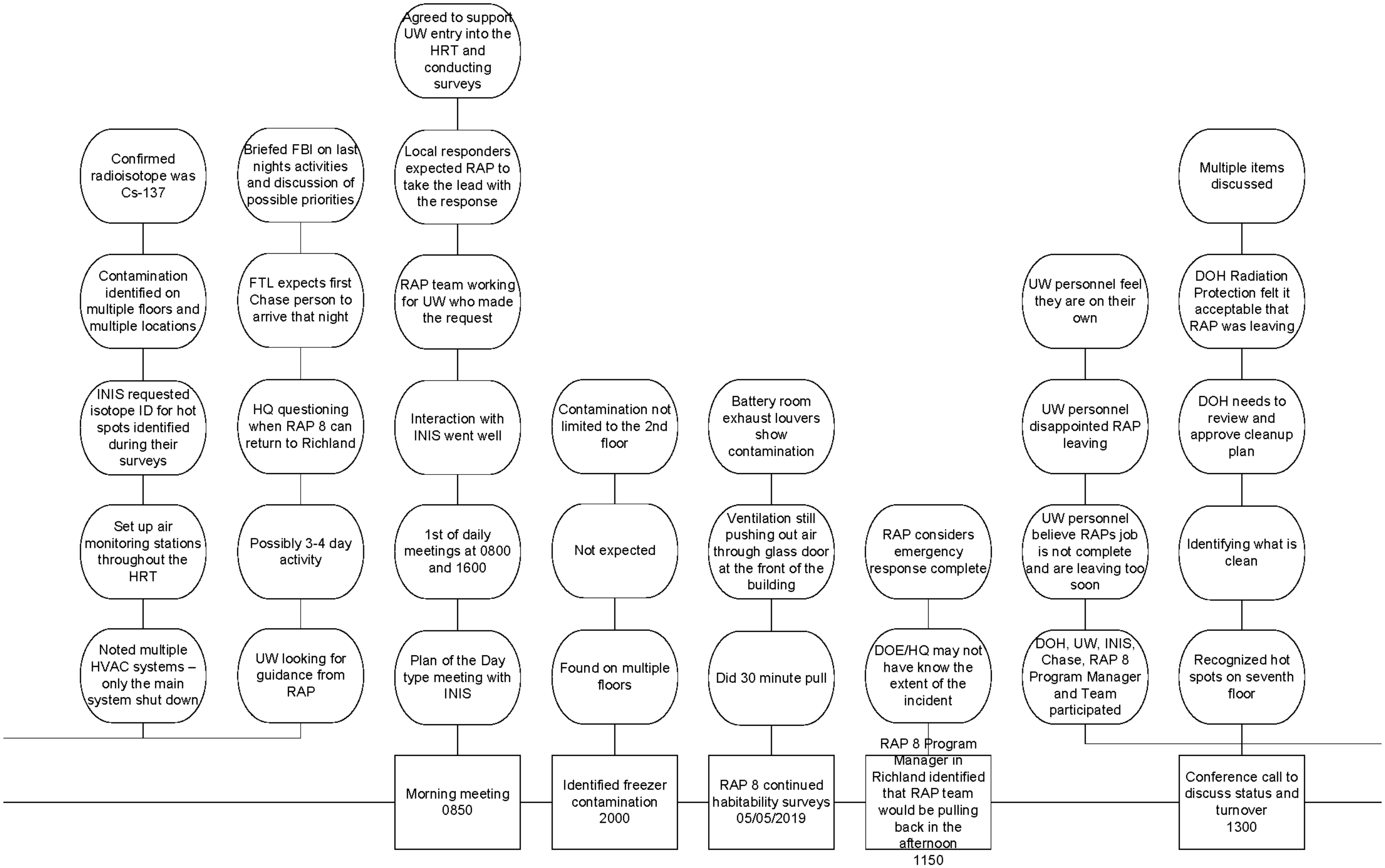

CC-4
Response coordination was not well implemented until the Unified Command was established (CF-4C)
No contamination detected
NA-21 manager acting as SEO
8-hr high volume air collection run
Work began to be conducted in a coordinated and smoother manner
Using hi-volume radiation collection
Knowledge of roles and responsibilities improved
Ventilation to the loading dock isolated
Unified Command established 05/17
R&T ventilation restarted

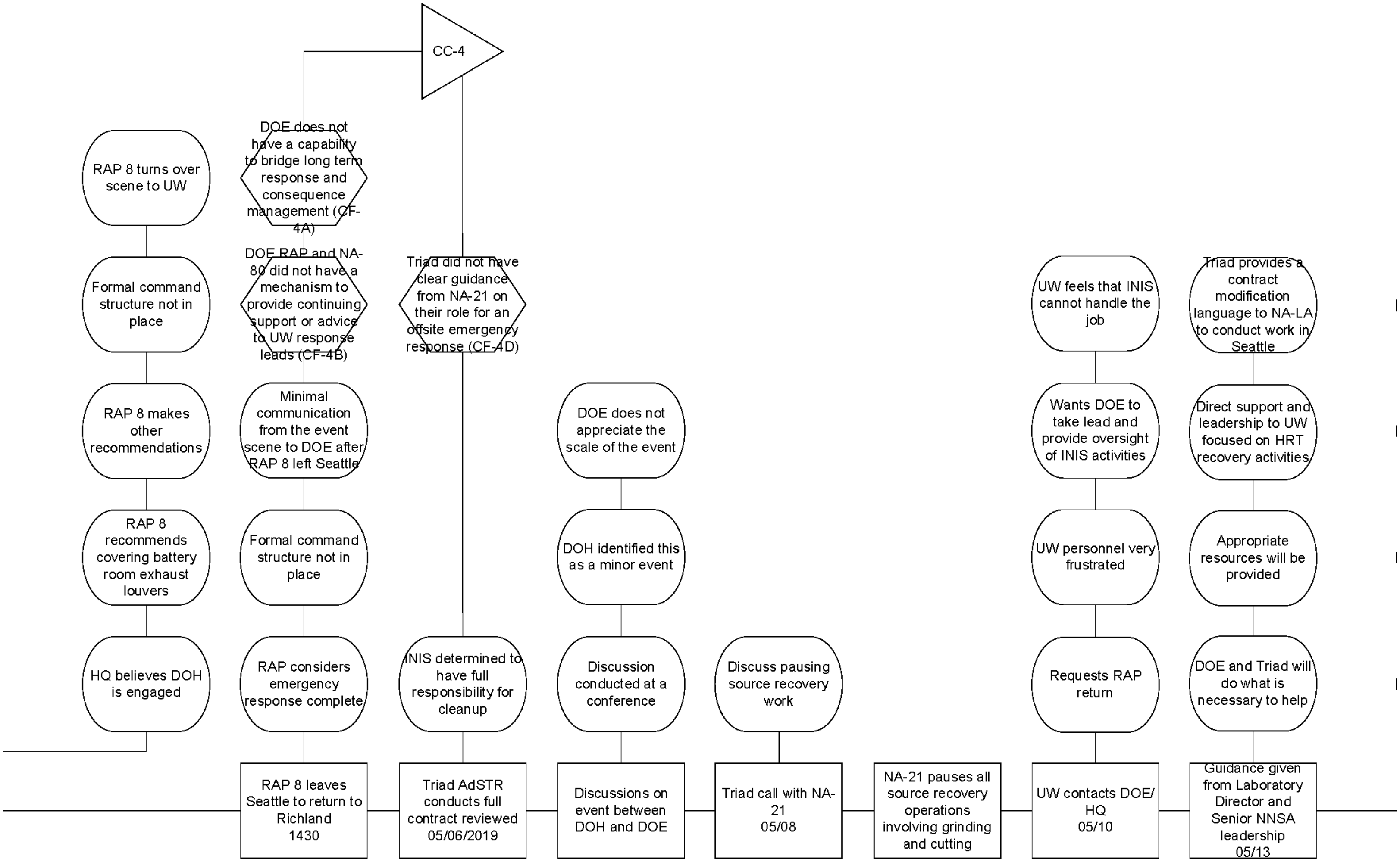

Check wounds and how to obtain Prussian Blue
REAC/TS make recommendations to SFD
Multiple people contaminated by cesium in Seattle
Call with REAC/TS, DOE RAP 2, DOE RAP 8, SFD
Oak Ridge Operations Center (OROC) notified of incident 05/02/2019 2320 - 05/03/2019 0000
REAC/TS talking with Harborview
Wet/Dry decon
Contamination Event in Seattle
RAP 8 Team Captain received call 05/03/2019 0030
NA-80 Watch Officer identified this as a notable event
Included several governmental agencies, including NA-80
NRC provides notification 0007 (0307 ET)
Discussed how to obtain radiogardase
Recommended complete blood counts with differentials (CBC) and urine bioassays
DOH advises REAC/TS that they had one person with detectible contamination around mouth
Discusses best practice to clean area
REAC/TS Call with Washington State DOH 0105
Discuss how to obtain radiogardase
Recommended CBC's and urine bioassays
Reassured and provided advice and recommendations
1st call with Harborview Medical Center Emergency Department Physician
REAC/TS 1st call with Harborview Medical Center (HMC) Emergency Department Physician 0120
RAP 8 FTL determined it would be prudent to prepare for deployment
Information provided to RAP 8 Team Captain
RAP 8 not deploying 0145

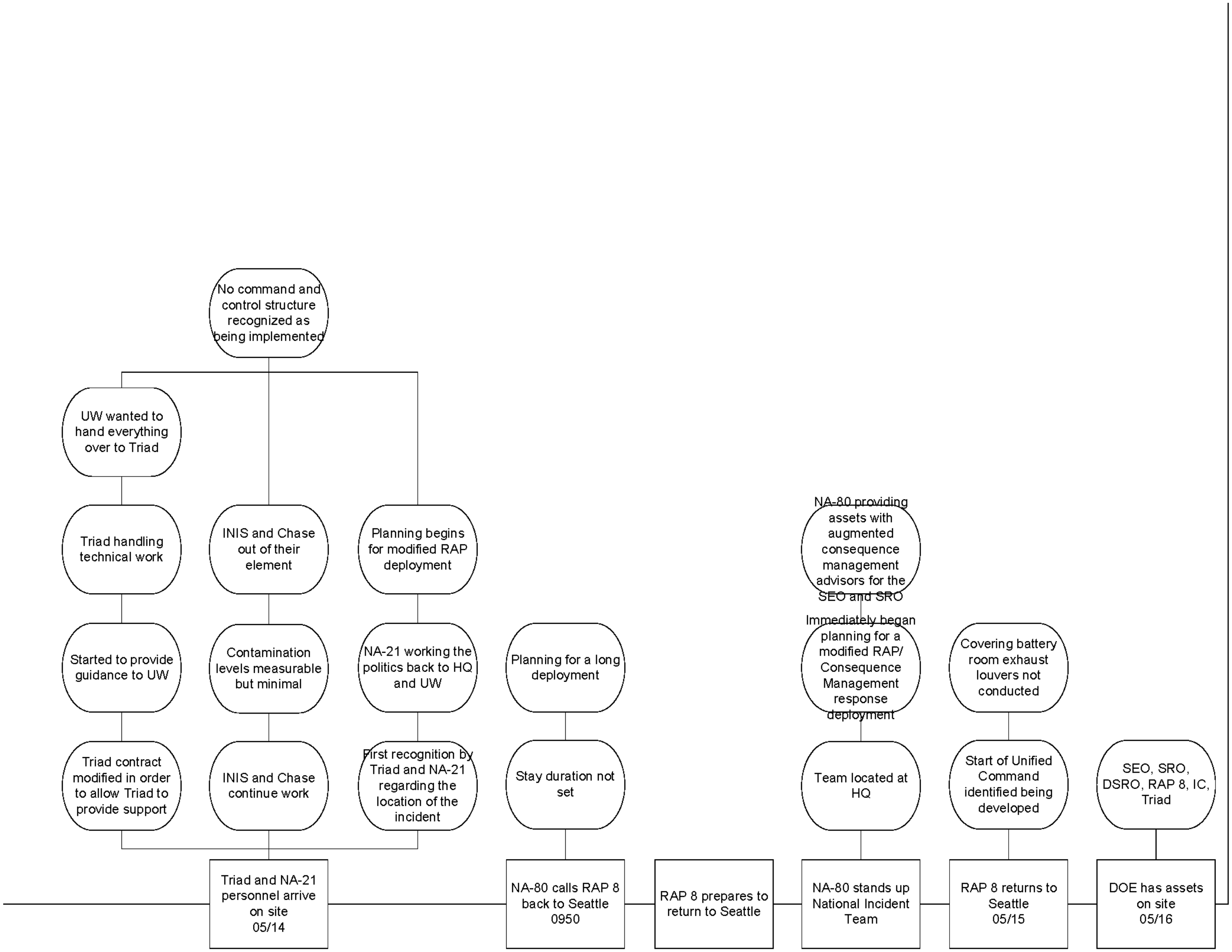

REAC/TS 1st call with HMC Emergency Department (ED) physician 0231
Health Inspector (DOH 2) and partner (DOH 1) returning to Olympia by car
Continued to discuss recommendations from the 0120 call
REAC/TS 2nd call with HMC Emergency Department (ED) physician 0530
1st report of contamination levels
Nasal swabs "positive" on two patients
No CBC's done
State of Washington DOH did not recommend blood work or urine collection
REAC/TS recommended CBC's and urine bioassays
For baseline and potential internal contamination levels
Recommend repeating CBC's in 12 hours
State of Washington Health Inspector (DOH 2) calls REAC/TS 0815
Reviewed multiparameter triage
Contamination on both – one with 300cpm in nose
Not seen by ED in Seattle
Would see ED in Olympia
Call with RAP 2 contact 0910
Worker may have received a dose to chest or head from grinding on unshielded source
Had discussed with DOH on location of Radiogardase
DOH was going to request one from Hanford
RAP 8 preparing to deploy
E-mail between REAC/TS and HMC follow-up nurse 0945
Nurse obtained laboratory (CBC and Diff) results from HMC ED
Recommends 24 hour urine bioassay and repeat CBCs 10-12 hours after initial collection
Try to get repeats on all personnel, or at least priority patients identified by REAC/TS MD
All patients have been discharged from HMC
Expressed concern that worker may have received a potentially harmful exposure when he damaged the source shielding
Triad AdSTR discusses event with RCO
RCO relays information on the event
AdSTR had previous voice message from RCO
AdSTR notifies COO ALDGS
Instructs Triad AdSTR to review contract
7 members identified
RAP 8 Fed Team Leader
RAP 8 Team Captain


Significance of the event not understood
RAP 8 Fed Team Leader and Team Captain present
Unplanned contamination event
Confirmed source strength
No TLDs or respirators identified for the INIS team
Team develops questions in case of deployment
NA-21 had been previously informed that morning via a colleague at NIH
Unable to obtain photos of source due to quarantine
HQ believes that the State of Washington can handle
RAP is not to be involved in cleanup work
Not sure of number of people contaminated or source strength
Team ready – awaiting deployment authorization
NA-1, 3, 20, 80 informed
Continued to express concern about breached source potentially giving a harmful dose to worker
HQ does not have an appreciation of the scope of the release
Questions developed
Decided to obtain bioassays on all patients
CsCl release
Calls made
Involved Triad subcontractor
Recommended CBC on priority patients and 24 hour bioassays
RAP not authorized to deploy
Calls made
Nurse Manager unable to determine which patient had internal contamination from documentation
RAP 8 preparation for mobilizing to Seattle
Los Alamos Field Office Manager informs HQ of the Event 1221
REAC/TS calls HMC Nurse Manager and Environmental Health and Safety Manager 1230
Request for RAP deployment from UW 1310
Permission received from NA-80 to deploy 1405
2nd REAC/TS call with HMC Nurse Manager 1435
RAP 8 leaves Richland 1516


REAC/TS call to HMC ED MD 1800
Confirming request for CBC and urine bioassay
Inquiry about intact skin contamination
RAP 8 team members arrived in Seattle 1907
State Patrol Officer present - no command structure identified
Site completely open
Yellow tape around building
Decon materials including decon water and red bags on site with clothes and other items from INIS personnel remain on site
Site personnel exhausted and were happy to see RAP 8 on-site
No INIS personnel on-site
RAP 8 performs general characteristic surveys
Found “spots” of contamination
Not high levels
Marked spots
No contamination found on walking surveys
RAP 8 set up hazmat tent and zip up decon tent
REAC/TS call to HMC ED MD 2105
Patients have returned for blood work
HMC ED MD will call with results
RAP 8 concludes activities for the evening 2130
REAC/TS call to HMC ED MD 2205
Results of CBCs provided by HMC ED MD
Discussed with REAC/TS MD
No further REAC/TS recommendations
Wearing booties and gloves for most surveys
Dressed out (Anti-Cs and respirators) to survey 2nd floor
No radiation postings identified inside or outside of the HRT
Building security was a challenge to conduct surveys
No great detailed floor plans available
RAP FTL needs for building facility support for ventilation
RAP 8 conducts surveys 05/04 0830 – late Saturday
Found “spots” of contamination
No contamination identified on louvers next to North loading dock roll-up door
Contamination in lunchroom, Rm 326 and other locations where people had been
Trying to decide between shine and contamination
No contamination identified in air samples
No contamination in Vivarium


Confirmed radioisotope was Cs-137
Contamination identified on multiple floors and multiple locations
INIS requested isotope ID for hot spots identified during their surveys
Set up air monitoring stations throughout the HRT
Noted multiple HVAC systems – only the main system shut down
Briefed FBI on last nights activities and discussion of possible priorities
FTL expects first Chase person to arrive that night
HQ questioning when RAP 8 can return to Richland
Possibly 3-4 day activity
UW looking for guidance from RAP
Agreed to support UW entry into the HRT and conducting surveys
Local responders expected RAP to take the lead with the response
RAP team working for UW who made the request
Interaction with INIS went well
1st of daily meetings at 0800 and 1600
Plan of the Day type meeting with INIS
Morning meeting 0850
Contamination not limited to the 2nd floor
Not expected
Found on multiple floors
Identified freezer contamination 2000
Battery room exhaust louvers show contamination
Ventilation still pushing out air through glass door at the front of the building
Did 30 minute pull
RAP 8 continued habitability surveys 05/05/2019
RAP considers emergency response complete
DOE/HQ may not have know the extent of the incident
RAP 8 Program Manager in Richland identified that RAP team would be pulling back in the afternoon 1150
UW personnel feel they are on their own
UW personnel disappointed RAP leaving
UW personnel believe RAPs job is not complete and are leaving too soon
DOH, UW, INIS, Chase, RAP 8 Program Manager and Team participated
Multiple items discussed
DOH Radiation Protection felt it acceptable that RAP was leaving
DOH needs to review and approve cleanup plan
Identifying what is clean
Recognized hot spots on seventh floor
Conference call to discuss status and turnover 1300


CC-4
RAP 8 turns over scene to UW
Formal command structure not in place
RAP 8 makes other recommendations
RAP 8 recommends covering battery room exhaust louvers
HQ believes DOH is engaged
DOE does not have a capability to bridge long term response and consequence management (CF-4A)
DOE RAP and NA-80 did not have a mechanism to provide continuing support or advice to UW response leads (CF-4B)
Minimal communication from the event scene to DOE after RAP 8 left Seattle
Formal command structure not in place
RAP considers emergency response complete
RAP 8 leaves Seattle to return to Richland 1430
Triad did not have clear guidance from NA-21 on their role for an offsite emergency response (CF-4D)
INIS determined to have full responsibility for cleanup
Triad AdSTR conducts full contract reviewed 05/06/2019
DOE does not appreciate the scale of the event
DOH identified this as a minor event
Discussion conducted at a conference
Discussions on event between DOH and DOE
Discuss pausing source recovery work
Triad call with NA-21 05/08
NA-21 pauses all source recovery operations involving grinding and cutting
UW feels that INIS cannot handle the job
Wants DOE to take lead and provide oversight of INIS activities
UW personnel very frustrated
Requests RAP return
UW contacts DOE/HQ 05/10
Triad provides a contract modification language to NA-LA to conduct work in Seattle
Direct support and leadership to UW focused on HRT recovery activities
Appropriate resources will be provided
DOE and Triad will do what is necessary to help
Guidance given from Laboratory Director and Senior NNSA leadership 05/13


No command and control structure recognized as being implemented
UW wanted to hand everything over to Triad
Triad handling technical work
INIS and Chase out of their element
Planning begins for modified RAP deployment
Started to provide guidance to UW
Contamination levels measurable but minimal
NA-21 working the politics back to HQ and UW
Triad contract modified in order to allow Triad to provide support
INIS and Chase continue work
First recognition by Triad and NA-21 regarding the location of the incident
Triad and NA-21 personnel arrive on site 05/14
Planning for a long deployment
Stay duration not set
NA-80 calls RAP 8 back to Seattle 0950
RAP 8 prepares to return to Seattle
NA-80 providing assets with augmented consequence management advisors for the SEO and SRO
Immediately began planning for a modified RAP/ Consequence Management response deployment
Team located at HQ
NA-80 stands up National Incident Team
Covering battery room exhaust louvers not conducted
Start of Unified Command identified being developed
RAP 8 returns to Seattle 05/15
SEO, SRO, DSRO, RAP 8, IC, Triad
DOE has assets on site 05/16