Response to SCA-TR-2017-007, *Draft Review of NIOSH's Evaluation Report for Petition SEC-00219, Idaho National Laboratory: Burial Ground, 1952–1970*

Response Paper

National Institute for Occupational Safety and Health

January 13, 2020

W. M. Findley
Oak Ridge Associated Universities Team

Reviewed by
M. L. Lobaugh, Ph.D., CHP
T. D. Taulbee, Ph.D., CHP
Division of Compensation Analysis and Support

INTRODUCTION

The initial evaluation report (ER) for petition SEC-00219, Idaho National Laboratory (INL) for 1952–1970, was presented by the National Institute of Occupational Safety and Health (NIOSH) to the Advisory Board on Radiation and Worker Heath (ABRWH) on March 26, 2015 [NIOSH 2015]. During that evaluation, it was determined that three areas at INL required further investigation; they were held in reserve until additional research was completed. One of these reserved areas was the Burial Ground from 1969–1970. Additional research was deemed necessary following identification of a small waste drum exhumation and retrieval project conducted in 1969. Prior to 1969, the Burial Ground's sole function had been waste burial. Exhumation and retrieval of buried waste was deemed to be an activity that could increase a workers' exposure potential; up to that time, the SEC-00219 evaluation team had discovered very little information on this endeavor. Upon completion of the additional Burial Ground research, as well as the investigation into the two other reserved areas, Rev. 2 of the ER for petition SEC-00219 was issued on February 22, 2017 [NIOSH 2017a]. The results of these further investigations were presented to the ABRWH on March 22, 2017.

Following its evaluation of the Burial Ground from 1952–1970, NIOSH concluded that occupational external, occupational internal, occupational medical, and ambient environmental external doses could be reconstructed. NIOSH determined that external dose could be reconstructed because external dosimeter requirements and exchange frequencies were known and documented. Any necessary biases/corrections that would need to be made to a worker's external dosimetry had already been evaluated; guidance is provided in the INL external technical basis document (TBD) [ORAUT 2011]. NIOSH determined that occupational medical and ambient environmental external doses could be reconstructed with the guidance in the medical and environmental TBDs [ORAUT 2009, 2010a].

For occupational internal dose, the conclusion needed a longer narrative. That narrative, from Rev. 2 of the SEC-00219 Petition ER [NIOSH 2017a, PDF pp. 236–237], is provided below in its entirety:

> *Mixed Fission and Activation Products*
>
> *For the Burial Ground, mixed fission and activation products were the primary internal dose hazards of concern. For urine samples only analyzed for gross beta, gross gamma, and/or strontium radioactivity, NIOSH will assess missed Sr-90 and/or Cs-137 intakes in accordance with ORAUT-OTIB-0054* [ORAUT 2014a] *and ORAUT-OTIB-0060* [ORAUT 2014b]. *Similarly, NIOSH will assess missed Cs-137 intakes when using in-vivo data in accordance with ORAUT-OTIB-0060. Based on the procedural information and the data on-hand, NIOSH finds that it has adequate monitoring data to allow for sufficiently accurate estimation of internal fission product doses for workers during the period from January 1, 1953 through December 31, 1970. Prior to 1953, NIOSH will assess internal dose in accordance with ORAUT-OTIB-0033* [ORAUT 2005].

Plutonium

The radiological monitoring program at the Burial Ground included the presence of a health physicist, safe work permits for all waste disposals, personnel surveys upon completion of work, air monitoring, and decontamination of vehicles at CPP if they were found to be contaminated. Air monitoring was always required through the entire process of handling and burying Rocky Flats waste. This was not the case with routine burials because the need for air monitoring on such occasions was at the discretion of the CFA [Central Facilities Area] *Health Physicist. Burial Ground workers who were suspected of internal exposure to Rocky Flats waste were placed on a follow-up bioassay program, as directed by the health physicist. Furthermore, Rocky Flats waste emplacement was unique from other types of waste buried at the Burial Ground in that: (1) it was scheduled for only certain days in a month; and (2) the waste was covered immediately after the waste drums were unloaded. This defense-in-depth approach was adequate to ensure that unmonitored intakes of plutonium did not occur.*

As discussed, the primary exposure source at the Burial Ground was fission products and any other radionuclides present with mixed fission products. The potential intakes of other radionuclides when mixed fission products were present (as indicated by data in personnel records) can be estimated on a case-by-case basis using the approach described in ORAUT-TKBS-0007-5 [ORAUT 2010b]. *Tables 5-29 and 5-30 in ORAUT-TKBS-0007-5 summarize the major radionuclides in the RWMC* [Radioactive Waste Management Complex] *waste inventory for the Subsurface Disposal Area (SDA) and Transuranic Storage Area (TSA), respectively. These values were generated and included in the INL Technical Basis for Internal Dosimetry to characterize potential exposure hazards at the Burial Ground (Characterization, 2001)* [INEEL 2001].

Based on the procedural information and the data on-hand, NIOSH finds that it has adequate monitoring data to allow for sufficiently accurate estimation of internal doses attributable to other radionuclides for Burial Ground workers during the period from January 1, 1969 through December 31, 1970.

Sanford Cohen & Associates (SC&A) was tasked by the ABRWH to review Rev. 2 of the SEC-00219 Petition ER, which included the Burial Ground 1952–1970 operational period [NIOSH 2017a]. In May 2017, SC&A issued SCA-TR-2017-SEC007, *Draft Review of NIOSH's Evaluation Report for Petition SEC-00219, Idaho National Laboratory*: *Burial Ground, 1952–1970* [Fitzgerald and Barton 2017].

This paper provides responses to the issues raised in the SC&A review in the order in which the preliminary findings are presented in the SC&A report. Examples from available site documentation are provided throughout the report to address findings in the SC&A report.

NOTE: Additional information on the Burial Ground was captured while performing a subsequent evaluation of the RWMC, which was designated in the 1970s and included the Burial Ground. This information was not available either to NIOSH during the SEC-00219 petition evaluation or to SC&A during the generation of their draft review.

RESPONSE TO SC&A'S REVIEW OF NIOSH'S EVALUATION REPORT FOR PETITION SEC-00219

SC&A's tasked review included analysis, preliminary findings, conclusions, and suggested lines of inquiry [Fitzgerald and Barton 2017]. SC&A identified three dose reconstruction "positions" in the ER, all of which pertained to occupational internal dose. The three positions are presented in the same order with responses to the preliminary findings for each position. The suggested lines of inquiry are reproduced in this report but, as stated in SC&A's review, the suggested lines of inquiry are items "that the Work Group should consider for resolving these issues." Additional information is provided for the Work Group to deliberate in consideration of the suggested lines of inquiry.

Response to SC&A Review of ER Position 1

Section 7.2.6 of Rev. 1 of the SEC-00219 Petition ER [NIOSH 2015, PDF p. 207], states the following conclusion about bounding internal doses for the Burial Ground:

> *The Burial Ground's internal dose monitoring program was based on a strict contamination control program with entry and exit monitoring. With the exception of Rocky Flats waste, mixed fission products were considered the controlling radionuclides. When workplace indicators indicated that an intake may have occurred, "special" (non-routine) bioassay would be requested by the area Health Physics staff.*

This conclusion was broken down into three separate positions in SCA-TR-2017-SEC007, which were addressed separately:

- Position 1(a): *The Burial Ground's internal dose monitoring program was based on a strict contamination control program with entry and exit monitoring.*
- Position 1(b): *With the exception of Rocky Flats waste, mixed fission products were considered the controlling radionuclides.*
- Position 1(c): *When workplace indicators indicated that an intake may have occurred, "special" (non-routine) bioassay would be requested by the area Health Physics staff.*

NIOSH Response to SC&A Analysis of Position 1(a)

Position 1(a): *The Burial Ground's internal dose monitoring program was based on a strict contamination control program with entry and exit monitoring.*

The INL Health Physics (HP) organization had the good fortune of being able to visit operational U.S. Atomic Energy Commission (AEC) sites to explore good operational health physics practices based on the experience of other sites. This preparation allowed for the establishment of a relatively mature HP program prior to the beginning of radiological operations in 1949. The use of Safe Work Permits (SWPs) and established procedures provided a framework for controlling radiological work at INL. This included the Burial Ground at the beginning of its operations in July 1952 when the first burial trench was opened for infrequent burial of INL-generated waste [Anderson and Schletter 1979]. From the beginning of radiological operations, the AEC Health Physicist in the CFA was responsible for the operation of and radiological control at the Burial Ground.

The burial of INL-generated waste, consisting primarily of mixed fission products (MFPs), was a relatively straightforward operation in which Dempster dumpsters were used to pick up packaged waste in the form of taped cardboard boxes from the multiple INL operating areas. The dumpsters were then emptied at the Burial Ground by backing the vehicle up to a waste trench and depositing the contents via hydraulic rams to lift the front of the bed (see Figure B-2 in Appendix B of this report for an example). On April 22, 1954, the Burial Ground received the first shipment of transuranic (TRU) waste from the Rocky Flats Plant (RFP). Between April 1954 and November 1957, RFP TRU-contaminated waste was mixed with INL MFP-contaminated waste in Trenches 1 through 10.

Despite waste burial being a radiologically low-risk activity, the use of SWPs and survey of equipment/personnel were indicative of a structured monitoring program. There was no routine bioassay program at the Burial Ground at that time. This is consistent with the standard health physics practice of establishing internal monitoring programs based on exposure potential [McCaslin 1963].

NIOSH obtained a 1955 procedure outlining the steps for routine waste disposal at INL [Piccot 1956]. It provides an informative snapshot of the established requirements of personnel, equipment, and schedule for waste collection and disposal. The text of this procedure is provided verbatim below:

Procedures for Routine Radioactive Waste Disposal [Issued by INL HP in 1955]

1. *The truck driver will be designated as a leadman for the entire operation. He will be responsible for making necessary contacts; obtaining instructions and clearances; reporting unusual events to AEC-HP, safety and security, and in general for the overall conduct of the detail.*

2. *The hot waste trailer must be kept at AEC-HP at all times when not in use. Approval must be obtained from AEC-HP for all assignments.*

3. *Routine waste pick-ups will be made each Tuesday and Friday morning. Special pick-ups may be made at other intervals if previously scheduled through AEC-HP.*

4. *Before starting on any run the driver and workmen must report to AEC-HP for clearance and instructions. This will include protective clothing requirements, locations of pick-ups required, and any additional information on hazards, etc.*

5. *The driver and workmen will then obtain and change into the recommended protective clothing at the CFA change house. Normally two pairs of coveralls; cotton shoecovers over rubber type shoecovers; cotton caps, and gloves will be worn at the start of the operation. Extra gloves and shoecovers can be carried to the jobs by the workmen to replace items which may become contaminated.*

6. *Upon arrival at each waste pick up point the leadman must contact the local Health Physicist or representative in regard to the hazards and precautions required prior to loading the waste. He will obtain one copy of an IHP-30 from each pick-up point.*

7. *Respirators will be worn at all times while handling waste in the trailer enclosure.*

8. *The driver and other workmen will remain in the waste truck while going between each pick-up point and the burial ground. (Guards will permit truck and personnel through the plant vehicle gates).*

9. *IDO* [AEC Idaho Operations Office]-*HP will meet the truck at the burial ground gate and collect all copies of the HP-30 forms from the driver. The trailer will then be unloaded under IDO-HP supervision and monitoring.*

10. *After unloading is complete, the outer pair of coveralls and shoecovers will be removed at the burial ground to prevent contamination of the cab.*

11. *The crew will then return and park the trailer at the AEC-HP area, and report to IDO-HP for monitoring of personnel and equipment. After obtaining an HP release the crew must wash up and change into personal clothing before leaving the CFA change house.*

Reminders
Wear a film and pocket meter at all times on this job.
Wear only approved coveralls-symbol and CFA on back.
Don't leave waste detail or enter "cold" areas while wearing protective clothing.
Keep the change room neat - IT BELONGS TO YOU [Piccot 1956, PDF p. 3].

NOTE: IHP-30 in step 6 and HP-30 in step 9 indicated the waste disposal form at the time. The forms were the same.

This procedure provided an established framework for the expected conduct of operations at the Burial Ground in 1955. The responsibilities for personnel involved in waste disposal, from waste pickup on site through the completion of unloading waste, are clearly stated. Protective clothing was prescriptive as was distribution of required paperwork. Step 9 is of particular interest as it states, "the trailer shall be unloaded under IDO-HP supervision and monitoring."

As early as 1962, there was a 25-page procedure in the INL Standard Practices Manual that was devoted specifically to the Burial Ground [Hayden 1962]. Standard Practice No. 5.61.2 stated that the "responsibility for the overall operation, record keeping, plot plan, reports and details as they arise is delegated to the Central Facilities Health Physicist." Sections of the Practice addressed a wide variety of topics, including:

- Radiation limits for routine acceptance of waste
- Burial schedules
- Vehicle checks for radiation and contamination prior to departure for the Burial Ground
- Conformance with Interstate Commerce Commission regulations for radiation and contamination limits
- Vehicle checks to detect truck contamination after unloading
- The use of specified forms for federal agencies
- Verification of shipment arrivals and the content of the packing lists
- Recording of disposal data, including the method of disposal, location, and date of burial
- Maintenance of a log book for recording burial data

- Costs of operation

In addition to the topics above, there are five numbered forms that were used for Burial Ground operations. Each form and a description of the required information is provided below:

- ID-110 Waste Disposal Request and Authorization

  - Section I: Originating organization, description of waste including form, radioactive or non-radioactive material, activity in curies if radioactive, external exposure rate at container surface and 1 meter (mR/hr), mode of transportation, and multiple approvals including a HP representative.

  - Section II: Assignment of an authorization number with approving signature.

  - Section III: Method of disposal, prescribed precautions, and multiple approvals by the IDO Health and Safety Division

  - Section IV: Completed and signed by person witnessing disposal.

- ID-136 Order for Disposal of Solid Packaged Radioactive Waste (for all Federal agencies)

- ID-137 Order for Disposal of Solid Packaged Radioactive Waste (other than Federal agencies)

- ID-136 and ID-137 both include a "Waste Shipment Data" sheet. The data sheet is a one-page form that documented highest radiation levels at the outside surface of packages and estimated radioisotope content quantity in curies.

- ID-109 (formerly IHP-30) Radioactive Shipment Record; sections include:

  - Details of shipment
  - HP monitoring results
  - IDO-HP approval of shipment
  - Traffic agent certification of shipment

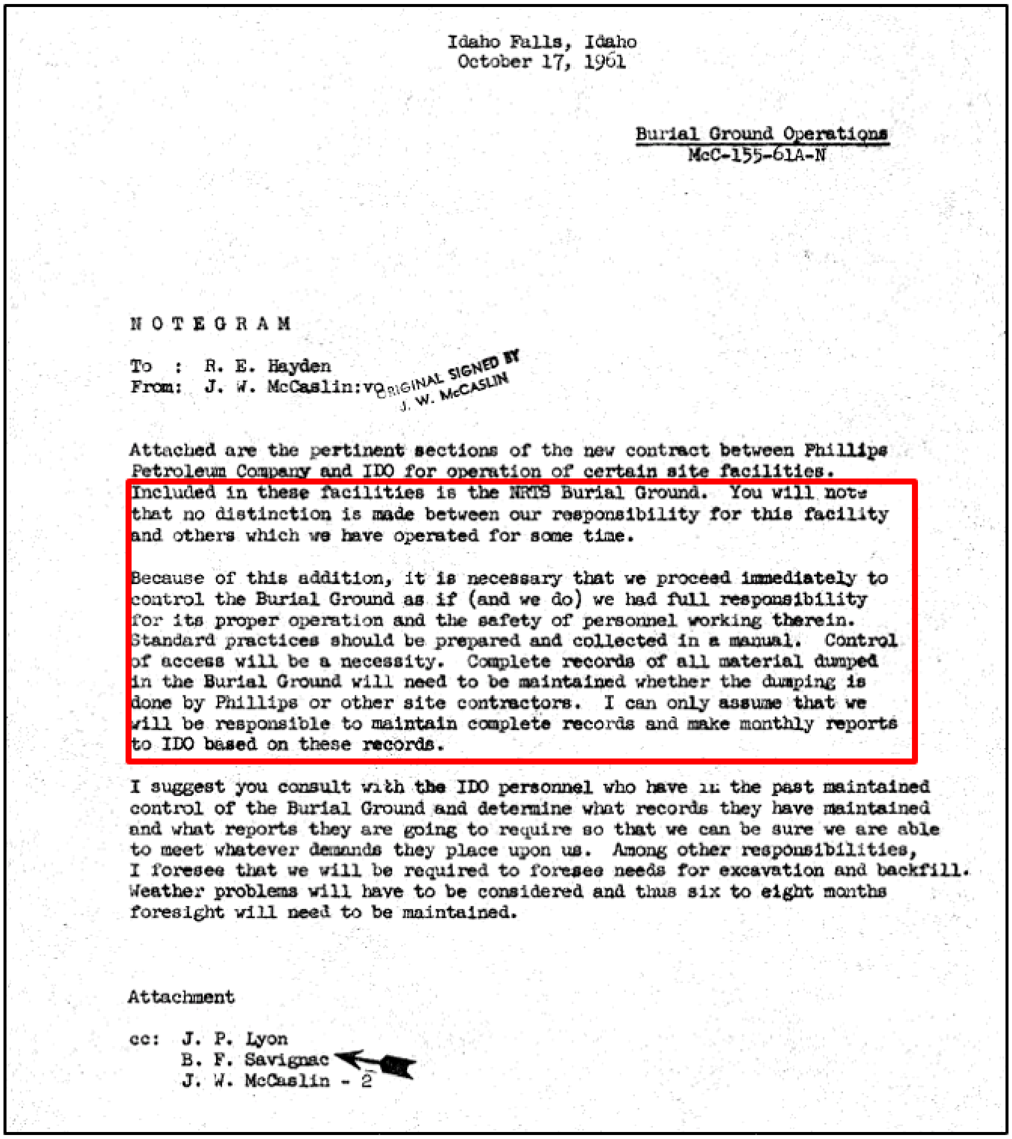
- ID-127 Radioactive Waste Reports

  - A monthly report generated by each area or plant facility.

The procedure for the Burial Ground operations had become more comprehensive by 1962 and was included in the INL Standards Practices Manual that applied to the entire site. The procedure clearly required an orderly operation with adherence to instituted requirements and established guidelines. It reiterated that the CFA Health Physicist was responsible for the overall operations of the Burial Ground.

During this era, there were very limited hours of operation. The facility was only open for unscheduled disposal from 8:30 to 4:00 on Tuesdays and Friday, or 15 hours a week. Scheduled burials could only be performed on Monday, Wednesday, and Thursday after contacting the CFA Health Physicist [Hayden 1962, PDF p. 3].

There is little evidence to support the assertion that INL management considered the Burial Ground as "low priority," as suggested in SCA-TR-2017-SEC007. Figure 1 is a memorandum on management expectations for operation of the Burial Ground after a contractor transition in 1961 [INL 1960–1961, PDF p. 103]. It clearly states that "no distinction is made between our responsibility for this facility and others which we have operated for some time."



Idaho Falls, Idaho
October 17, 1961

Burial Ground Operations
McC-155-61A-N

N O T E G R A M

To : R. E. Hayden
From: J. W. McCaslin:vp ORIGINAL SIGNED BY J. W. McCASLIN

Attached are the pertinent sections of the new contract between Phillips Petroleum Company and IDO for operation of certain site facilities. Included in these facilities is the NRTS Burial Ground. You will note that no distinction is made between our responsibility for this facility and others which we have operated for some time.

Because of this addition, it is necessary that we proceed immediately to control the Burial Ground as if (and we do) we had full responsibility for its proper operation and the safety of personnel working therein. Standard practices should be prepared and collected in a manual. Control of access will be a necessity. Complete records of all material dumped in the Burial Ground will need to be maintained whether the dumping is done by Phillips or other site contractors. I can only assume that we will be responsible to maintain complete records and make monthly reports to IDO based on these records.

I suggest you consult with the IDO personnel who have in the past maintained control of the Burial Ground and determine what records they have maintained and what reports they are going to require so that we can be sure we are able to meet whatever demands they place upon us. Among other responsibilities, I foresee that we will be required to foresee needs for excavation and backfill. Weather problems will have to be considered and thus six to eight months foresight will need to be maintained.

Attachment

cc: J. P. Lyon
B. F. Savignac
J. W. McCaslin - 2

Figure 1. 1961 memorandum on management expectations for the Burial Ground.

An October 1961 CFA HP monthly report discusses the problems associated with shipments arriving at the Burial Ground later in the day because shipping and radiation safety requirements had to be completed before sending trucks away [Sauvignac 1961, PDF p. 7]:

> *Some shipments for burial arrive late in the day. At times, casks for contaminated waste remain on trucks and are returned to off site areas. These casks or containers being returned to off site installations are considered as radioactive shipments. Sufficient time is necessary to prepare these return shipments. Tie-downs, radiation control, safety inspections, necessary documents, and approval by different individuals are all required. We have requested our shipping agent to*

> *make arrangements, so that such shipments will arrive early during the day. On site shipments to burial grounds: 54. Off-site shipments to burial grounds: 9.*

Monitoring practices at other INL facilities and an evaluation of the Burial Ground in the 1970s demonstrates that radiological monitoring was based on the exposure potential of workers. It was not until the 1969–1970 period that significant changes in facility work scope, federal regulations, and increased shipments for burial created a need for change in the operation of the Burial Ground. This change will be discussed in more detail later.

In order to address the position that *"the Burial Ground's internal dose monitoring program was based on a strict contamination control program with entry and exit monitoring,"* a thorough review of available CFA monthly HP reports, available CFA HP logbooks, and available CFA HP log sheets was performed; these were deemed to be the likely sources of documenting non-routine radiological conditions encountered at the Burial Ground. In addition, available SWPs were reviewed to provide insight into what personal protection equipment and radiological monitoring was required for burial operations. Numerous personnel interviews performed for the Burial Ground were reviewed to gain insights from the personal recollections of Burial Ground workers during the 1952–1970 time period. Multiple examples of collection of contamination smears and air sampling are provided herein because SCA-TR-2017-SEC007 expressed concerns about whether these forms of monitoring were performed and, if so, the adequacy of the monitoring.

Table 1 shows the availability (Yes or No) of the CFA monthly HP reports for review of the 1952–1970 time period. While not a complete set, the available reports represent 58% of the possible total for July 1952–December 1970. Unfortunately, no CFA monthly HP reports are currently available during the late 1960s, a time of increased work activity and impending change at the Burial Ground.

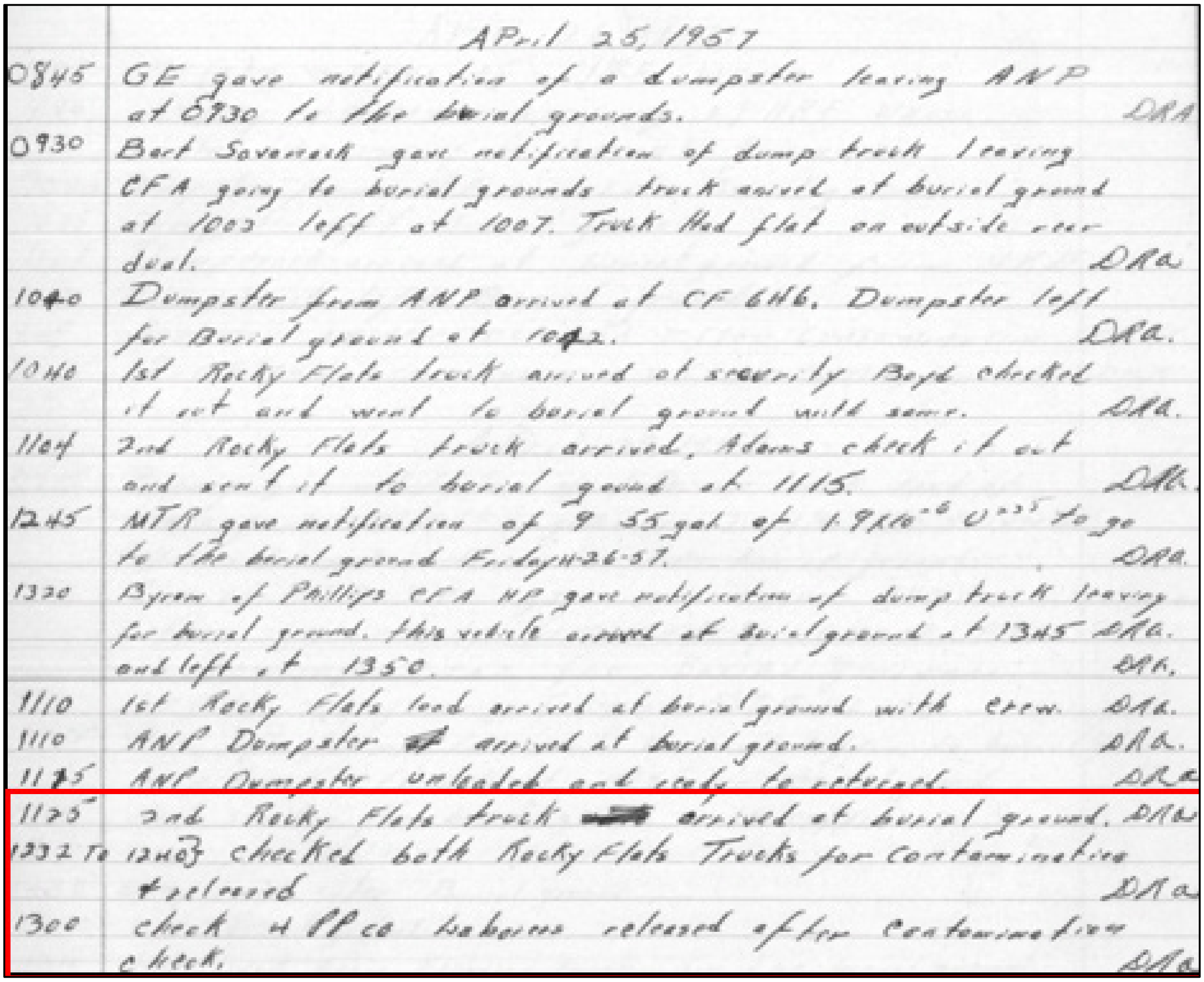
As stated in SCA-TR-2017-SEC007, CFA monthly HP reports routinely list hundreds of "smears collected and counted" in the early and mid-1960s; however, there is no way to ascertain how many of those were taken at the Burial Ground. However, review of available CFA HP documentation during the period under evaluation, as well as information from worker interviews indicate that contamination smears were indeed performed at the Burial Ground.

Table 1. Availability of CFA HP reports in the Site Research Database (SRDB).

Month	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
JAN	N/A[a]	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	No	No
FEB	N/A[a]	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	No	No
MAR	N/A[a]	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	No	No
APR	N/A[a]	No	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	No	No	No	No	No
MAY	N/A[a]	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	No	No
JUN	N/A[a]	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	No	No
JUL	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	No	No
AUG	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	No	No
SEP	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	No	No	No
OCT	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	No	No
NOV	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	No	No
DEC	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	No	No	No

[a] The designation of N/A (Not Applicable) is indicated for January through June 1952 because the first trench for disposal of waste was not opened until July 3, 1952.

The following examples pertain to contamination smears from the review of the available CFA monthly HP reports, HP logbooks, and HP log sheets. Figure 2 shows April 1957 entries documenting vehicle and personnel contamination checks pertaining to burial of RFP waste [DRA 1957, PDF p. 3].



April 25, 1957

0845 GE gave notification of a dumpster leaving ANP at 0730 to the burial grounds. DRA

0930 Bert Savenack gave notification of dump truck leaving CFA going to burial grounds truck arrived at burial ground at 1003 left at 1007. Truck had flat on outside rear dual. DRA

1040 Dumpster from ANP arrived at CF 646. Dumpster left for Burial ground at 1042. DRA.

1040 1st Rocky Flats truck arrived at security Boyd checked it out and went to burial ground with same. DRA.

1104 2nd Rocky Flats truck arrived, Adams check it out and sent it to burial ground at 1115. DRA.

1245 MTR gave notification of 9 55 gal of 1.9x10-6 U235 to go to the burial ground Friday 4-26-57. DRA.

1330 Byron of Phillips CFA HP gave notification of dump truck leaving for burial ground. this vehicle arrived at burial ground at 1345 DRA. and left at 1350. DRA.

1110 1st Rocky Flats load arrived at burial ground with crew. DRA.

1110 ANP Dumpster arrived at burial ground. DRA.

1125 ANP Dumpster unloaded and ready to released. DRA

1135 2nd Rocky Flats truck arrived at burial ground. DRA

1232 To 1240 checked both Rocky Flats Trucks for contamination & released DRA

1300 check 4 PPCo laborers released after contamination check. DRA

Figure 2. CFA HP logbook entries for April 25, 1957.

An October 22, 1965 entry in a CFA HP Log Sheet reads [INL 1964–1965, PDF p. 135]:

> *Checked Rock Flats yardman with alpha meter and smears -- no contamination found!*

A November 4, 1966 CFA HP Log Sheet contained three entries related to the Burial Ground (shown below). They demonstrate typical entries in the CFA HP Log Sheets. The majority of Burial Ground entries simply state which HP technician was assigned to the Burial Ground and the tasks to be completed. One entry involves a Jeep that served as an office for the HP because there were no buildings at the Burial Ground during the 1952-1970 time period (see Figure B-1 in Appendix B of this report for an aerial photograph of the Burial Ground in 1970). While not directly attributable to the Burial Ground, the second entry below notes that a box had been opened in transit to the Naval Reactors Facility (NRF). CFA HP responded by taking four contamination smears. This is further evidence that contamination smears were taken as deemed necessary [INL 1965–1966a, PDF p. 68].

> *0800 Jeep Battery -- dead or something?*
>
> *0900 [REDACTED]- Hazards control at CF690 called wants a survey on a* [illegible] *box containing U^{235} going to NRF @ S&G. Box had been open in transit. 4 Smears taken on open end of box indicate no contamination.*
>
> *BG - Four Rocky Flats trucks and regular had waste today.*

The following November 17, 1966 entry in a CFA Log Sheet notes the arrival of an offsite cask sent to the Burial Ground from CFA. During that time period, all offsite waste shipments were first received at CFA for radiological surveys and clearance for transfer to the Burial Ground. Surface contamination of 300 dpm β/γ was found on the General Atomics cask at the Burial Ground. It was returned to CFA and then sent to the Chemical Processing Plant (CPP) for decontamination. CPP had a large decontamination facility that was used by the entire INL site. In this case, the shipment contamination was found at the Burial Ground rather than the CFA. The effort to reroute the cask and decontaminate over such a small quantity of β/γ contamination demonstrates the tight radiological controls in place and the unwillingness to tolerate even small quantities of contamination [INL 1965–1966a, PDF p. 73].

> *Cask from Gen Atomics Canoga Park arrived last night - 150 c/m (300 d/m $\beta\gamma$ on cask) sent to burial ground, returned to CFA, sent to CPP decontaminated by* [illegible][REDACTED]. *90 to 150 c/m smears on base and top. Refused empty cask tagged empty but with inter* [internal contamination].

A review of interview summaries for former workers who worked at the Burial Ground between 1952 and 1970 revealed some inconsistencies in the recollections regarding if and when contamination smears were taken. However, the interviews are fairly clear on the issue of the CFA HP being present and in charge of waste-disposal activities.

Below are excerpts from three different personnel interviews pertaining to contamination smears:

1. *An HP was there to monitor for all RFP waste burial jobs. There were usually 4-5 laborers unloading RFP waste. There was usually just one HP monitoring the workers; the HP took smears and air samples. He* [REDACTED] *does not recall a time when they didn't have HP coverage for waste disposal at the Burial Ground* [ORAUT 2016a, PDF p. 5].

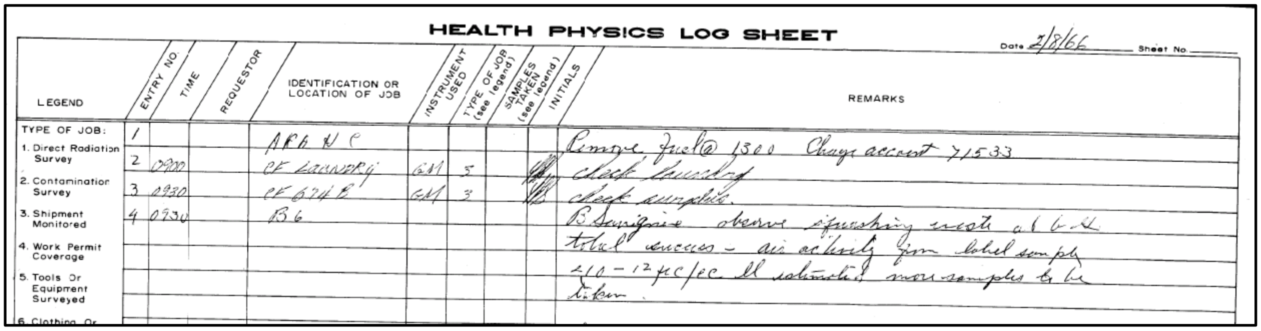
2. *The dumpster type vehicles were filled with disposal material, and they just backed up to the waste pits/trenches. Most of the dumpsters were associated with specific areas. Most likely, the HPs in those areas/facilities did surveys and smears of the vehicles before they left for the Burial Ground* [ORAUT 2016b, PDF p. 7].

3. *In 1965 most waste at the Burial Ground was local waste so it was primarily beta/gamma contamination but without alpha contamination equipment it was not known definitively. He stated that they may have taken smears from alpha contamination but doesn't recall taking these types of smears. If they were counted for alpha, they would have to be taken to Central Facilities* [ORAUT, 2018a, PDF p. 3].

Smear-counting equipment does not appear to have been available at the Burial Ground. All indications are that contamination smears were counted at the CFA HP office in CF-690.

Regarding air monitoring for radioactive material at the Burial Ground, multiple examples were provided in the document *Special Bioassay and Air Sampling Examples from the INL Burial Ground 1952–1970* [NIOSH 2017b]. NIOSH compiled the examples at the request of the ABRWH. Those examples are provided below to respond to the air-sampling concerns expressed in SCA-TR-2017-SEC007, which was released prior to the issuance of NIOSH's compilation [NIOSH 2017b].

Example 1
Air sample results were commonly recorded on HP Log Sheets kept at CFA. Figure 3 shows an example in which multiple job locations are mentioned, including the Auxiliary Reactor Area (ARA) and the Burial Ground, which were covered from CFA. [REDACTED], the CFA HP Manager observed "squashing waste" and the use of lapel air samplers [INL 1965–1966a, PDF p. 8].



HEALTH PHYSICS LOG SHEET — Date 2/8/66 — Sheet No.

LEGEND	ENTRY NO.	TIME	REQUESTOR	IDENTIFICATION OR LOCATION OF JOB	INSTRUMENT USED	TYPE OF JOB (see legend)	SAMPLES TAKEN (see legend)	INITIALS	REMARKS
TYPE OF JOB:	1			ARA II C					Remove fuel @ 1300 Charge account 71533
1. Direct Radiation Survey	2	0900		CF Laundry	GM	5		[illegible]	check laundry
2. Contamination Survey	3	0930		CF 674 B	GM	3		[illegible]	check samples.
3. Shipment Monitored	4	0930		B6					B. [illegible] observe [illegible] waste at [illegible]
4. Work Permit Coverage									total success – air activity from [illegible] sample
5. Tools Or Equipment Surveyed									2/10 – 12 µc/cc. [illegible] more samples to be
6. Clothing Or									taken.

Figure 3. 1966 CFA HP log sheet.

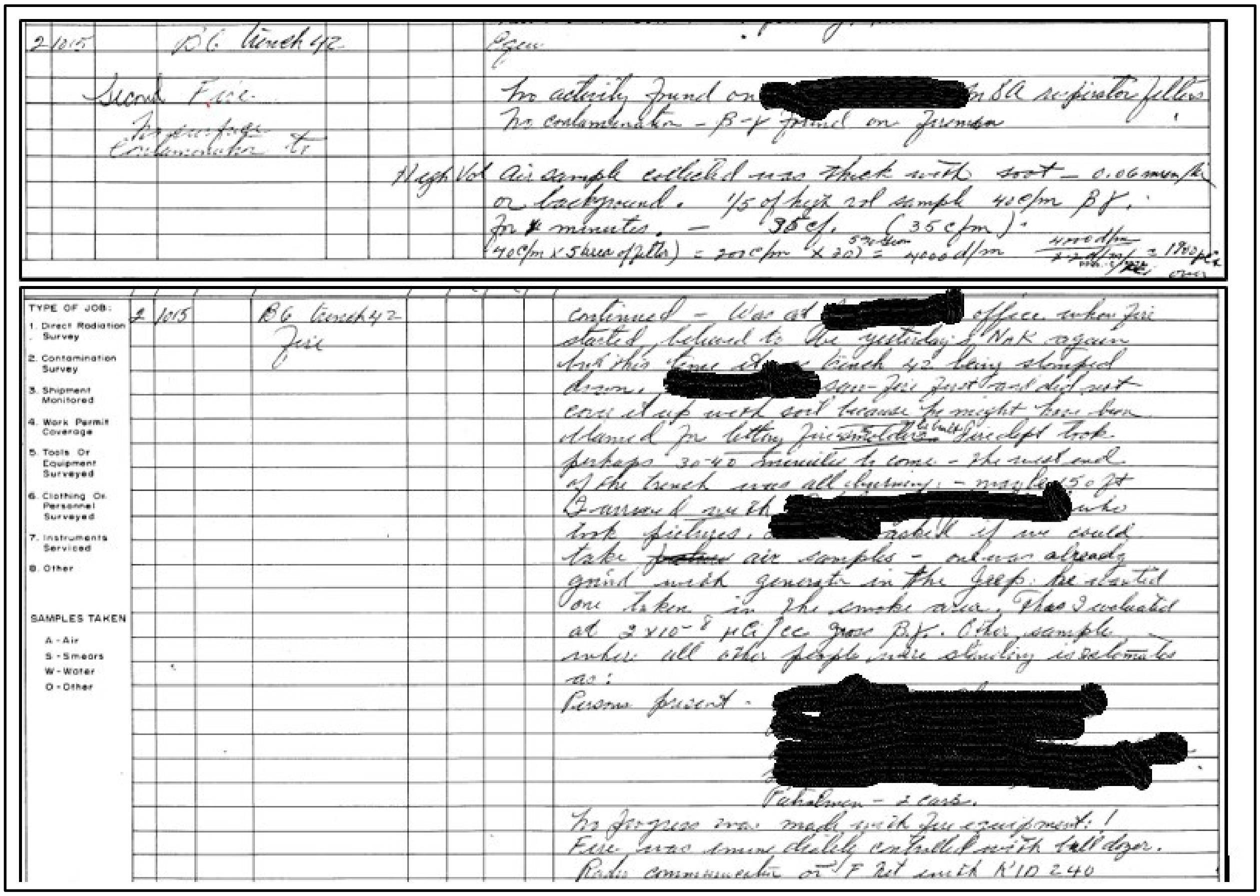
Example 2

An air sample result from a February 1966 CFA HP Log Sheet, while difficult to read, states [INL 1965–1966a, PDF p. 10]:

> *BG: Conducted water pressing operation #2 on the first* [illegible] *#41 (0' to 100') air sample taken to determine degree of S*[illegible]. *Sample #1 = 35. Sample #2 = 37 -- 10* [illegible] *above Bkg. The operation was started at 3 and completed at 515 pm -- the air sample was taken continuously during the pressing operation. The clothing of the two operators was monitored at completion, no activity was evident.*

Example 3

Figure 4 shows a September 1966 entry on a CFA HP Log Sheet that describes air samples taken due to a fire in Trench No. 42. The results are provided along with a listing of personnel present during the fire, including firemen [INL 1965–1966a, PDF pp. 51–52].


2 | 1015 | B6 Trench 42 | Open

Second Fire — No surface contamination

No activity found on [redacted] on SA respirator filter. No contamination — β-γ found on [illegible]

High Vol: Air sample collected was thick with soot — 0.06 mr/hr on background. 1/5 of high vol sample 40 c/m βγ, for [illegible] minutes. — 35 cf. (35 cfm). (40 c/m x 5 [illegible] of filter) = 200 c/m x 20 = 4000 d/m [illegible] = 1.9 x 10[illegible]

TYPE OF JOB: 1. Direct Radiation Survey 2. Contamination Survey 3. Shipment Monitored 4. Work Permit Coverage 5. Tools Or Equipment Surveyed 6. Clothing Or Personnel Surveyed 7. Instruments Serviced 8. Other

SAMPLES TAKEN: A - Air, S - Smears, W - Water, O - Other

2 | 1015 | B6 Trench 42 Fire

continued — Was at [redacted] office when fire started, believed to be yesterday's NaK again but this time at the trench 42 being stomped down. [redacted] [illegible] — fire just [illegible] did not cover it up with soil because he might have been blamed for letting fire [illegible]. Fire dept took perhaps 30-40 minutes to come — the west end of the trench was all burning — maybe 150 ft. [illegible] with [redacted] who took pictures. [redacted] asked if we could take air samples — one was already going with generator in the jeep. He started one taken in the smoke area, this I evaluated at 2 x 10⁻⁸ μCi/cc gross βγ. Other sample where all other people were standing [illegible] as:

Persons present: [redacted]

Patrolmen — 2 cars.

No progress was made with fire equipment! Fire was immediately controlled with [illegible] dozer. Radio communication on F net with K10 240

Figure 4. 1966 CFA HP log sheet entry for Trench No. 42 fire.

<u>Example 4</u>

The September 1966 CFA HP Monthly Report provided a description of the Trench No. 42 fire. Of interest is that an isotopic analysis was performed on a high-volume air filter sample collected "directly over Trench No. 42 during the burial ground fire." In addition, concentrations of gamma and alpha emitters were calculated based on analysis of four soil samples [Sauvignac 1965–1966, PDF p. 9].

> *Results of radiochemistry determination from high volume air filter samples collected directly over Trench #42 during the burial ground fire, have been received. No radio-iodine and no other gamma identification could be reported. No significant alpha could be detected. Calculations indicate the concentration was less than 10^{-12} μCi/cc of air over Trench #42 during the burial ground fire. No gamma scan identifications were reportable from four soil samples collected along Trench #2. Alpha determinations were reported to be less than 1.4x10-^{8} μCi/g.*

Example 5

An entry in a December 1966 CFA HP Log Book gives the name of the individual assigned to the Burial Ground that day and discusses an air sample result considered to be likely from natural radioactivity. It attributes collected samples to two individuals known to have routinely worked at the Burial Ground [INL 1965–1966a, PDF p. 85].

> *0800 Brashear - burial ground day. Some air activity now - probably determined from natural activity from samples collected by [REDACTED] and [REDACTED].*

Example 6

The January 1966 CFA HP Monthly Report captures a suggestion by an experienced HP technician who worked primarily at the Burial Ground until retirement in 1970. Two air samples were taken, alpha activity reported, and conclusions drawn [Sauvignac 1965–1966, PDF pp. 23-24].

> *A suggestion by [REDACTED] to compress routine waste boxes in trenches at the burial ground might save a lot of money. Two samples collected at the burial ground during such operations indicated radioactive particle concentration in air to be less than 10^{-12} uc/cc. Disturbances to waste do not appear worse than the actual refill of trenches with bulldozers. Erosion due to voids in filled trenches might be decreased.*

National Bureau of Standards (NBS) Handbook 69 was the standard at the time. Handbook 69 presented tables of maximum permissible body burdens and maximum permissible concentrations (MPCs) of radionuclides in air for occupational exposure. The MPC for Pu-239 for a 40-hour week was 2E-12 μCi/cm^3 for bone surfaces and 1E-11 μCi/cm^3 for the total body.

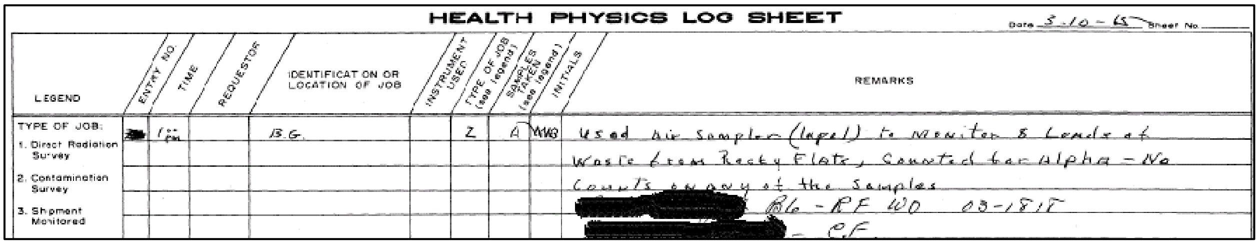
Example 7

The February 1965 CFA HP Monthly Report states [Sauvignac 1965–1966, PDF p. 46]:

> *Air samples have been collected with high volume air samplers or battery operated lapel samplers at the CF laundry, burial ground, and the sewer. Control samples are collected at CF-610 as a basis for background. No air activity above background was detected.*

Example 8

Figure 5 shows a March 1965 CFA HP Log Sheet that contains an entry stating that lapel air samplers were used while unloading eight loads of waste from RFP. Waste drums from RFP were typically buried in mass on dedicated specific days at the Burial Ground [INL 1964–1965, PDF p. 40].



HEALTH PHYSICS LOG SHEET

Date 3-10-65 Sheet No.

LEGEND	ENTRY NO.	TIME	REQUESTOR	IDENTIFICATION OR LOCATION OF JOB	INSTRUMENT USED	TYPE OF JOB (see legend)	SAMPLES TAKEN (see legend)	INITIALS	REMARKS
TYPE OF JOB:	[redacted]	1:00 PM		B.G.		2	A	WWB	Used air sampler (lapel) to monitor 8 loads of
1. Direct Radiation Survey									Waste from Rocky Flats, Counted for Alpha - No
2. Contamination Survey									Counts on any of the samples
3. Shipment Monitored									[redacted] B6 - RF WO 03-1815
									[redacted] - CF

Figure 5. March 1965 CFA HP log sheet entry.

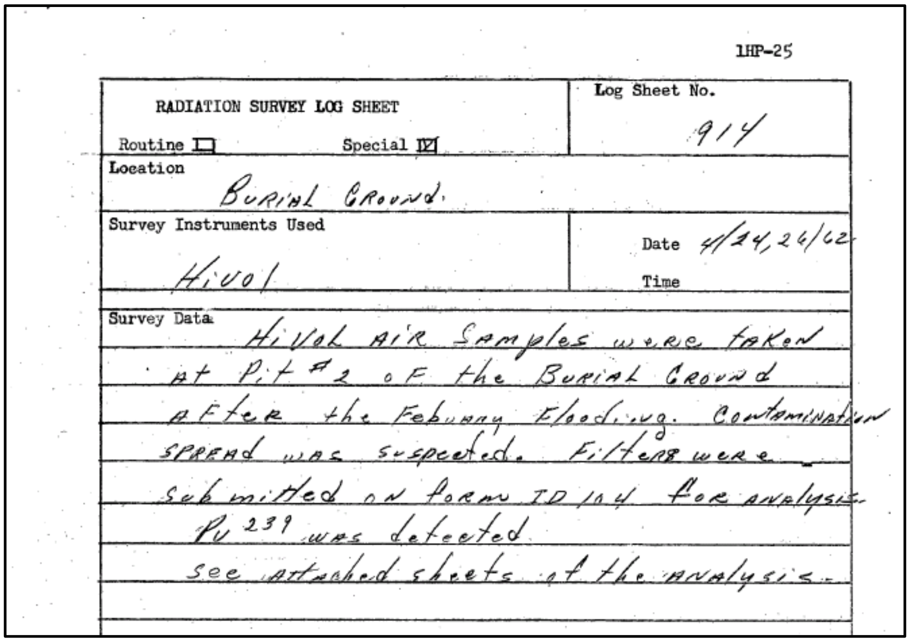
Example 9

The July 1963 CFA HP Monthly Report has a section on the Burial Ground that provides evidence that HP duties included control of operations and radiological surveillance. The entry also indicates that ten air samples were collected at the Burial Ground and CFA [Sauvignac 1963, PDF p. 14].

> *Accountable materials were buried this month. Forms ID-110 were distributed as specified in the Standard Practices.*
>
> *Surveillance becomes a bit involved whenever activities require HP duties in more than one location at one time in the burial ground. Health Physics is sometimes required to check and identify arriving off-site shipments, while crews are preparing to unload high level waste from a cask and routine waste is being dumped. Signs placed near trenches where exposures might be received do some good. Frequent verbal warnings are still necessary.*
>
> *All the trenches and pits are now marked with monuments. Ten air samples at the burial ground and at CFA were collected. Estimates of concentrations were according to guides published in the NBS Handbook #69.*

Example 10

In February 1962, the "Chinook" flood event at the Burial Ground impacted Pits 2 and 3, as well as Trenches 24 and 25 (which were open at the time of the flood). Figure 6 shows the April 1962 Radiation Survey Log Sheet discussing high-volume air samples collected at Pit No. 2, which contained RFP waste drums, thus sparking concern over the potential spread of plutonium contamination [Ebersole 1962, PDF p. 2].



1HP-25

RADIATION SURVEY LOG SHEET

Log Sheet No. 914

Routine ☐ Special ☑

Location: Burial Ground.

Survey Instruments Used: Hivol

Date 4/24, 26/62

Time

Survey Data: HiVol Air Samples were taken at Pit #2 of the Burial Ground after the Febuary Flooding. Contamination spread was suspected. Filters were submitted on form ID 104 for analysis. Pu 239 was detected. see attached sheets of the analysis.

Figure 6. April 1962 radiation survey log sheet on high volume air samples taken at Pit No. 2.

Example 11

The May 1962 CFA HP Monthly Report provides the air sampling rationale and results for samples collected at Pit No. 3 as a result of the "Chinook" flood. Pit No. 3 contained RFP waste drums, so there was a concern over the potential spread of plutonium contamination [Sauvignac 1962, PDF p. 20]:

> *Airdust samples were collected at the edge of pit #3. This pit contains a vast number of drums containing plutonium contaminated waste which was disturbed by floods. Results of samples indicate a minute amount of plutonium possibly on two samples and possibly none on the other three.*
>
> *The most significant results indicate a plutonium dust concentration in air of 1×10^{-13} uc/cc or less. In a variety of cases, NBS concentration guides for plutonium in air vary between 7×10^{-7} uc/cc down to 6×10^{-13} uc/cc.*

Regarding Examples 10 and 11 above, SC&A's review provided the following account [Fitzgerald and Barton 2017, PDF p. 9]:

> *One exception noted were samples taken on May 9–10, 1962 near Pit #2, which indicated air concentrations of plutonium "2-3 times the radioactivity concentration guides for a 40 hour week"* [Wehmann 1962, PDF p. 2]. *Respirators were not routinely used, nor alpha contamination routinely surveyed, at the time of this 1962 contamination event.*

It should be noted that these results were part of the monitoring following the 1962 "Chinook" flood and that respiratory protection was required until a better understanding of potential changes in radiological conditions due to the flood were understood. The following entry from the June 1962 CFA HP Monthly Report provides additional information on the post-flood follow-up effort [Sauvignac 1962, PDF p. 23]:

> *Since the flood, we have requested the IDO Site Survey Group to collect air-dust samples at the burial grounds. We have been verbally informed that plutonium was identified on samples collected. We have since appropriated surplus electric generators. These generators had been very slightly used by Site Survey. Electric power to operate some health physics instruments is now available at the burial grounds.*

Figure 7 provides a further excerpt from the June 1962 CFA HP Monthly Report that includes sampling results [Sauvignac 1962, PDF p. 25].

Floods have stopped operations for an indefinite period. Proposals for action in the future are being discussed. Some alpha contamination levels of 107 d/m/ml in flood waters have been reported by the CPP Special Analysis Section. These results were obtained from a sample taken in the rocky flats pit. A detailed survey is planned by ALD Health Physics.

Grub samples were analysed and some results believed to be somewhat representative of migrating contaminants are reported as follows:

			gamma/m/ml	alpha (d/m/ml)
Flood water	Pit #2*		4.4	108.0
Flood water	Pit #4		1.8	Background
			d/m/sample**	
Soil	Pit #2	$Fe^{59}Co^{60}$		No alpha determination
		$Zr\ Nb^{95}$	608	
		Cs^{137}	4150	
		Ce^{144}	5920	
Soil	Pit #4	$Zr\ Nb^{95}$	502	
		Cs^{137}	1120	

* As expected, Rocky Flats pit contained alpha emitters.
** Samples contained approximately 35 g of soil.

Figure 7. June 1962 CFA HP monthly report indicating a planned detailed radiological survey.

Example 12

In June 1970, a fire occurred in a waste drum stored at the TSA-1 above-ground storage pad. Figure 8 shows a log that provides a narrative on the response, including the collection of air samples and the air sample results. Interestingly, the site AEC manager was involved in the communications described in the log [Beers 1970, PDF p. 2].

LOG - [redacted]

June 1, 1970

At 2155 [redacted] got a call from WCC that a barrel of waste at the Burial Ground was smoldering. [redacted] went to WCC to monitor the radio. We found that at 2039 Patrol 304 called Post 300 and reported smoke issuing from under a cover over barrels of waste. At 2041 Fire Dept responded - 2045 CPP HP responded - 2045 [redacted] had called home (WCC learned) and was aware of it and would respond.

At 2224 I called [redacted] and advised him. At 2225 I got [redacted] on radio ([redacted] could hear over phone). [redacted] said a lid on one drum was sprung and contents of the barrel were smoldering. No easy way to extinguish. FD suggests (and he agrees) best not to disturb barrel as fire may flare up. He took three air samples - 35 min. - one six feet away - two right in plume. Will go count and call back. I suggested they cover drum with Hi-X foam. Apparently, they figured it would be very hard to do. FD does not think it would help. At 2245 [redacted] called me. He said the drums are piled three high, 12 - 14 rows wide - about 300' long. Drum smoldering is on top row about four rows in. Drum is discolored. They cooled it down, but could not get water inside effectively (crack too small). Very little wind - smoke not spreading - are just watching. Firemen went to CF and were checked by HP - no contamination.

At 2304 WCC called [redacted]. I briefed him. [redacted] had talked to [redacted]. No press release anticipated.

At 2255 [redacted] called. Hi Vol sample taken 6' out, 5,000 c/min - 17,000 d/m (2 x 10^{-9} uCi/cc). At 2330 [redacted] called back. Samples taken right at the crack were 10^{-8} uCi/cc and 10^{-7} uCi/cc. He figures no smoke inhalation problems. Crack too small to even get A-B-C powder in (which I suggested). [redacted], [redacted], [redacted] are there now and [redacted] on the phone. They decided to suit up and have equipment operator transfer drum to a hole and cover with dirt. I suggested FD suit up - put on Scotts and stand by with hose line.

[redacted] mentioned a load of drums came in today with holes. Rocky Flats said they had been dug up and moved to NRTS. [redacted] said they plan to put them in larger drums before burial.

At 2350 [redacted] called. Briefed him on most everything up to this point. At 0005 I called [redacted] - suggested he have firemen in yellow F.D. anti-C's taped up - with Scott - have hand line tested to assure pressure is not too high - stand by in case lid comes off when transfer is made. Be ready to extinguish immediately if fire breaks out. At 0007 [redacted] called - said wind is from S-SW - may be a good idea to run a check to NE. Tried to get [redacted] at CP-690 - couldn't reach him. Called [redacted] back at 0013 - told him CFA and TRA air samplers would be best to check and requested he ask [redacted] to do this when he arrives at the Burial Ground.

Figure 8. June 1, 1970 log on waste barrel fire.

SCA-TR-2017-SEC007 states:

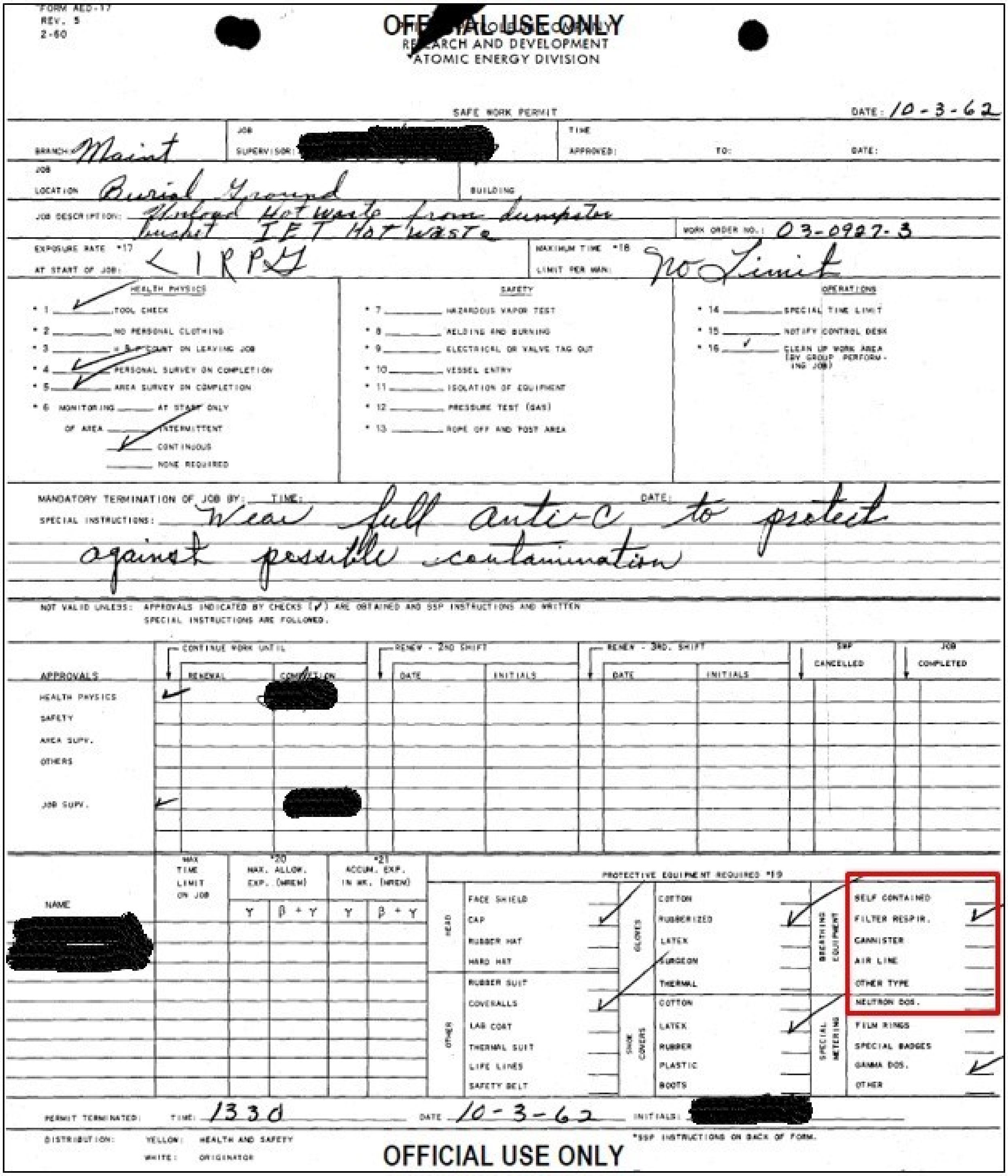
> *…only relatively "low" volume air sampling was performed at the Burial Ground prior to February 1976; higher volume air samplers were introduced in February 1977 to enable sufficient air volume through the filters to permit adequate plutonium detection analysis to be performed (EG&G 1983).*

Indeed, the implementation of a routine air-sampling program was not implemented at the Burial Ground until the mid-1970s. However, high-volume air samplers were available for use at least as early as 1963 [AEC/ID 1963]. A July 1966 HP Monthly Report states [Sauvignac 1965–1966, PDF p. 14]:

> *Because the use of a constant air monitor at the burial ground is not yet practical, a portable high volume air sampler is used. A 1000 watt portable electric generator provides power. Electric lights can also be used when burial ground operations continue after darkness.*

NIOSH has obtained CFA documentation that indicates that air sampling was performed at the Burial Ground, but there are likely further records of air sampling at the Burial Ground that have not been identified to date. Figure 9 is a SWP that authorized emptying waste originating from the Initial Engine Test, which was part of the Aircraft Nuclear Propulsion Program in Test Area North. This was waste generated onsite and, given its origin location, was likely an MFP source term. However, respiratory protection (highlighted by the red box) was required for the work activity; this indicates an increased concern over potential internal exposure [INL 1962–1964, PDF p. 92].

Figures 10, 11, and 12 below are provided as examples of SWPs from three different years for disposal of RFP waste. Concerns were raised in SC&A's review that air sampling may not have been performed during dumping of RFP waste at the Burial Ground due to inconsistencies in the SWPs used for the dumping activity. While all three SWPs are for the same type of work activity, the "Health Physics" box is not always identical. The 1965 example does not have as many requirements checked in the requirement box as the other two examples; however, it does state "Per HP" under Special Instructions. Again, this is another indicator that the HP staff were directly involved and oversaw Burial Ground operations [INL 1962–1964, PDF p. 13, 1965–1966b, PDF p. 31, 1970–1976, PDF p. 95].



FORM AED-17
REV. 5
2-60

OFFICIAL USE ONLY
RESEARCH AND DEVELOPMENT
ATOMIC ENERGY DIVISION

SAFE WORK PERMIT

DATE: 10-3-62

BRANCH: Maint
JOB SUPERVISOR: [redacted]
TIME APPROVED:
TO:
DATE:

JOB LOCATION: Burial Ground
BUILDING:
JOB DESCRIPTION: Unload Hot waste from dumpster bucket IET Hot waste
WORK ORDER NO.: 03-0927-3

EXPOSURE RATE *17 AT START OF JOB: < 1 R/Hr
MAXIMUM TIME *18 LIMIT PER MAN: No Limit

HEALTH PHYSICS	SAFETY	OPERATIONS
* 1 ✓ TOOL CHECK	* 7 ___ HAZARDOUS VAPOR TEST	* 14 ___ SPECIAL TIME LIMIT
* 2 ___ NO PERSONAL CLOTHING	* 8 ___ WELDING AND BURNING	* 15 ___ NOTIFY CONTROL DESK
* 3 ___ CHECK COUNT ON LEAVING JOB	* 9 ___ ELECTRICAL OR VALVE TAG OUT	* 16 ✓ CLEAN UP WORK AREA (BY GROUP PERFORMING JOB)
* 4 ✓ PERSONAL SURVEY ON COMPLETION	* 10 ___ VESSEL ENTRY	
* 5 ✓ AREA SURVEY ON COMPLETION	* 11 ___ ISOLATION OF EQUIPMENT	
* 6 MONITORING OF AREA ___ AT START ONLY; ✓ INTERMITTENT; ___ CONTINUOUS; ___ NONE REQUIRED	* 12 ___ PRESSURE TEST (GAS)	
	* 13 ___ ROPE OFF AND POST AREA	

MANDATORY TERMINATION OF JOB BY: TIME: DATE:
SPECIAL INSTRUCTIONS: Wear full anti-C to protect against possible contamination

NOT VALID UNLESS: APPROVALS INDICATED BY CHECKS (✓) ARE OBTAINED AND SSP INSTRUCTIONS AND WRITTEN SPECIAL INSTRUCTIONS ARE FOLLOWED.

APPROVALS	CONTINUE WORK UNTIL: RENEWAL	COMPLETION	RENEW - 2ND SHIFT: DATE	INITIALS	RENEW - 3RD. SHIFT: DATE	INITIALS	SWP CANCELLED	JOB COMPLETED
HEALTH PHYSICS	✓	[redacted]						
SAFETY								
AREA SUPV.								
OTHERS								
JOB SUPV.	✓	[redacted]						

NAME	MAX TIME LIMIT ON JOB	*20 MAX. ALLOW. EXP. (MREM) γ	β + γ	*21 ACCUM. EXP. IN MR. (MREM) γ	β + γ
[redacted]					

PROTECTIVE EQUIPMENT REQUIRED *19

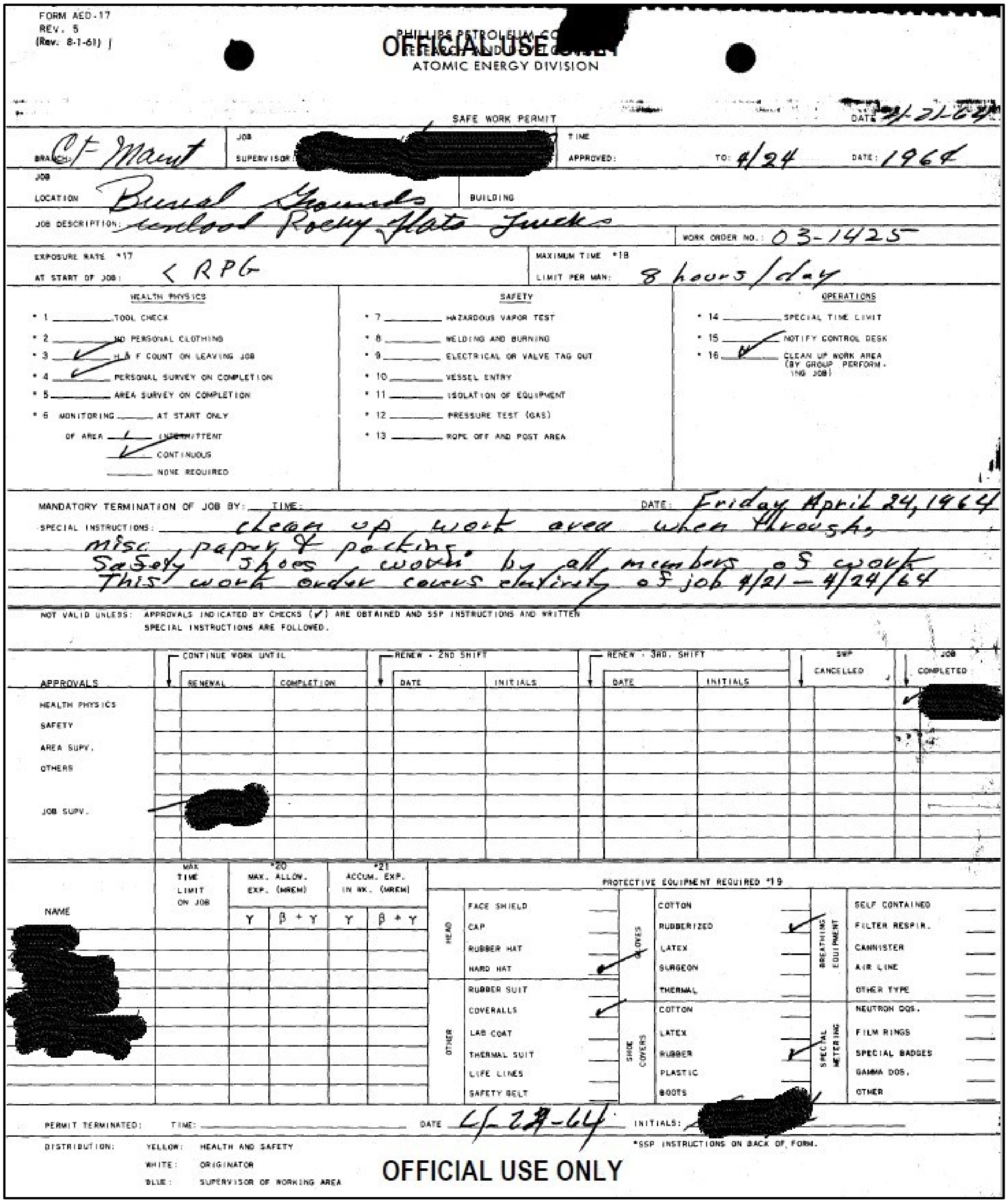
HEAD	FACE SHIELD	GLOVES	COTTON	BREATHING EQUIPMENT	SELF CONTAINED
	CAP ✓		RUBBERIZED ✓		FILTER RESPIR. ✓
	RUBBER HAT		LATEX		CANNISTER
	HARD HAT		SURGEON		AIR LINE
OTHER	RUBBER SUIT		THERMAL		OTHER TYPE
	COVERALLS ✓	SHOE COVERS	COTTON	SPECIAL METERING	NEUTRON DOS.
	LAB COAT		LATEX ✓		FILM RINGS
	THERMAL SUIT		RUBBER		SPECIAL BADGES
	LIFE LINES		PLASTIC		GAMMA DOS. ✓
	SAFETY BELT		BOOTS		OTHER

PERMIT TERMINATED: TIME: 1330 DATE: 10-3-62 INITIALS: [redacted]

DISTRIBUTION: YELLOW: HEALTH AND SAFETY; WHITE: ORIGINATOR
*SSP INSTRUCTIONS ON BACK OF FORM.

OFFICIAL USE ONLY

Figure 9. SWP on October 3, 1962 requiring respiratory protection.


FORM AED-17
REV. 5
(Rev. 8-1-61)

OFFICIAL USE
PHILLIPS PETROLEUM CO[redacted]
ATOMIC ENERGY DIVISION

SAFE WORK PERMIT

DATE 4-21-64

BRANCH: CF Maint | JOB SUPERVISOR: [redacted] | TIME APPROVED: | TO: 4/24 | DATE: 1964

JOB LOCATION: Burial Grounds | BUILDING:

JOB DESCRIPTION: unload Rocky Flats Trucks | WORK ORDER NO.: 03-1425

EXPOSURE RATE *17 AT START OF JOB: < RPG | MAXIMUM TIME *18 LIMIT PER MAN: 8 hours/day

HEALTH PHYSICS	SAFETY	OPERATIONS
*1 ___ TOOL CHECK	*7 ___ HAZARDOUS VAPOR TEST	*14 ___ SPECIAL TIME LIMIT
*2 ___ NO PERSONAL CLOTHING	*8 ___ WELDING AND BURNING	*15 ✓ NOTIFY CONTROL DESK
*3 ✓ H & F COUNT ON LEAVING JOB	*9 ___ ELECTRICAL OR VALVE TAG OUT	*16 ✓ CLEAN UP WORK AREA (BY GROUP PERFORMING JOB)
*4 ✓ PERSONAL SURVEY ON COMPLETION	*10 ___ VESSEL ENTRY	
*5 ___ AREA SURVEY ON COMPLETION	*11 ___ ISOLATION OF EQUIPMENT	
*6 MONITORING ___ AT START ONLY	*12 ___ PRESSURE TEST (GAS)	
OF AREA ✓ INTERMITTENT	*13 ___ ROPE OFF AND POST AREA	
✓ CONTINUOUS		
___ NONE REQUIRED		

MANDATORY TERMINATION OF JOB BY: TIME: DATE: Friday April 24, 1964

SPECIAL INSTRUCTIONS: clean up work area when through, misc paper & packing. Safety Shoes worn by all members of work. This work order covers activity of job 4/21 – 4/24/64

NOT VALID UNLESS: APPROVALS INDICATED BY CHECKS (✓) ARE OBTAINED AND SSP INSTRUCTIONS AND WRITTEN SPECIAL INSTRUCTIONS ARE FOLLOWED.

APPROVALS	CONTINUE WORK UNTIL: RENEWAL	COMPLETION	RENEW - 2ND SHIFT: DATE	INITIALS	RENEW - 3RD SHIFT: DATE	INITIALS	SWP CANCELLED	JOB COMPLETED
HEALTH PHYSICS								✓ [redacted]
SAFETY								
AREA SUPV.								
OTHERS								
JOB SUPV.	[redacted]							

NAME	MAX TIME LIMIT ON JOB	*20 MAX. ALLOW. EXP. (MREM) γ	β + γ	*21 ACCUM. EXP. IN WK. (MREM) γ	β + γ
[redacted]					

PROTECTIVE EQUIPMENT REQUIRED *19

HEAD		GLOVES		BREATHING EQUIPMENT	
FACE SHIELD		COTTON		SELF CONTAINED	
CAP		RUBBERIZED	✓	FILTER RESPIR.	
RUBBER HAT		LATEX		CANNISTER	
HARD HAT	✓	SURGEON		AIR LINE	
OTHER		**SHOE COVERS**		OTHER TYPE	
RUBBER SUIT		THERMAL		**SPECIAL METERING**	
COVERALLS	✓	COTTON		NEUTRON DOS.	
LAB COAT		LATEX		FILM RINGS	
THERMAL SUIT		RUBBER	✓	SPECIAL BADGES	
LIFE LINES		PLASTIC		GAMMA DOS.	
SAFETY BELT		BOOTS		OTHER	

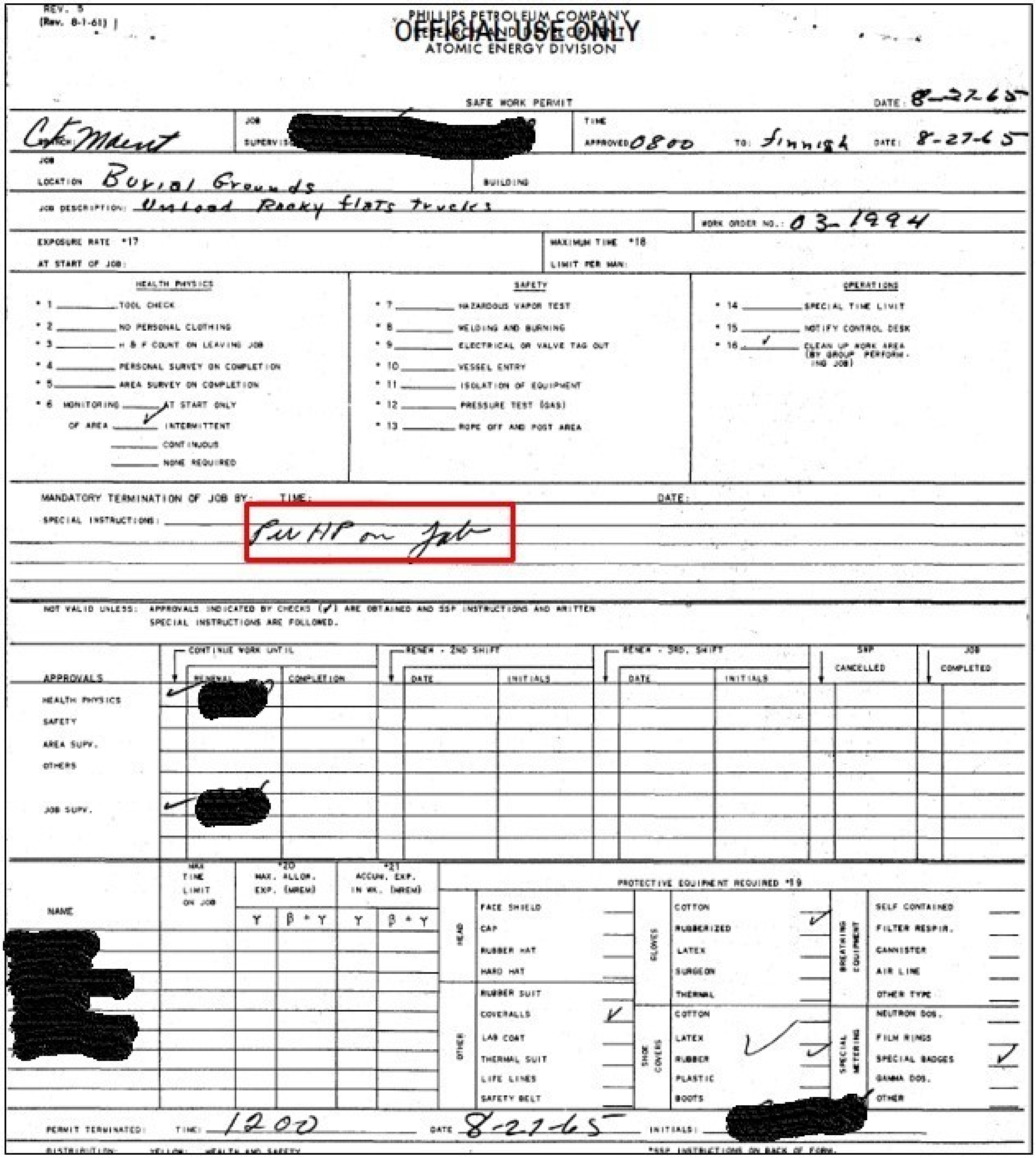
PERMIT TERMINATED: TIME: DATE 4-24-64 INITIALS: [redacted]

*SSP INSTRUCTIONS ON BACK OF FORM.

DISTRIBUTION: YELLOW: HEALTH AND SAFETY; WHITE: ORIGINATOR; BLUE: SUPERVISOR OF WORKING AREA

OFFICIAL USE ONLY

Figure 10. SWP to unload RFP waste on April 21 and 24, 1964.



REV. 5
(Rev. 8-1-61)

PHILLIPS PETROLEUM COMPANY
OFFICIAL USE ONLY
ATOMIC ENERGY DIVISION

SAFE WORK PERMIT — DATE: 8-27-65

CRAFT: Cpt. Maint — JOB SUPERVISOR: [redacted] — TIME APPROVED: 0800 TO: Finnish — DATE: 8-27-65

JOB LOCATION: Burial Grounds — BUILDING:

JOB DESCRIPTION: Unload Rocky Flats trucks — WORK ORDER NO.: 03-1994

EXPOSURE RATE AT START OF JOB: *17 — MAXIMUM TIME LIMIT PER MAN: *18

HEALTH PHYSICS	SAFETY	OPERATIONS
* 1 ___ TOOL CHECK	* 7 ___ HAZARDOUS VAPOR TEST	* 14 ___ SPECIAL TIME LIMIT
* 2 ___ NO PERSONAL CLOTHING	* 8 ___ WELDING AND BURNING	* 15 ___ NOTIFY CONTROL DESK
* 3 ___ H & F COUNT ON LEAVING JOB	* 9 ___ ELECTRICAL OR VALVE TAG OUT	* 16 ✓ CLEAN UP WORK AREA (BY GROUP PERFORMING JOB)
* 4 ___ PERSONAL SURVEY ON COMPLETION	* 10 ___ VESSEL ENTRY	
* 5 ___ AREA SURVEY ON COMPLETION	* 11 ___ ISOLATION OF EQUIPMENT	
* 6 MONITORING OF AREA ___ AT START ONLY; ✓ INTERMITTENT; ___ CONTINUOUS; ___ NONE REQUIRED	* 12 ___ PRESSURE TEST (GAS)	
	* 13 ___ ROPE OFF AND POST AREA	

MANDATORY TERMINATION OF JOB BY: TIME: DATE:

SPECIAL INSTRUCTIONS: Full HP on Job

NOT VALID UNLESS: APPROVALS INDICATED BY CHECKS (✓) ARE OBTAINED AND SSP INSTRUCTIONS AND WRITTEN SPECIAL INSTRUCTIONS ARE FOLLOWED.

APPROVALS	CONTINUE WORK UNTIL: RENEWAL	COMPLETION	RENEW - 2ND SHIFT: DATE	INITIALS	RENEW - 3RD SHIFT: DATE	INITIALS	SWP CANCELLED	JOB COMPLETED
HEALTH PHYSICS	✓ [redacted]							
SAFETY								
AREA SUPV.								
OTHERS								
JOB SUPV.	✓ [redacted]							

NAME	MAX TIME LIMIT ON JOB	*20 MAX. ALLOW. EXP. (MREM) γ	β + γ	*21 ACCUM. EXP. IN WK. (MREM) γ	β + γ
[redacted]					

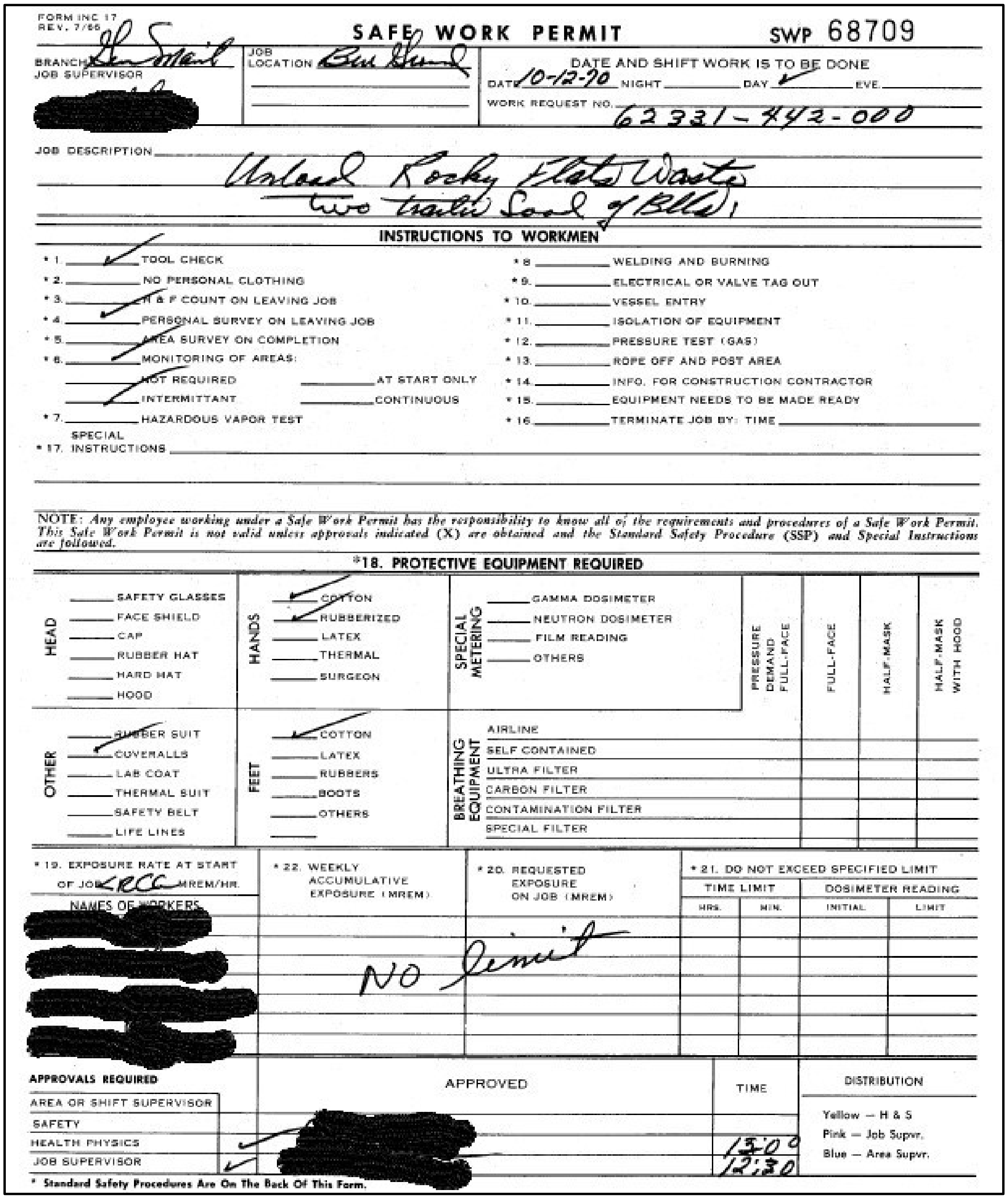
PROTECTIVE EQUIPMENT REQUIRED *19

HEAD		GLOVES		BREATHING EQUIPMENT	
FACE SHIELD		COTTON		SELF CONTAINED	
CAP		RUBBERIZED	✓	FILTER RESPIR.	
RUBBER HAT		LATEX		CANNISTER	
HARD HAT		SURGEON		AIR LINE	
OTHER		THERMAL		OTHER TYPE	
RUBBER SUIT		**SHOE COVERS**		**SPECIAL METERING**	
COVERALLS	✓	COTTON		NEUTRON DOS.	
LAB COAT		LATEX		FILM RINGS	
THERMAL SUIT		RUBBER	✓	SPECIAL BADGES	✓
LIFE LINES		PLASTIC		GAMMA DOS.	
SAFETY BELT		BOOTS		OTHER	

PERMIT TERMINATED: TIME: 1200 DATE: 8-27-65 INITIALS: [redacted]

DISTRIBUTION: YELLOW: HEALTH AND SAFETY — *SSP INSTRUCTIONS ON BACK OF FORM.

Figure 11. SWP to unload Rocky Flats Plant waste on August 27, 1965.



FORM INC 17 REV. 7/66

SAFE WORK PERMIT — SWP 68709

BRANCH: Gen Maint
JOB SUPERVISOR: [redacted]
JOB LOCATION: Bur Grnd

DATE AND SHIFT WORK IS TO BE DONE: DATE 10-12-70 NIGHT ___ DAY ✓ EVE ___
WORK REQUEST NO. 62331-442-000

JOB DESCRIPTION: Unload Rocky Flats Waste two trailer load of Bbls

INSTRUCTIONS TO WORKMEN

* 1. ✓ TOOL CHECK
* 2. ___ NO PERSONAL CLOTHING
* 3. ✓ H & F COUNT ON LEAVING JOB
* 4. ✓ PERSONAL SURVEY ON LEAVING JOB
* 5. ✓ AREA SURVEY ON COMPLETION
* 6. ✓ MONITORING OF AREAS:
  ✓ NOT REQUIRED ___ AT START ONLY
  ✓ INTERMITTANT ___ CONTINUOUS
* 7. ___ HAZARDOUS VAPOR TEST
* 8. ___ WELDING AND BURNING
* 9. ___ ELECTRICAL OR VALVE TAG OUT
* 10. ___ VESSEL ENTRY
* 11. ___ ISOLATION OF EQUIPMENT
* 12. ___ PRESSURE TEST (GAS)
* 13. ___ ROPE OFF AND POST AREA
* 14. ___ INFO. FOR CONSTRUCTION CONTRACTOR
* 15. ___ EQUIPMENT NEEDS TO BE MADE READY
* 16. ___ TERMINATE JOB BY: TIME ___
* 17. SPECIAL INSTRUCTIONS ___

NOTE: *Any employee working under a Safe Work Permit has the responsibility to know all of the requirements and procedures of a Safe Work Permit. This Safe Work Permit is not valid unless approvals indicated (X) are obtained and the Standard Safety Procedure (SSP) and Special Instructions are followed.*

*18. PROTECTIVE EQUIPMENT REQUIRED

HEAD: ___ SAFETY GLASSES, ___ FACE SHIELD, ___ CAP, ___ RUBBER HAT, ___ HARD HAT, ___ HOOD
HANDS: ✓ COTTON, ✓ RUBBERIZED, ___ LATEX, ___ THERMAL, ___ SURGEON
SPECIAL METERING: ___ GAMMA DOSIMETER, ___ NEUTRON DOSIMETER, ___ FILM READING, ___ OTHERS
PRESSURE DEMAND FULL-FACE | FULL-FACE | HALF-MASK | HALF-MASK WITH HOOD
OTHER: ✓ RUBBER SUIT, ✓ COVERALLS, ___ LAB COAT, ___ THERMAL SUIT, ___ SAFETY BELT, ___ LIFE LINES
FEET: ✓ COTTON, ___ LATEX, ___ RUBBERS, ___ BOOTS, ___ OTHERS
BREATHING EQUIPMENT: AIRLINE, SELF CONTAINED, ULTRA FILTER, CARBON FILTER, CONTAMINATION FILTER, SPECIAL FILTER

* 19. EXPOSURE RATE AT START OF JOB <RCG MREM/HR.
* 22. WEEKLY ACCUMULATIVE EXPOSURE (MREM)
* 20. REQUESTED EXPOSURE ON JOB (MREM): NO limit
* 21. DO NOT EXCEED SPECIFIED LIMIT — TIME LIMIT (HRS. / MIN.) — DOSIMETER READING (INITIAL / LIMIT)

NAMES OF WORKERS: [redacted]

APPROVALS REQUIRED	APPROVED	TIME
AREA OR SHIFT SUPERVISOR	[redacted]	
SAFETY		
HEALTH PHYSICS ✓		1300
JOB SUPERVISOR ✓		12:30

DISTRIBUTION: Yellow — H & S; Pink — Job Supvr.; Blue — Area Supvr.

* Standard Safety Procedures Are On The Back Of This Form.

Figure 12. SWP to unload RFP waste on October 12, 1970.

Figures B-4, B-5, and B-6 in Appendix B of this report show photographs of three separate RFP waste dumping events. In each example, an air sampler is used during the work activity. From the review of the SWPs covering RFP waste operations, respiratory protection was not required for RFP waste activities. The following statement from CFA's June 1962 HP Monthly Report provides some insight into why this decision might have been made. This statement is important in that it reflects both the routine nature of the RFP shipments and the fact that they do not create many problems (assumed to mean contamination). On the other hand, off-normal shipments tend to lead to contamination. In addition, it provides evidence of the recognition that RFP waste is alpha waste that would inherently require alpha monitoring [Sauvignac 1962, PDF p. 9]:

> *Regular shipments such as Rocky Flats alpha waste, Valecitos high level waste in casks do not create many problems. We do return Valecitos casks as radioactive shipment.*
>
> *Less than carload lots and irregular shipments where all concerned are not familiar with procedures often present problems.*

NIOSH Conclusion Regarding Position 1(a)

Based on an extensive review of additional records obtained since the release of Rev. 2 of the SEC-00219 INL ER in February 2017, NIOSH concludes that there is ample evidence to support the conclusion [Position 1(a)] that the Burial Ground was a well-managed facility and *"the Burial Ground's internal dose monitoring program was based on a strict contamination control program with entry and exit monitoring."*

Due to CFA's strict contamination control program and the low level of exposure potential from waste burial, a routine bioassay program was deemed not to be necessary. It is important to remember that the HP organization was responsible not only for the radiological control program, but also for the entire Burial Ground operation. This was the only such arrangement at INL. Logically, an operation that was entrusted to an organization specializing in radiological controls would make a priority of a strict contamination control program; otherwise, the operation of the Burial Ground would be adversely affected by radiation and contamination problems. There are no data to suggest that this was the case at the Burial Ground between 1952 and 1970.

SC&A's Suggested Lines of Inquiry for Position 1(a) and NIOSH Responses

In SCA-TR-2017-SEC007, SC&A provided suggested lines of inquiry to the ABRWH pertaining to Position 1(a). These are provided below, along with NIOSH responses.

- SC&A: *What contamination smear data and air sampling results from the Burial Grounds for the pre-1970 era has been identified in NIOSH's data capture and does it include analyses for alpha emitters?*

NIOSH: Multiple examples of contamination smear data and air sampling results are provided in this section. Direct text from HP logbooks on contamination smears from an NRF shipment and a General Atomics cask shipment in 1965 were provided. In addition, there were three personal communications with former workers where they discussed the collection of contamination smears at the Burial Ground. Twelve examples of air sampling are provided above. Examples 4, 10, and 11 indicate that isotopic analysis was performed.

- SC&A: *What is NIOSH's position regarding the identified inadequacy of smear-counting capability at the Burial Ground identified in 1972 in terms of its implications for contamination surveying in the 1960s?*

  NIOSH: Contamination smears for both alpha and β/γ emitters were collected at the Burial Ground throughout the time period under evaluation (1952–1970). Smear counting was performed at CFA until the first buildings, the WMF-601 Radiological Control Office and the WMF-602 High Bay and Decontamination Facility South, were erected at the Burial Ground in 1974. Examples of contamination smears are provided above.

  The 1972 assessment covers a time period outside the 1952–1970 period for SEC-00219. NIOSH review of the cited assessment revealed that it was driven by a reorganization at the facility as it was transitioning away from simple low-risk burials to above-ground TRU storage, waste retrievals, and increased operations. The underlying reasons for the reorganization of the Burial Ground are discussed in detail in the section titled "Response to SC&A Review of ER Position 3" of this paper. In 1969, two major events (including one at another AEC facility), a change in federal environmental laws, a change in the AEC policy on waste, and the Burial Ground's first waste retrieval project precipitated the first major change in the operation of the Burial Ground since it began operations in 1952.

- SC&A: *What is NIOSH's position regarding the inadequacies of alpha monitoring in the 1950s–1960s at the Burial Ground, and its implications for adequate contamination control, bioassay, and dose estimation for that time period?*

  NIOSH: NIOSH has not found inadequacies in alpha monitoring at the Burial Ground. The HP group knew that alpha emitters were part of the buried source term. Examples are provided above demonstrating that alpha monitoring was performed for shipments as deemed necessary by the Burial Ground HP review of the work. Samples taken in support of safety and operations would be measured at CFA, as would have been expected given the lack of infrastructure at the Burial Ground. The HP organization was also responsible for the operation of the Burial Ground, which would be severely impaired if contamination control was not tightly enforced.

  Because the Burial Ground workers did not participate in a routine bioassay program during this time period, and because NIOSH has determined they had a low potential for internal exposures in line with other INL workers, Burial Ground workers would be considered "unmonitored workers" for dose reconstruction purposes. If there are special bioassay samples available for a specific claim, those would be used in the dose reconstruction process and as for occupational internal dose, see the proposal in the next line of inquiry.

- SC&A: *How would NIOSH estimate and bound exposures of workers handling waste containers and cleaning up spills if source terms are uncertain, bioassay is lacking, and air sampling is not representative?*

  NIOSH: As is the case program-wide, individual claims are completed with any bioassay data that is available. Because (1) the Burial Ground was not operated differently than other facilities at INL, as demonstrated in the section above and (2) the available monitoring data does not demonstrate uncontrolled source terms, Burial Ground workers are considered as exposed to similar levels of MFPs as other unmonitored INL workers. The INL unmonitored worker approach will be updated with coworker models that are currently being developed for several bioassay analyses used at INL, including those applicable for assessing MFPs.

  As for the actinide dose potentially due to off-site burials (e.g., RFP), the current INL unmonitored worker approach would not account for this. NIOSH proposes to use the bioassay data from the 18 workers that participated in the exhumation work in the 1970s to provide a bounding estimate for internal actinide doses to Burial Ground workers during the burial period (1952–1970). This would be considered bounding because the burial activities had a much lower potential for contamination and therefore a lower potential for internal exposure than the unearthing activities that took place.

- SC&A: *Does NIOSH have any examples of special or event-driven bioassays being conducted following a worker contamination at the Burial Ground in the 1952–1970 period?*

  NIOSH: Multiple examples of special bioassay are provided in the section titled Response to SC&A Analysis of NIOSH ER Position 1(c) of this response paper.

Response to SC&A Analysis of NIOSH ER Position 1(b)

Position 1(b): *With the exception of Rocky Flats waste, mixed fission products were considered the controlling radionuclides.*

In its review, SC&A raised a concern over not knowing the specific radionuclide content of both onsite and offsite solid waste shipments. The concern was expressed by the following statement:

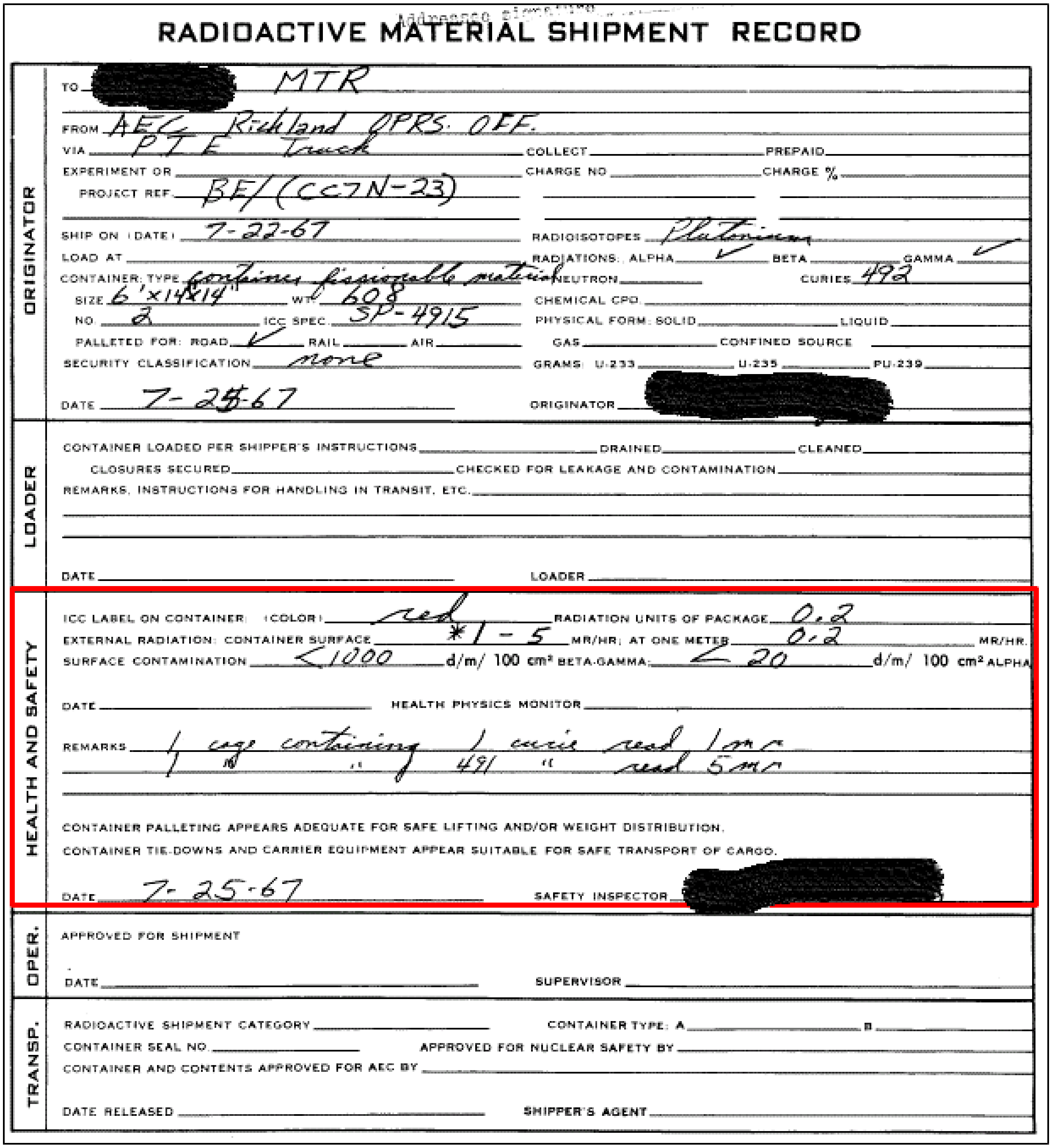
> *While MFPs and RFP plutonium did undoubtedly dominate the waste being managed at the Burial Ground, the actual radionuclide content of specific onsite and offsite solid waste being handled at any given time was not normally known. For example, the onsite waste from other areas of the NRTS* [National Reactor Testing Station] *is nominally described as "mixed fission products," but could consist of a variety of radioactive constituents* [AEC/ID 1970].

It is true that the exact isotopic mix (as applicable) and activity content were unknown for many shipments (e.g., Rocky Flats did not provide this information until 1970 due to classification concerns). However, that information is not needed to perform proper radiological monitoring. Even today, most radiological monitoring is performed with "gross" concept instrumentation. Handheld β/γ and α contamination monitors are familiar examples. Routine monitoring does not require the exact composition of a source term to be known.

The routine radiological monitoring at the Burial Ground during this time period was designed for what a worker would likely encounter during normal work activities and was based on the general source term information that was available. The source term information was available from information on the required forms for each waste disposal. The Burial Ground HP group was responsible for keeping records of where waste shipments were emplaced at the Burial Ground.

SCA-TR-2017-SEC007 lists radionuclides present in the RFP waste stream that could have been present in shipments to INL. SC&A specifically mentioned concerns about commercial and military radioactive waste received at the Burial Ground between 1960 and 1963. During its years as an interim burial ground, INL received primarily β/γ-contaminated waste from other AEC contractors, universities, private industry, and the armed forces [INEL 1985]. Although isotopic data and quantities were not available for many shipments, radiation and contamination surveys were performed by the site of origin and then again by INL when received. Contamination controls were in place well before any waste made it to the Burial Ground.

Figures 13, 14, and 15 from 1967 demonstrate this monitoring [INL 1967, PDF pp. 25, 37, 28]. Note in the following examples that activities and elements were sometimes provided.



RADIOACTIVE MATERIAL SHIPMENT RECORD

ORIGINATOR

TO [redacted] MTR

FROM AEC Richland OPRS. OFF.

VIA PTE Truck — COLLECT — PREPAID

EXPERIMENT OR PROJECT REF. BE/(CC7N-23) — CHARGE NO — CHARGE %

SHIP ON (DATE) 7-22-67 — RADIOISOTOPES Plutonium

LOAD AT — RADIATIONS: ALPHA ✓ BETA — GAMMA ✓

CONTAINER: TYPE contains fissionable material — NEUTRON — CURIES 492

SIZE 6'x14x14" WT 608 — CHEMICAL CPD.

NO. 2 ICC SPEC. SP-4915 — PHYSICAL FORM: SOLID — LIQUID

PALLETED FOR: ROAD ✓ RAIL — AIR — GAS — CONFINED SOURCE

SECURITY CLASSIFICATION none — GRAMS: U-233 — U-235 — PU-239

DATE 7-25-67 — ORIGINATOR [redacted]

LOADER

CONTAINER LOADED PER SHIPPER'S INSTRUCTIONS — DRAINED — CLEANED

CLOSURES SECURED — CHECKED FOR LEAKAGE AND CONTAMINATION

REMARKS, INSTRUCTIONS FOR HANDLING IN TRANSIT, ETC.

DATE — LOADER

HEALTH AND SAFETY

ICC LABEL ON CONTAINER (COLOR) red — RADIATION UNITS OF PACKAGE 0.2

EXTERNAL RADIATION: CONTAINER SURFACE *1 - 5 MR/HR; AT ONE METER 0.2 MR/HR.

SURFACE CONTAMINATION <1000 d/m/ 100 cm² BETA-GAMMA; < 20 d/m/ 100 cm² ALPHA

DATE — HEALTH PHYSICS MONITOR

REMARKS 1 cage containing 1 curie read 1 mr
1 " " 491 " read 5 mr

CONTAINER PALLETING APPEARS ADEQUATE FOR SAFE LIFTING AND/OR WEIGHT DISTRIBUTION.

CONTAINER TIE-DOWNS AND CARRIER EQUIPMENT APPEAR SUITABLE FOR SAFE TRANSPORT OF CARGO.

DATE 7-25-67 — SAFETY INSPECTOR [redacted]

OPER.

APPROVED FOR SHIPMENT

DATE — SUPERVISOR

TRANSP.

RADIOACTIVE SHIPMENT CATEGORY — CONTAINER TYPE: A — B

CONTAINER SEAL NO. — APPROVED FOR NUCLEAR SAFETY BY

CONTAINER AND CONTENTS APPROVED FOR AEC BY

DATE RELEASED — SHIPPER'S AGENT

Figure 13. July 1967 INL receipt radiological survey of radioactive shipment from Hanford.

Within [ ] Outside [X]

Battelle Memorial Institute

G-5040-74 [X] Prepaid / Collect

RADIOACTIVE [redacted] Date 5/8/67 Time 1115 by [redacted]

To Idaho Nuclear Corp; TRA Site; Attention [redacted] Date Time by Room

Scoville, Idaho Forwarded by [redacted]

Addressee signature [redacted]

From Battelle Memorial Institute; Research Reactor; [redacted] Room JN-3

Date Shipped 5/4/67 Time ~~0900~~ 1615 Via Tri-State Long Haul License No. 914 528 Mo

Container No. 1 Wooden Box Weight 150# Acct. Ship. No. CAF-JWB-4 Ship. Memo No. G-6948

Recipient's By-Product License No. Licensed B of E No.

Carrier Tri-State Trailer No. 1683

Date Surveyed 5/3/67 Surveyor [redacted] Type Instrument Used Survey meter

Proposed Use of Material

Date of approval of "Application for Radioisotope Procurement"

Item No.	Material Description	Material Reading in mr/hr Contact	1 foot	1 meter	curies	Maximum Radiation of Container in mr/hr At Contact	At 1 Meter
1	Wooden box radioactive material				0.5	< 1	< 1
	6" x 6" x 30'						
	Class D Blue label applied						
	Unclassified						
	7.69 g Pu encapsulated (solid)						
	.5 curies						

Counter Efficiency α 34.39 βγ 61.60 Background α 0 βγ 20

Smear Location	Alpha c/m/net	Alpha d/m/cm²	Beta Gamma c/m/net	Beta Gamma d/m/cm²
Top	0	-	3	< 2
Side	0	-	-	< 2
Bottom	0	-	5	< 2

Remarks:

Shipment of this material is in accord with ICC Regulations.

Signature

Signature [redacted] Accountability / Responsible Staff Member

Signature [redacted] Vehicle Driver

cc: [redacted]
Radiological Safety Committee
Recipient
Originator
Vehicle Driver

Figure 14. May 1967 Battelle Memorial Institute radiological survey of radioactive shipment to INL.

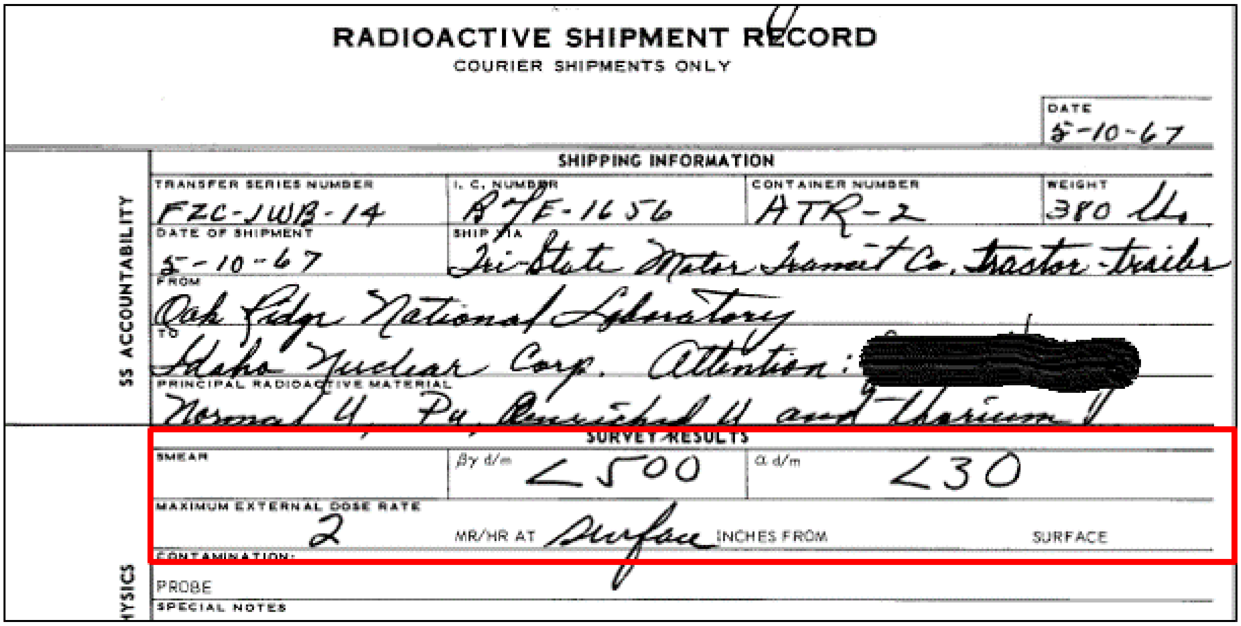


Figure 15. May 1967 INL receipt radiological survey of radioactive shipment from the Oak Ridge National Laboratory.

Routine radiological monitoring programs were, and still are, based on dosimetrically "limiting" radionuclides. As such, this design criteria is used to "bound" the potential broad spectrum of potential exposures that routine monitoring is designed to identify. In off-normal radiological conditions, the conditions and exposure potential for the worker would be evaluated and special follow-up monitoring would be requested, as required.

An excellent example of how INL investigated to better understand the source term during off-normal conditions is the follow-up radiological monitoring at the Burial Ground after the 1962 "Chinook" flood. A historical account of the Radioactive Waste Management Complex (formerly the Burial Ground) states [Hiaring et al. 1992, PDF p. 57]:

> *During 1962, Trenches 24 through 29 and Pits 2 and 3 were open. In February 1962, approximately 1.8 inches of rain fell on 8 inches of snow in three days. The rain caused the snow to partially melt, and an estimated 30 acre-feet of water infiltrated the Burial Ground. Approximately, the upper foot of undisturbed ground was frozen, causing above average runoff from the area surrounding the Burial Grounds. Pits 2 and 3 and Trenches 24 and 25 were open and filled with water. Some of the waste boxes and barrels floated around in the flood water. No general contamination spread was detected on the ground surface. After this local flooding, a diversion drainage system of dikes and ditches was constructed around the perimeter of the Burial Grounds. In some cases the waste containers were broken and the contents were scattered. The waste was reburied in the nearest burial ground location.*

After the flood, special radiological monitoring was performed to determine the extent of contamination and to identify the isotopic composition of the contaminants. Figure 7 provides an example of a detailed isotopic analysis performed as a result of this off-normal event. An April 22, 1962 memo from the manager of the Health and Safety Branch to the Director of the AEC Health and Safety Division provides a preliminary summary of the Burial Ground radiological survey performed after the flood. The summary included contamination and radiation levels found in open pits and trenches, covered pits and trenches, and undeveloped areas. A map of the Burial Ground was also provided for visually locating the results [McCaslin 1962].

Based on the weight of the evidence, NIOSH believes that the statement "w*ith the exception of Rocky Flats waste, mixed fission products were considered the controlling radionuclides*" is correct. While shipping manifests with isotopic composition and activity content of waste shipments would have been useful, they were not needed for radiological control at the Burial Ground. MFPs comprised the bulk of all INL-generated waste. The contaminated waste from off site (with the exception of RFP waste) during the time that the INL Burial Ground was designated as a national waste burial site (1960–1963), was primarily mixed fission and activation products [AMWTP 2014]. Due to the purpose of the operations at RFP, the dose controlling radionuclides were Am-241 and Pu-239.

SC&A's Suggested Lines of Inquiry for Position 1(b) and NIOSH Responses

In SCA-TR-2017-SEC007, SC&A provided suggested lines of inquiry to the ABRWH pertaining to Position 1(b). These are provided below, along with NIOSH responses.

- SC&A: *How does NIOSH reconcile the presence of offsite waste (e.g., commercial and military) and Rocky Flats waste containing a spectrum of radionuclides besides plutonium in terms of assigning "dominance" of MFPs and plutonium, respectively, for developing an approach for bounding worker doses at the Burial Ground?*

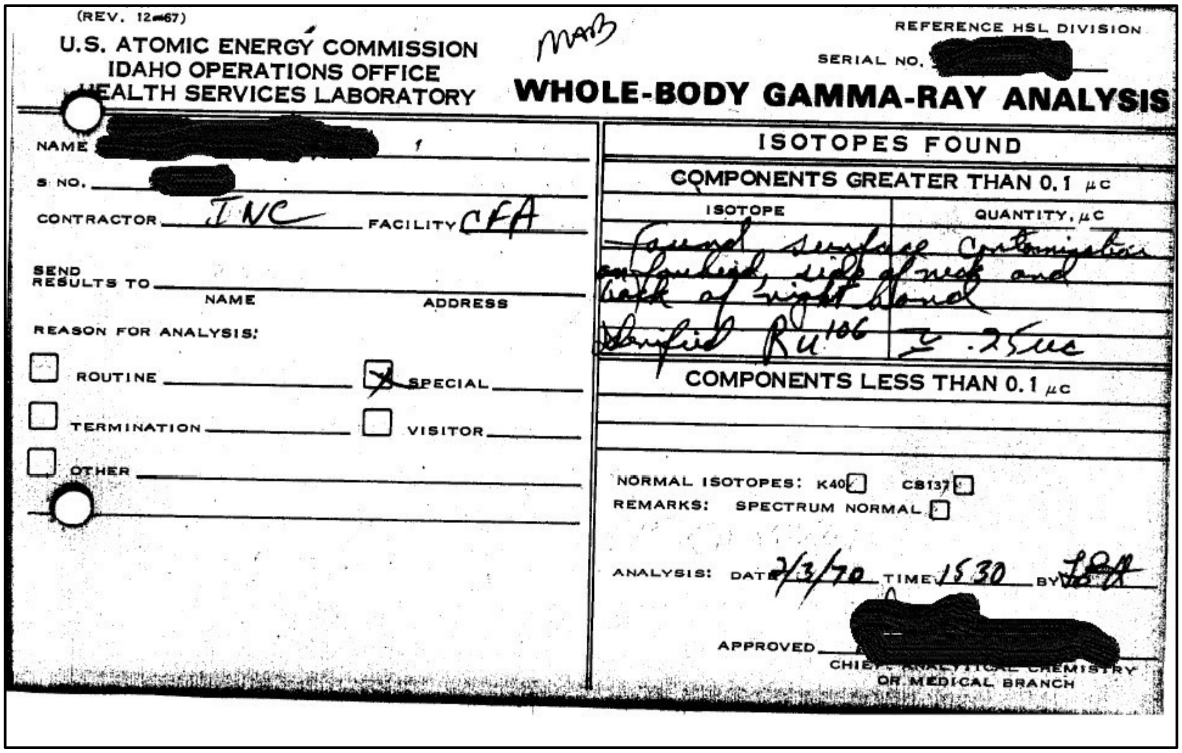
  NIOSH: The Burial Ground was primarily a two day a week operation during much of the 1952–1970 evaluation period. MFPs were the dominant constituent of the waste stream for on-site burials in terms of activity levels as evidenced in the reports by AEC [Hogg et al. 1971]. Plutonium and americium isotopes dominated the waste stream both in terms of exposure potential and activities from off-site burials due to the large volume of waste from the RFP [Hogg et al. 1971]. Waste from a number of non-INL generators (universities and private waste handlers) were limited to 1960–1963. These generators contributed less than 10% by volume of the overall waste at the Burial Ground [AMWTP 2014, PDF p. 18].

  The CFA HP monthly reports reveal that the number of off-site waste burials represents a small fraction (roughly 11%) of the total number of waste burials during the 1952–1970 evaluation period, although an increase in off-site waste burials did occur in the late 1960s [Byrom 1954, 1955; Holmes 1958a,b,c,d,e,f,g,h; Piccot 1955; Sauvignac 1956, 1956–1957, 1958a,b,c,d, 1959a,b,c, 1960, 1961, 1962, 1963, 1965–1966].

If non-routine radiological circumstances arose, INL would perform special monitoring to determine the radionuclides involved and would request special bioassay, if deemed necessary. In these cases, NIOSH would use those bioassay results to assign internal dose. One of the needs identified by the SEC Petition-00219 ER were coworker models. There are a number of INL coworker models under development at this time including fission product models that would apply to Burial Ground workers during the 1952–1970 evaluation period. It is believed that these models will be bounding for fission product internal exposures to the Burial Ground because the models are being developed from bioassay data from workers who were placed on routine bioassay programs at INL due to the potential for internal exposure.

- SC&A: *What about the incomplete or inaccurate inventories of waste shipments in the early years? If actinides were inadequately monitored and quantitatively measured, how can dose contribution be adequately apportioned for the thousands of Rocky Flats shipments?*

  NIOSH: INL's Burial Ground HP staff relied on tight radiological controls to limit personnel exposures. Waste shipments were surveyed by the originating site with subsequent "receipt" surveys at CFA prior to shipment to the Burial Ground. The adequacy of the paperwork accompanying the waste shipments does not affect the internal exposure potential to workers who were emplacing waste that had received both shipping and receipt radiological surveys. In addition, special bioassay was requested if radiological indicators, such as surface contamination and/or air sampling, indicated an elevated potential for internal exposure. Special bioassay included isotopic identification of the contaminant. An example of this is provided in Figure 16 [INL 1950–1985, PDF p. 320].



(REV. 12-67)
U.S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
HEALTH SERVICES LABORATORY

REFERENCE HSL DIVISION
SERIAL NO. [redacted]

WHOLE-BODY GAMMA-RAY ANALYSIS

NAME [redacted]
S NO. [redacted]
CONTRACTOR INC FACILITY CFA
SEND RESULTS TO ____ NAME ____ ADDRESS
REASON FOR ANALYSIS:
☐ ROUTINE ☒ SPECIAL
☐ TERMINATION ☐ VISITOR
☐ OTHER

ISOTOPES FOUND
COMPONENTS GREATER THAN 0.1 μc

ISOTOPE	QUANTITY, μc
Found surface contamination on forehead, side of neck and back of right hand	
Identified Ru^{106}	≤ .25 μc

COMPONENTS LESS THAN 0.1 μc

NORMAL ISOTOPES: K40 ☐ CS137 ☐
REMARKS: SPECTRUM NORMAL ☐
ANALYSIS: DATE 2/3/70 TIME 1530 BY [illegible]
APPROVED [redacted]
CHIEF, ANALYTICAL CHEMISTRY OR MEDICAL BRANCH

Figure 16. 1970 Special whole body count with isotopic identification of contaminant

NIOSH proposes to use the bioassay data from the 18 workers who participated in the exhumation work in the 1970s to provide a bounding estimate for actinide internal doses to Burial Ground workers during the burial period (1952–1970). This would be considered bounding because the burial activities have a much lower potential for contamination and therefore a lower potential for internal exposure than the unearthing activities that took place.

Response to SC&A Analysis of NIOSH ER Position 1(c)

Position 1(c): *When workplace indicators indicated that an intake may have occurred, "special" (non-routine) bioassay would be requested by the area Health Physics staff.*

The SEC-00219 ER states: "…special bioassay also exists, but the results could not be directly related to a contamination event at the Burial Ground" [NIOSH 2017a, PDF p. 234]. INL *in-vivo* and *in-vitro* bioassay analytical results (including special bioassay) typically included the area to which the worker was assigned. Because the Burial Ground prior to the mid-1970s was not considered an "area" per se, but was operated by workers primarily from CFA, the ability to definitively tie a special bioassay with the Burial Ground is difficult at best. Compounding this issue was the fact that CFA was where many INL workers dropped off their bioassay when having *in-vivo* counts and also where workers had their pre-employment and termination screenings. Additionally, responsibility for operations by CFA-based personnel included not only

CFA and the Burial Ground but also other areas like the ARA-I Hot Cell after 1961 and the Organic Moderated Reactor Experiment after 1963.

The 1963 Standard Practice on whole-body counting [McCaslin 1963] clearly lays out the requirements for workers at facilities such as CPP and the reactors at the Test Reactor Area (TRA), including frequency by occupation and/or location for each facility. The count frequency is directly related to the exposure potential for the occupation and/or location. The guidance states that routine counts are performed for workers "who are working continuously with contaminated materials." CFA work would have been reviewed under this procedure to determine routine internal dosimetry monitoring requirements. Because CFA is not listed on the whole body count frequency schedule, the applicable guidance for CFA, and by default the Burial Ground, would be for a special whole body count when "requested by the Health Physics sections when internal exposure is suspected due to events occurring in the plant." This philosophy applied to *in-vitro* bioassay as well for CFA.

NIOSH was not able to find evidence of a worker between 1952–1970 being placed on special bioassay as a result of a specific contamination event at the Burial Ground; this is corroborated by the fact that there is little evidence of contamination events in the available HP monthly reports, HP logbooks, and HP log sheets reviewed for this evaluation. NIOSH reviewed a compilation of INL incident reports for 1958 and found no entries for the Burial Ground [INL 1958a]. In addition, NIOSH reviewed the INL intake registry of known internal dose assignments from 1960 until 1978 when the report was generated by the AEC Health Physicist in the Environmental Science Branch. There were no internal dose assignments associated with the Burial Ground between 1952–1970 [Dickson 1981].

The document, *Summarization of RWMC Subsurface Disposal Area Source Term Interviews*, contains 33 interviews with former workers who may have had knowledge of waste-disposal practices at the Burial Ground. The introduction specifically calls out the years 1952–1970 [DeWitt 1990]. The primary purpose of the interviews was to gain knowledge of not only the waste disposal practices but also the types of waste. The 33 interviewees had employment that spanned the 18 years under evaluation and there was no mention of any personnel contamination events or special bioassay requested due to potential for internal exposure. The lone exception was related to the initial response to the Stationary Low-Power Reactor No. 1 (SL-1) accident by medical personnel. The following excerpts from personnel interviews seemingly confirm this.

> *"Bioassay was only done for suspected intakes. [REDACTED] never saw an incident that required bioassay while he was there."* [ORAUT 2016c, PDF p. 5]

> *"Sampling was primarily event-driven, and they didn't really have events that would be considered accidents with the solid waste disposal during the early years."* [ORAUT 2016b, PDF p. 5]

The mass dumping of RFP waste drums seemed to be a point of particular focus regarding special bioassay, as discussed in SCA-TR-2017-SEC007. During the 1963–1969 period, when

RFP waste drums were being put into pits via mass dumping, the lids may have come off. There were several personnel interviews in which this condition was reported. However, it was learned during the personnel interviews for the RWMC 83.14 determination evaluation [NIOSH 2019] that there was actually double containment of the RFP waste – a poly bag with the waste enclosed that was packaged inside a steel waste drum. As the principal engineer for the Early Waste Retrieval (EWR) project stated during an in-person interview [ORAUT 2018b, PDF p. 5]:

> *[REDACTED] indicated that the waste encountered on the EWR project was remarkably intact. The carbon steel drums were typically badly deteriorated but the plastic drum liner was usually in good shape. He mentioned that one could read documents through the plastic bags. However, waste could be extremely deteriorated with 10,000 counts of alpha being encountered.*

The mass dumping of drums would not have, by itself, triggered special bioassay. It would depend on the results of surveys and air sampling that were being performed, as seen in the photographs in Appendix B. However, NIOSH does not have a comprehensive compilation of air sampling data during that period. It should be noted that the reason for moving away from the mass dumping of RFP waste drums in 1969 was because of space efficiency and not due to contamination events. If contamination events had been commonplace due to mass dumping, it is highly unlikely that the practice would have persisted over an almost 7-year period and special bioassay would have been commonplace.

Regarding special bioassay for the Burial Ground, multiple examples were provided in the document *Special Bioassay and Air Sampling Examples from the INL Burial Ground 1952–1970* [NIOSH 2017b]. NIOSH compiled the examples at the request of the ABRWH. Those examples are provided below to respond to the special bioassay concerns expressed in SC&A's review, which was released prior to the issuance of NIOSH's compilation.

Example 1

Figure 17 shows an October 1963 special urine bioassay sample collected from Joseph Cathey, who was part of a group of workers who routinely worked at the Burial Ground [INEL 1958–1986a, PDF p. 8316].

ID-104 (R-1-65)

U. S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
HEALTH AND SAFETY BRANCH

Serial No. [redacted]

ROUTINE__ SPECIAL X

IDO H & S SAMPLE RECORD SHEET

[redacted]

Sample from: CFA (PHILLIPS) | Samples Received: 10-7-63 1000 | Analyzed by: DW
Collected by: AEC Medical Services Branch | Analysis Completed: 10-8-63 1350
Date submitted: October 7, 1963

Method: End Window__; Prop. counter__; Spectrophotometric__; Fluorometric__; Polarographic__.

Sample No.	Date 1963	Hour	Sample Description	Anal. for	Quant. used, ml.	U +6 or K + Trans.	Count time, min.	Total Count.	Gross Count, c/m.	Bkgd., c/m.	Net count, c/m.	K40 corr., c/m.	Foreign activity c/m.	Foreign activity d/m
			SPECIAL											
14	10-7	02 0852	[redacted]	Gamma	60	10-8 1330	5	2465	533±10	502±10	31±14	27±15	4±21	16±84

Figure 17. 1963 Special *in-vitro* bioassay gamma analysis.

Example 2

Figure 18 shows January 1963 special urine bioassay samples collected from [REDACTED] and [REDACTED] [INEL 1958–1986a, PDF p. 10313]. Both routinely worked at the Burial Ground. A review of SWPs for 1963 did not identify them for work being performed at the ARA-1 Hot Cell [INL 1963]. After the end of the Army Reactor program due to the SL-1 accident, the ARA became the responsibility of the CFA. The ARA-I Hot Cell was a facility that continued operation for special projects at INL. It represented one of the most likely places a CFA worker could have been placed on special bioassay. Therefore, it is likely these samples were requested due to Burial Ground work.

ID-104 (R-1-55)

U. S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
HEALTH AND SAFETY BRANCH

KP

Serial No. [redacted]

ROUTINE__ SPECIAL X

IDO H & S SAMPLE RECORD SHEET

Sample from: CFA (PHILLIPS) | Samples Received: 1-31-63 1100 | Analyzed by: DW
Collected by: AEC Medical Services Branch | Analysis Completed: 1-31-63 1230
Date submitted: January 30, 1963

Method: End Window__; ~~Prop. counter~~ ✓; Spectrophotometric__; Fluorometric__; Polarographic__.

Sample No.	Date 1963	Hour	Sample Description	Anal. for	Quant. used, ml.	U +6 or K + Trans.	Count time, min.	Total Count.	Gross Count, c/m.	Bkgd., c/m.	Net count, c/m.	K40 corr., c/m.	Foreign activity c/m.	Foreign activity d/m
			ROUTINE SPECIAL											
1	1-30	02 1506	[redacted]	Gamma	55	1-31 1235	5	3775	755±12	726±12	29±17	27±15	2±23	8±92
2	1-30	02 1506	[redacted]	Gamma	75	"	5	2719	544±10	491±10	53±14	27±15	26±21	104±84

Figure 18. 1963 Two special *in-vitro* bioassay gamma analyses.

Example 3

Figures 19 and 20 show eight special urinalysis results for four individuals from January 1961 [INEL 1958–1986b, PDF pp. 4044–4045]. [REDACTED], [REDACTED], [REDACTED], and [REDACTED] routinely worked at the Burial Ground. Although these samples were taken around the time of the SL-1 accident, analytical records associated with SL-1 are typically marked as such. None of these records is so marked.

ID-104 (R-1-55)

U. S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
HEALTH AND SAFETY BRANCH
IDO H & S SAMPLE RECORD SHEET

ROUTINE __ SPECIAL XX

Serial No. [redacted]

Sample from: CFA (PHILLIPS)
Collected by: AEC Medical Services Branch
Date submitted: 1/9/61

Samples Received: 1-10-61 1255
Analyzed by:
Analysis Completed:
Method: End Window__; Prop. counter__; Spectrophotometric__; Fluorometric__; Polarographic__.

Sample No.	Date 1961	Hour	Sample Description	Anal. for	Quant. used, ml.	U or K+ trans.	Count time, min.	Total Count.	Gross Count, c/m.	Bkgd., c/m.	Net count, c/m.	K40 corr., c/m.	Foreign activity c/m.	Foreign activity d/m.
			SPECIAL											
132	1/9	02 0830	[redacted]	Gamma	60	1-10 1500	5	2442	488±10	486±10	2±14	27±15	0±21	NS 0±52
			" "	Sr										
133	1/9	02 0830	[redacted]	Gamma	75	"	5	2101	420±9	389±9	31±13	27±15	4±20	NS 10±50
			" "	Sr										
134	1/9	02 0845	[redacted]	Gamma	75	1505	5	2648	529±10	449±9	80±13	27±15	53±20	132±50
			" "	Sr										
135	1/9	02 0845	[redacted]	Gamma	60	"	5	2103	421±9	370±9	51±13	27±15	24±20	NS 60±50
			" "	Sr										

Figure 19. First four of eight special *in-vitro* bioassay gamma analyses from 1961.

ID-104 (R-1-55)

U. S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
HEALTH AND SAFETY BRANCH

ROUTINE__ SPECIAL XX

IDO H & S SAMPLE RECORD SHEET

Serial No. [redacted]

Sample from: CF (PHILLIPS)

Collected by: AEC Medical Services Branch

Date submitted: 1/9/61 [redacted]

Samples Received: 1-10-61 1255

Analyzed by: [redacted]

Analysis Completed:

Method: End Window__ ; ~~Prop.~~ WM counter ✓ ; Spectrophotometric__ ; Fluorometric__ ; Polurographic__ .

Sample No.	Date 1961	Hour	Sample Description	Anal. for	Quant. used, ml.	~~Eff~~ U 238 % Trans.	Count time, min.	Total Count.	Gross Count, c/m.	Bkgd., c/m.	Net count, c/m.	K[40] corr., c/m.	Foreign activity c/m.	Foreign activity d/m.
			SPECIAL											
136	1/9	02 1020	[redacted]	Gamma	75	1-10 1505	5	3292	658±11	486±10	172±15	27±15	145±21	36~~8~~ 3±52
			" "	Sr										
137	1/9	02 1600	[redacted]	Gamma	75	"	5	2507	501±10	389±9	112±13	27±15	85±20	212±50
			" " "	Sr										
138	1/9	02 1600	[redacted]	Gamma	70	1510	5	2245	449±9	370±9	79±13	27±15	52±20	139 130±50
			" "	Sr										
139	1/9	02 2030	[redacted]	Gamma	75	1510	5	2652	530±10	486±10	44±14	27±15	17±21	N.S. 42±52
			" "	Sr										

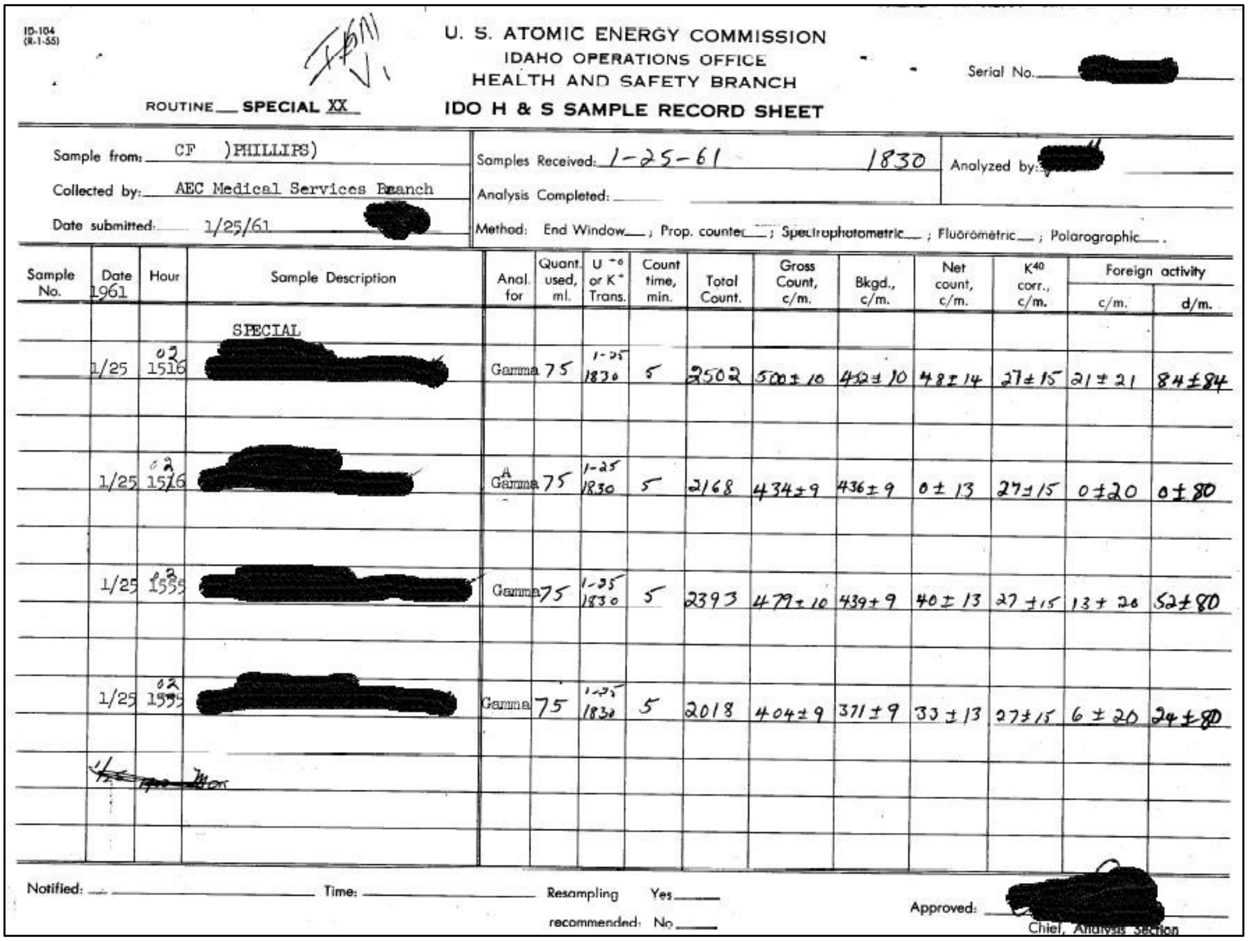
Notified: ___ Time: ___ Resampling recommended: Yes No

Approved: [redacted]

Figure 20. Second four of eight special *in-vitro* bioassay gamma analyses from 1961.

Example 4

Figure 21 shows additional special urinalyses results from later in January 1961 from workers who routinely worked at the Burial Ground [INEL 1958–1986b, PDF p. 4216]. Again, these records are not marked as SL-1 records.



ID-104 (R-1-55)

U. S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
HEALTH AND SAFETY BRANCH
IDO H & S SAMPLE RECORD SHEET

ROUTINE ___ SPECIAL XX

Serial No. [redacted]

Sample from: CF)PHILLIPS)
Collected by: AEC Medical Services Branch
Date submitted: 1/25/61 [redacted]

Samples Received: 1-25-61 1830
Analyzed by: [redacted]
Analysis Completed:
Method: End Window___; Prop. counter___; Spectrophotometric___; Fluorometric___; Polarographic___.

Sample No.	Date 1961	Hour	Sample Description	Anal. for	Quant. used, ml.	U or K Trans.	Count time, min.	Total Count.	Gross Count, c/m.	Bkgd., c/m.	Net count, c/m.	K40 corr., c/m.	Foreign activity c/m.	Foreign activity d/m.
			SPECIAL											
	1/25	02 1516	[redacted]	Gamma	75	1-25 1830	5	2502	500 ± 10	452 ± 10	48 ± 14	27 ± 15	21 ± 21	84 ± 84
	1/25	02 1516	[redacted]	Gamma	75	1-25 1830	5	2168	434 ± 9	436 ± 9	0 ± 13	27 ± 15	0 ± 20	0 ± 80
	1/25	02 1555	[redacted]	Gamma	75	1-25 1830	5	2393	479 ± 10	439 ± 9	40 ± 13	27 ± 15	13 ± 20	52 ± 80
	1/25	02 1555	[redacted]	Gamma	75	1-25 1830	5	2018	404 ± 9	371 ± 9	33 ± 13	27 ± 15	6 ± 20	24 ± 80

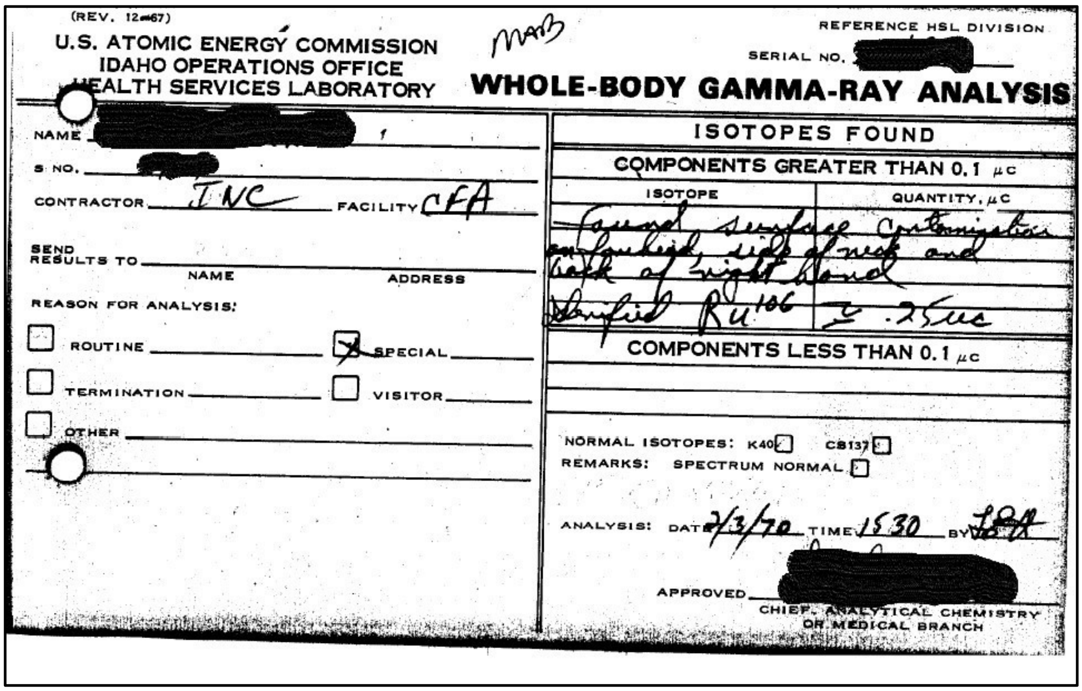
Notified: ___ Time: ___ Resampling recommended: Yes ___ No ___

Approved: [redacted] Chief, Analysis Section

Figure 21. Four special *in-vitro* bioassay gamma analyses from 1961.

Example 5

Figure 22 shows a special whole body count performed in February 1970 [INL 1950–1985, PDF p. 320]. [REDACTED] routinely worked at the Burial Ground and was one of the six workers identified in the November 1969 waste drum retrieval described in the SEC-00219 ER. Note that Cs-137 is marked as "normal," which indicates that the result was determined to be from nuclear weapons testing fallout in the environment. No activity was provided. Further checks of SWPs for the ARA-I Hot Cell in 1970 did not include [REDACTED]. Additional information on this *in-vivo* bioassay record can be found in Appendix A of this report.



(REV. 12-67)
U.S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
HEALTH SERVICES LABORATORY

REFERENCE HSL DIVISION
SERIAL NO. [redacted]

WHOLE-BODY GAMMA-RAY ANALYSIS

NAME [redacted]
S NO. [redacted]
CONTRACTOR INC FACILITY CFA
SEND RESULTS TO ____ NAME ____ ADDRESS
REASON FOR ANALYSIS:
☐ ROUTINE ☒ SPECIAL
☐ TERMINATION ☐ VISITOR
☐ OTHER

ISOTOPES FOUND
COMPONENTS GREATER THAN 0.1 μc
ISOTOPE | QUANTITY, μc
found surface contamination on eyelid, side of neck and back of right hand
Identified Ru106 ≥ .25uc
COMPONENTS LESS THAN 0.1 μc

NORMAL ISOTOPES: K40 ☒ CS137 ☒
REMARKS: SPECTRUM NORMAL ☒

ANALYSIS: DATE 2/3/70 TIME 1530 BY [illegible]

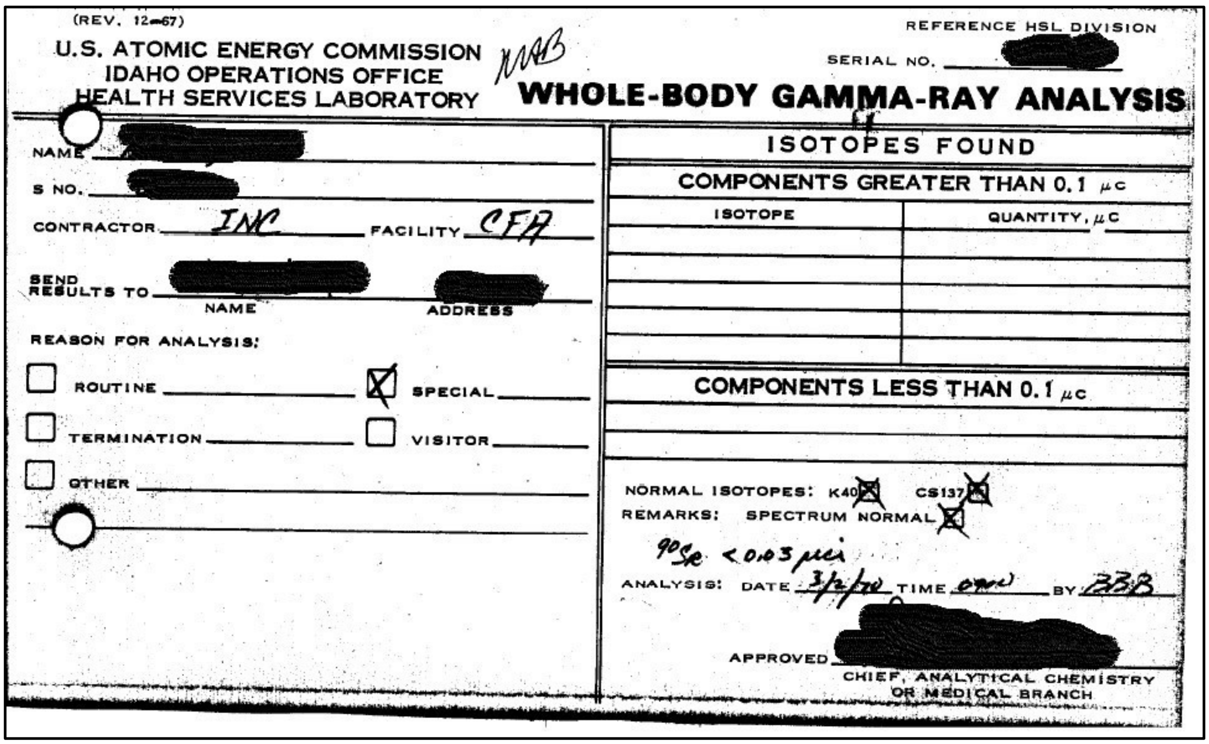
APPROVED [redacted]
CHIEF, ANALYTICAL CHEMISTRY OR MEDICAL BRANCH

Figure 22. 1970 special whole body count for Worker 3.

Example 6

Figure 23 shows a subsequent special whole body count performed on [REDACTED] but in March 1970 [INL 1950–1985, PDF p. 319]. Further checks of SWPs for the ARA-I Hot Cell in 1970 did not include [REDACTED]. Note that again, Cs-137 is marked as "normal," which indicates that the result was determined to be from nuclear weapons testing fallout in the environment. No activity was provided. Likewise, Sr-90 has a "less than" handwritten result.

NOTE: INL developed a bremsstrahlung counter for the skull to measure Sr-90. During this time period the bremsstrahlung count was done when the whole body count was performed.



(REV. 12-67)
U.S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
HEALTH SERVICES LABORATORY

REFERENCE HSL DIVISION
SERIAL NO. [redacted]

WHOLE-BODY GAMMA-RAY ANALYSIS

NAME [redacted]
S NO. [redacted]
CONTRACTOR INC FACILITY CFA
SEND RESULTS TO [redacted] NAME [redacted] ADDRESS

REASON FOR ANALYSIS:
☐ ROUTINE ☒ SPECIAL
☐ TERMINATION ☐ VISITOR
☐ OTHER

ISOTOPES FOUND

COMPONENTS GREATER THAN 0.1 μc

ISOTOPE	QUANTITY, μC

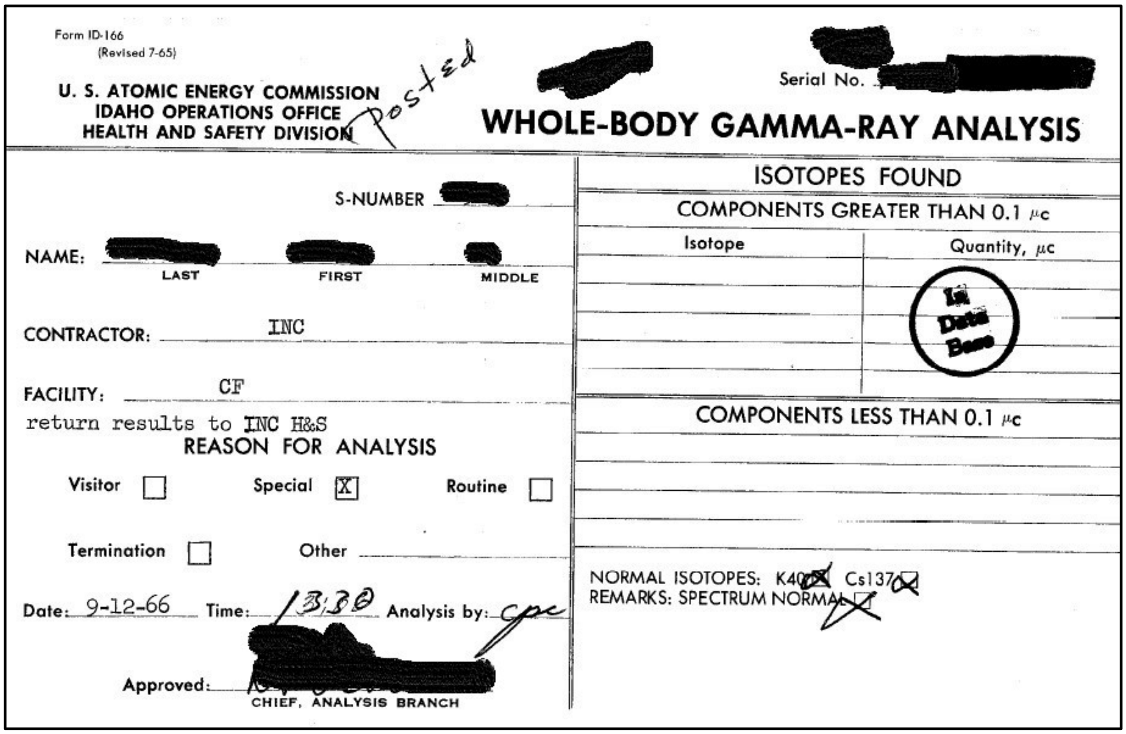
COMPONENTS LESS THAN 0.1 μc

NORMAL ISOTOPES: K40 ☒ CS137 ☒
REMARKS: SPECTRUM NORMAL ☒
90Sr < 0.03 μci
ANALYSIS: DATE 3/2/70 TIME [illegible] BY BBB
APPROVED [redacted]
CHIEF, ANALYTICAL CHEMISTRY OR MEDICAL BRANCH

Figure 23. Subsequent 1970 special whole body count for Worker 3.

Example 7

Figures 24 and 25 below show two special whole body counts performed on [REDACTED] and [REDACTED] on the same day in 1966 [INEL 1961–1977, PDF p. 4965–4966]. Both individuals were routine Burial Ground workers. As previously noted, the Cs-137 is marked as "normal", which indicates that the result was determined to be from nuclear weapons testing fallout in the environment.



Form ID-166
(Revised 7-65)

U. S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
HEALTH AND SAFETY DIVISION

Posted

[redacted]

Serial No. [redacted]

WHOLE-BODY GAMMA-RAY ANALYSIS

S-NUMBER [redacted]

NAME: [redacted] (LAST) [redacted] (FIRST) [redacted] (MIDDLE)

CONTRACTOR: INC

FACILITY: CF

return results to INC H&S

REASON FOR ANALYSIS

Visitor ☐ Special ☒ Routine ☐

Termination ☐ Other ______

Date: 9-12-66 Time: 13:30 Analysis by: [illegible]

Approved: [redacted]
CHIEF, ANALYSIS BRANCH

ISOTOPES FOUND

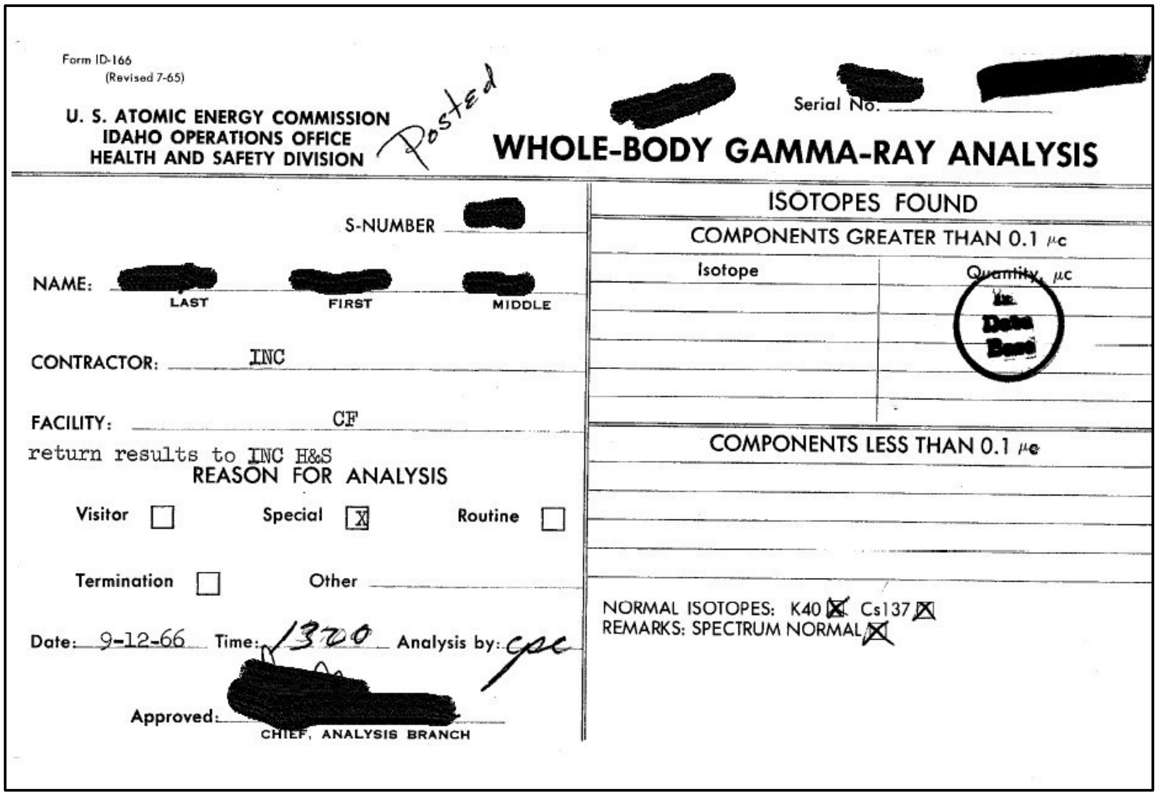
COMPONENTS GREATER THAN 0.1 μc

Isotope	Quantity, μc
	In Data Base

COMPONENTS LESS THAN 0.1 μc

NORMAL ISOTOPES: K40 ☒ Cs137 ☒
REMARKS: SPECTRUM NORMAL ☒

Figure 24. 1966 special whole body count 1.



Form ID-166
(Revised 7-65)

U. S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
HEALTH AND SAFETY DIVISION

Posted

[redacted] Serial No. [redacted]

WHOLE-BODY GAMMA-RAY ANALYSIS

S-NUMBER [redacted]

NAME: [redacted]
LAST FIRST MIDDLE

CONTRACTOR: INC

FACILITY: CF

return results to INC H&S

REASON FOR ANALYSIS

Visitor ☐ Special ☒ Routine ☐

Termination ☐ Other

Date: 9-12-66 Time: 1300 Analysis by: cpc

Approved: [redacted]
CHIEF, ANALYSIS BRANCH

ISOTOPES FOUND

COMPONENTS GREATER THAN 0.1 μc

Isotope	Quantity, μc
	In Data Base

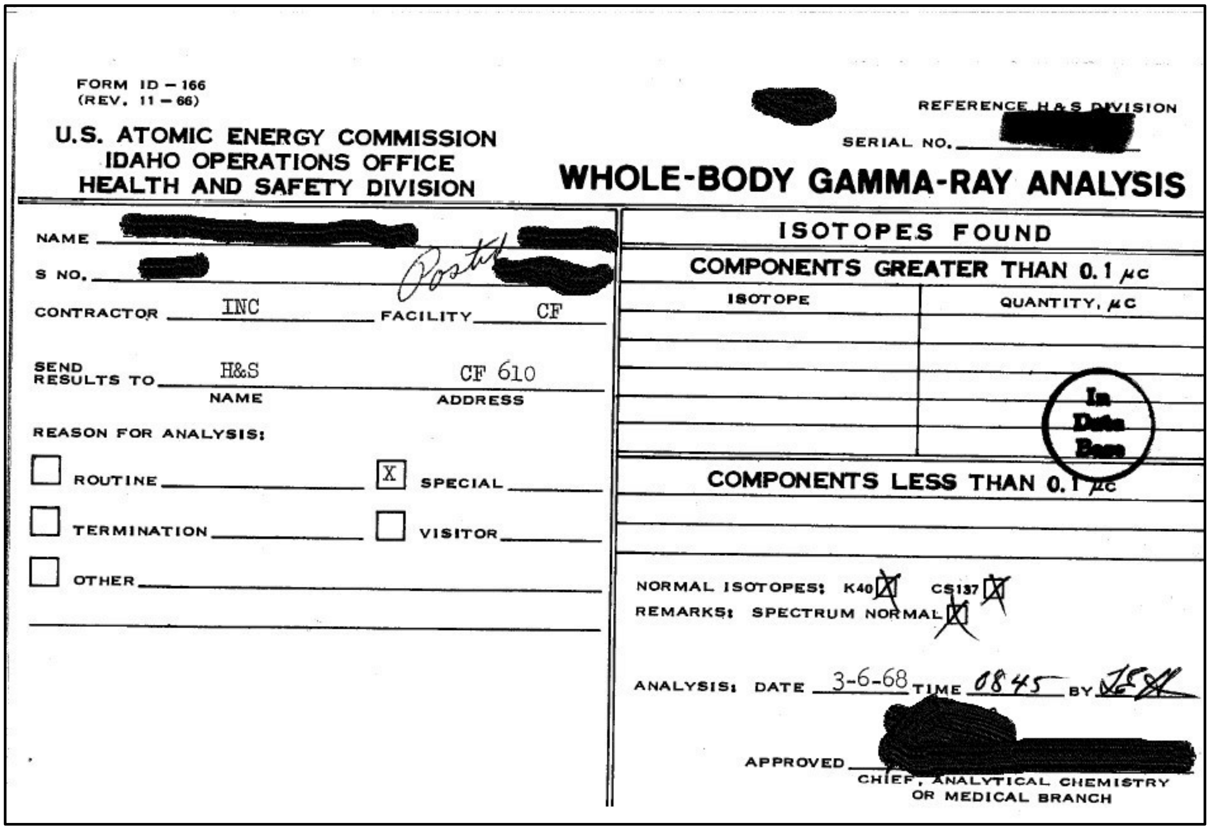
COMPONENTS LESS THAN 0.1 μc

NORMAL ISOTOPES: K40 ☒ Cs137 ☒
REMARKS: SPECTRUM NORMAL ☒

Figure 25. 1966 special whole body count 2.

Example 8

Figure 26 shows a special whole body count performed on [REDACTED], a heavy equipment operator, in March 1968 [INEL 1961–1977, PDF p. 5960]. [REDACTED] was a routine Burial Ground worker.



FORM ID – 166
(REV. 11 – 66)

U.S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
HEALTH AND SAFETY DIVISION

[redacted]
REFERENCE H&S DIVISION
SERIAL NO. [redacted]

WHOLE-BODY GAMMA-RAY ANALYSIS

NAME [redacted]

S NO. [redacted] Posts [redacted]

CONTRACTOR INC FACILITY CF

SEND RESULTS TO H&S (NAME) CF 610 (ADDRESS)

REASON FOR ANALYSIS:

☐ ROUTINE

☒ SPECIAL

☐ TERMINATION

☐ VISITOR

☐ OTHER

ISOTOPES FOUND

COMPONENTS GREATER THAN 0.1 μc

ISOTOPE	QUANTITY, μc

In Data Base

COMPONENTS LESS THAN 0.1 μc

NORMAL ISOTOPES: K40 ☒ CS137 ☒

REMARKS: SPECTRUM NORMAL ☒

ANALYSIS: DATE 3-6-68 TIME 0845 BY [illegible]

APPROVED [redacted]
CHIEF, ANALYTICAL CHEMISTRY OR MEDICAL BRANCH

Figure 26. 1968 special whole body count.

Example 9

This example shows two special whole body counts performed on the same day in 1964 on [REDACTED] (Figure 27) and [REDACTED] (Figure 29) [INEL 1961–1977, PDF pp. 10619, 10622]. These individuals routinely worked at the Burial Ground. Of particular interest are accompanying questionnaires for whole body counting. [REDACTED] lists his occupation as "yardman," which was a labor pool that was used for emplacing waste at the Burial Ground (Figure 28); [REDACTED] is listed as a "laborer" (Figure 30) [INEL 1961–1977, PDF pp. 10620, 10623].

ID-100
(Revised 12-62)

U. S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
HEALTH AND SAFETY DIVISION

Posted
Needs Locater

Serial No. [redacted]

WHOLE-BODY GAMMA-RAY ANALYSIS

Report to CF 690
1-27-64

S-NUMBER [redacted]

NAME: [redacted] (LAST) [redacted] (FIRST) [redacted] (MIDDLE)

CONTRACTOR: Phillips Petroleum company

FACILITY: [redacted] CF HP

REASON FOR ANALYSIS

Visitor ☐ Special ☒ Routine ☐

Termination ☐ Other ____

Date: 1-28-64 Time: 1305 Analysis by: M O.

Approved: [redacted]
CHIEF, ANALYSIS BRANCH

ISOTOPES FOUND

COMPONENTS GREATER THAN 0.1 μc

Isotope	Quantity, μc

COMPONENTS LESS THAN 0.1 μc

55 Cs 137
40 Zr Nb 95

REMARKS: K 40 NORMAL ☒

Figure 27. 1964 special whole body count 1.

QUESTIONNAIRE FOR WHOLE BODY COUNTING

1. SERIAL NO. [redacted]

2. DAY 28 MO. 1 YR 64

SUBJECT:

3. S-NUMBER [redacted] | 4. LAST NAME [redacted] | FIRST NAME [redacted] | MIDDLE NAME [redacted]

5. AGE (NEAREST YR.) [redacted] | 6. WEIGHT (LBS.) [redacted] | 7. HEIGHT (INCHES) [redacted] 13 | 8. CHEST DEPTH (CENTIMETERS) 24

9. ☒ MALE ☐ FEMALE

10. EMPLOYMENT STATUS ☒ NRTS ☐ VISITOR

11. REASON FOR COUNT ☐ NEW EMPLOYEE ☐ TERMINATION ☐ ROUTINE ☒ SPECIAL ☐ VISITOR

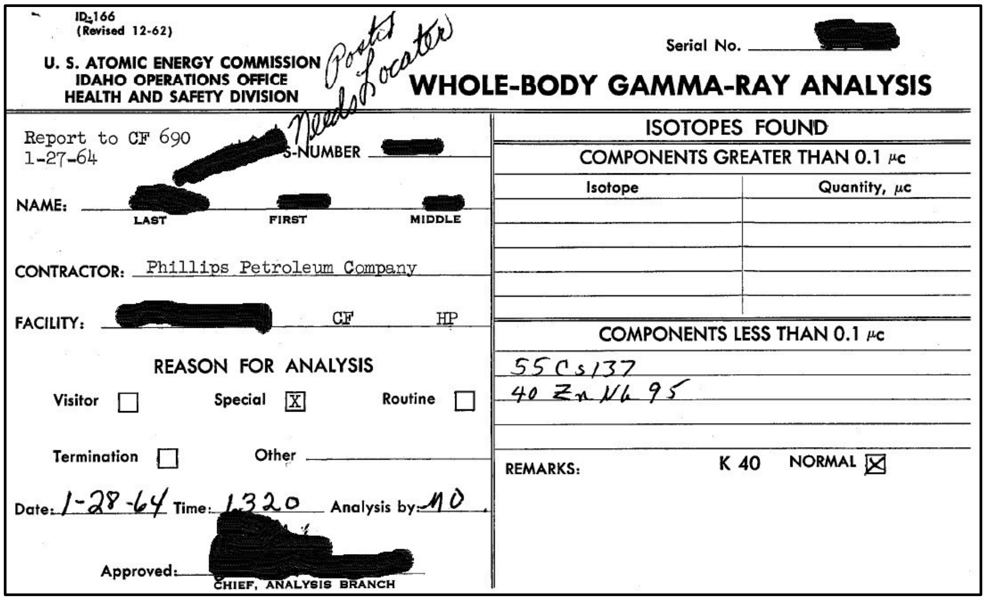
12. CRAFT OR PROFESSION YARdmeN

13. EMPLOYER P.P.Co

14. PRESENT WORK AREA CFA

15. NUMBER OF CONSECUTIVE YEARS IN PRESENT WORK AREA 0 To 1 yR.
(EXAMPLE: 0 TO 1 YR., 1 TO 2 YRS., 2 TO 3 YRS., ETC.)

Figure 28. Questionnaire for whole body count 1.



ID-166
(Revised 12-62)

U. S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
HEALTH AND SAFETY DIVISION

Needs Postal Locater

Serial No. [redacted]

WHOLE-BODY GAMMA-RAY ANALYSIS

Report to CF 690
1-27-64 [redacted] S-NUMBER [redacted]

NAME: [redacted] LAST [redacted] FIRST [redacted] MIDDLE

CONTRACTOR: Phillips Petroleum Company

FACILITY: [redacted] CF HP

REASON FOR ANALYSIS

Visitor ☐ Special ☒ Routine ☐

Termination ☐ Other ____

Date: 1-28-64 Time: 1320 Analysis by: MO

Approved: [redacted]
CHIEF, ANALYSIS BRANCH

ISOTOPES FOUND

COMPONENTS GREATER THAN 0.1 μc

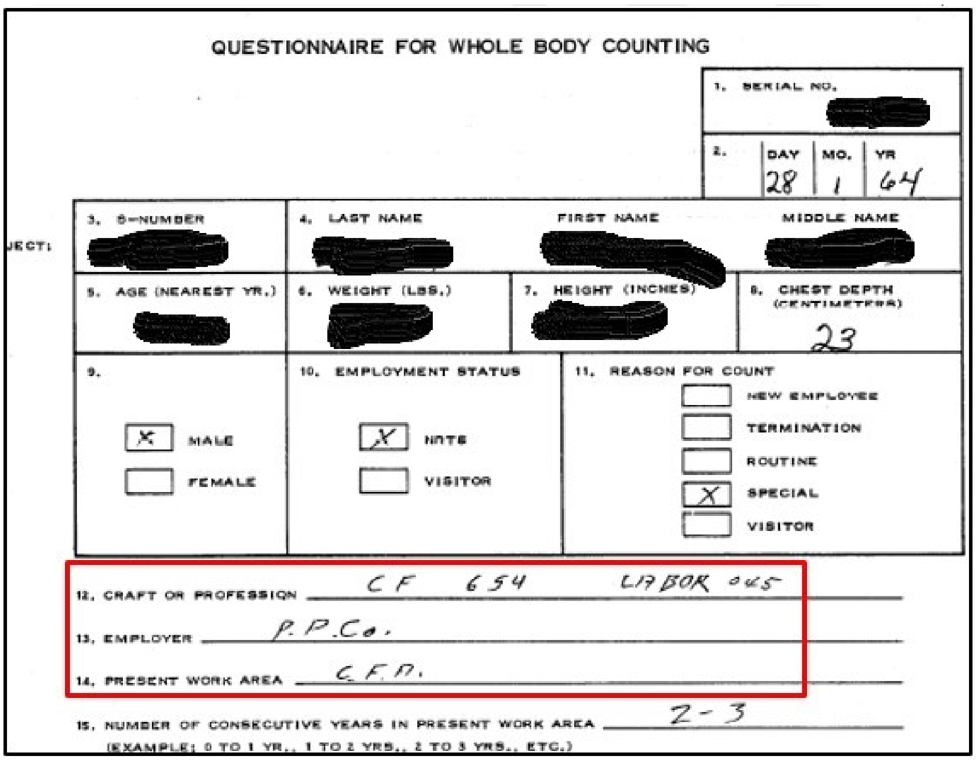
Isotope	Quantity, μc

COMPONENTS LESS THAN 0.1 μc

55 Cs 137
40 Zn Nb 95

REMARKS: K 40 NORMAL ☒

Figure 29. 1964 special whole-whoody count 2.



QUESTIONNAIRE FOR WHOLE BODY COUNTING

1. SERIAL NO. [redacted]

2. DAY 28 | MO. 1 | YR 64

JECT:

3. S-NUMBER [redacted]
4. LAST NAME [redacted] FIRST NAME [redacted] MIDDLE NAME [redacted]
5. AGE (NEAREST YR.) [redacted]
6. WEIGHT (LBS.) [redacted]
7. HEIGHT (INCHES) [redacted]
8. CHEST DEPTH (CENTIMETERS) 23
9. ☒ MALE ☐ FEMALE
10. EMPLOYMENT STATUS ☒ NRTS ☐ VISITOR
11. REASON FOR COUNT ☐ NEW EMPLOYEE ☐ TERMINATION ☐ ROUTINE ☒ SPECIAL ☐ VISITOR
12. CRAFT OR PROFESSION CF 654 LABOR ous
13. EMPLOYER P.P.Co.
14. PRESENT WORK AREA C.F.A.
15. NUMBER OF CONSECUTIVE YEARS IN PRESENT WORK AREA 2-3
(EXAMPLE: 0 TO 1 YR., 1 TO 2 YRS., 2 TO 3 YRS., ETC.)

Figure 30. Questionnaire for whole body count 2.

It should be noted that for these two whole body counts, Cs-137 is listed under "COMPONENTS LESS THAN 0.1 μCi." Dose contributions from MFPs would use the coworker models being developed for INL workers and ORAUT-OTIB-0054 to determine the isotopic contributions [ORAUT 2014a]. Whole body counts were the most common form of bioassay after 1960 for MFPs.

Based on the weight of the evidence, NIOSH believes that the statement "*when workplace indicators indicated that an intake may have occurred, "special" (non-routine) bioassay would be requested by the area Health Physics staff*" is accurate. Apart from a small waste-retrieval endeavor in November 1969, the INL Burial Ground operation was strictly burial of waste. Because the potential for internal exposure during waste burial work was reviewed and considered low by the HP covering the Burial Ground operation, *in-vitro* and *in-vivo* bioassay were only requested when radiological indicators suggested an increased potential for internal exposure. Responsibility for the operation and oversight of the Burial Ground resided in CFA through the early 1970s. Records, including bioassay records, were typically CFA records between the years 1952 and 1970; they sometimes did not provide the detail needed to discern exact locations. The CFA HP records held by NIOSH are not comprehensive, but they clearly provide examples of special bioassay performed when deemed necessary.

SC&A's Suggested Lines of Inquiry for Position 1(c) and NIOSH Responses

In SCA-TR-2017-SEC007, SC&A provided suggested lines of inquiry to the ABRWH pertaining to Position 1(c). These are provided below, along with NIOSH responses.

- SC&A: *Has NIOSH identified any "special bioassays" related to exposure at the Burial Ground for 1952–1970?*

  NIOSH: Multiple examples of "special bioassays" are provided above for several workers known to have worked at the Burial Ground.

- SC&A: *Has NIOSH identified any Burial Ground contamination events for which a "special bioassay" was requested by the area health physicist?*

  NIOSH: Multiple examples of "special bioassays" are provided. While some of these workers were known to have worked at the Burial Ground, as SC&A pointed out, it is difficult to identify a worker as a "Burial Ground worker" because there was no Burial Ground-specific area denoted on location cards or bioassay records. Workers at the Burial Ground during this time period were categorized under the "CFA" area and typically had professions of "laborer" or "yardman". However, special urine bioassay samples and in vivo measurements were identified for workers who were known to have worked at the Burial Ground. The names of workers were found on Burial Ground SWPs, HP logs, and other documents.

RESPONSE TO SC&A REVIEW OF ER POSITION 2

NIOSH made the following statements regarding the Burial Ground in Rev. 2 of the SEC-00219 Petition ER, which SC&A designates as NIOSH ER Position 2:

> Position 2: *NIOSH has determined that internal exposures at the Burial Ground were directly related to the materials being disposed of in the grounds. Up to the point in time that drum retrieval commenced in 1969, exposure potential was virtually all from mixed fission products in the INL waste being buried, and plutonium for the Rocky Flats Plant waste that was received for disposal. Internal monitoring data are available for the workers who supported the waste disposal activities and drum retrieval activity in 1969.* [NIOSH, 2017a, PDF p. 5]
>
> *For the Burial Ground, mixed fission and activation products were the primary internal dose hazards of concern. For urine samples only analyzed for gross beta, gross gamma, and/or strontium radioactivity, NIOSH will assess missed Sr-90 and/or Cs-137 intakes in accordance with ORAUT-OTIB-0054* [ORAUT 2014a] *and ORAUT-OTIB-0060* [ORAUT 2014b]. *Similarly, NIOSH will assess missed Cs-137 intakes when using in-vivo data in accordance with ORAUT-OTIB-0060. Based on the procedural information and the data on-hand, NIOSH finds that it has adequate monitoring data to allow for sufficiently accurate estimation of internal fission product doses for workers during the period from January 1, 1953 through December 31, 1968.* [NIOSH, 2017a, PDF p. 235]

In its review, SC&A expressed concern that the ability to determine potential internal exposures at the Burial Ground is "undercut by the lack of waste-content records in the early years (particularly before 1964 for RFP waste)" [Fitzgerald and Barton 2017, PDF p. 22]. Radioactive shipments from RFP prior to 1964 did not include paperwork depicting the form and radionuclide content of the waste due to classification concerns. Per a summary of RFP waste buried at INL, AEC courier receipts were obtained for 1963 and early 1964 indicating the shipment of classified material to INL. Unfortunately, the courier receipts did not identify the contents of the classified material. At that time, RFP had a large backlog of low-level plutonium residues that exceeded the economic discard limit. RFP requested permission from the AEC Albuquerque Operations Office to send the residues to INL for burial. Permission was granted, but RFP was required to provide health physics escorts for safety reasons [Vejvoda 2005].

A 1971 review of INL waste management practices estimated the volume of waste stored at the Burial Ground based on December 1969 data [Hogg et al. 1971]. The estimate for on-site-produced waste was 1,900,000 ft^3 (approx. 1 Ci/ft^3, MFP and Co-60), [Hogg et al. 1971, PDF p. 197]. The estimate of the off-site component was 2,000,000 ft^3 (<0.1 Ci/ft^3, Pu and Am) [Hogg et al. 1971, PDF p. 197]. It should be noted that although weapons-grade plutonium is typically thought of when RFP waste is discussed, it is worth reiterating that Am-241 is (unsurprisingly) a major component of the received waste. In fact, Am-241 is the most prevalent alpha-emitter in Table 5-30 of ORAUT-TKBS-0007-5 [ORAUT 2010b], the INL internal dosimetry TBD (isotopic composition provided below in Table 2). These data were compiled by INL in 2001 [INEEL 2001].

Table 2. Isotopic composition of stored contact-handled TRU waste in the TSA.
(Total volume = 65,000m^3. Total Ci = 4.06E+05 Ci)

Radionuclide	Concentration (Ci/m^3)	Percentage (%)
Pu-241	2.50E+00	44.1
Am-241	1.40E+00	24.7
Pu-238	9.70E-01	17.1
Pu-239	6.30E-01	11.1
Pu-240	1.50E-01	2.6
U-233	1.40E-02	0.2
Cm-244	8.00E-03	0.1

Later, the Historical Data Task project was implemented by INL to compile a comprehensive inventory of waste buried in the SDA (also known as the Old Burial Ground) from 1952 through 1983. The inventory information is organized according to waste generator and divided into waste streams for each generator. Waste information available in facility operating records, technical and programmatic reports, shipping records, and databases were included in the inventory. The SDA disposal units covered in the project include TRU-contaminated pits and trenches, non-TRU contaminated pits and trenches, the Acid Pit, and soil vault rows that were open from 1952 through 1983. Total best-estimate, upper-bound, and lower-bound quantities were generated for each contaminant, covering all waste streams from all generators for the period from 1952 to 1983 [Holdren et al. 2002]. INL used these data to summarize the major radionuclides in the waste inventory for the SDA. These data are provided in Table 5-20 of ORAUT-TKBS-0007-5, the INL internal dosimetry TBD [ORAUT 2010b].

As previously stated, there was no routine bioassay program at the Burial Ground (later RWMC) until 1978. Special bioassay was prescribed, as deemed appropriate by HP personnel, and any bioassay data available for a claim will be used for dose reconstruction. Burial Ground workers from the 1952–1970 period would have dose contributions from MFPs using applicable coworker models being developed for INL workers and ORAUT-OTIB-0054 to determine the isotopic contributions [ORAUT 2014a].

Because (1) the Burial Ground was not operated differently than other facilities at INL and as demonstrated in the section above and (2) the available monitoring data does not demonstrate uncontrolled source terms, Burial Ground workers are considered as exposed to similar levels of MFPs as other unmonitored INL workers. The INL unmonitored worker approach will be updated with coworker models that are currently being developed for several bioassay analyses used at INL, including those applicable for assessing MFPs.

As for the actinide dose potentially due to off-site burials (e.g., RFP), the current INL unmonitored worker approach would not account for this. NIOSH proposes to use the bioassay data from the 18 workers that participated in the exhumation work in the 1970s to provide a bounding estimate for internal actinide doses to identified Burial Ground workers during the burial period (1952–1970). This would be considered bounding because the burial activities had a much lower potential for contamination and therefore a lower potential for internal exposure than the unearthing activities that took place.

SC&A's Suggested Lines of Inquiry for Position 2 and NIOSH Responses

In SCA-TR-2017-SEC007, SC&A provided suggested lines of inquiry to the ABRWH pertaining to Position 2. These are provided below, along with NIOSH responses.

- SC&A: *With what quantitative data regarding Burial Ground waste constituents does NIOSH intend to demonstrate a bounding dose contribution from MFPs and plutonium?*

  NIOSH: Tables 5-29 and 5-30 in ORAUT-TKBS-0007-5, the INL internal dose TBD, contain radioactive waste inventories for both the SDA and the TSA [ORAUT 2010b]. Those data were compiled from extensive waste inventory reconstruction efforts by INL. Table 30, replicated in Table 2 of this report, provides isotopic ratios that can be used to bound the dose contributions from plutonium by accounting for other alpha emitters. The TRU material that was formerly in the SDA was exhumed and transferred to the TSA. NIOSH proposes to use the bioassay data from the 18 workers that participated in the exhumation work in the 1970s and these ratios to provide a bounding estimate for internal actinide doses to potential Burial Ground workers during the burial period (1952–1970). This would be considered bounding because the burial activities had a much lower potential for contamination and therefore a lower potential for internal exposure than the unearthing activities that took place.

  Dose contributions from MFPs would use the coworker models being developed for INL workers and ORAUT-OTIB-0054 [ORAUT 2014a] to determine the isotopic contributions.

- SC&A: *How would ORAUT-OTIB-0054 and ORAUT-OTIB-0060 be applied as proposed? What is NIOSH's response to SC&A's two reviews of their application at INL (SC&A 2016, 2017), as they would pertain to the Burial Ground?*

  NIOSH: The method described in the *Technical Information Bulletin: Fission and Activation Product Assignment for Internal Dose-Related Gross Beta and Gross Gamma Analyses* [ORAUT 2014a] was determined to be appropriate and applicable for the INL site because some INL reactor data were used to develop that method. The method is used for gross beta and gamma bioassay. Because most of the bioassay measurements performed for INL workers did not determine the potential mixtures of the activation and fission products that the workers were exposed to, and because those potential mixtures have a significant impact on the workers' doses, a method for estimating the mixtures of the activation and fission products needed to be selected for the INL site. This method is applied for those workers with bioassay results.

However, as previously discussed there was no routine bioassay program at the Burial Ground. Section 5.4, Assignment of Missed or Unmonitored Dose, of ORAUT-OTIB-0060 allows for the application of coworker data. A series of coworker models are being developed that can be applied to the Burial Ground 1952–1970.

SCA-TR-2016-SEC007, *SC&A's Evaluation of Cs-137/Sr-90 Values and Actinides Using INL Waste Reports in Relationship to Assigning Intakes*, and SCA-TR-2017-SEC001, *SC&A's Evaluation of Cs-137/Sr-90, Fission and Activation Product, and Actinide Values Using INL Monthly and Annual Waste Reports in Relationship to Assigning Intakes,* pertain to the same topic. A response to this topic has yet to be developed due to higher priority work. Until the topic can be researched and responded to, ORAUT-OTIB-0054 will continue to be used for reconstruction of these doses at INL.

RESPONSE TO SC&A REVIEW OF ER POSITION 3

NIOSH made the following statement regarding the Burial Ground in Rev. 2 of the SEC-00219 Petition ER, which SC&A designates as NIOSH ER Position 3:

> *Position 3: The radiological monitoring program at the Burial Ground included the presence of a health physicist, safe work permits for all waste disposals, personnel surveys upon completion of work, air monitoring, and decontamination of vehicles at CPP if they were found to be contaminated…. This defense-in-depth approach was adequate to ensure that unmonitored intakes of plutonium did not occur* [NIOSH, 2017a, PDF p. 236].

The "rigor and effectiveness of the radiological monitoring program at the Burial Ground" was questioned in SCA-TR-2017-SEC007. Furthermore, SC&A suggested that the dual operational and radiological oversight roles of the CFA HP group might have represented an organizational conflict of interest resulting in major organizational changes at the Burial Ground in 1969–1970. The conclusion that the Burial Ground was "considered a low priority by INL management" is simply not substantiated for the 1952–1970 time period.

In 1969–1970, the Burial Ground had (in a very short period) gone from a simple single objective (buried waste disposal) low-risk operation to a much more complex operation that was reflected in the change in organization. Evidence (such as Figure 1) clearly indicates that the operation of the Burial Ground and the safety of personnel working there were expected to be held to the same standard as other site areas. As stated in the SEC-00219 ER [NIOSH 2015, PDF p. 163]:

> *INL took advantage of the practices and experiences of other AEC facilities established earlier, such as Oak Ridge National Laboratory and Hanford, to establish their health physics program. AEC-IDO policy regarding health physics responsibilities and services at INL was established in 1952 creating centralized services (Johnston, 1952).*

SWPs and survey of equipment and personnel are indicative of a fairly rigorous monitoring program for a low-risk activity such as waste burial. Routine health physics monitoring programs, even today, are based on risk of exposure to radioactive material. Burial operations were low-risk activities compared to other site activities in which the source term is in some way disturbed, such as fuel separation to recover highly enriched uranium at CPP, or the large-scale waste retrievals that began in earnest during the 1970s at the Burial Ground. Even during the Initial Drum Retrieval project, which reported the exhumation of 20,262 recently-buried waste drums, respiratory protection was not required [McKinley and McKinney 1978, PDF p. 6]. Even then, as a precautionary measure, respirators were required to be worn around the neck in case breached drums were encountered. This further illustrates just how low the internal exposure risk was during waste placement and burial. Vehicle checks for radiation and contamination were conducted prior to departure for the Burial Ground. Similar checks of vehicles and personnel were performed prior to exit from the Burial Ground.

The Standard Practice procedure for the Burial Ground required compliance with the radiation and contamination limits promulgated by the Interstate Commerce Commission (ICC), which was responsible for the standards for transportation of radioactive material at the time [Hayden 1962]. For both vehicles and railcars, the ICC alpha contamination limit was 500 dpm/100cm^2 [Transportation rules 1965].

Using the following assumptions, the maximum committed effective doses from inhalation (Type M) and ingestion (unknown form) are 5.21E-01 and 1.67E-02 mrem, respectively.

- Contamination level: 500 dpm/100cm^2
- Inhalation: 2.00E-05 resuspension factor
- Inhalation: 1.2 m^3/hr (20 L/hr) breathing rate
- Ingestion: 1.00E-04 ingestion rate (NUREG/CR-5512 Vol 3)
- Exposure period: 8 hours

The radiological monitoring performed at the Burial Ground was considered proportional to the radiological risk per the work reviews conducted by health physicists. This was evident beginning in the 1970s when waste retrieval projects began and the internal exposure potential increased. For example, during the Initial Drum Retrieval project, the retrieved waste was in good physical condition, as it represented some of the more recently buried RFP waste drums. Even then, respirators were required to be worn around the neck in case breached drums were encountered. During the EWR project, full plastic suits and a moveable containment hut were used because the waste being exhumed represented some of the worst radiological conditions that were thought to exist. These activities present a larger radiological hazard than waste disposal and the use of HP work safety reviews is reflected in the radiological controls and increased use of personal protective equipment.

There is no evidence to support the notion that the Burial Ground was reorganized due to poor radiological controls. The reasons for the reorganization of the Burial Ground had its roots in 1969. The facility was transitioning away from simple low-risk burials to above-ground TRU storage, waste retrievals, and increased operations. Examples of major changes during that time were [INEL 1985]:

- In May 1969, a major fire in a glovebox at RFP Building 776 resulted in a dramatic increase in waste shipments to an ever-dwindling storage capacity at the Burial Ground. At this time, mass dumping of RFP waste drums stopped in an effort to better make use of existing space.
- Another major flood affecting the Burial Ground occurred in 1969.
- Initial federal environmental laws were passed, resulting in the National Environmental Policy Act of 1969.
- In 1969, a General Manager's Task Force on AEC Operation Radioactive Waste Management was established to "develop long-range policies, standards, and criteria for management of AEC waste."
- The first attempt at waste exhumation at the Burial Ground was conducted in 1969.

Beginning in 1969, the Idaho Nuclear Corporation was reorganized and the Nuclear and Operational Safety (NOS) Division (combined Health and Safety Branch, Operations Surveillance Branch, and Nuclear Safety Committee) was formed and became responsible for independent internal review of burial operations. NOS was responsible for all waste management and pollution control beginning in 1970 [INEL 1985, PDF p. 10]. Burial Ground operations were conducted Monday through Friday. Records involving the movement of waste to the Burial Ground from off-site and non-AEC sources became centralized by the NOS Division. All information covering waste types, volumes, activity levels, and burial locations was entered as computer input weekly from Form ID-136 [Hogg et al. 1971].

An interesting metric that bears out the increased activity at the Burial Ground is the number of monthly onsite and offsite burials during the 1952–1970 time period. Table 3 provides the onsite and offsite burials per month. Note the sizeable increase in offsite shipments in the middle of 1969 due to the May 1969 RFP fire.

Table 3. Onsite and offsite burial metrics.

Month	1959-Onsite	1959-Offsite	1960-Onsite	1960-Offsite	1961-Onsite	1961-Offsite	1962-Onsite	1962-Offsite	1963-Onsite	1963-Offsite	1965-Onsite	1965-Offsite	1966-Onsite	1966-Offsite	1969-Onsite	1969-Offsite
JAN	NP[c]	NP[c]	41	4	62	NP[c]	55	8	110	3	NP[c]	0	79	11	91	12
FEB	NP[c]	NP[c]	45	4	64	8	37	8	68	6	74	9	67	14	90	8
MAR	NP[c]	NP[c]	58	4	59	NP[c]	21	2	70	0	65	17	NP[c]	NP[c]	95	19
APR	27[b]	2[b]	59	7	50	9	68	3	65	1	NA[a]	NA[a]	NA[a]	NA[a]	89	12
MAY	79	4	55	7	70	10	NP[c]	NP[c]	51	3	145	8	85	12	105	12
JUN	68	5	56	8	70	23	54	15	129	1	81	8	81	6	118	18
JUL	57	5	50	15	45	7	53	14	100	0	87	3	72	10	115	34
AUG	80	4	66	4	68	13	58	7	120	0	NP[c]	NP[c]	101	18	170	30
SEP	108	4	56	2	55	9	70	19	60	NP[c]	NA[a]	NA[a]	83	12	161	34
OCT	58	4	34	0	54	9	50	26	58	NP[c]	NP[c]	NP[c]	76	16	169	24
NOV	51	4	56	14	51	7	NP[c]	NP[c]	NP[c]	NP[c]	COMP[d]	COMP[d]	88	17	103	20
DEC	56	6	61	9	27	11	NP[c]	NP[c]	NA[a]	NA[a]	NP[c]	NP[c]	98	12	134	28

[a] NA indicates that the data are not available because the corresponding HP monthly report was not found.
[b] Only a half-month's data provided in April 1959 report.
[c] NP indicates that the number of burials was not provided in the notated HP report.
[d] Only a composite total of 233 was provided for November 1965.

Evidence of the simplicity of the Burial Ground operation up until 1969 is revealed in its operating costs. Table 4 provides the itemized cost of operations from the second half of 1964 through the first half of 1966 [McCaslin 1963–1966]. It should be noted that the "HP Labor" costs and "Non-HP Labor" costs were very similar for several time frames. The monetary support for radiological safety labor at the Burial Ground was about equal to the monetary support for workers, demonstrating management's recognition of the need for and support of radiation safety.

Table 4. Semi-annual 1964–1966 costs for Burial Ground.

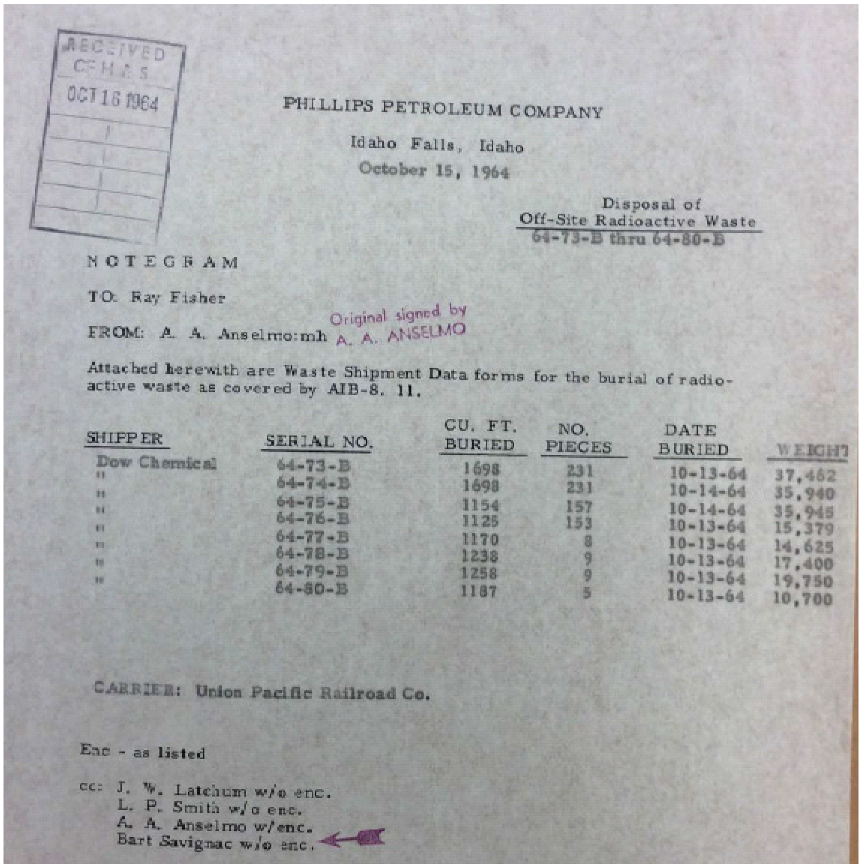
Item	Jul–Dec 1964[a]	Jan–Jun 1965	Jul–Dec 1965	Jan–Jun 1966
HP labor	$2,682.30	$3,231.36	$3,386.13	$3,063.53
Non-HP labor	Not Specified	$4,979.95	$9,310.73	$5,280.20
Burden	Not Specified	$1,545.88	$1,831.95	$1,775.03
Materials	$37.63	$64.96	$296.77	$150.84
Equipment usage	$1,347.67	$3,688.69	$5,986.81	$2,692.44
Maintenance	$9,211.52	Not Specified	Not Specified	Not Specified
Miscellaneous	$1,618.03	Not Specified	Not Specified	Not Specified
Sum	$14,897.15	$13,510.84	$20,812.39	$12,962.04
Cost per cubic foot (cents)	11.8	9.4	17	7.6
Semi-annual cost if today's dollar	$115,452.91[b]	$104,709.01[b]	$161,296.02[b]	$100,455.81[b]

Source: [McCaslin 1963–1966]
[a] Jul–Dec 1964 costs were categorized differently from the other three time periods.
[b] $1.00 in 1966 is equal to $7.75 today.

The facility was not used on a full-time basis and was a simple operation that did not require enormous expense. In addition, RFP disposal records during the 1964–1966 period (for which operating costs records were found) demonstrate that waste burial was only performed on certain days with a large number of items buried at a time. Figure 31 shows such a record for 1964 [AEC 1964, PDF p. 20]. Note the "No. Pieces" and "Date Buried" columns.

Even when the RWMC was assigned its own area code for external dosimetry (Area Code 815 – RWMC, Area Code 825 – RWMX [RWMC construction], and Area Code 814 – RWMC Temporary Dosimetry), there were very few workers at the facility. A total of 49 workers are listed on the 4th Quarter 1975 RWMC area external dosimetry report (RWMC Area Exposure Reports, 1975). Personnel interviews confirm that there simply were not many workers at the Burial Ground from beginning of operations through the 1970s.

Based on available records including the INL intake registry of known internal dose assignments from 1960 until 1978, NIOSH believes based on the weight of the evidence that the defense-in-depth approach, including operational and radiological monitoring control of the Burial Ground, safe work permits for all waste disposals, personnel surveys upon completion of work, air monitoring, etc. was adequate to ensure that unmonitored intakes of plutonium did not occur exceeding intakes that occurred during the 1970s exhumation activities. Organizational changes and increased management oversight were the result of many factors but were never explicitly tied to poor radiological conditions at the Burial Ground, as SC&A hypothesizes.



RECEIVED CFHAS OCT 16 1964

PHILLIPS PETROLEUM COMPANY

Idaho Falls, Idaho
October 15, 1964

Disposal of
Off-Site Radioactive Waste
64-73-B thru 64-80-B

NOTEGRAM

TO: Ray Fisher

FROM: A. A. Anselmo:mh Original signed by A. A. ANSELMO

Attached herewith are Waste Shipment Data forms for the burial of radioactive waste as covered by AIB-8. 11.

SHIPPER	SERIAL NO.	CU. FT. BURIED	NO. PIECES	DATE BURIED	WEIGHT
Dow Chemical	64-73-B	1698	231	10-13-64	37,462
"	64-74-B	1698	231	10-14-64	35,940
"	64-75-B	1154	157	10-14-64	35,945
"	64-76-B	1125	153	10-13-64	15,379
"	64-77-B	1170	8	10-13-64	14,625
"	64-78-B	1238	9	10-13-64	17,400
"	64-79-B	1258	9	10-13-64	19,750
"	64-80-B	1187	5	10-13-64	10,700

CARRIER: Union Pacific Railroad Co.

Enc - as listed

cc: J. W. Latchum w/o enc.
L. P. Smith w/o enc.
A. A. Anselmo w/enc.
Bart Savignac w/o enc.

Figure 31. 1964 disposal record for RFP waste.

SC&A's Suggested Lines of Inquiry for Position 3

SCA-TR-2017-SEC007 provided no suggested lines of inquiry to the ABRWH regarding Position 3.

RESPONSE TO SC&A PRELIMINARY CONCLUSION

SCA-TR-2017-SEC007 provides the following statement as a Preliminary Conclusion:

- SC&A: *The NIOSH ER concludes that worker exposures at the Burial Ground can be dose reconstructed for 1952–1970 on the basis of stringent contamination controls, a radiation control program for plutonium exemplifying a "defense-in-depth" approach, and available internal dose data for known radioactive waste source terms that lend themselves to standard dose reconstruction methods (e.g., ORAUT-OTIB-0054* [ORAUT 2014a] *and ORAUT-OTIB-*

0060 [ORAUT 2014b]*). SC&A finds all of these basic tenets fall short given a review of available SRDB documentation and an extensive series of former worker interviews.*

NIOSH: Review of all the available CFA monthly reports (completeness displayed in Table 1), available CFA HP logbooks, and available CFA HP log sheets does not show contamination events to be common. The characterization of a facility that was not given proper management attention and was fundamentally flawed in the monitoring of workers is not borne out by the available records. While there was some inconsistency among former interviewees, most interviewees were favorable about radiological control practices and health physics monitoring at the Burial Ground. In fact, during personnel interviews related to the ongoing RWMC 83.14 determination, the interviewees stated that the Burial Ground was a preferred area to work. There was no information obtained from the interviews with former workers that suggests that the proposed internal dose reconstruction methods wouldn't bound exposures to BG workers during the 1952–1970 timeframe.

DOSE RECONSTRUCTION CONCLUSION

- NIOSH believes based on the weight of the evidence that our ability to reconstruct dose for the workers at the Burial Ground from 1952–1970 is still valid. Some revisions to the reconstruction methods described in the Petition SEC-00219 evaluation report are being recommended based on data uncovered during the 83.14 determination evaluation for the Burial Ground 1970–1980 and the development of coworker models. The recommended dose reconstruction methods are as follows: There was no routine bioassay program at the Burial Ground (later RWMC) until 1978. Prior to implementation of a routine bioassay program, special bioassay was prescribed as deemed necessary by Health Physics. Any bioassay data available for a claim will be used for dose reconstruction.

- Burial Ground workers from the 1952–1970 period would have dose contributions from MFPs using applicable coworker models being developed for INL workers and ORAUT-OTIB-0054 to determine the isotopic contributions. Burial Ground workers would be considered exposed to similar levels of MFPs as other unmonitored INL workers. The INL unmonitored worker approach will be updated with coworker models that are currently being developed for several bioassay analyses used at INL, including those applicable for assessing MFPs.

- For actinide dose reconstruction, NIOSH proposes to use the bioassay data from the 18 workers that participated in the exhumation work in the 1970s to provide a bounding estimate for internal actinide doses to identified Burial Ground workers during the burial period (1952–1970). This would be considered bounding because the burial activities had a much lower potential for contamination and therefore a lower potential for internal exposure than the unearthing activities that took place.

- Revision to ORAUT-TKBS-0007-5, Revision 03, *Idaho National Laboratory and Argonne National Laboratory-West - Occupational Internal Dose* technical basis document [ORAUT 2010b] will be made during the next revision to incorporate these changes.

Implementation of the dose reconstruction methods proposed relies on the identification of an INL worker that worked at the Burial Ground in the 1952–1970 time period. External dosimetry records specific to the Burial Ground did not exist until the mid-1970s when the Burial Ground became a facility with its own dosimetry area code. Monitoring records for workers that were assigned to the Burial Ground typically indicated CFA as the work location. This was also found to be true when reviewing the Locator File Cards (LFC) for workers known to have worked at the Burial Ground.

The additional research performed on the 1952–1970 time period at the Burial Ground and a review of the personnel monitoring practices in the 1970s did bring into focus that there were certain job titles or occupations that were commonly associated with Burial Ground work. This was verified in personnel interviews in which former Burial Ground workers indicated that health physicists, laborers, and equipment operators were universally present when the Burial Ground was open [ORAUT 2016a,b,c,d,e,f, 2018a,b]. It was also learned that the career path to becoming an equipment operator was through the labor pool at CFA and that the Burial Ground was the preferred location on site to gain experience so that a laborer could advance to equipment operator and then heavy equipment operator.

The CFA job titles which should be considered likely Burial Ground workers include the following:

- Laborer or Yardman
- Driver or Truck Driver or Teamster
- Equipment Operator
- Heavy Equipment Operator
- Health Physicist or Health Physics Technician or HP

The dose reconstruction methods summarized in this section should be applied to these job titles as they represent the workers most likely to have worked at the Burial Ground prior to 1971.

REFERENCES

AEC [1964]. Waste disposal request and authorizations September 1964 – December 1964. Idaho National Laboratory. Idaho Falls, ID: U.S. Atomic Energy Commission, Idaho Operations Office. [SRDB Ref ID: 142167]

AEC/ID [1963]. Procedure for hi-volume (hi-vol) sampling of airborne radioactive materials. Standard operating procedure SOP 4-63. Scoville, ID: Atomic Energy Commission, Idaho Operations Office, Health and Safety Division. November 15. [SRDB Ref ID: 125785]

AEC/ID [1970]. Appraisal of NRTS solid radioactive waste disposal June 1970. Scoville, ID: Atomic Energy Commission, Idaho Operations Office. June. [SRDB Ref ID: 138957]

AMWTP [2014]. Acceptable knowledge document for pre-1980 INL-exhumed SDA waste. RPT-TRUW-91 Rev. 2. Advanced Mixed Waste Treatment Project. Scoville, ID: Idaho National Laboratory. February 5. [SRDB Ref ID: 167963]

Anderson BC, Schletter RM [1979]. A history of the radioactive waste management complex at the Idaho National Engineering Laboratory. Idaho National Engineering Laboratory. Scoville, ID: EG&G Idaho. PR-W-79-038. September. [SRDB Ref ID: 83011]

Beers RJ [1970]. Log notes regarding INL burial ground fire of June 1, 1970. Scoville, ID: Idaho National Laboratory. June 1. [SRDB Ref ID: 178606]

Byrom JP [1954]. CFA health physics monthly reports 1954. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. [SRDB Ref ID: 27626]

Byrom JP [1955]. CFA health physics monthly reports December 26, 1954 through October 31, 1955. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. [SRDB Ref ID: 125816]

DeWitt LM [1990]. Summarization of RWMC subsurface disposal area source term interviews. Idaho Falls, ID: Haz Answers, Inc. August. [SRDB Ref ID: 141861]

Dickson [1981]. Report of internal dose assignments 1972–1975. Idaho Falls, ID: U.S. Department of Energy, Idaho Operations Office. January 13. [SRDB Ref ID: 168519]

DRA [1957]. Health physics logbook April 25, 1957 – May 24, 1957. Scoville, ID: Idaho National Laboratory. Author initials: DRA. Various dates from April 25 through May 24. [SRDB Ref ID: 118871]

Ebersole EW [1962]. H&S sample record sheets burial ground. Idaho National Laboratory. Idaho Falls, ID: U.S. Atomic Energy Commission, Idaho Operations Office, Health and Safety Branch. April. [SRDB Ref ID: 150285]

Federal register transportation rules and regulations carriers by rail cleaning cars and shipments. 30 CFR 108 (1965). [SRDB Ref ID: 176845]

Fitzgerald J, Barton R [2017]. Draft review of NIOSH's evaluation report for petition SEC-00219 INL burial ground 1952–1970. SCA-TR-2017-SEC007. Arlington, VA: Sanford Cohen & Associates (SC&A). May. [SRDB Ref ID: 176496]

Hayden RE [1962]. Phillips petroleum company standard practice 5.61.2 NRTS burial ground. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. April 13. [SRDB Ref ID: 141097]

Hiaring CM, Horton RB, Schlafman MJ [1992]. A photographic report of disposal and storage activities at the radioactive waste management complex June 1992. WM-ERP-92-014. Scoville, ID: Idaho National Laboratory. June. [SRDB Ref ID: 159553]

Hogg GW, Holcomb WF, Lakey LT, Jones LH, Coward DD [1971]. A survey of NRTS waste management practices volume II. ACI-104. Idaho National Laboratory. Scoville, ID: Allied Chemical Corporation. September. [SRDB Ref ID: 87711]

Holdren KJ, Becker BH, Hampton NL, Koeppen LD, Magnuson SO, Meyer TJ, Olson GL, Sondrup AJ [2002]. Ancillary basis for risk analysis of the subsurface disposal area. INEEL/EXT-02-01125. Idaho National Engineering and Environmental Laboratory, Environmental Restoration Program. Scoville, ID: Bechtel BWXT Idaho. September. [SRDB Ref ID: 153660]

Holmes AW [1958a]. CFA health physics monthly report for April 1958. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. April. [SRDB Ref ID: 138738]

Holmes AW [1958b]. CFA health physics monthly report for May 1958. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. May. [SRDB Ref ID: 138737]

Holmes AW [1958c]. CFA health physics monthly report for June 1958. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. June. [SRDB Ref ID: 138735]

Holmes AW [1958d]. CFA health physics monthly report for July 1958. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. July. [SRDB Ref ID: 138734]

Holmes AW [1958e]. CFA health physics monthly report for August 1958. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. August. [SRDB Ref ID: 138733]

Holmes AW [1958f]. CFA health physics monthly report for September 1958. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. September. [SRDB Ref ID: 138728]

Holmes AW [1958g]. CFA health physics monthly report for October 1958. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. October. [SRDB Ref ID: 138720]

Holmes AW [1958h]. CFA health physics monthly report for November 1958. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. November. [SRDB Ref ID: 138718]

INEL [1958–1986a]. INEL bioassay CD 2 of 3. Scoville, ID: Idaho National Laboratory. Various dates in 1958–1986. [SRDB Ref ID: 123096]

INEL [1958–1986b]. INEL bioassay CD 3 of 3. Scoville, ID: Idaho National Laboratory. Various dates in 1958–1986. [SRDB Ref ID: 123104]

INEL [1961–1977]. INEL Whole Body Count CD 1 of 5. Scoville, ID: Idaho National Engineering Laboratory. Various dates in 1961–1977. [SRDB Ref ID: 123105]

INEL [1985]. A history of the radioactive waste management complex at the Idaho National Engineering Laboratory. WM-F1-81-003 Rev. 3. Idaho National Engineering Laboratory, Waste Program Division, RWMC Operations Branch. Scoville, ID: EG&G Idaho. July. [SRDB Ref ID: 83913]

INEEL [2001]. INEEL M and O contractor technical basis for internal dosimetry. Scoville, ID: Idaho National Engineering and Environmental Laboratory. May 30. [SRDB Ref ID: 8479]

INL [1950–1985]. Dosimetry records for [REDACTED] Scoville, ID: Idaho National Laboratory. [SRDB Ref ID: 152471]

INL [1958a]. Incident Reports (1958). Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. [SRDB Ref ID: 31934]

INL [1958b]. 1958 burial ground photographs. Scoville, ID: Idaho National Laboratory. [SRDB Ref ID: 142102]

INL [1958–1973]. Burial ground aerial color 1958–1973 photographs. Scoville, ID: Idaho National Laboratory. Various exposure dates from 1958 through 1973. [SRDB Ref ID: 151677]

INL [1959–1995a]. Dosimetry records for [REDACTED] 1959–1995. Scoville, ID: Idaho National Laboratory. [SRDB Ref ID: 152469]

INL [1959–1995b]. Dosimetry records for [REDACTED] 1953–1993. Scoville, ID: Idaho National Laboratory. [SRDB Ref ID: 152470]

INL [1960–1961]. Health physics monthly reports 1960–1961. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. [SRDB Ref ID: 138196]

INL [1962–1964]. Safe work permit burial ground January 1962 – December 1964. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. [SRDB Ref ID: 138194]

INL [1963]. CFA health physics safe work permits 1963. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. [SRDB Ref ID: 141606]

INL [1964–1965]. CFA health physics log sheets December 31, 1964 – December 21, 1965. Scoville, ID: Idaho National Laboratory. [SRDB Ref ID: 141601]

INL [1965]. Photographs of NRTS burial ground. Scoville, ID: Idaho National Laboratory. [SRDB Ref ID: 138921]

INL [1965–1966a]. CFA health physics log sheets January 1965 – December 1966. Scoville, ID: Idaho National Laboratory. [SRDB Ref ID: 139293]

INL [1965–1966b]. CFA health physics safe work permits for January 1965 – January 1966. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. [SRDB Ref ID: 141608]

INL [1965–1968]. Dosimetry records for [REDACTED] Scoville, ID: Idaho National Laboratory. [SRDB Ref ID: 152474]

INL [1965–1970]. Dosimetry records for [REDACTED] Scoville, ID: Idaho National Laboratory. [SRDB Ref ID: 152472]

INL [1967]. Radioactive material shipment records (selected TRA) for incoming off-site shipments 1967. Idaho National Laboratory. [SRDB Ref ID: 152022]

INL [1967–2001]. Dosimetry records for [REDACTED] Scoville, ID: Idaho National Laboratory. [SRDB Ref ID: 152473]

INL [1969]. 1969 burial ground photographs. Scoville, ID: Idaho National Laboratory. [SRDB Ref ID: 142133]

INL [1970–1976]. Burial ground safe work permits 1970–1976. Idaho National Laboratory. Scoville, ID: Idaho Nuclear Corporation. [SRDB Ref ID: 167872]

INL [1975]. Area exposure reports RWMC Y 1975. Idaho National Laboratory. Scoville, ID: Aerojet Nuclear Company. December 31. [SRDB Ref ID: 156620]

INL [1976–1977]. RWMC M area exposure report summary December 1976 through December 1977. Idaho National Laboratory. Scoville, ID: EG&G Idaho. [SRDB Ref ID: 166759]

INL [1978]. RWMC M area exposure report summary 1978. Idaho National Laboratory. Scoville, ID: EG&G Idaho. February 8. [SRDB Ref ID: 166762]

INL [1979]. RWMC M area exposure report summary January – November 1979. Idaho National Laboratory. Scoville, ID: EG&G Idaho. [SRDB Ref ID: 166764]

INL [1979–1980]. RWMC M Area Exposure Report Summary December 1979 – December 1980. Idaho National Laboratory. Scoville, ID: EG&G Idaho. [SRDB Ref ID: 166768]

Johnston LE [1952]. Health physics services provided at the NRTS April 14, 1952. ID-B&M. April 14. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. [SRDB Ref ID: 139103]

McCaslin JW [1962]. J. W. McCaslin correspondence 1962. McC-53-62A. Memorandum to Horan JR. April 20. Idaho Falls, ID: Phillips Petroleum Company, Atomic Energy Division. [SRDB Ref ID: 126068]

McCaslin JW [1963]. Health and safety standard practices manual – whole body counting procedures. 6.24.1. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company, Atomic Energy Division. April 1. [SRDB Ref ID: 132561]

McCaslin JW [1963–1966]. NRTS burial ground reports and plot plans 1963–1966. Idaho National Laboratory. Idaho Falls, ID: Idaho Nuclear Corporation. 1963–1966. [SRDB Ref ID: 152026]

McKinley KB, McKinney JD [1978]. Initial drum retrieval final report. TREE-1286. August. Idaho National Engineering Laboratory. Scoville, ID: EG&G Idaho. [SRDB Ref ID: 83907]

Niccum MR [1969]. An advance planning study of the proposed east extension of the NRTS burial ground November 1969. Idaho National Laboratory. Scoville, ID: Idaho Nuclear Corporation. November. [SRDB Ref ID: 151682]

NIOSH [2015]. SEC petition evaluation report – petition SEC-00219 – Idaho National Laboratory. Rev. 1. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. July 21. [SRDB Ref ID: 156484]

NIOSH [2017a]. SEC petition evaluation report – petition SEC-00219 – Idaho National Laboratory. Rev. 2. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. February 22. [SRDB Ref ID: 166679]

NIOSH [2017b]. Special bioassay and air sampling examples from the INL burial ground 1952–1970. Rev. 0. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. July 28. [SRDB Ref ID: 176497]

NIOSH [2019]. Evaluation of INL burial ground/RWMC post-1970 (SEC00219). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. March 25. [SRDB Ref ID: 176871]

ORAUT [2005]. Application of internal doses based on claimant-favorable assumptions for processing as best estimates. ORAUT-OTIB-0033 Rev. 00. Oak Ridge, TN: Oak Ridge Associated Universities Team. April 20. [SRDB Ref ID: 19457]

ORAUT [2009]. Idaho National Laboratory and Argonne National Laboratory–West – occupational medical dose. ORAUT-TKBS-0007-3 Rev. 02. Oak Ridge, TN: Oak Ridge Associated Universities Team. December 21. [SRDB Ref ID: 77829]

ORAUT [2010a]. Idaho National Laboratory and Argonne National Laboratory–West – occupational environmental dose. ORAUT-TKBS-0007-4 Rev. 02. Oak Ridge, TN: Oak Ridge Associated Universities Team. January 8. [SRDB Ref ID: 78635]

ORAUT [2010b]. Idaho National Laboratory and Argonne National Laboratory–West – occupational internal dose. ORAUT-TKBS-0007-5 Rev. 03. Oak Ridge, TN: Oak Ridge Associated Universities Team. March 2. [SRDB Ref ID: 79571]

ORAUT [2011]. Idaho National Laboratory and Argonne National Laboratory–West – occupational external dose. ORAUT-TKBS-0007-6 Rev. 03. Oak Ridge, TN: Oak Ridge Associated Universities Team. April 19. [SRDB Ref ID: 94104]

ORAUT [2014a]. Technical information bulletin: fission and activation product assignment for internal dose-related gross beta and gross gamma analyses. ORAUT-OTIB-0054 Rev. 02. Oak Ridge, TN: Oak Ridge Associated Universities Team. March 6. [SRDB Ref ID: 130852]

ORAUT [2014b]. Internal dose reconstruction. ORAUT-OTIB-0060 Rev. 01. Oak Ridge, TN: Oak Ridge Associated Universities Team. September 8. [SRDB Ref ID: 135808]

ORAUT [2016a]. Documented communication with [REDACTED] on INL November 8, 2016. Oak Ridge, TN: Oak Ridge Associated Universities Team. November 8. [SRDB Ref ID: 166588]

ORAUT [2016b]. Documented communication SEC-00219 with [REDACTED]on Idaho National Laboratory February 16, 2016. Oak Ridge, TN: Oak Ridge Associated Universities Team. February 16. [SRDB Ref ID: 159722]

ORAUT [2016c]. Documented communication with [REDACTED] on Idaho National Laboratory January 25, 2016. Oak Ridge, TN: Oak Ridge Associated Universities Team. January 25. [SRDB Ref ID: 166027]

ORAUT [2016d]. Documented communication SEC-00219 with [REDACTED] on Idaho National Laboratory February 16, 2016. Oak Ridge, TN: Oak Ridge Associated Universities Team. February 16. [SRDB Ref ID: 159716]

ORAUT [2016e]. Documented Communication SEC-00219 with [REDACTED] on Idaho National Laboratory January 25, 2016. Oak Ridge, TN: Oak Ridge Associated Universities Team, January 25. [SRDB Ref ID: 159728]

ORAUT [2016f]. Documented communication with [REDACTED] on Idaho National Laboratory November 9, 2016. Oak Ridge, TN: Oak Ridge Associated Universities Team. November 9. [SRDB Ref ID: 166572]

ORAUT [2016g]. Documented communication with site expert [REDACTED] on Idaho National Laboratory January 26 and 27, 2016. Oak Ridge, TN: Oak Ridge Associated Universities Team. January 25 and 27. [SRDB Ref ID: 166550]

ORAUT [2018a]. Documented communication SEC-00219 with [REDACTED] on knowledge of radiation practices at Idaho National Laboratory June 7, 2018. Oak Ridge, TN: Oak Ridge Associated Universities Team. June 7. [SRDB Ref ID: 172630]

ORAUT [2018b]. Documented communication SEC-00219 with [REDACTED] on knowledge of radiation practices at Idaho National Laboratory June 5, 2018. Oak Ridge, TN: Oak Ridge Associated Universities Team. June 5. [SRDB Ref ID: 172637]

Piccot AR [1955]. CFA health physics monthly report November 1–30, 1955. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. [SRDB Ref ID: 178615]

Piccot AR [1956]. Procedure for routine radioactive waste disposal. Memorandum to Williams P and Strupp B. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. February 21. [SRDB Ref ID: 178686]

Sauvignac BF [1956]. CFA health physics monthly reports for October 31 through December 31, 1956. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. [SRDB Ref ID: 125818]

Sauvignac BF [1956–1957]. CFA health physics monthly report October 1956–November 1957. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. [SRDB Ref ID: 141919]

Sauvignac BF [1958a]. CFA health physics monthly report for January 1958. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. [SRDB Ref ID: 138747]

Sauvignac BF [1958b]. CFA health physics monthly report for February 1958. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. [SRDB Ref ID: 138745]

Sauvignac BF [1958c]. CFA health physics monthly report for March 1958. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. [SRDB Ref ID: 138744]

Sauvignac BF [1958d]. CFA health physics monthly report for December 1958. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. [SRDB Ref ID: 125932]

Sauvignac BF [1959a]. CFA health physics monthly reports 1959. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. [SRDB Ref ID: 138763]

Sauvignac BF [1959b]. CFA health physics monthly report for August 1959. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. [SRDB Ref ID: 178618]

Sauvignac BF [1959c]. CFA health physics monthly report for December 1959. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. [SRDB Ref ID: 138756]

Sauvignac BF [1960]. CFA health physics monthly reports for January through December 1960. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. [SRDB Ref ID: 178619]

Sauvignac BF [1961]. CFA health physics monthly report for 1961; Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. [SRDB Ref ID: 139258]

Sauvignac BF [1962]. CFA health physics monthly reports for 1962. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. [SRDB Ref. ID 139106]

Sauvignac BF [1963]. CFA health physics monthly reports January - November 1963. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company. [SRDB Ref ID: 138704]

Sauvignac BF [1965-1966]. CFA health physics monthly reports January 1965 – December 1966. Idaho National Laboratory. Idaho Falls, ID: Phillips Petroleum Company (Jan65–May66); Idaho Nuclear (Jun65–Dec66). [SRDB Ref ID: 139207]

Vejvoda E [2005]. Summary of Rocky Flats Plant waste buried in the subsurface disposal area April 2005. ICP/EXT-04-00717 Rev 0. Idaho National Laboratory. Scoville, ID: Bechtel BWXT Idaho. April. [SRDB Ref ID: 33009]

Wehmann G [1962]. Health physics practices at the NRTS burial ground. Internal memorandum to Gammill WP. Idaho Falls, ID: U.S. Atomic Energy Commission, Idaho Operations Office. May 16. [SRDB Ref ID: 141859]

APPENDIX A: MONITORING RECORDS FROM IDENTIFIED BURIAL GROUND WORKERS

SCA-TR-2017-SEC007 presents a detailed review of the INL claimant population with covered employment during the 1952–1970 time period [Fitzgerald and Barton 2017]. As rightly pointed out, a claimant cannot easily be identified as a Burial Ground worker compared to most INL areas (e.g., CPP and Materials Test Reactor [MTR] workers). The Location File Cards (LFC) for former INL workers typically listed each facility and external monitoring time period at the facility. Because the Burial Ground was sparsely used and did not have an assigned area external dosimetry code, Burial Ground workers cannot easily be identified using the LFCs. The first known area exposure report for the Burial Ground area (renamed the RWMC at that time) was not until 1975, thus providing no help in identifying Burial Ground workers during the 1952–1970 era. Interestingly, even when area exposure reports began for the RWMC, there were very few workers listed. For example, in 4Q 1975 there were only 49 workers monitored during the three-month period [INL 1975, PDF p. 2]. The RWMC monthly exposure reports for the years 1976 through 1980 only have between 17 and 44 workers listed per month; even with an increased work scope in the 1970s, there were not many RWMC workers [INL 1976–1977, 1978, 1979, 1979–1980].

The claimant population review performed by SC&A [Fitzgerald and Barton 2017, Appendix A] focused on likely job titles, which included equipment operator, truck driver, laborer, and yardman (a term used for workers from a general labor pool). These would have been the most likely occupations at the Burial Ground from 1952–1970. Eleven dose reconstruction claims were found to definitively contain information placing the claimant at the Burial Ground during the period under evaluation with data from the claimant documentation presented.

During development of the SEC-00219 ER, the 1969–1970 time period for the Burial Ground was reserved pending additional research and evaluation; thus, it was not included in Revisions 0 and 1. The time period was reserved due to the discovery of a waste exhumation and retrieval effort conducted in November 1969. This marked the first known attempt to exhume waste at the Burial Ground and was of concern to NIOSH due to the potential for internal exposure because of the nature of the work. A thorough investigation into the waste exhumation and retrieval effort was completed and the analysis and conclusions were provided in Rev. 2 of the SEC-00219 ER. NIOSH determined that continuous health physics coverage was provided during the waste exhumation and retrieval effort with no apparent contamination issues. Bioassay records were reviewed for personnel known to be involved, and none of the workers was placed on special bioassay as a result of the work.

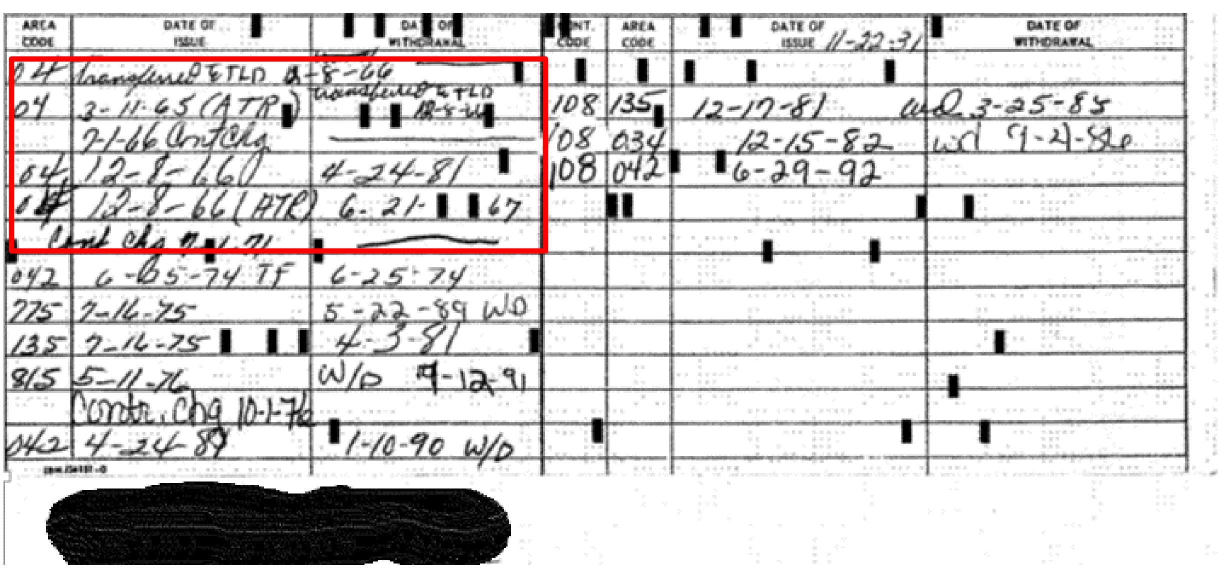
The major focus of NIOSH's additional research was the identification of the workers involved with the waste exhumation and retrieval effort to determine what radiological monitoring had been provided. Photographic records of the waste exhumation and retrieval were discovered during a data capture trip to the INL Records Storage Center. The identities of the workers in the photos were determined during an in-person interview with a former Burial Ground HP technician as well as from a list of potential names generated during a review of documentation that included CFA external dosimetry records [ORAUT 2016g]. The monitoring records for all six workers involved with the November 1969 waste exhumation and retrieval were requested. This was important because it positively identified workers known to have worked at the Burial Ground. Pertinent monitoring records for all six workers are provided in this appendix. They are referred to as Worker No. 1 through Worker No. 6 with occupation and first year of employment at INL provided. The LFC and pertinent monitoring data are provided for these six workers.

Worker No. 1

[JOB TITLE REDACTED]

Started work at INL in 1959

Figure A-1 shows a Location File Card for Worker No. 1, who is known to have worked at the Burial Ground [INL 1959–1995a, PDF p. 20]. All *in-vitro* and *in-vivo* bioassay data for this worker are coded 04 for the Test Reactor Area. It is not until 1976 that Burial Ground (area code 815) appears as the worker's facility on bioassay records. NIOSH believes that Worker No. 1 may have been an HP supervisor at the Test Reactor Area at the time and also served as a fill-in supervisor for the CFA when needed.



AREA CODE	DATE OF ISSUE	DATE OF WITHDRAWAL	ENT. CODE	AREA CODE	DATE OF ISSUE	DATE OF WITHDRAWAL
04	transferred to TLD 2-8-66					
04	3-11-65 (ATR)	transferred to TLD 12-8-66	108	135	12-17-81	wd 3-25-85
	2-1-66 Cont Chg		108	034	12-15-82	wd 9-24-86
04	12-8-66	4-24-81	108	042	6-29-92	
04	12-8-66 (ATR)	6-21-67				
	Cont chg 7-1-71					
042	6-25-74 TF	6-25-74				
775	7-16-75	5-22-89 WD				
135	7-16-75	4-3-81				
815	5-11-76	W/D 9-12-91				
	Contr. Chg 10-1-76					
042	4-24-89	1-10-90 W/D				

[redacted]

Figure A-1. Location file card for Worker No. 1.

Figure A-2 below shows a Quarterly Exposure Summary for 4Q 1969 that includes Worker No. 1 (denoted by the handwritten star in the lower left) [INL 1959-1995a, PDF p. 228]. Once again, the area code is 04 for TRA.

[redacted]

QUARTERLY EXPOSURE SUMMARY — PAGE 38

CONTRACTOR IDAHO NUCLEAR CORP — CODE 124 — PERIOD 09/28/69 TO 12/31/69

IDOL BADGE PAYROLL NUMBER NUMBER AREA REAS IRR. CODE CODE CODE	CONT CODE	NAME / DATE / NEW DETAILS B G N	CURRENT QUARTER B	G	N	CURRENT YEAR BETA	GAMMA	NEUTRON	NRTS TO DATE BETA	GAMMA	NEUTRON	TOTAL PEN	YR BANK
[redacted]	124	[redacted]	0	0	0	0	0	0	60	300	0	300	246
[redacted]	124	[redacted]	80	230	0	80	1155	0	4940	17200	170	17370	
[redacted]	124	[redacted]	65	0	0	65	0	0	545	3045	50	3095	
[redacted]	124	[redacted]	380	940	0	1805	9630	0	4775	8965	0	8965	
[redacted]	124	[redacted]	0	0	0	0	0	0	20	95	0	95	
[redacted]	124	[redacted]	INACTIVE			0	0	0	490	7560	40	7600	
[redacted]	124	[redacted]	30	270	0	30	510	0	640	10310	80	10390	
[redacted]	124	[redacted]	0	0	0	0	0	0	90	980	0	980	
[redacted]	124	[redacted]	0	0	0	0	0	0	35	1110	146	1256	
[redacted]	124	[redacted]	0	50	0	0	155	0	5185	16275	70	16345	
[redacted]	124	[redacted]	0	0	0	0	0	0	2950	12305	73	12378	
[redacted]	124	[redacted]	0	0	0	0	70	0	2620	13845	70	13915	
[redacted]	124	[redacted]	0	0	0	0	50	0	4045	11100	80	11180	
[redacted]	124	[redacted]	0	0	0	0	0	0	1920	11780	80	11860	
[redacted]	124	[redacted]	0	0	0	0	30	0	4560	14880	220	15100	
[redacted]	124	[redacted]	0	0	0	0	0	0	20	160	0	160	
[redacted]	124	[redacted]	0	0	0	0	0	0	345	3605	0	3605	
[redacted]	124	[redacted]	INACTIVE			0	250	0	50	5875	26	5901	
[redacted]	124	[redacted]	0	0	0	0	0	0	415	3885	40	3925	
[redacted]	124	[redacted]	0	0	0	0	0	0	200	2230	70	2300	

Figure A-2. 4th quarter 1969 area exposure report for Worker No. 1.

Worker No. 2

[JOB TITLE REDACTED]

Started work at INL in 1953

Figure A-3 shows a Location File Card for Worker No. 2, who is known to have worked at the Burial Ground [INL 1959–1995b, PDF p. 60].

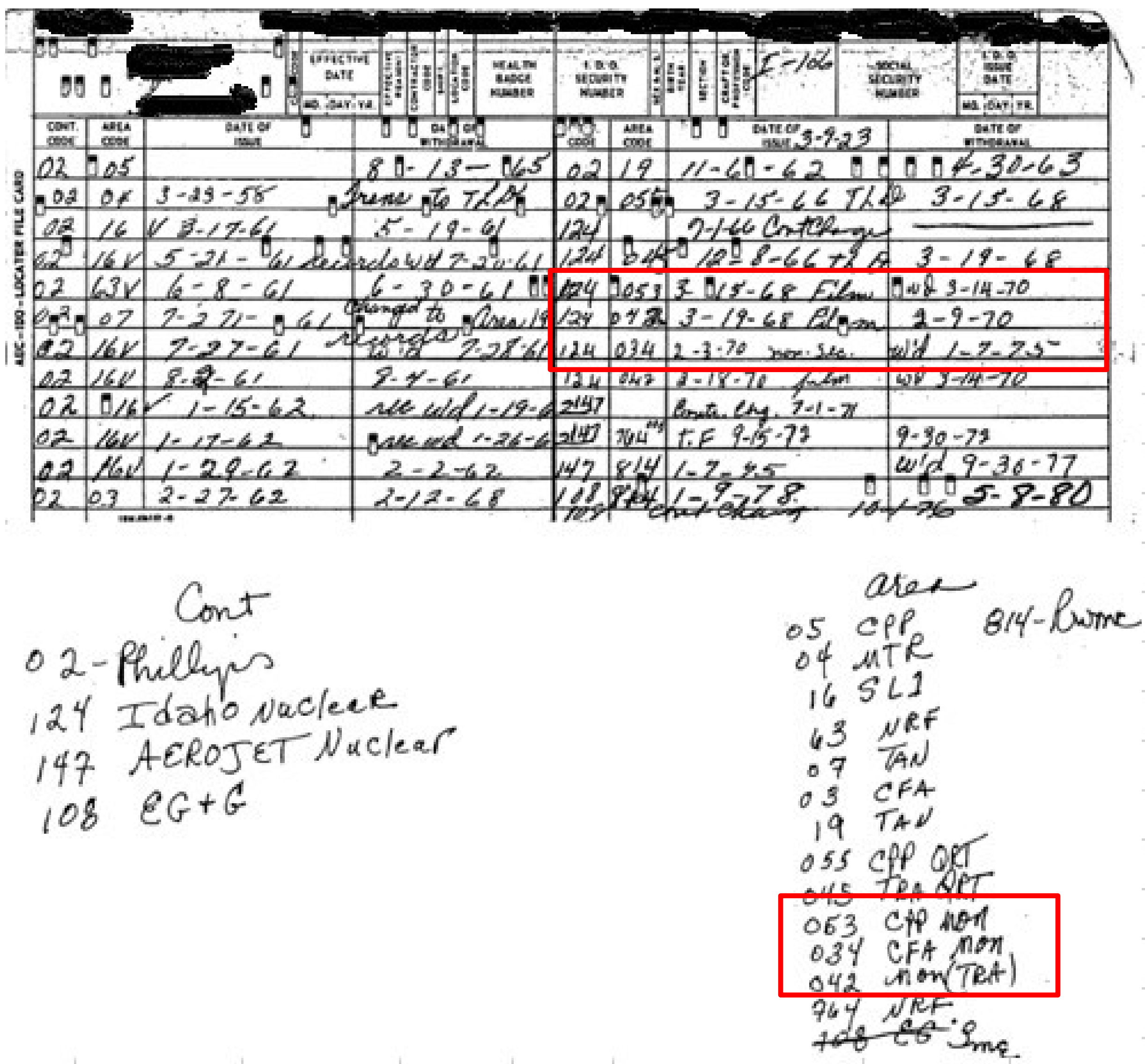


Figure A-3. Location file card for Worker No. 2.

Table A-1 shows the available *in-vitro* bioassay data for Worker No. 2 following a record search up to 1971. Of note are three special urine bioassay samples. Although the facility is designated CFA for two of the three samples, the sample dates align with the SL-1 accident and therefore the likely reason for the samples is that accident. SL-1 is identified as the facility for the February 15, 1961 sample.

Table A-1. *In-vitro* bioassay data for Worker No. 2.

Sample Date	Type	Sample Matrix	Analyte	Activity	Uncertainty	Unit	Area
[m/d]/1954	Not Specified	Urine	Beta	36	8	dpm	CFA
[m/d]/1955	Routine	Urine	Beta	0	20	dpm	CFA
[m/d]/1955	Routine	Urine	Beta	10	20	dpm	CFA
[m/d]/1957	Routine	Urine	Beta	20	20	dpm	CFA
[m/d]/1958	Routine	Urine	Beta	10	20	dpm	CFA
[m/d]/1958	Routine	Urine	Beta	0	20	dpm	Not Specified
[m/d]/1959	Not Specified	Urine	Beta	0	12	dpm	Not Specified
[m/d]/1960	Routine	Urine	Beta	8	12	dpm	CFA
[m/d]/1961	Special	Urine	Gamma	42	52	dpm	CFA
[m/d]/1961	Special	Urine	Gamma	0	80	dpm	CFA
[m/d]/1961	Routine	Urine	Gamma	0	80	dpm	CFA
[m/d]/1961	Special	Urine	Sr	0	2	dpm	SL-1
[m/d]/1962	Routine	Urine	Gamma	36	84	dpm	CFA
[m/d]/1962	Routine	Urine	Sr	8	8	dpm	CFA
[m/d]/1963	Routine	Urine	Gamma	16	84	dpm	CFA
[m/d]/1964	Routine	Urine	Gamma	28	88	dpm	CFA
[m/d]/1965	Routine	Urine	Gamma	0	88	dpm	CFA
[m/d]/1965	Routine	Urine	Sr	2	2	dpm	CFA

Table A-2 shows the available *in-vivo* bioassay data for Worker No. 2 following a record search up to 1971.

Table A-2. *In-vivo* bioassay data for Worker No. 2.

Count Date	Count Type	Type	Area
[m/d]/1964	WBC	Routine	CFA
[m/d]/1965	WBC	Routine	CFA
[m/d]/1969	WBC	Routine	CFA

Because the Burial Ground was a very lightly-trafficked facility with no assigned personnel, personnel who visited there were from other facilities, and thus, were included in the area exposure reports for their facilities of origin. The example shown in Figure A-4 is for a worker known to have worked at the Burial Ground but who was obviously assigned to TRA [INL 1959–1995b, PDF p. 625].

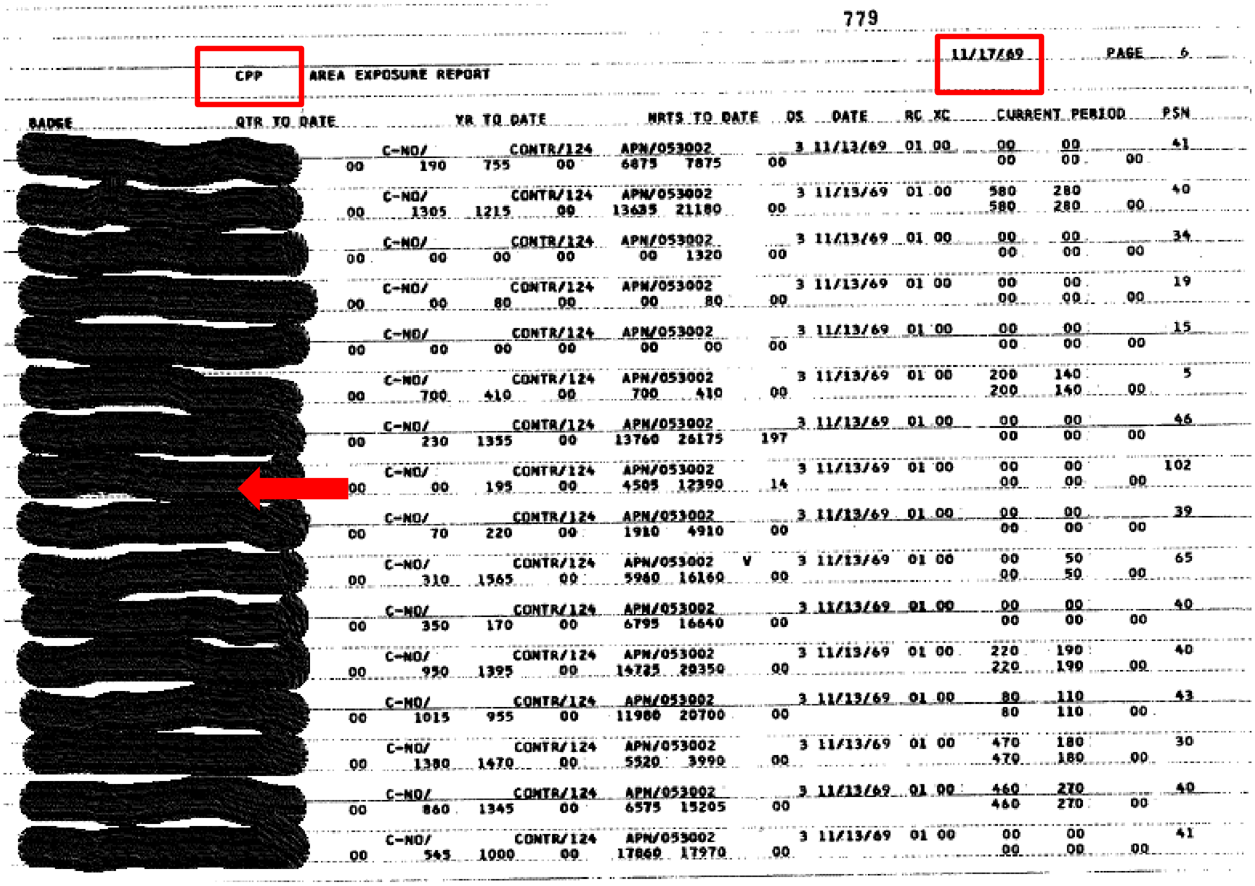
[redacted]

TRA AREA EXPOSURE REPORT — 11/20/69 — PAGE 15 — 630

BADGE	QTR TO DATE		YR TO DATE		NRTS TO DATE		DS	DATE	RC XC	CURRENT PERIOD			PSN
[redacted]		C-NO/		CONTR/124	APN/042002		3	11/10/69	06 00	200	180		40
						042002	3	11/19/69	01 00	00	180		041
	00	2565	3210	00	3325	4305	00			200	360	00	
[redacted]		C-NO/		CONTR/124	APN/042002		3	11/12/69	06 00	00	320		37
						042002	3	11/19/69	01 00	00	00		038
	00	245	1185	00	245	2130	00			00	320	00	
[redacted]		C-NO/		CONTR/124	APN/042002		3	11/18/69	04 00	00	00		34
	00	760	2240	00	760	3130	00			00	00	00	
[redacted]		C-NO/		CONTR/124	APN/042002		3	11/19/69	01 00	00	00		91
	00	00	95	00	1130	19950	278			00	00	00	
[redacted]		C-NO/		CONTR/124	APN/042002		3	11/14/69	06 00	00	460		91
						042002	3	11/19/69	01 00	00	140		092
	00	120	3160	00	1210	20755	357			00	600	00	
[redacted]		C-NO/		CONTR/124	APN/042002		3	11/19/69	01 00	00	00		83
	00	00	325	00	10	6990	516			00	00	00	
[redacted]		C-NO/		CONTR/124	APN/042002		3	11/19/69	01 00	00	00		80
	00	00	[illegible]	00	205	11280	472			00	00	00	
[redacted]		C-NO/		CONTR/124	APN/042002		3	11/19/69	01 00	00	00		103
	00	00	199	00	4505	12390	14			00	00	00	
[redacted]		C-NO/		CONTR/124	APN/042002		3	11/19/69	01 00	00	260		20
	00	00	1175	00	00	1175	00			00	260	00	
[redacted]		C-NO/		CONTR/124	APN/042002		3	11/19/69	01 00	00	00		81
	00	00	1270	00	9975	11550	00			00	00	00	
[redacted]		C-NO/		CONTR/124	APN/042002		3	11/19/69	01 00	00	00		91
	00	2320	1195	00	11285	25550	728			00	00	00	
[redacted]		C-NO/		CONTR/124	APN/042002		3	11/19/69	01 00	00	00		82
	00	00	429	00	2005	12285	206			00	00	00	
[redacted]		C-NO/		CONTR/124	APN/042002		3	11/19/69	01 00	00	350		97
	00	00	1095	00	2730	33050	154			00	350	00	
[redacted]		C-NO/		CONTR/124	APN/042002		3	11/19/69	01 00	00	00		93
	00	00	1065	00	3585	39555	95			00	00	00	
[redacted]		C-NO/		CONTR/124	APN/042002		3	11/19/69	01 00	00	00		87
	00	00	795	00	155	10835	28			00	00	00	

Figure A-4. Worker No. 2 on November 1969 TRA area exposure report.

The example shown in Figure A-5 is for the same worker but shows up on the CPP area exposure report during the same month and year [INL 1959–1995b, PDF p. 706].


779

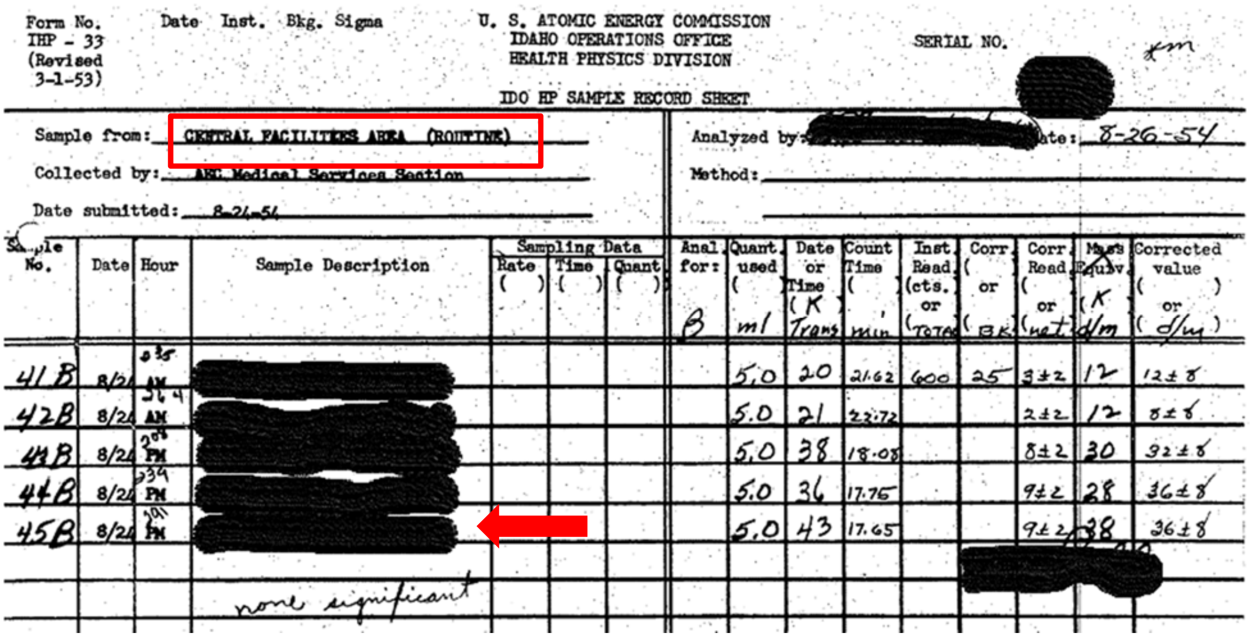
CPP AREA EXPOSURE REPORT 11/17/69 PAGE 6

BADGE	QTR TO DATE		YR TO DATE		MRTS TO DATE		DS	DATE	RC XC	CURRENT PERIOD			PSN
[redacted]		C-NO/		CONTR/124	APN/053002			3 11/13/69	01 00	00	00		41
	00	190	755	00	6875	7875	00			00	00	00	
[redacted]		C-NO/		CONTR/124	APN/053002			3 11/13/69	01 00	580	280		40
	00	1305	1215	00	13635	21180	00			580	280	00	
[redacted]		C-NO/		CONTR/124	APN/053002			3 11/13/69	01 00	00	00		34
	00	00	00	00	00	1320	00			00	00	00	
[redacted]		C-NO/		CONTR/124	APN/053002			3 11/13/69	01 00	00	00		19
	00	00	80	00	00	80	00			00	00	00	
[redacted]		C-NO/		CONTR/124	APN/053002			3 11/13/69	01 00	00	00		15
	00	00	00	00	00	00	00			00	00	00	
[redacted]		C-NO/		CONTR/124	APN/053002			3 11/13/69	01 00	200	140		5
	00	700	410	00	700	410	00			200	140	00	
[redacted]		C-NO/		CONTR/124	APN/053002			3 11/13/69	01 00	00	00		46
	00	230	1355	00	13760	26175	197			00	00	00	
[redacted]		C-NO/		CONTR/124	APN/053002			3 11/13/69	01 00	00	00		102
	00	00	195	00	4505	12390	14			00	00	00	
[redacted]		C-NO/		CONTR/124	APN/053002			3 11/13/69	01 00	00	00		39
	00	70	220	00	1910	4910	00			00	00	00	
[redacted]		C-NO/		CONTR/124	APN/053002	V		3 11/13/69	01 00	00	50		65
	00	310	1565	00	5960	16160	00			00	50	00	
[redacted]		C-NO/		CONTR/124	APN/053002			3 11/13/69	01 00	00	00		40
	00	350	170	00	6795	16640	00			00	00	00	
[redacted]		C-NO/		CONTR/124	APN/053002			3 11/13/69	01 00	220	190		40
	00	950	1395	00	14725	20350	00			220	190	00	
[redacted]		C-NO/		CONTR/124	APN/053002			3 11/13/69	01 00	80	110		43
	00	1015	955	00	11980	20700	00			80	110	00	
[redacted]		C-NO/		CONTR/124	APN/053002			3 11/13/69	01 00	470	180		30
	00	1380	1470	00	5520	3990	00			470	180	00	
[redacted]		C-NO/		CONTR/124	APN/053002			3 11/13/69	01 00	460	270		40
	00	860	1345	00	6575	15205	00			460	270	00	
[redacted]		C-NO/		CONTR/124	APN/053002			3 11/13/69	01 00	00	00		41
	00	545	1000	00	17860	17970	00			00	00	00	

Figure A-5. Worker No. 2 on November 1969 CPP area exposure report.

Figure A-6 shows an *in-vitro* bioassay result for Worker No. 2 [INL 1959–1995b, PDF p. 177].

Figure A-7 shows a 1969 whole body count for Worker No. 2; note that MTR is listed as the worker's facility, but the results were to be sent to CFA according to the address [INL 1959–1995b, PDF p. 1266].



Form No. IHP - 33 (Revised 3-1-53) | Date | Inst. | Bkg. | Sigma

U. S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
HEALTH PHYSICS DIVISION

SERIAL NO. [redacted]

IDO HP SAMPLE RECORD SHEET

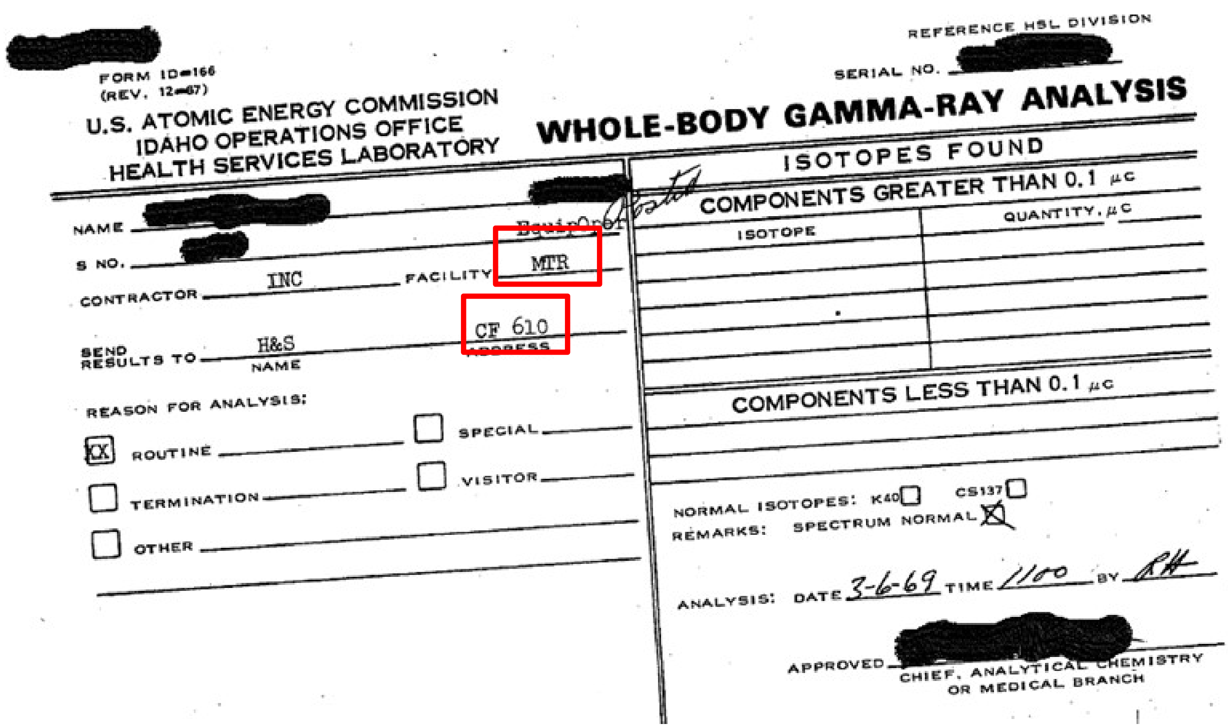
Sample from: CENTRAL FACILITIES AREA (ROUTINE)
Collected by: AEC Medical Services Section
Date submitted: 8-24-54

Analyzed by: [redacted] Date: 8-26-54
Method:

Sample No.	Date	Hour	Sample Description	Sampling Data Rate ( )	Time ( )	Quant ( )	Anal for: β	Quant. used (ml)	Date or Time (K Trans)	Count Time (min)	Inst. Read (cts. or Total)	Corr (or BK)	Corr Read (or net)	Mass Equiv. (K d/m)	Corrected value (or d/m)
41B	8/24	8:35 AM	[redacted]					5.0	20	21.62	600	25	3±2	12	12±8
42B	8/24	9:04 AM	[redacted]					5.0	21	22.72			2±2	12	8±8
44B	8/24	2:08 PM	[redacted]					5.0	38	18.08			8±2	30	32±8
44B	8/24	2:39 PM	[redacted]					5.0	36	17.75			9±2	28	36±8
45B	8/24	3:01 PM	[redacted]					5.0	43	17.65			9±2	38	36±8

none significant [redacted]

Figure A-6. Example of *In-Vitro* Bioassay Result for Worker No. 2.



[redacted]

FORM ID-166 (REV. 12-67)

REFERENCE HSL DIVISION
SERIAL NO. [redacted]

U.S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
HEALTH SERVICES LABORATORY

WHOLE-BODY GAMMA-RAY ANALYSIS

NAME [redacted] [redacted] EquipOper
S NO. [redacted]
CONTRACTOR INC FACILITY MTR
SEND RESULTS TO H&S (NAME) CF 610 (ADDRESS)

REASON FOR ANALYSIS:
[X] ROUTINE
[ ] TERMINATION
[ ] OTHER
[ ] SPECIAL
[ ] VISITOR

ISOTOPES FOUND
COMPONENTS GREATER THAN 0.1 µc
ISOTOPE | QUANTITY, µc

COMPONENTS LESS THAN 0.1 µc

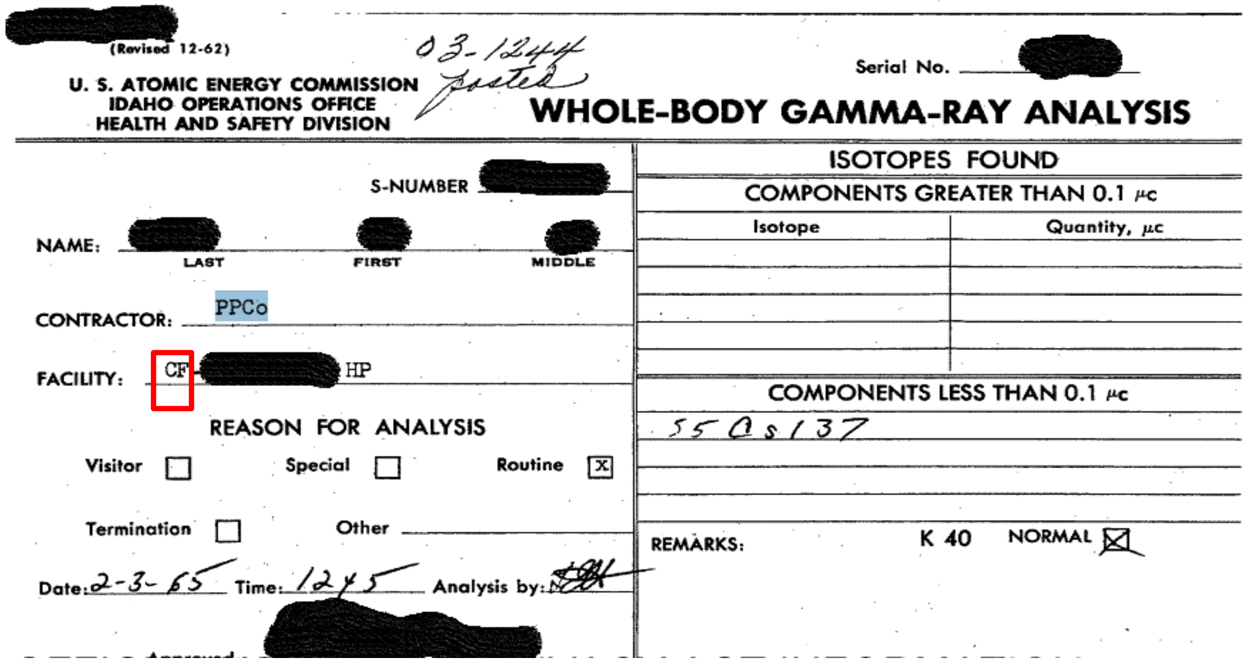
NORMAL ISOTOPES: K40 [ ] CS137 [ ]
REMARKS: SPECTRUM NORMAL [X]

ANALYSIS: DATE 3-6-69 TIME 1100 BY RH

APPROVED [redacted]
CHIEF, ANALYTICAL CHEMISTRY OR MEDICAL BRANCH

Figure A-7. 1969 whole body count for Worker No. 2.

Figure A-8 shows a 1965 whole body count for Worker No. 2 [INL 1959–1995b, PDF p. 1237]. Figure A-9 shows a 1964 whole body count for Worker No. 2 [INL 1959–1995b, PDF p. 1234].


[redacted] (Revised 12-62)
03-1244
posted
U. S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
HEALTH AND SAFETY DIVISION
Serial No. [redacted]

WHOLE-BODY GAMMA-RAY ANALYSIS

S-NUMBER [redacted]

NAME: [redacted] (LAST) [redacted] (FIRST) [redacted] (MIDDLE)

CONTRACTOR: PPCo

FACILITY: CF [redacted] HP

REASON FOR ANALYSIS

Visitor ☐ Special ☐ Routine ☒

Termination ☐ Other

Date: 2-3-65 Time: 1245 Analysis by: [illegible]

Approved: [redacted]

ISOTOPES FOUND

COMPONENTS GREATER THAN 0.1 μc

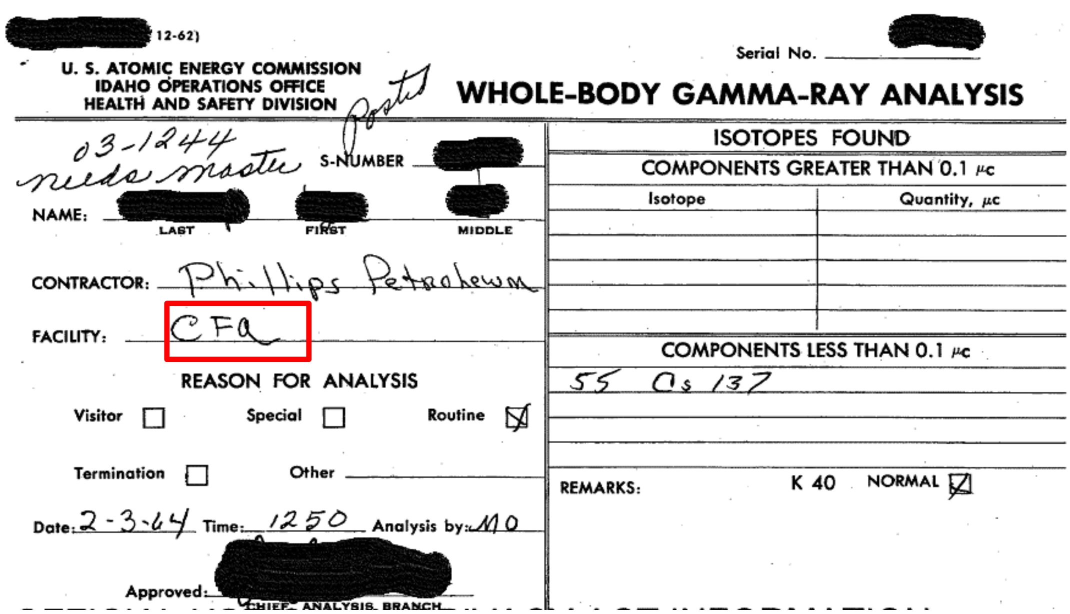
Isotope	Quantity, μc

COMPONENTS LESS THAN 0.1 μc

55 Cs 137

REMARKS: K 40 NORMAL ☒

Figure A-8. 1965 whole body count for Worker No. 2.


[redacted] 12-62)
U. S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
HEALTH AND SAFETY DIVISION
posted
Serial No. [redacted]

WHOLE-BODY GAMMA-RAY ANALYSIS

03-1244
needs master
S-NUMBER [redacted]

NAME: [redacted] (LAST) [redacted] (FIRST) [redacted] (MIDDLE)

CONTRACTOR: Phillips Petroleum

FACILITY: CFA

REASON FOR ANALYSIS

Visitor ☐ Special ☐ Routine ☒

Termination ☐ Other

Date: 2-3-64 Time: 1250 Analysis by: MO

Approved: [redacted] CHIEF, ANALYSIS BRANCH

ISOTOPES FOUND

COMPONENTS GREATER THAN 0.1 μc

Isotope	Quantity, μc

COMPONENTS LESS THAN 0.1 μc

55 Cs 137

REMARKS: K 40 NORMAL ☒

Figure A-9. 1964 whole body count for Worker No. 2.

Worker No. 3

[JOB TITLE REDACTED]

Started work at INL in 1956

Figure A-10 shows a Location Card File for Worker No. 3 [INL 1950–1985, PDF p. 21].

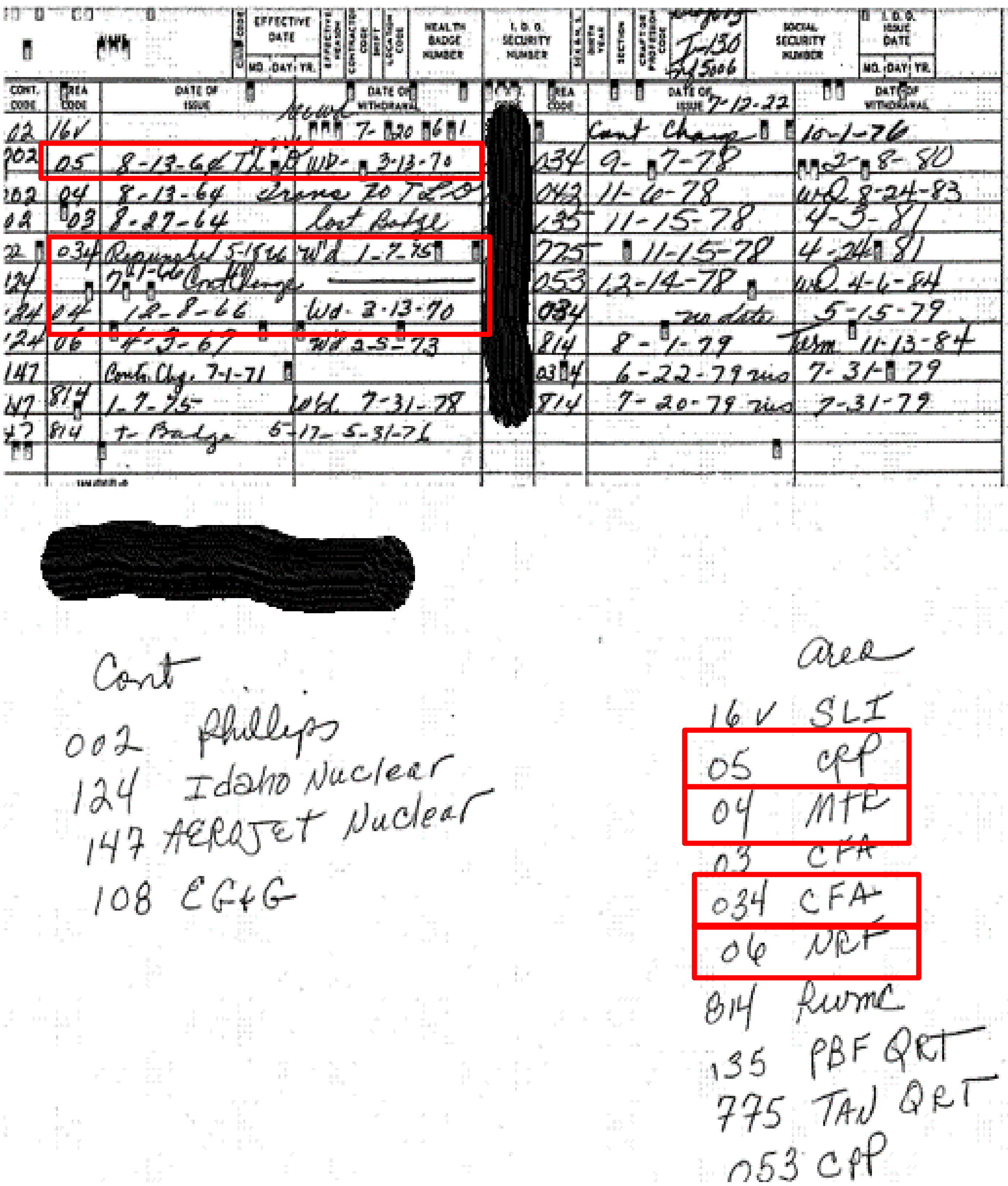
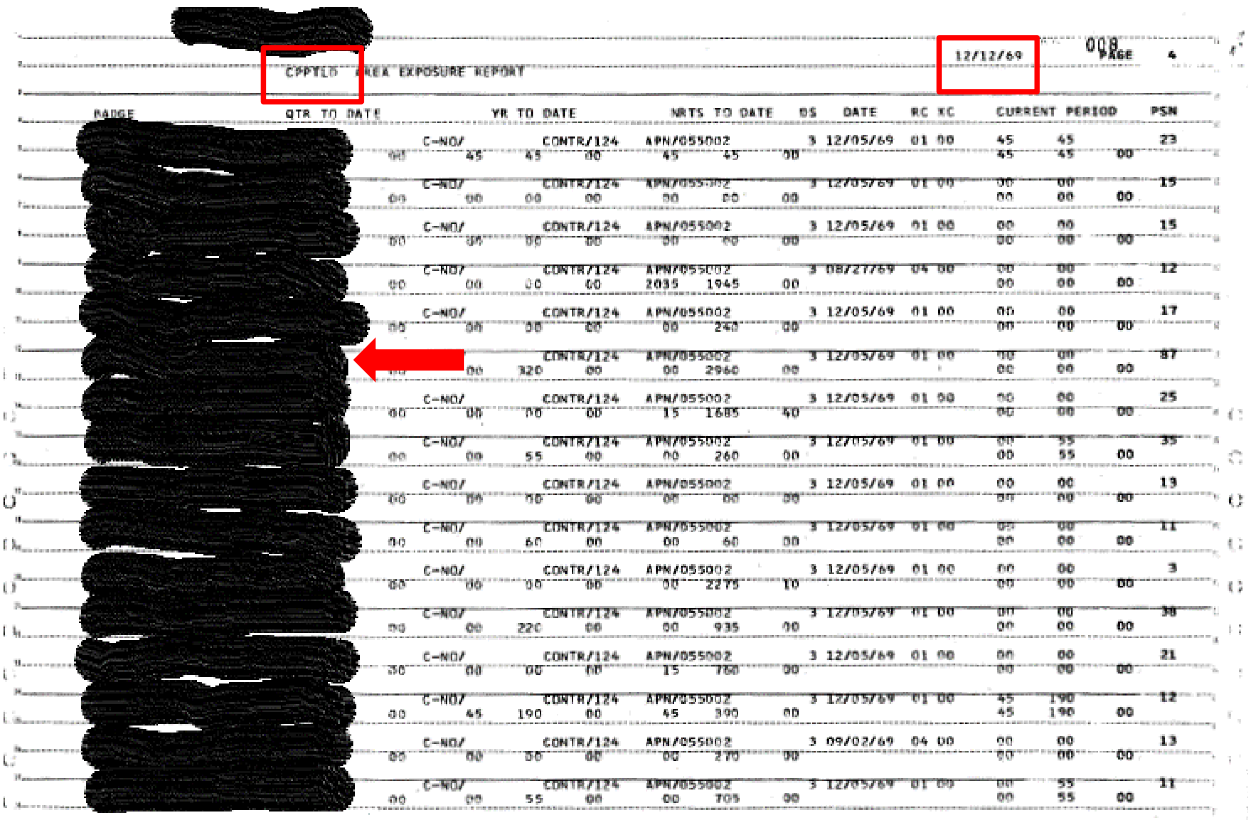


Figure A-10. location file card for Worker No. 3.

Figure A-11 shows Worker 3 on the 4Q 1969 CPP TLD Area Exposure Report [INL 1950–1985, PDF p. 315]. Table A-3 shows the available *in-vitro* bioassay data for Worker No. 3 following a record search up to 1971.


[redacted]

CPPTLD AREA EXPOSURE REPORT 12/12/69 008 PAGE 4

BADGE	QTR TO DATE			YR TO DATE		NRTS TO DATE		DS	DATE	RC XC	CURRENT PERIOD			PSN
[redacted]		C-NO/		CONTR/124		APN/055002		3	12/05/69	01 00	45	45		23
	00	45	45	00	45	45	00				45	45	00	
		C-NO/		CONTR/124		APN/055002		3	12/05/69	01 00	00	00		15
	00	00	00	00	00	00	00				00	00	00	
		C-NO/		CONTR/124		APN/055002		3	12/05/69	01 00	00	00		15
	00	00	00	00	00	00	00				00	00	00	
		C-NO/		CONTR/124		APN/055002		3	08/27/69	04 00	00	00		12
	00	00	00	00	2035	1945	00				00	00	00	
		C-NO/		CONTR/124		APN/055002		3	12/05/69	01 00	00	00		17
	00	00	00	00	00	240	00				00	00	00	
				CONTR/124		APN/055002		3	12/05/69	01 00	00	00		87
		00	320	00	00	2960	00				00	00	00	
		C-NO/		CONTR/124		APN/055002		3	12/05/69	01 00	00	00		25
	00	00	00	00	15	1685	40				00	00	00	
		C-NO/		CONTR/124		APN/055002		3	12/05/69	01 00	00	55		35
	00	00	55	00	00	260	00				00	55	00	
		C-NO/		CONTR/124		APN/055002		3	12/05/69	01 00	00	00		13
	00	00	00	00	00	00	00				00	00	00	
		C-NO/		CONTR/124		APN/055002		3	12/05/69	01 00	00	00		11
	00	00	60	00	00	60	00				00	00	00	
		C-NO/		CONTR/124		APN/055002		3	12/05/69	01 00	00	00		3
	00	00	00	00	00	2275	10				00	00	00	
		C-NO/		CONTR/124		APN/055002		3	12/05/69	01 00	00	00		38
	00	00	220	00	00	935	00				00	00	00	
		C-NO/		CONTR/124		APN/055002		3	12/05/69	01 00	00	00		21
	30	00	00	00	15	760	00				00	00	00	
		C-NO/		CONTR/124		APN/055002		3	12/05/69	01 00	45	190		12
	00	45	190	00	45	390	00				45	190	00	
		C-NO/		CONTR/124		APN/055002		3	09/02/69	04 00	00	00		13
	00	00	00	00	00	270	00				00	00	00	
		C-NO/		CONTR/124		APN/055002		3	12/05/69	01 00	00	55		11
	00	00	55	00	00	705	00				00	55	00	

Figure A-11. Worker No. 3 on 4th quarter 1969 CPP TLD area exposure report.

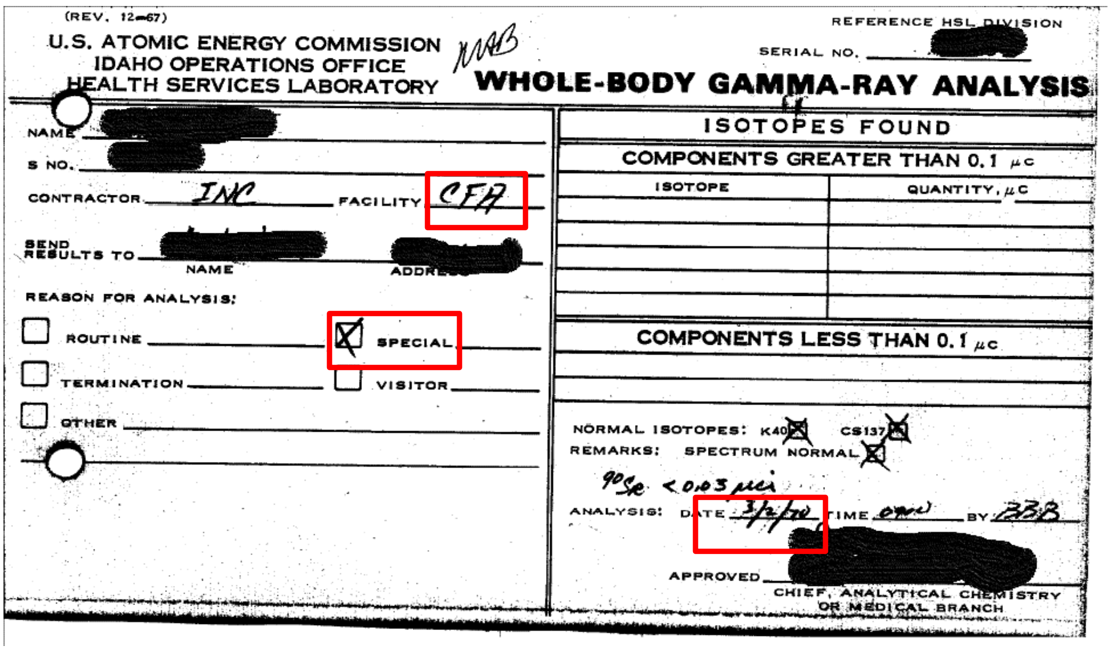
Table A-3. *In-vitro* bioassay data for Worker No. 3.

Sample Date	Type	Sample Matrix	Analyte	Activity	Uncertainty	Unit	Area
[m/d]/1956	Routine	Urine	Beta	0	20	dpm	CFA
[m/d]/1959	Not Specified	Urine	Beta	0	12	dpm	CFA
[m/d]/1961	Routine	Urine	Gamma	0	84	dpm	CFA
[m/d]/1961	Routine	Urine	Sr	12	8	dpm	CFA
[m/d]/1962	Routine	Urine	Gamma	0	84	dpm	CFA
[m/d]/1962	Routine	Urine	Sr	2	2	dpm	CFA
[m/d]/1965	Routine	Urine	Sr	8	2	dpm	CFA
[m/d]/1965	Routine	Urine	Gamma	9	88	dpm	CFA
[m/d]/1965	Routine	Urine	Gamma	0	80	dpm	CFA

Table A-4 shows the available *in-vivo* bioassay data for Worker No. 3 following a record search up to 1971. Figure A-12 shows a special whole body count for Worker No. 3 [INL 1950–1985, PDF p. 319].

Table A-4. *In-vivo* bioassay data for Worker No. 3.

Count Date	Count Type	Type	Area
[m/d]/1965	WBC	Routine	CFA
[m/d]/1968	WBC	Routine	CFA
[m/d]/1970	WBC	Special	CFA
[m/d]/1970	WBC	Special	CFA


(REV. 12–67)
U.S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
HEALTH SERVICES LABORATORY
REFERENCE HSL DIVISION
SERIAL NO. [redacted]
WHOLE-BODY GAMMA-RAY ANALYSIS

NAME [redacted]
S NO. [redacted]
CONTRACTOR INC FACILITY CFA
SEND RESULTS TO [redacted] NAME [redacted] ADDRESS
REASON FOR ANALYSIS:
☐ ROUTINE ☒ SPECIAL
☐ TERMINATION ☐ VISITOR
☐ OTHER

ISOTOPES FOUND
COMPONENTS GREATER THAN 0.1 μc

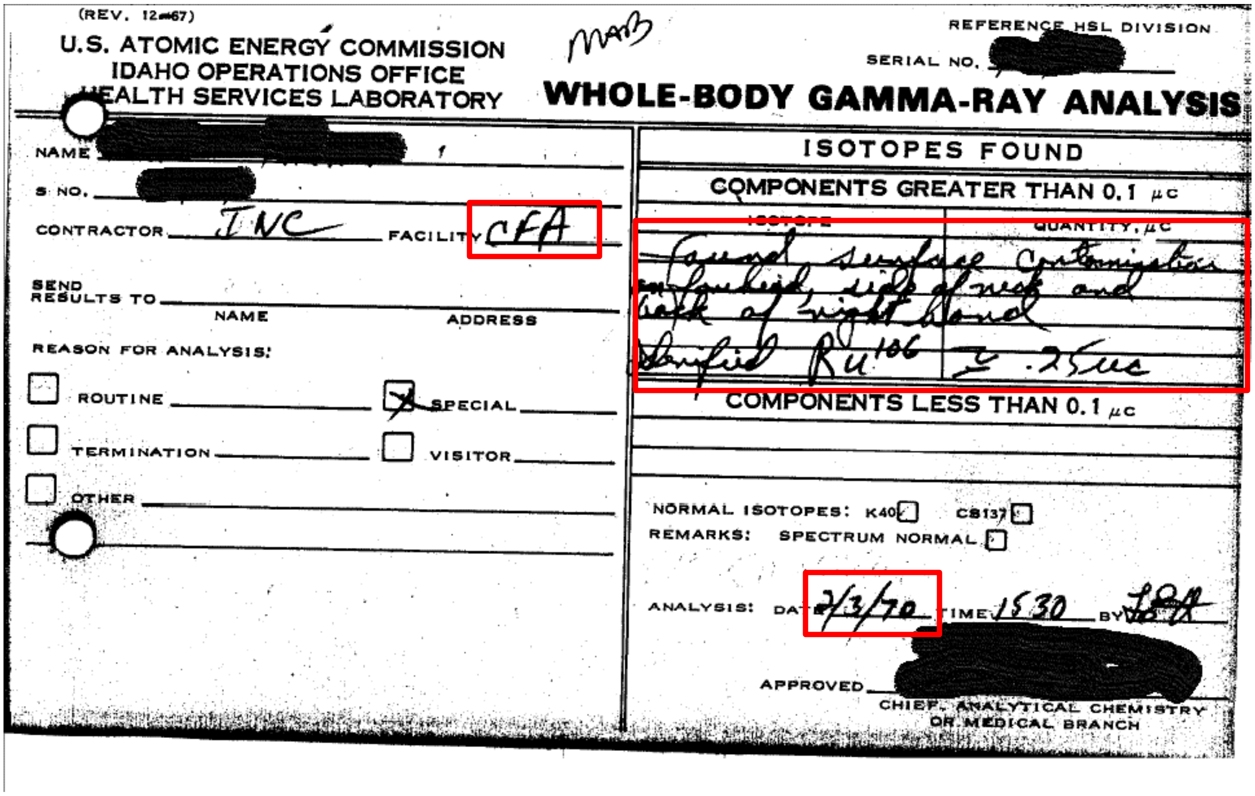
ISOTOPE	QUANTITY, μc

COMPONENTS LESS THAN 0.1 μc

NORMAL ISOTOPES: K40 ☒ CS137 ☒
REMARKS: SPECTRUM NORMAL ☒
90Sr < 0.03 μci
ANALYSIS: DATE 3/2/70 TIME [illegible] BY BBB
APPROVED [redacted]
CHIEF, ANALYTICAL CHEMISTRY OR MEDICAL BRANCH

Figure A-12. Special whole body count for Worker No. 3 on March 2, 1970.

Figure A-13 shows special whole body count for Worker No. 3 [INL 1950–1985, PDF p. 320]. The narrative under the ISOTOPES FOUND box states "found surface contamination on forehead, side of neck and back of right hand. Identified Ru^{106} ~0.25 μc." Ru-106 is a fission product with only a very weak beta emission. The Ru-106 could not have been detected by the whole body counter so clearly the *in-vivo* count was performed to help in the identification of the contaminant. A chemical analysis of the contaminant must have been performed by the Human Services Laboratory (later renamed the Radiological and Environmental Sciences Laboratory). There is no notation about where the contamination event occurred, but given the radionuclide, it certainly would have been somewhere that fresh fission products were present.


(REV. 12-67)

U.S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
HEALTH SERVICES LABORATORY

REFERENCE HSL DIVISION
SERIAL NO. [redacted]

WHOLE-BODY GAMMA-RAY ANALYSIS

NAME [redacted]
S NO. [redacted]
CONTRACTOR INC FACILITY CFA
SEND RESULTS TO ____ NAME ____ ADDRESS ____

REASON FOR ANALYSIS:
☐ ROUTINE ☒ SPECIAL
☐ TERMINATION ☐ VISITOR
☐ OTHER

ISOTOPES FOUND

COMPONENTS GREATER THAN 0.1 μc

ISOTOPE	QUANTITY, μc
Found surface contamination on forehead, side of neck and back of right hand	
Identified Ru^{106}	≥ .25uc

COMPONENTS LESS THAN 0.1 μc

NORMAL ISOTOPES: K40 ☐ CS137 ☐
REMARKS: SPECTRUM NORMAL ☐

ANALYSIS: DATE 2/3/70 TIME 1530 BY [illegible]

APPROVED [redacted]
CHIEF, ANALYTICAL CHEMISTRY OR MEDICAL BRANCH

Figure A-13. Special whole body count for Worker No. 3 on February 3, 1970.

Worker No. 4

[JOB TITLE REDACTED]

Started work at INL in 1965

Figure A-14 shows a Location File Card for Worker No. 4 [INL 1965–1970, PDF p. 7].

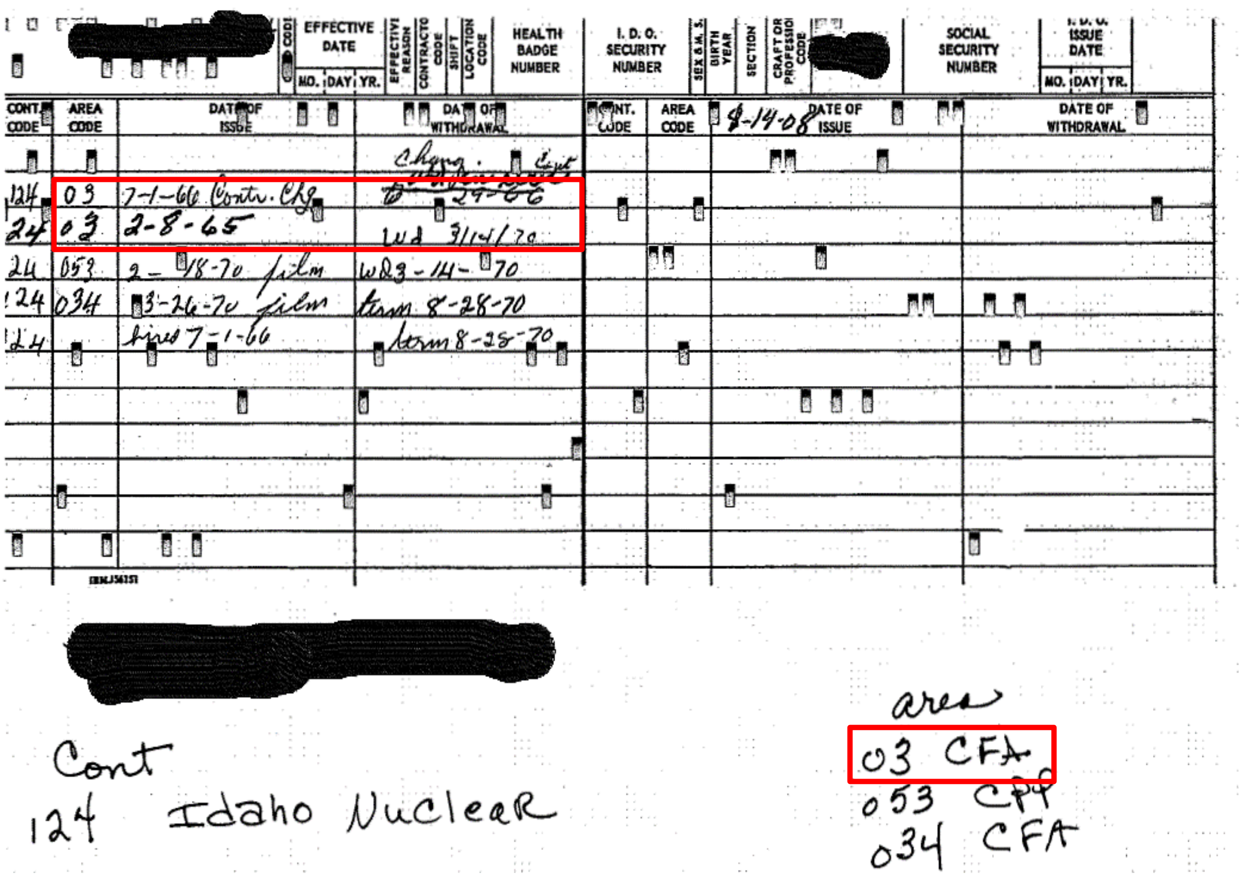


Figure A-14. Location file card for Worker No. 4.

Figure A-15 shows Worker No. 4 on a November 1969 CFA Area Exposure Report [INL 1965–1970, PDF p. 85].

CFAINC AREA EXPOSURE REPORT | 12/05/69 SUMMARY DATES | PAGE 1

PERIOD COVERED FROM 11/05/69 TO 12/02/69 | SLIDING QUARTER / / - / /

IDAHO NUCLEAR CORP | CALENDAR QUARTER 09/28/69 - 12/02/69

BADGE	QTR TO DATE			YR TO DATE	NRTS TO DATE	DS	DATE	RC XC	CURRENT PERIOD			PSN
[redacted]		C-NO/		CONTR/124	APN/034001		3 11/28/69	03 00	00	00		14
	00	00	35	00	00 35	00			00	00	00	
		C-NO/		CONTR/124	APN/034001		3 12/02/69	01 00	00	100		40
	00	00	800	00	20 3290	00			00	100	00	
		C-NO/		CONTR/124	APN/034001		3 12/02/69	01 00	00	80		72
	00	00	400	00	00 705	00			00	80	00	
		C-NO/		CONTR/124	APN/034001		3 12/02/69	01 00	00	110		69
	00	150	1010	00	560 4360	00			00	110	00	
		C-NO/		CONTR/124	APN/034001		3 12/02/69	01 00	00	80		85
	00	00	320	00	00 2960	00			00	80	00	
		C-NO/		CONTR/124	APN/034001		3 12/02/69	01 00	00	120		43
	00	130	1795	00	130 11150	00			00	120	00	
		C-NO/		CONTR/124	APN/034001		3 11/28/69	03 00	00	00		96
	00	00	510	00	735 6265	00			00	00	00	
		C-NO/		CONTR/124	APN/034001		0 12/02/69	01 02				20
	00	00	1870	00	00 2350	00			00	00	00	
		C-NO/		CONTR/124	APN/034001		3 12/02/69	01 00	00	00		129
	00	00	340	00	115 3195	00			00	00	00	
		C-NO/		CONTR/124	APN/034001		3 12/02/69	01 00	00	00		82
	00	70	340	00	475 6115	00			00	00	00	
		C-NO/		CONTR/124	APN/034001		3 12/02/69	01 00	00	60		64
	00	70	980	00	1445 9780	00			00	60	00	
		C-NO/		CONTR/124	APN/034001		3 12/02/69	01 00	00	00		8
	00	00	100	00	00 100	00			00	00	00	
		C-NO/		CONTR/124	APN/034001		3 12/02/69	01 00	00	390		68
	00	00	4100	00	10570 31580	441			00	390	00	
		C-NO/		CONTR/124	APN/034001		3 12/02/69	01 00	00	00		60
	00	00	40	00	470 2060	00			00	00	00	
		C-NO/		CONTR/124	APN/034001		0 12/02/69	01 02				61
	00	00	40	00	4010 7280	00			00	00	00	
		C-NO/		CONTR/124	APN/034001		3 12/02/69	01 00	00	00		65
	00	80	420	00	2310 7020	30			00	00	00	

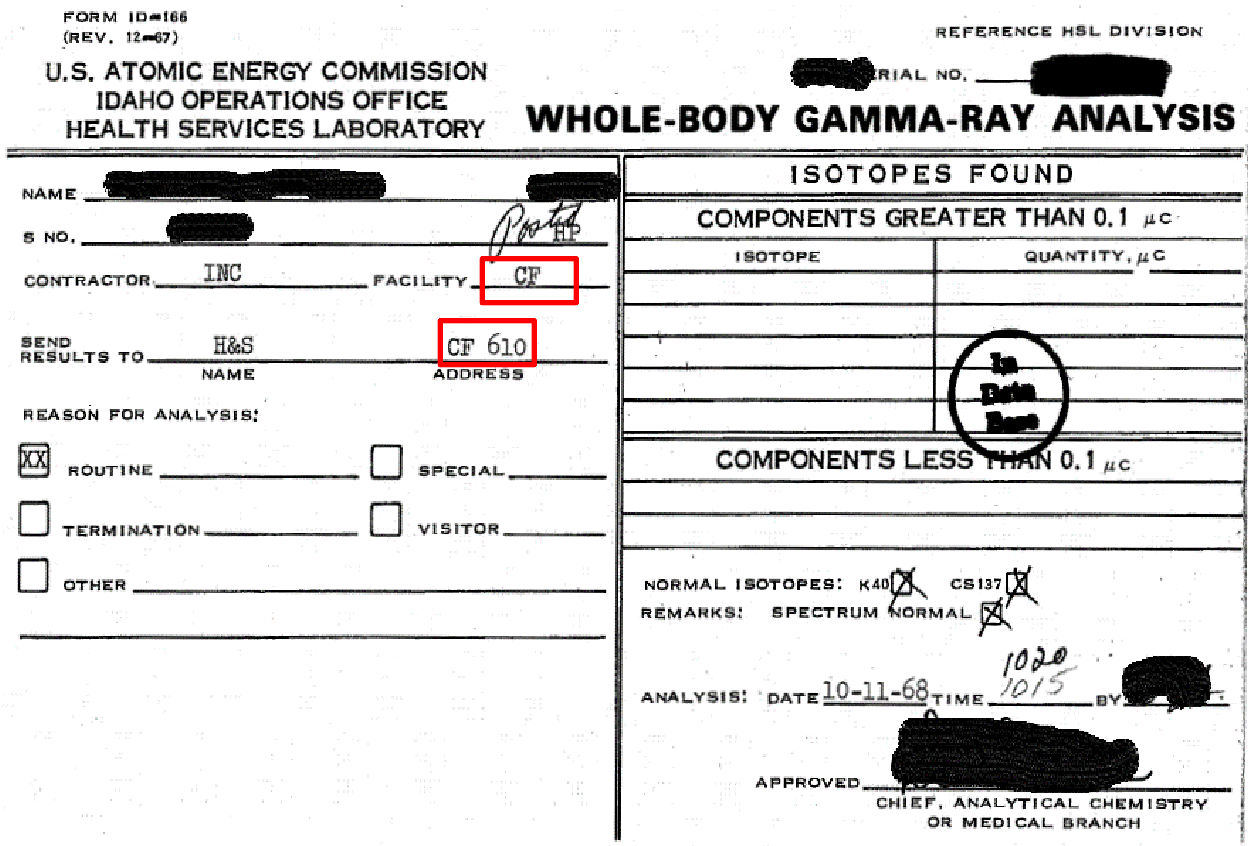
Figure A-15. Worker No. 4 in November 1969 CFA area exposure report.

Table A-5 shows the available *in-vivo* bioassay data for Worker No. 4 following a record search up to 1971. Worker No. 4 did not have any *in-vitro* bioassay data during employment at INL.

Table A-5. *In-vivo* bioassay data for Worker No. 4.

Count Date	Count Type	Type	Area
[m/d]/1968	WBC	Routine	CFA
[m/d]/1970	WBC	Termination	CFA

Figure A-16 shows a routine body count for Worker No. 4 [INL 1965–1970, PDF p. 102].



FORM ID-166
(REV. 12-67)

U.S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
HEALTH SERVICES LABORATORY

REFERENCE HSL DIVISION

[redacted]RIAL NO. [redacted]

WHOLE-BODY GAMMA-RAY ANALYSIS

NAME [redacted] [redacted]

S NO. [redacted] Posted HP

CONTRACTOR INC FACILITY CF

SEND RESULTS TO H&S (NAME) CF 610 (ADDRESS)

REASON FOR ANALYSIS:

[XX] ROUTINE
[ ] SPECIAL
[ ] TERMINATION
[ ] VISITOR
[ ] OTHER

ISOTOPES FOUND

COMPONENTS GREATER THAN 0.1 μc

ISOTOPE	QUANTITY, μc

In Data Base

COMPONENTS LESS THAN 0.1 μc

NORMAL ISOTOPES: K40 [X] CS137 [X]

REMARKS: SPECTRUM NORMAL [X]

ANALYSIS: DATE 10-11-68 TIME 1020 1015 BY [redacted]

APPROVED [redacted]
CHIEF, ANALYTICAL CHEMISTRY OR MEDICAL BRANCH

Figure A-16. Routine body count for Worker No. 4 on October 11, 1968.

Worker No. 5

[JOB TITLE REDACTED]

Started work at INL in 1967

Figure A-17 shows a Location File Card for Worker No. 5 [INL 1967–2001, PDF p. 5].

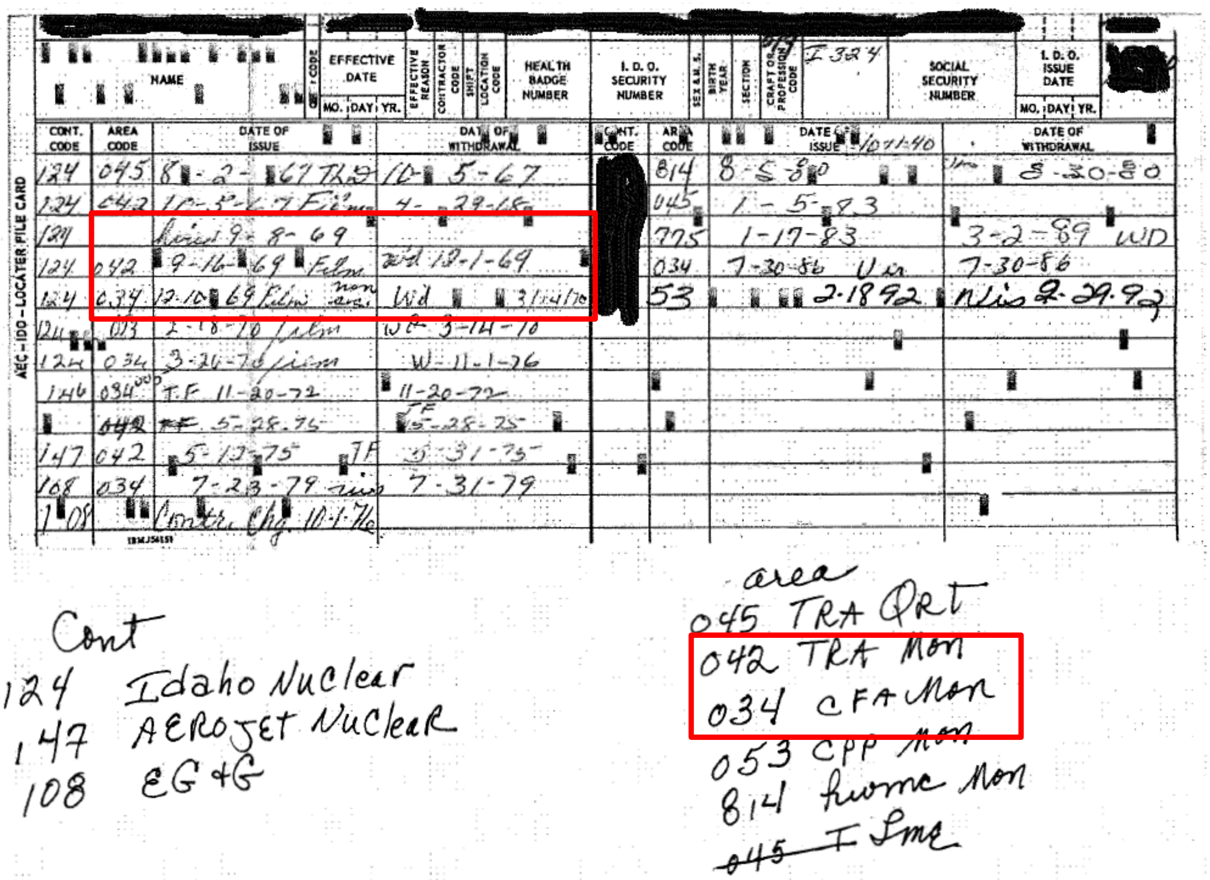


Figure A-17. Location file card for Worker No. 5.

Figure A-18 shows Worker No. 5 on a 4Q 1969 Quarterly Summary Exposure Report [INL 1967–2001, PDF p. 922]. Code 34 is area code for CFA. Table A-6 shows the available *in-vitro* bioassay data for Worker No. 5 following a record search up to 1971. Table A-7 shows the available *in-vivo* bioassay data for Worker No. 5 following a record search up to 1971.

QUARTERLY EXPOSURE SUMMARY PAGE 17

CONTRACTOR IDAHO NUCLEAR CORP CODE 124 PERIOD 09/28/69 TO 12/31/69

[redacted]

CONT CODE	CURRENT QUARTER B	CURRENT QUARTER G	CURRENT QUARTER N	CURRENT YEAR BETA	CURRENT YEAR GAMMA	CURRENT YEAR NEUTRON	NRTS TO DATE BETA	NRTS TO DATE GAMMA	NRTS TO DATE NEUTRON	TOTAL PEN
124	0	0	0	0	0	0	15	60	0	60
124	0	310	0	0	820	0	9855	6195	0	6195
124	100	770	0	900	1765	0	3940	17665	0	17665
124	120	105	0	120	425	0	525	6200	0	6200
124	0	0	0	0	0	0	0	190	0	190
124	0	0	0	0	0	0	0	90	0	90
124	0	60	0	0	545	0	55	1100	0	1100
124	0	0	0	0	30	0	0	160	0	160
124	0	0	0	0	155	0	0	1990	0	1990
124	0	0	0	0	490	0	0	970	0	970
124	0	180	0	0	930	0	1020	4845	0	4845
124	770	390	0	1390	1315	0	3395	2635	0	2635
124	0	0	0	0	130	0	425	870	0	870
124	0	0	0	0	0	0	0	0	0	0
124	0	0	0	0	70	0	0	230	0	230
124	80	55	0	30	55	0	30	55	0	55
124	0	0	0	290	90	0	290	90	60	150
124	0	0	0	0	0	0	0	0	0	0
124	INACTIVE			0	60	0	0	155	0	155
124	INACTIVE			0	0	0	0	0	0	0
124		370	0	0	370	0	0	625	0	625
124	220	990	0	330	2530	0	330	1530	0	1530
124	0	0	0	0	0	0	0	0	0	0
124	0	0	0	0	0	0	0	0	0	0
124	INACTIVE			0	0	0	0	0	0	0
124	0	0	0	0	0	0	0	0	0	0
124	0	0	0	0	0	0	0	0	0	0
124	100	1140	0	730	4045	0	800	8170	0	8170
124	0	0	0	0	0	0	0	70	0	70
124	0	50	0	0	50	0	0	50	0	50
124	80	670	0	2525	3215	0	5695	8465	0	8465
124	780	440	0	1220	2240	0	4840	4460	0	4460
124	0	0	0	0	0	0	0	0	0	0
124	INACTIVE			0	0	0	0	80	0	80
124	0	0	0	0	1995	0	655	7175	0	7175
124	0	0	0	0	0	0	0	0	0	0
124	0	0	0	0	0	0	0	0	0	0
124	0	0	0	0	0	0	0	0	0	0
124	INACTIVE			160	2415	0	520	5070	0	5070
124	0	50	0	0	100	0	0	600	0	600
124	0	0	0	0	0	0	0	0	0	0
124	INACTIVE			0	170	0	1605	1350	0	1350
124	0	0	0	0	0	0	0	45	0	45
124	0	0	0	0	0	0	0	0	0	0

Figure A-18. Worker No. 5 on 4th quarter 1969 quarterly summary exposure report.

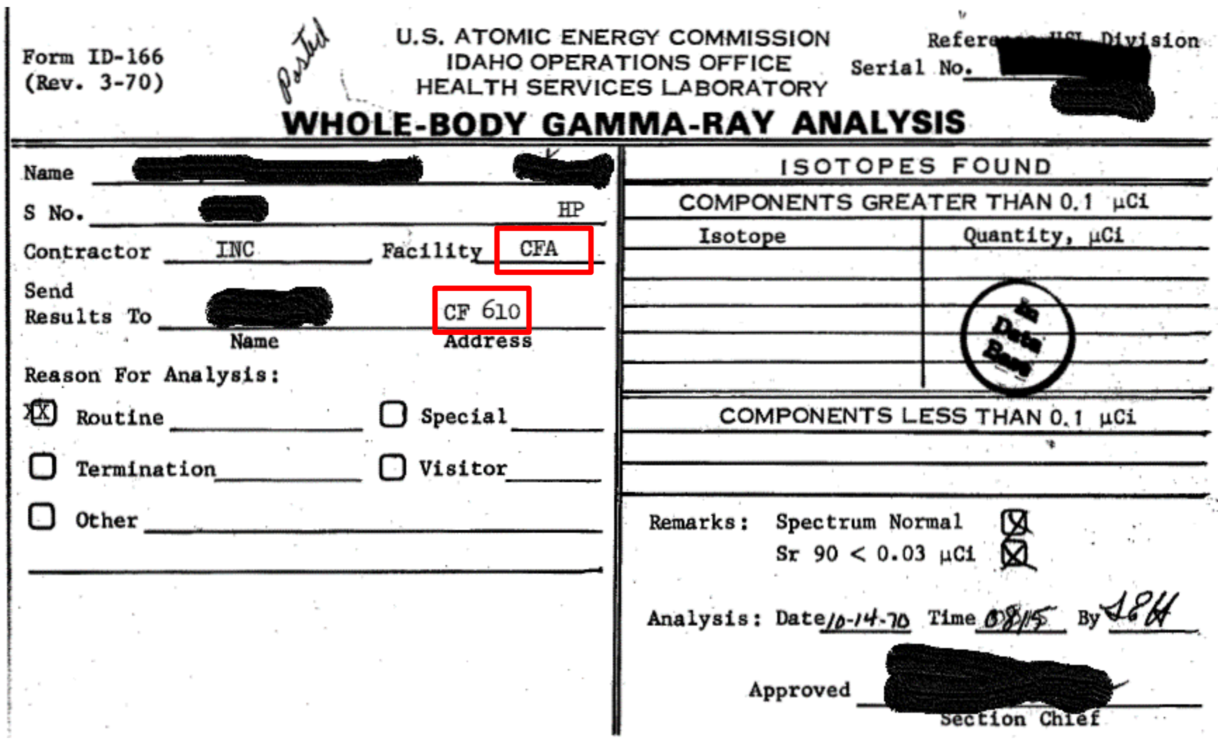
Table A-6. *In-vitro* bioassay data for Worker No. 5.

Sample Date	Type	Sample Matrix	Analyte	Activity	Uncertainty	Unit	Area
[m/d]/1968	Routine	Urine	b(ox)	2.00E-08	Not Specified	uCi/ml	TRA

Table A-7. *In-vivo* bioassay data for Worker No. 5.

Count Date	Count Type	Type	Area
[m/d]/1970	WBC	Routine	CFA

Figure A-19 shows a routine body count for Worker No. 5 [INL 1967–2001, PDF p. 897].



Form ID-166
(Rev. 3-70)

Posted

U.S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
HEALTH SERVICES LABORATORY

Refere[redacted] Division
Serial No. [redacted]

WHOLE-BODY GAMMA-RAY ANALYSIS

Name [redacted]
S No. [redacted] HP
Contractor INC Facility CFA
Send Results To [redacted] CF 610
Name Address

Reason For Analysis:
☒ Routine
☐ Special
☐ Termination
☐ Visitor
☐ Other

ISOTOPES FOUND
COMPONENTS GREATER THAN 0.1 μCi

Isotope	Quantity, μCi

In Data Base

COMPONENTS LESS THAN 0.1 μCi

Remarks: Spectrum Normal ☒
Sr 90 < 0.03 μCi ☒

Analysis: Date 10-14-70 Time 0815 By [illegible]

Approved [redacted]
Section Chief

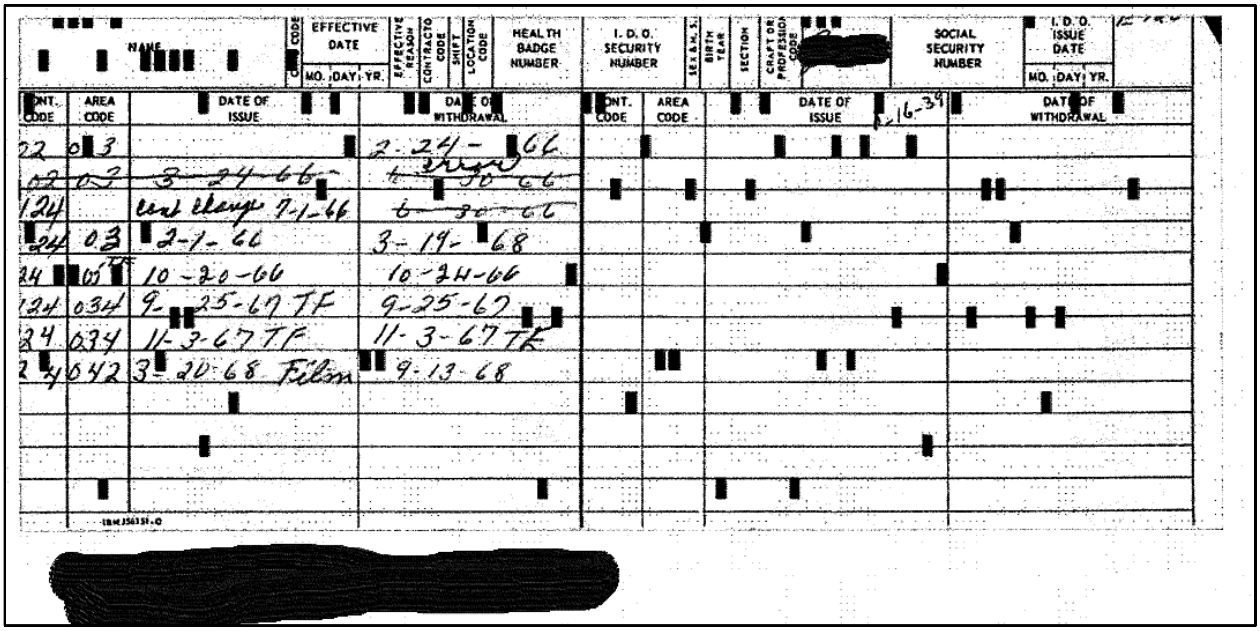
Figure A-19. Routine body count for Worker No. 5 on October 14, 1970.

Worker No. 6

[JOB TITLE REDACTED]

Started work at INL in 1965

Figure A-20 shows a Location File Card for Worker No. 6 [INL 1965–1968, PDF p. 5]. Though identified by a former co-worker via photographs as participating in the November 1969 waste exhumation and retrieval at the Burial Ground, Worker No. 6 terminated employment in 1968 per monitoring records provided by INL. However, the records below are included as an example of monitoring at CFA. Table A-8 shows *in-vivo* bioassay data for Worker No. 6. Worker No. 6 did not have any *in-vitro* monitoring while employed at INL. However, two *in-vivo* counts were performed during the time period under evaluation.


NAME | EFFECTIVE DATE (MO. DAY YR.) | HEALTH BADGE NUMBER | I. D. O. SECURITY NUMBER | [redacted] | SOCIAL SECURITY NUMBER | I. D. O. ISSUE DATE (MO. DAY YR.)

CONT. CODE	AREA CODE	DATE OF ISSUE	DATE OF WITHDRAWAL
22	03		2-24-66
02	03	~~3-24-66~~	~~6-30-66~~
124		last change 7-1-66	6-30-66
24	03	2-7-66	3-19-68
24	05	10-20-66	10-24-66
124	034	9-25-67 TF	9-25-67
24	034	11-3-67 TF	11-3-67 TF
24	042	3-20-68 Film	9-13-68

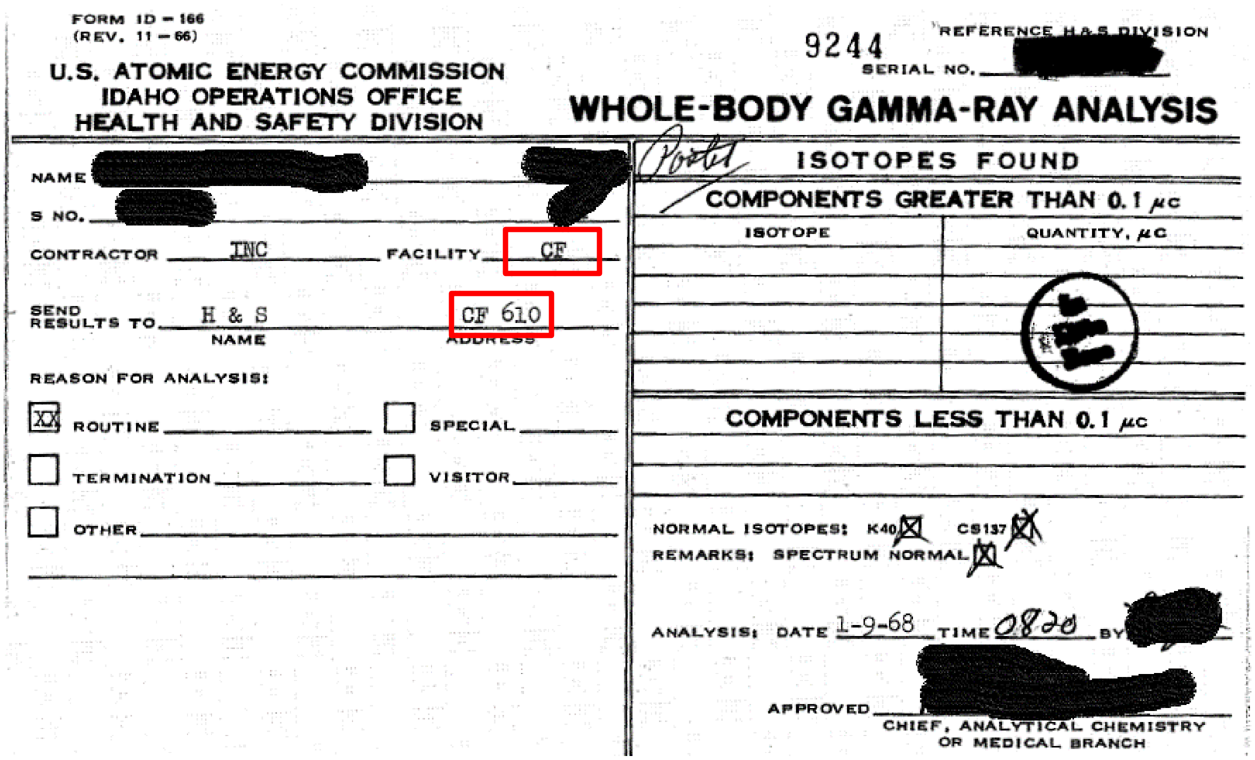
[redacted]

Figure A-20. Location file card for Worker No. 6.

Table A-8. *In-vivo* bioassay data for Worker No. 6.

Count Date	Count Type	Type	Area
[m/d]/1968	WBC	Routine	CFA
[m/d]/1968	WBC	Termination	TRA

Figure A-21 shows a routine body count for Worker No. 6 [INL 1965–1968, PDF p. 72].



FORM ID – 166
(REV. 11 – 66)

U.S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
HEALTH AND SAFETY DIVISION

9244
SERIAL NO. [redacted]
REFERENCE H&S DIVISION

WHOLE-BODY GAMMA-RAY ANALYSIS

NAME [redacted]
S NO. [redacted]
CONTRACTOR INC FACILITY CF
SEND RESULTS TO H & S (NAME) CF 610 (ADDRESS)

REASON FOR ANALYSIS:
[XX] ROUTINE [ ] SPECIAL
[ ] TERMINATION [ ] VISITOR
[ ] OTHER

ISOTOPES FOUND
COMPONENTS GREATER THAN 0.1 μc
ISOTOPE	QUANTITY, μc

COMPONENTS LESS THAN 0.1 μc

NORMAL ISOTOPES: K40 [X] CS137 [X]
REMARKS: SPECTRUM NORMAL [X]

ANALYSIS: DATE 1-9-68 TIME 0820 BY [redacted]

APPROVED [redacted]
CHIEF, ANALYTICAL CHEMISTRY OR MEDICAL BRANCH

Figure A-21. Routine body count for Worker No. 6 on January 9, 1968.

NIOSH Conclusion Regarding Identified Burial Ground Workers

The monitoring records of the above five workers who can be definitively placed (with the noted exception of Worker No. 6) during the November 1969 waste exhumation and retrieval effort at the Burial Ground demonstrate that it is difficult at best to identify a worker as a "Burial Ground" worker. The paucity of bioassay monitoring, especially *in-vitro* bioassay, in conjunction with the demonstrated use of operations/work reviews by health physicists, speaks to the low-level operational risk at the Burial Ground and the likely transient nature of the time spent by most workers at that location.

The 1969 waste retrieval project was an original and unusual work activity at the Burial Ground during the 1952–1970 time period. Because of the close proximity of personnel to waste buried for years, it was a concern to the SEC-00219 Petition evaluation team resulting in reserving 1969 and 1970. This allowed for further research to assess the exposure potential, radiological controls, and monitoring results for identified personnel. It was determined that the internal dose monitoring was consistent with the rest of the evaluation period in which a strict contamination control program was used with special bioassay requested as deemed necessary by the area HP staff.

APPENDIX B: ADDITIONAL BURIAL GROUND PHOTOGRAPHS

In Appendix B of SC&A's review, a series of photographs were presented to demonstrate the operational conditions at the Burial Ground during the period under evaluation. More photographs are presented here to provide additional information and perspective.

Figure B-1 shows an aerial photo of the Burial Ground [INL 1958–1973, PDF p. 6]. In 1970, there were no buildings, assigned facility equipment, or assigned facility workers. TSA-1 can be seen in the foreground (within red oval). The asphalt pad was installed in 1970 after a 1969 directive was given to store TRU waste above ground. Some stored TRU waste can be seen on the far-right side of the TSA-1 (red arrow).

Figure B-1. An aerial photo of the Burial Ground in 1970.

Figure B-2 shows a 1958 photograph of dumping of INL-generated waste into a waste trench along with a HP Technician monitoring with a handheld instrument [INL 1958b, PDF p. 5].

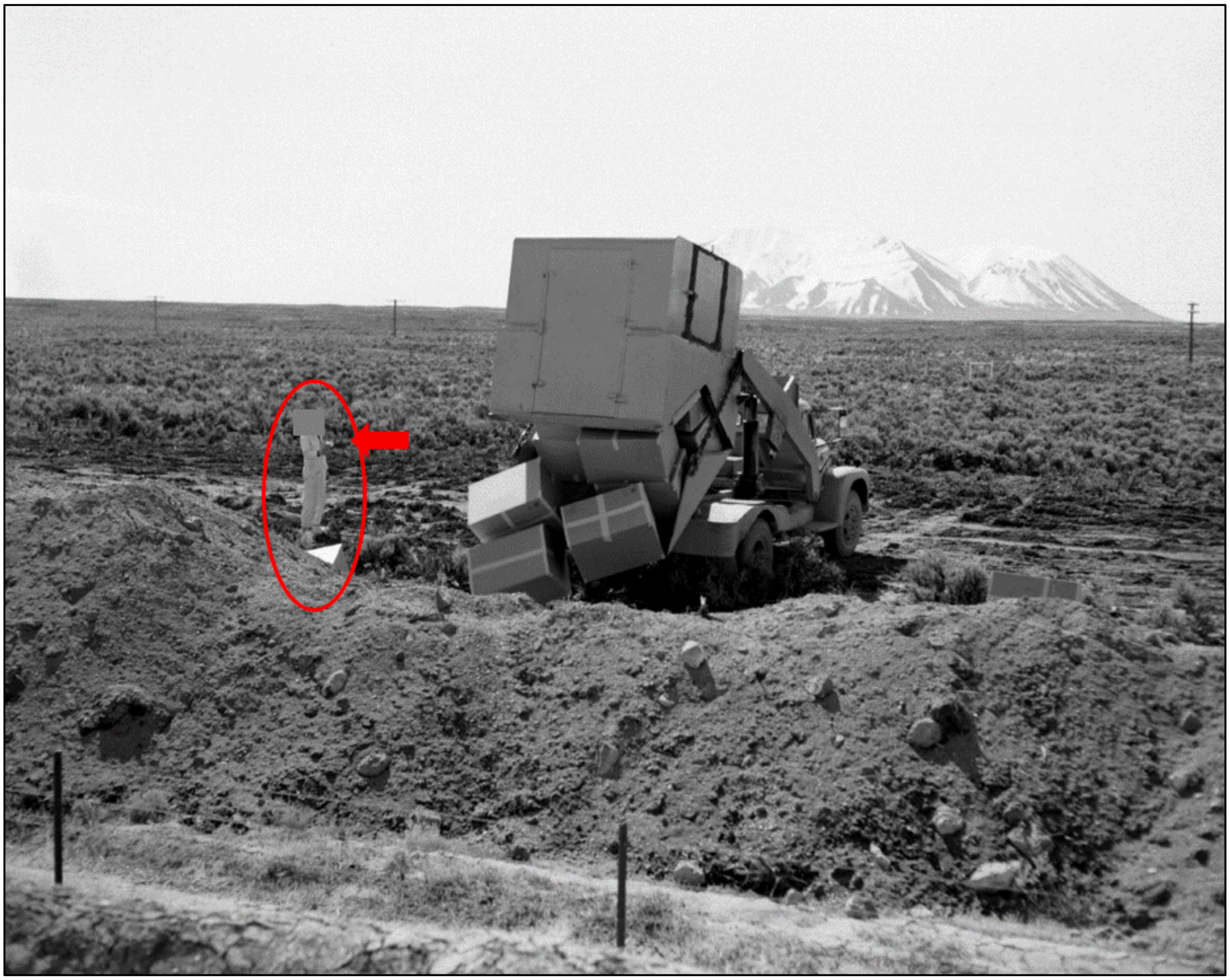


Figure B-2. Dumping of INL-generated waste into a waste trench in 1958.

Figure B-8 in SC&A's review [Fitzgerald and Barton 2017] (Figure B-3 below) shows the manual unloading and stacking of 55-gallon waste drums of RFP TRU waste in 1958 [INL 1958b, PDF p. 3]. The practice of manually unloading and stacking TRU drums changed in 1963. Beginning that year, the waste drums were dumped in mass into the waste pits instead of stacked, in an effort to minimize external radiation exposures to personnel and to reduce labor costs. This change to mass dumping was demonstrated in Figure B-6 in SC&A's review (see Figure B-4 below). This practice of dumping TRU drums continued until mid-1969 when it reverted to stacking [Hiaring et al. 1992]. The primary reason for the change was to optimize utilization of available burial space due to an increased rate of burial primarily due to the waste generated from clean-up of the May 1969 fire at the RFP. In addition, a study of burial methods for calendar year 1968 determined that usage had grown to over four acres per year and that only 14 acres of usable land was left at the existing Burial Ground footprint [Niccum 1969, PDF p. 8].

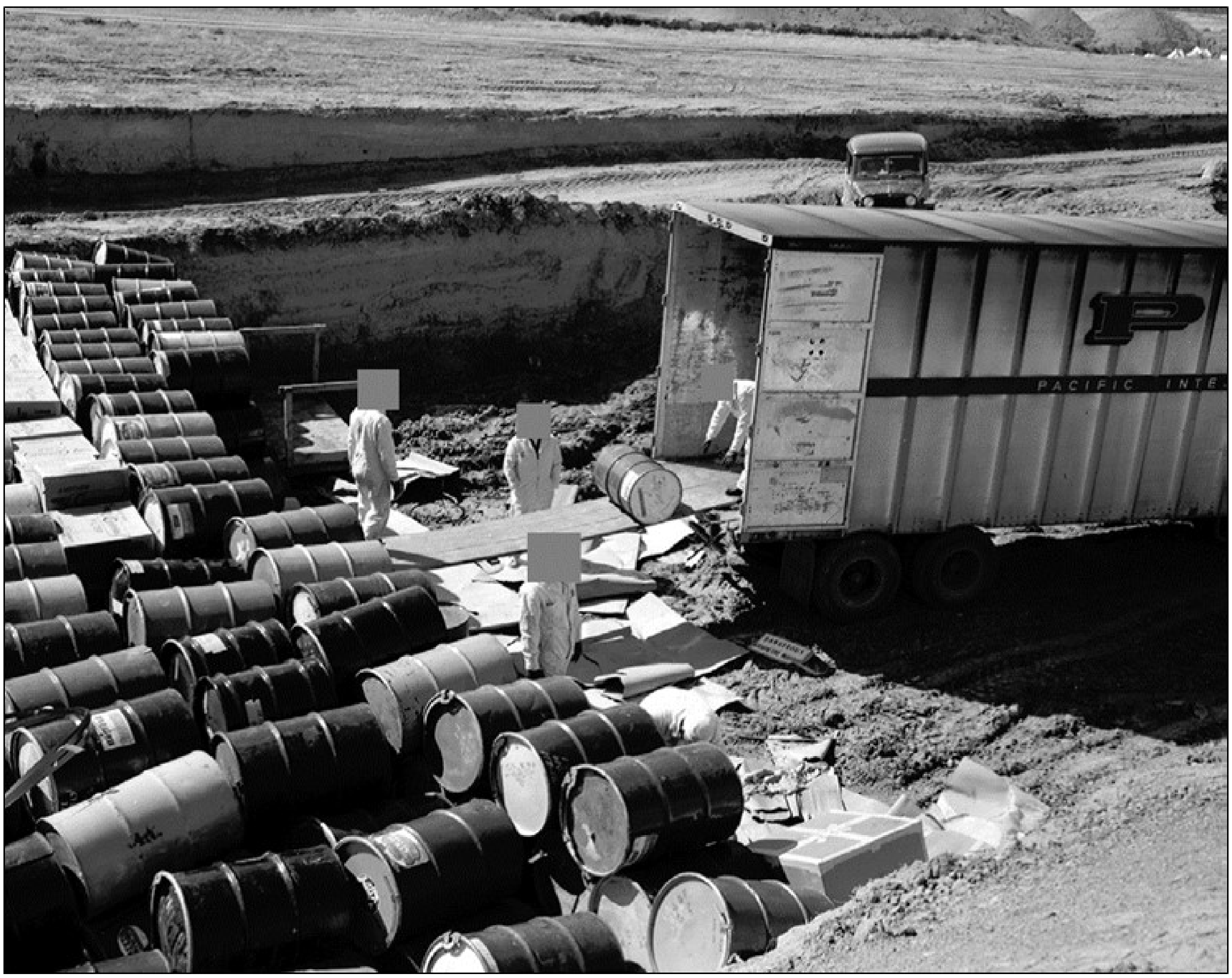


Figure B-3. Figure B-8 from SCA-TR-2017-SEC007 (1958)

While Figure B-6 from SC&A's review (Figure B-4 below) is an excellent demonstration of the mass dumping of TRU drums, the photo unfortunately captures only a small portion of the air sampler used during the work evolution [Fitzgerald and Barton 2017, PDF p. 54]. The air sampling pump is located to the far left just below the workers while the sample head is between the waste being dumped and the workers.

Figure B-4. Figure B-6 from SCA-TR-2017-SEC007 (1969).

Figure B-5 [INL 1969, PDF p. 7] and Figure B-6 [INL 1958–1973, PDF p. 3] below show more clearly the air sampling in other years. They also provide visual proof of the requirement to perform air sampling when dumping RFP TRU waste drums. There was some concern in Section 2.2 (Radiological Control and Monitoring) of SCA-TR-2017-SEC007 that occupational air monitoring was not identified during a review of 1965 SWPs.

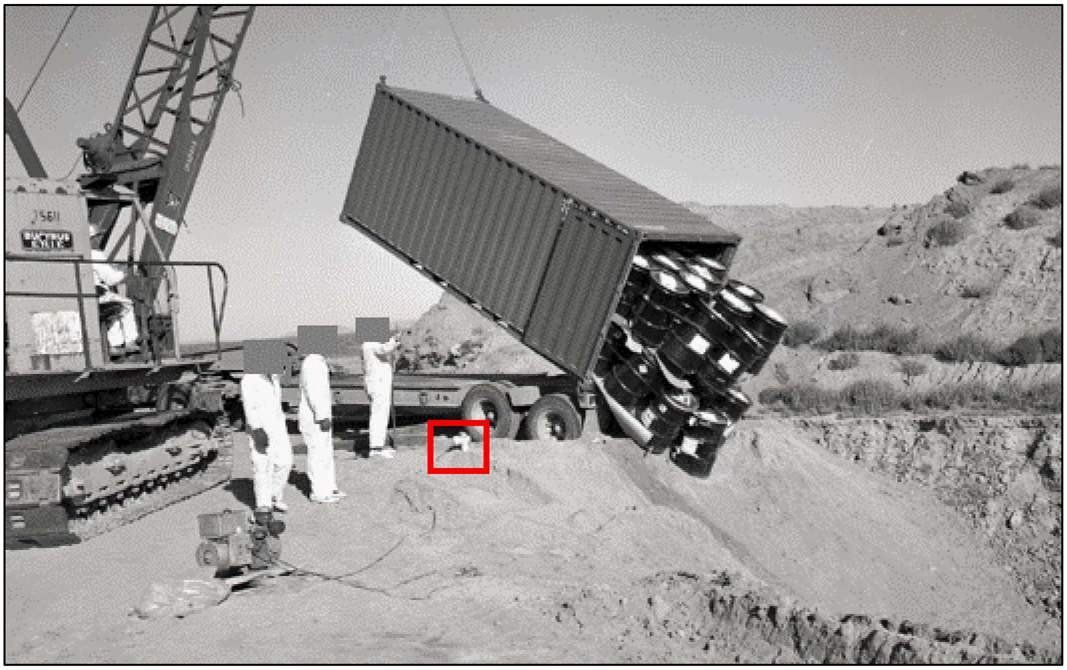


Figure B-5. 1969 photo of mass dumping of RFP waste drums with air sampling.

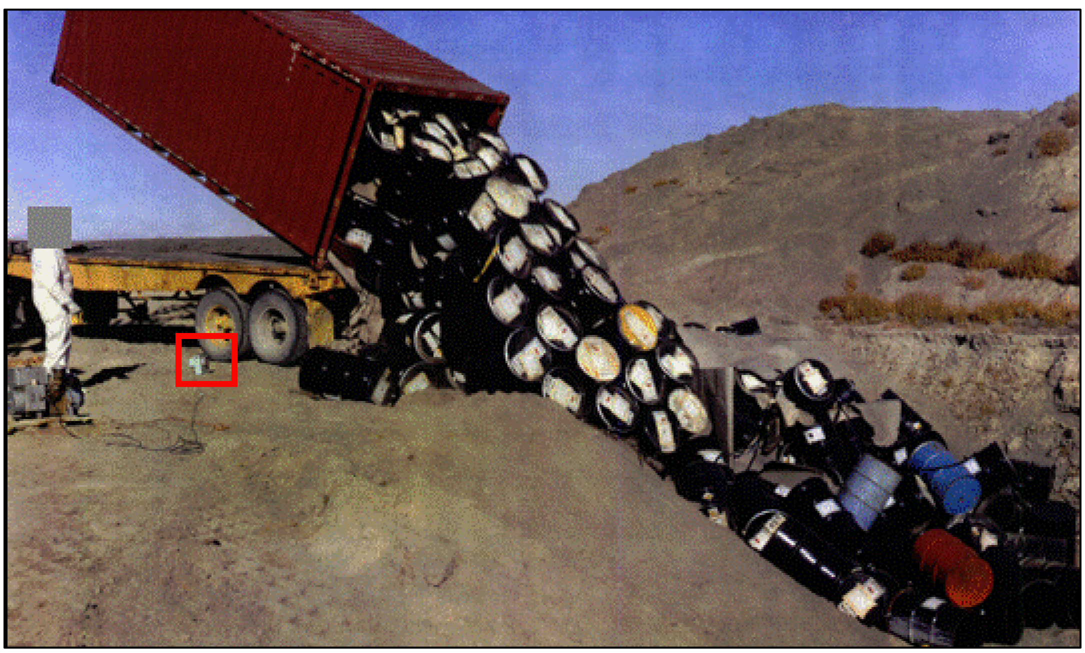


Figure B-6. Photo of mass dumping of RFP waste drums with air sampling (undated).

Figures B-4 and B-5 in SCA-TR-2017-SEC007 (Figures B-7 and B-8 below) show a bulldozer operator in anti-contamination clothing covering RFP TRU waste [INL 1965, PDF pp. 3–4]. The second photograph shows the bulldozer operator positioned between unloaded transfer trucks and an open waste pit.

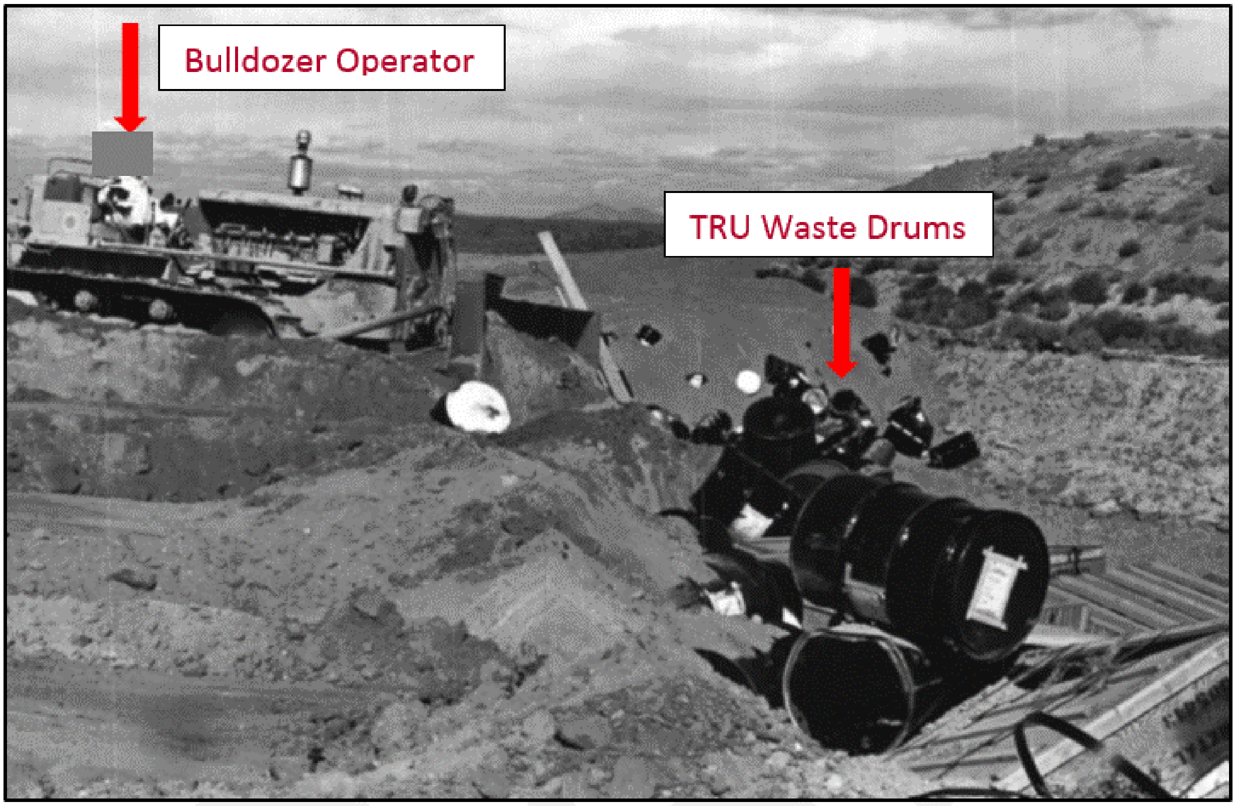


Figure B-7. Figure B-4 from SCA-TR-2017-SEC007 (1965).

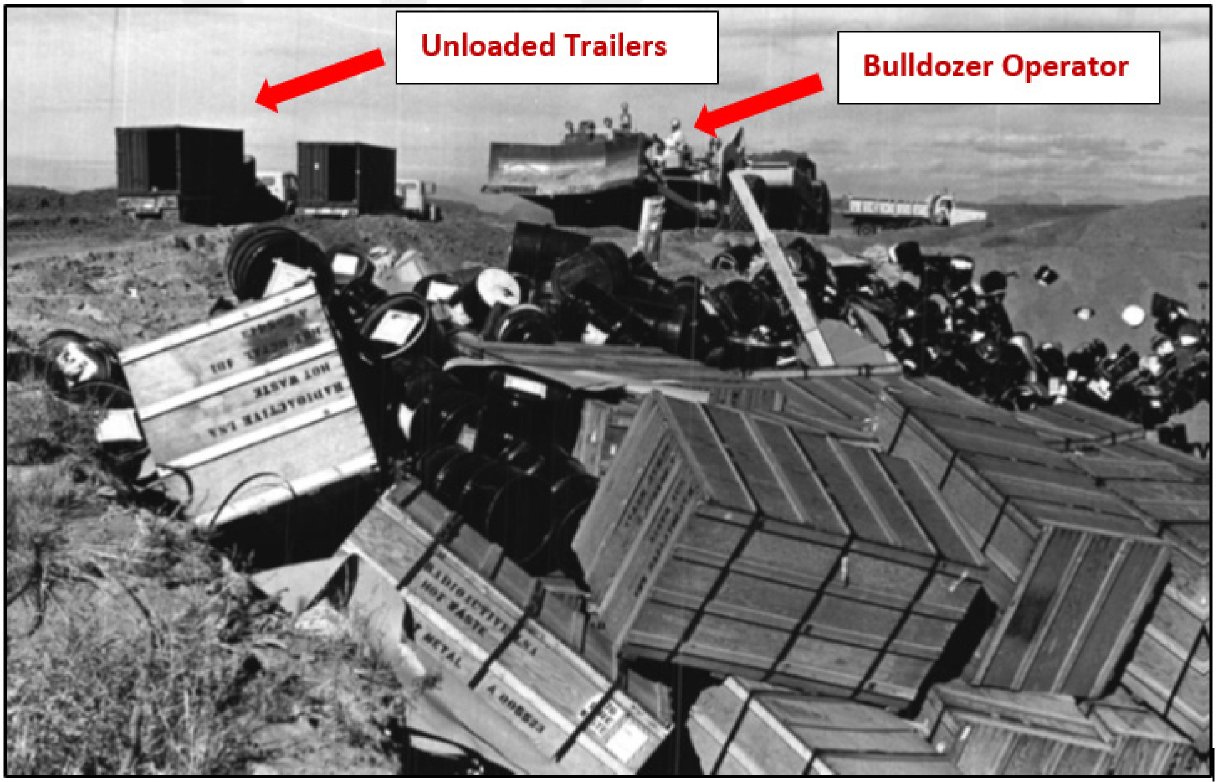


Figure B-8. Figure B-5 from SCA-TR-2017-SEC007 (1965).

The two photographs above are part of a series of photographs [INL 1965, PDF pp. 3–4]. Interestingly, PDF p. 2 from the same reference (shown in Figure B-9 below) shows five men in dress suits next to the open waste pit. An expanded view was added to the image to more clearly demonstrate the clothing. The photograph series was discovered in a folder titled "Photos – NRTS Burial Ground (Board of Health Visitors)." It appears that members of the State of Idaho's Board of Health were permitted into the Burial Ground and allowed close access to an open TRU waste pit. It can be inferred that there was not a potential for contamination as members of a regulatory body were permitted close access to an open waste burial pit at the Burial Ground. A waste drum transfer truck can be seen to the right. The bulldozer used to cover the waste is located between the transfer truck and the Board of Health visitors.

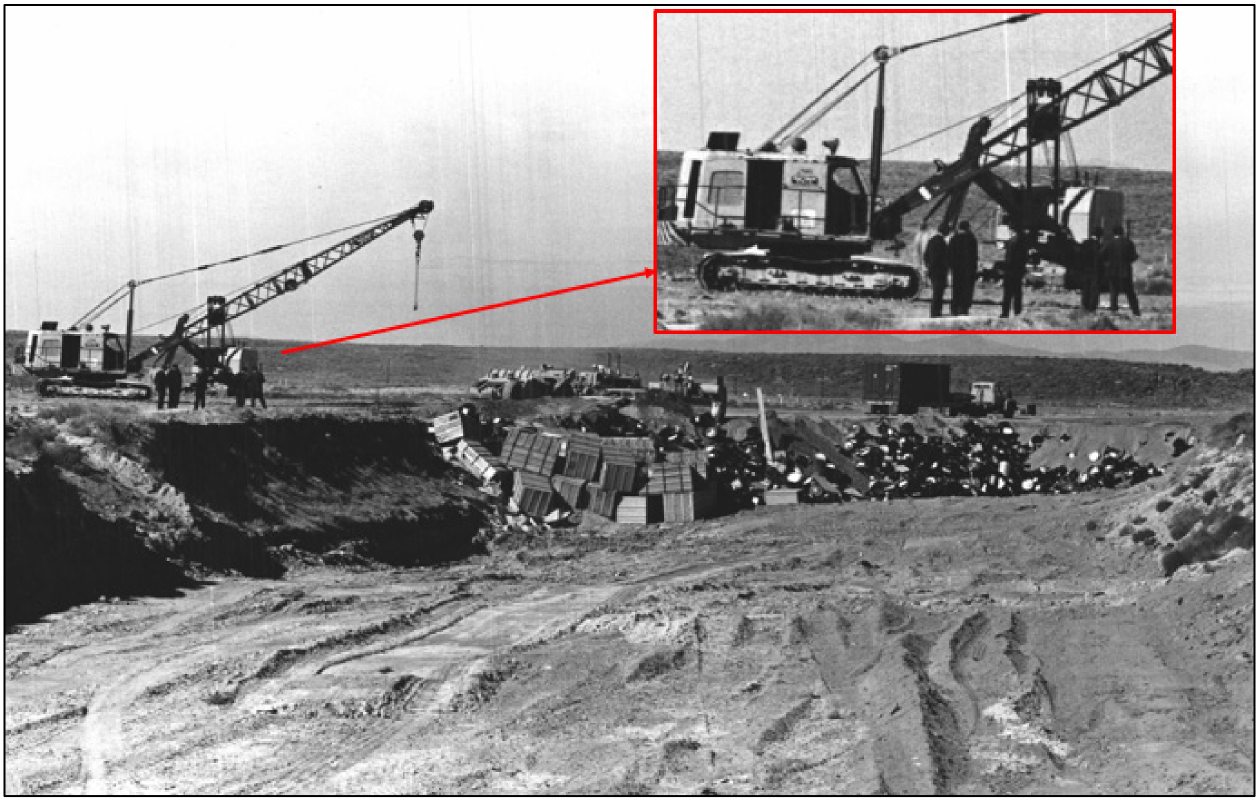


Figure B-9. Tour group next to open TRU waste pit in 1965.

Figure B-3 in SCA-TR-2017-SEC007 (Figure B-10 below) was titled "A Worker in Street Clothes Appears to be Inspecting or Monitoring a 55-Gallon Drum of Rocky Flats TRU Waste (1969)" [Fitzgerald and Barton 2017, PDF p. 51]. This is indeed the case as it is from the 1969 waste drum retrieval project which was the first waste retrieval ever performed at the Burial Ground. The worker was identified by a former co-worker as a Burial Ground HP Technician. This can be validated in Figure B-11 in which the same HP Technician can be seen with a handheld survey instrument [INL 1958–1973, PDF p. 5]. It is a reasonable conclusion that if the worker responsible for radiological monitoring of the work area and other workers was not wearing anti-contamination clothing that a minimal contamination potential, at best, existed.

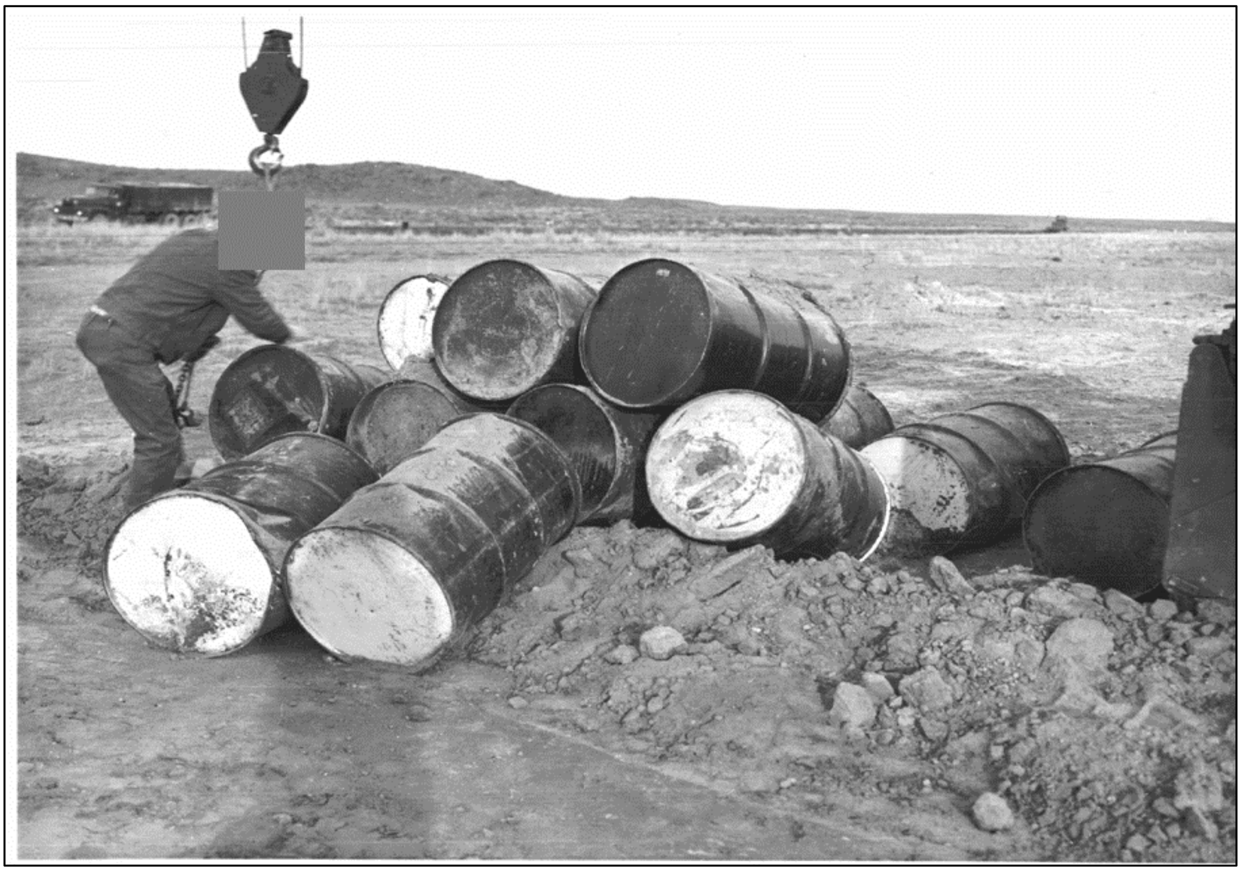


Figure B-10. Figure B-3 from SCA-TR-2017-SEC007 (1969).

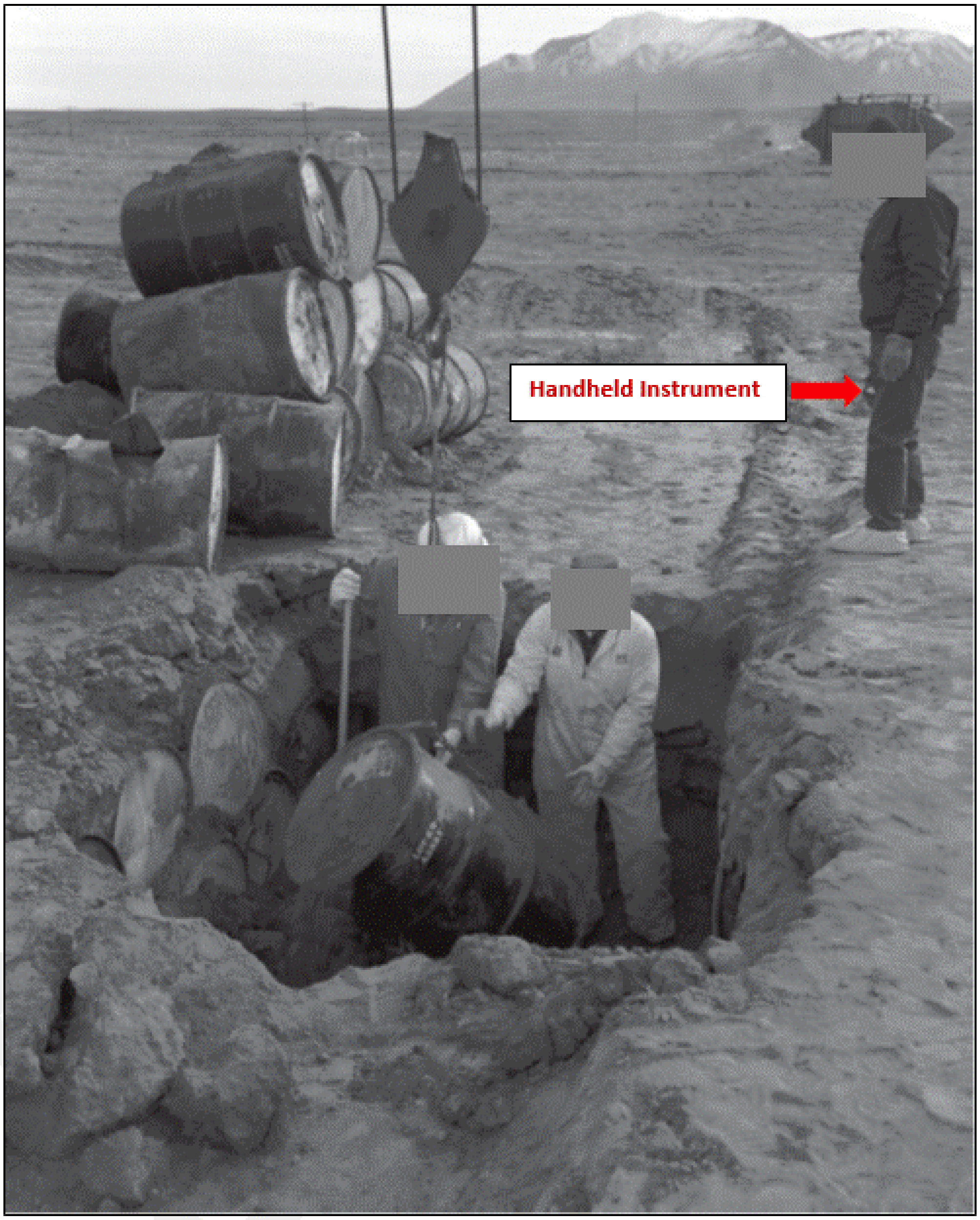


Figure B-11. 1969 waste retrieval project with HP technician with handheld instrument.