Draft

ADVISORY BOARD ON
RADIATION AND WORKER HEALTH

National Institute for Occupational Safety and Health

DRAFT REVIEW OF INTERNAL ALPHA EXPOSURE POTENTIAL AT CPP PRIOR TO 1963

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ABBREVIATIONS AND ACRONYMS

α	alpha
µCi/cc	microcurie per cubic centimeter
ABRWH	Advisory Board on Radiation and Worker Health
CAMS	continuous air monitoring system
CATI	computer-assisted telephone interview
cpm, c/m	counts per minute
CPP	Chemical Processing Plant
Cs	cesium
DOE	U.S. Department of Energy
dpm/100cm^2	disintegrations per minute per 100 square centimeters
DR	dose reconstruction
EE	energy employee
ER	evaluation report
FAP	fission and activation products
HEU	highly enriched uranium
HP	health physics or health physicist
INL	Idaho National Laboratory
MPC	maximum permissible concentration
NIOSH	National Institute for Occupational Safety and Health
ORAUT	Oak Ridge Associated Universities Team
RESL	Radiological and Environmental Sciences Laboratory
RWP	Radiation Work Permit
SEC	Special Exposure Cohort
Sr	strontium
SRDB	Site Research Database
TBD	technical basis document
U	uranium
U_3O_8	uranium oxide
WG	Work Group

EXECUTIVE SUMMARY

This report presents SC&A's review of the feasibility of dose reconstruction (DR) at the Chemical Processing Plant (CPP) prior to the currently recommended Special Exposure Cohort (SEC) period, which begins in 1963. SC&A's review focuses on the feasibility of reconstructing internal doses to alpha-emitting material at CPP, as this was the basis for the proposed SEC period from 1963 to 1974. Currently, the National Institute for Occupational Safety and Health (NIOSH) proposes to employ a "ratio method" using existing internal urinalysis results for fission and activation products (FAP) to reconstruct internal doses to uranium and other transuranic constituents found in the radiological source terms at CPP.

It is important to note that SC&A has issued a previous report (SC&A 2015) on reconstructing internal doses to fission products in which it concluded that DR was feasible if a sufficiently robust coworker model could be developed in accordance with Neton 2015. This was discussed and agreed upon at the March 2016 Idaho National Laboratory (INL) Work Group meeting (ABRWH 2016). Additionally, SC&A has prepared a report that evaluates the proposed method of using modeled activity ratios of alpha to beta/gamma constituents (namely strontium-90 [Sr-90] and cesium-137 [Cs-137]) to develop intakes of unmonitored uranium and transuranic contaminants. That report, titled *SC&A's Evaluation of Cs-137/Sr-90, Fission and Activation Product, and Actinide Values Using INL Monthly and Annual Waste Reports in Relation to Assigning Intakes* (SC&A 2017), is currently under consideration by NIOSH and the INL Work Group.

While both of those reports discuss site-wide issues related to internal monitoring, this report focuses solely on the exposure potential to alpha emitting material at the CPP for the period of radiological operations prior to 1963. Based on its review, SC&A identified five findings and five observations as follows:

Finding 1: SC&A found multiple examples in sampled Health Physics (HP) logbooks that indicate alpha contamination was detected without corresponding indications that beta/gamma contamination was also present. This is indicative that there were certain situations and locations at CPP in which alpha contamination may have existed that was not comingled with FAP material.

Finding 2: SC&A found examples of alpha monitoring taking place in the Product Bottle Room, including smear surveys of product bottles and bird cages, as well as air monitoring for alpha. This is evidence that alpha contamination, including airborne contamination, was of concern to the HP staff for this area. Given the nature of routine work activities encountered in the Product Bottle Room, it is unlikely that workers in this area would also encounter FAP that are comingled with the enriched uranium.

Finding 3: SC&A identified several area contamination survey maps from 1954, 1955, 1957, 1960, and 1961 that indicate that alpha contamination may have been the primary radiological concern for certain locations at the time of the survey. In many cases, the survey is a general contamination survey that did not detect beta/gamma activity, but directed that the identified locations with alpha contamination be cleaned up.

Finding 4: Based on a limited set of air samples in Room 216 from November of 1954, it is apparent that there was airborne alpha activity present. Evidence suggests the airborne alpha activity was uranium-233 (U-233) in the form of uranium oxide (U_3O_8). In two of the three examples, the airborne long-lived alpha activity bounded the airborne beta activity.

Finding 5: SC&A identified a single example in which [redacted] (specifically U-[redacted]) occurred out of the 32 reviewed claims who held job titles with the potential for laboratory work at CPP. [redacted] were provided in [redacted] monitoring record; however, a log of all medical treatment indicates that [redacted] occurred, which are missing from the dosimetry records supplied by the U.S. Department of Energy. [redacted] was located via the NIOSH process known as "optical recognition imaging." The disposition and availability of the [redacted] is unknown.

Observation 1: Based on five identified interviews with former CPP workers having some knowledge of radiological operations, it is apparent that the HP staff were aware of, and took steps to control, alpha contamination in certain areas of the plant. These areas include the laboratories and other "product" areas. While the interviews indicate that an "incident"-based internal monitoring program was employed for alpha emitters, it is unclear what levels of alpha contamination would actually trigger "special bioassay" samples versus more common decontamination activities.

Observation 2: [redacted] who worked at CPP prior to [redacted] and had job types most likely to be associated with laboratory work did not have any [redacted]. It cannot be inferred from available [redacted] files whether these workers should have been monitored and were not, were monitored and the records are unavailable, or did not experience any exposure potential to [redacted] warranting routine monitoring.

Observation 3: During its review of claimants who may have worked in the [redacted] areas of CPP, SC&A identified several non-claimants who appear to have been part of a regular routine monitoring program for [redacted]. This is logically indicative that a group of workers existed at CPP who had the potential for [redacted] that was of radiological concern to the health and safety staff.

Observation 4: A documented [redacted] incident involving airborne [redacted] activity in the [redacted] indicates that HP was notified immediately and appropriate actions were taken, including air sampling, area swipe contamination surveys, and worker nasal swipes. Multiple [redacted] samples were collected in the days immediately following the incident. Analysis of the available [redacted] related to the incident indicates that exposures were likely minimal. This incident was also discussed in NIOSH 2015b.

Observation 5: A documented incident in [redacted] describes a [redacted] maintenance activity that resulted in a [redacted] in the [redacted]. The activity involved an [redacted]" and also had an HP presence in at least [redacted] maintenance locations. Follow-up reports indicate HP and safety permits required more detail to avoid future incidents. Although not specified in the incident report, SC&A located at least one [redacted] sample that was taken for a [redacted] involved in the [redacted].

Based on these findings and observations, SC&A has concluded that exposure potential to alpha-emitting material that was not comingled with significant FAP material likely existed for at least some workers, time periods, and locations within CPP. This conclusion is based on area contamination survey maps, HP daily shift logs, product smear surveys and air sampling found for certain locations.

Internal monitoring for alpha-emitting material, in particular transuranic material, was expectedly limited as such monitoring was incident-based and the actual exposure potential was likely restricted to a relatively small portion of the workforce. Evidence of incident-based, rather than routine, monitoring was identified in interviews with former CPP workers (see Sections 6.1 and 6.5). Additionally, SC&A located two incident reports in which uranium spills occurred and involved follow-up internal sampling (see Section 8.0).

However, SC&A also found evidence to suggest that at least some workers were on a routine uranium monitoring schedule. Such routine monitoring could potentially form the basis of a uranium coworker model and would be beneficial to explore. SC&A would note that while the number of workers on a routine uranium monitoring program is likely small, such limitations are allowed for in coworker model development if the exposed population is also likely small (Neton 2015).

Furthermore, evidence suggests that the CPP HP staff were aware that alpha contamination could be an issue in certain locations and for certain activities, such as laboratory work and the final steps in the product analysis and bottling. This premise is demonstrated by planned alpha contamination surveys and air sampling in specific areas of CPP as seen in Sections 2.0–5.0. Additionally, interviews with former workers discuss the use of blotter paper, regular surveys, and cleaning of the laboratory areas as frequently as every shift (see Sections 6.1, 6.2, and 6.5). Therefore, it is unlikely that a high-level alpha source term could have existed for an extended period of time at the facility that would automatically preclude the feasibility of DR.

Nonetheless, based on the findings/observations of this review (and in conjunction with the conclusions found in SC&A 2017), SC&A does not feel it has been sufficiently demonstrated that the ratio methods presented in the INL technical basis document for occupational internal dose (NIOSH 2010) adequately bound the exposure potential to at least some workers and locations. Namely, those workers who may have worked in laboratory areas in which the source term could have primarily been alpha-emitting material. Justification of any proposed ratio method is necessary to assure that assigned doses are sufficiently accurate and bounding to all of the exposed workers at CPP.

Summary Conclusion: SC&A identified several example locations and time periods for which alpha contamination was identified and was not directly comingled with FAP. Reconstruction of internal exposures to alpha material by ratioing to calculated intakes of FAP material would not be technically appropriate for at least some workers, activities, and locations within CPP.

1.0 INTRODUCTION, BACKGROUND, AND APPROACH

On July 21, 2015, the National Institute for Occupational Safety and Health (NIOSH) issued Revision 01 to the Idaho National Laboratory (INL) Special Exposure Cohort evaluation report (SEC ER) (NIOSH 2015b). In that report (NIOSH 2015b), NIOSH determined that dose reconstruction (DR) was infeasible for energy employees (EE) exposed at the Chemical Processing Plant (CPP) for the period from January 1, 1963, through December 31, 1974. The chosen start date for the recommended SEC was explained as follows:

> *The SEC class start date was established as January 1, 1963 because, in the face of increased alpha contamination, the CPP radiation protection program did not initiate a corresponding increase in the number of bioassay samples taken.* [NIOSH 2015b, page 3]

Furthermore, NIOSH 2015b, page 6, states:

> *For the period from January 1, 1963 through December 31, 1974 at CPP, NIOSH has not located sufficient personnel or area monitoring documentation to support complete reconstruction of internal personnel exposures to uranium, neptunium, plutonium, and other related transuranic radionuclides. Without additional personnel radiation monitoring data or air monitoring data during this period, NIOSH has insufficient information to appropriately characterize radioactive material intakes of these radionuclides during these INL operations.*

It is important to note that the technical basis for the recommended SEC designation was identical in Revision 00 of the SEC ER (NIOSH 2015a), Revision 01 (NIOSH 2015b) and Revision 02 (NIOSH 2017). NIOSH presented its original SEC ER findings to the Advisory Board on Radiation and Worker Health (ABRWH) on March 26, 2015, during the 104th meeting of the ABRWH in Hanford, WA (ABRWH 2015). At that time, SC&A, Inc. was tasked by the ABRWH to review NIOSH 2015a, including the recommended cohort as well as the relevant areas at INL for which NIOSH has deemed DR feasible. This report represents SC&A's review of the DR feasibility at the CPP prior to 1963 (i.e., prior to the recommended SEC period from 1963 to 1974).

As described above, the basis for the SEC from 1963 to 1974 was the inability to reconstruct internal exposures to alpha-emitting material with sufficient accuracy. NIOSH contends that such alpha exposures can be feasibly reconstructed prior to 1963. Although not specifically stated in the SEC ER, it is SC&A's understanding that NIOSH plans to use available beta/gamma urinalysis data in conjunction with ratio methods developed in Tables 5-22 and 5-23 of the INL technical basis document (TBD) for occupational internal dose (NIOSH 2010). Underpinning this method is the assumption that alpha-emitting radionuclides are comingled with fission products to allow for a sufficiently accurate ratio to be developed, which bounds the dose from alpha emitters. It is important to note that the development of appropriate ratios between fission products and alpha-emitting material is evaluated in a separate document (SC&A 2017) and therefore not discussed further in this report.

SC&A's initial review focused on available documentation referenced in the SEC ER (NIOSH 2015a, 2015b, 2017), the site-specific INL Internal TBD (NIOSH 2010), and available references contained on the Site Research Database (SRDB). SC&A, along with concurrence from the INL Work Group (WG), recommended that further site-specific data capture and interviews with former workers would be beneficial in establishing whether DR was indeed feasible with sufficient accuracy at CPP prior to 1963. SC&A's concerns centered on whether internal exposures to alpha-emitting material prior to 1963 might be similarly infeasible to reconstruct, as was the case during the subsequent SEC period (1963–1974). Therefore, data capture and interview efforts were focused on the potential for internal exposure to such alpha-emitting material that may not have been comingled with fission and activation product (FAP) contaminants to allow for a sufficiently accurate and/or bounding ratio method. SC&A, in conjunction with NIOSH/Oak Ridge Associated Universities Team (ORAUT) and the INL WG, undertook several interview efforts with former workers, as well as two data capture trips, as follows:

- January 25, 2016, to January 27, 2016: In-person interviews with former INL workers
- January 28, 2016: INL onsite data capture
- February 16, 2016: Telephone interviews with former INL workers
- March 15, 2016, to March 16, 2016: INL onsite data capture
- April 5, 2016: Telephone interviews with former INL workers
- November 8, 2016, to November 10, 2016: In-person interviews with former INL workers
- December 15, 2016: Telephone interviews with former INL workers

Data that was captured at INL during these efforts included Health Physics (HP) shift logbooks (Section 2.0), air monitoring results (Sections 3.0 and 5.0), and area contamination survey maps (Section 4.0). The results of interviews with former workers having knowledge germane to exposure source terms at CPP prior to 1963 are discussed in Section 6.0.

In addition to the interview and data capture efforts, SC&A conducted an exhaustive review of the current INL claimant population to identify scientists, laboratory workers, and other technicians who may have been included in alpha contamination events and subsequent internal monitoring. The results of this claim review are presented and discussed in Section 7.0. Finally, Section 8.0 discusses two documented contamination incidents identified at CPP that involved uranium material spills in which the contaminants became airborne.

2.0 HEALTH PHYSICS DAILY SHIFT REPORTS AND LOGBOOKS

SC&A examined a set of HP Daily Shift Reports (for brevity called "Shift Reports" in this section) for information concerning exposure potential to alpha contamination which may not have been comingled with FAP (CPP HP Various Dates-a). Figure 1 presents an example screenshot of a Shift Report from January 10, 1955. The bottom of the figure indicates that this is the report from Crew "C" on the third shift (1600–2400 hours). Highlighted in the figure are entries 6, 7, 9 and 10 which indicate HP activities in Room 207. The second column of the Shift Report indicates that the work was performed for "Ch," which presumably represents the chemistry division at CPP. The horizontal checklist for these entries indicates the following services performed:

- Contamination survey
- Consultation or special services
- Smears taken
- Smears counted

For entries 6 and 7, the "Remarks and Explanations" column (highlighted to the far right) indicates that alpha contamination was found on the floor (9 smears taken and counted) and wall (5 swipes taken and counted) of Room 207. Entries 9 and 10 are likely representative of a "resmearing" of the room and again found alpha contamination present on the floor and wall (9 and 4 smears, respectively). Notably, entry 7 also indicates the instrument used was a "Samson," which was a common alpha detector used at the time.

Table 1 provides additional examples of observed Shift Reports from 1953 to 1955 where alpha contamination was identified. As seen in the table, there were several specific areas that were associated with alpha contamination including laboratory areas, individual hot cells, and the product room area.

Figure 1. Example Screenshot of Health Physics Daily Logsheet Indicating Alpha Contamination on the Floor and Wall of Room 207 from January 1995 (CPP HP Various Dates-a)

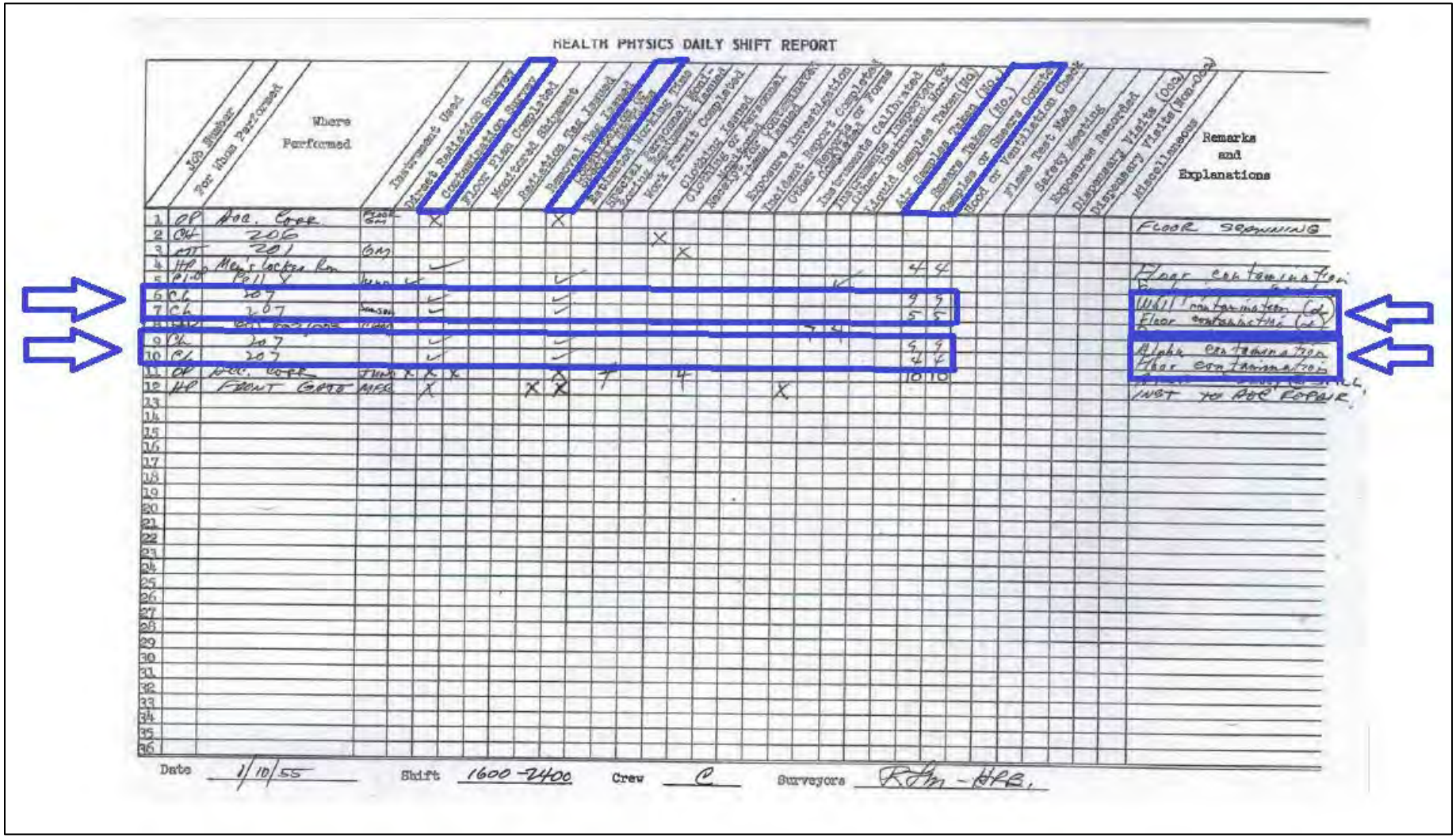


Table 1. Examples of Alpha Contamination Identified in Captured Health Physics Logbooks (CPP HP Various Dates-a)

Ex. #	Date	Shift (Military Time)	Origin of Job Request	Remarks and Explanations from Logbooks (Direct Quotes)	Actions Taken	Area	Instrument	Additional SC&A Notes
1	11/23/1953	0800-1600	Health Physics	"Alpha Contamination"	Contamination Survey, Radiation Tag Issued, Consultation or Special Services, Clothing Issued, Samples or Smears Taken (approx. 250)	All Areas	Samson	—
2	12/2/1953	1600-2400	Operations	"Survey - cont. (α)"	Contamination Survey, Radiation Tag Issued, Consultation or Special Services, Samples or Smears Taken (50)	LB Halls	Smear	—
3	12/2/1953	1600-2400	Operations	"α contamination incident"	Contamination Survey, Radiation Tag Issued (3), Consultation or Special Services, Clothing Issued, Air Samples Taken (1), Samples or Smears Taken (24)	W. Stairwell Product Rm & LC Hallway	UV Hudson, Samson	—
4	12/3/1953	1600-2400	"WL"	"α cont. check"	Contamination Survey, Consultation or Special Services, Samples or Smears Taken (14)	LC-12	Smear	Area was rechecked on the same shift with an additional 8 smears taken and counted.
5	12/4/1953	Not Listed	Operations	"α contamination"	Contamination Survey, Consultation or Special Services, Incident Report Completed, Samples or Smears Taken (20)	PO Corr	Samson	—
6	12/11/1953	800-1600	Operations	"α cont hands"	Contamination Survey, Consultation or Special Services, Clothing Issued	LB-1	Samson	—
7	1/8/1954	1600-2400	Operations	"Alpha contamination"	Contamination Survey, Consultation or Special Services, Samples or Smears Taken (8)	PM Area	Not Listed	Smear samples taken on two different occasions during the shift.
8	1/8/1954	1600-2400	Operations	"Alpha Contamination"	Contamination Survey, Consultation or Special Services, Clothing Issued	LB-1	Samson	—

Ex. #	Date	Shift (Military Time)	Origin of Job Request	Remarks and Explanations from Logbooks (Direct Quotes)	Actions Taken	Area	Instrument	Additional SC&A Notes
9	1/21/1954	800–1600	Chemistry	"Spill of α contaminated liquid"	Contamination Survey	208	Samson	A separate activity was logged during shift involving a survey with a Samson meter in 208 that was requested by the maintenance branch. Record states: "Surveyed hood before cocooning"
10	4/20/1954	800–1600	Chemistry	"α contamination"	Contamination Survey, Radiation Tag Issued (2), Samples or Smears Taken (1)	LB-1	Not Listed	—
11	11/17/1954	800–1600	Samson	"α - floor near hood"	Contamination Survey, Samples or Smears Taken (2)	207	Samson	A second contamination survey for α-β-γ on the floor of Area 207 occurred using a "Sampson" meter and Geiger-Mueller counter. Later in the log, an "alpha spill" was also noted for Area 207. After that, an alpha contamination check was made in the 200 Hallway at the request of the Chemistry Branch.
12	1/19/1954	800–1600	Operations	"α cont. on coveralls"	Contamination Survey, Consultation or Special Services, Clothing or Personnel Monitored	LB-1	Samson	—
13	11/19/1954	800–1600	Chemistry	"α contamination"	Contamination Survey, Consultation or Special Services, Samples or Smears Taken (22)	212-216	Samson	—
14	12/4/1954	800–1600	Health Physics	"α contamination"	Contamination Survey, Floor Plan Completed, Radiation Tag Issued, Consultation or Special Services, Clothing Issued, Samples or Smears Taken (35)	212-216	Samson	—

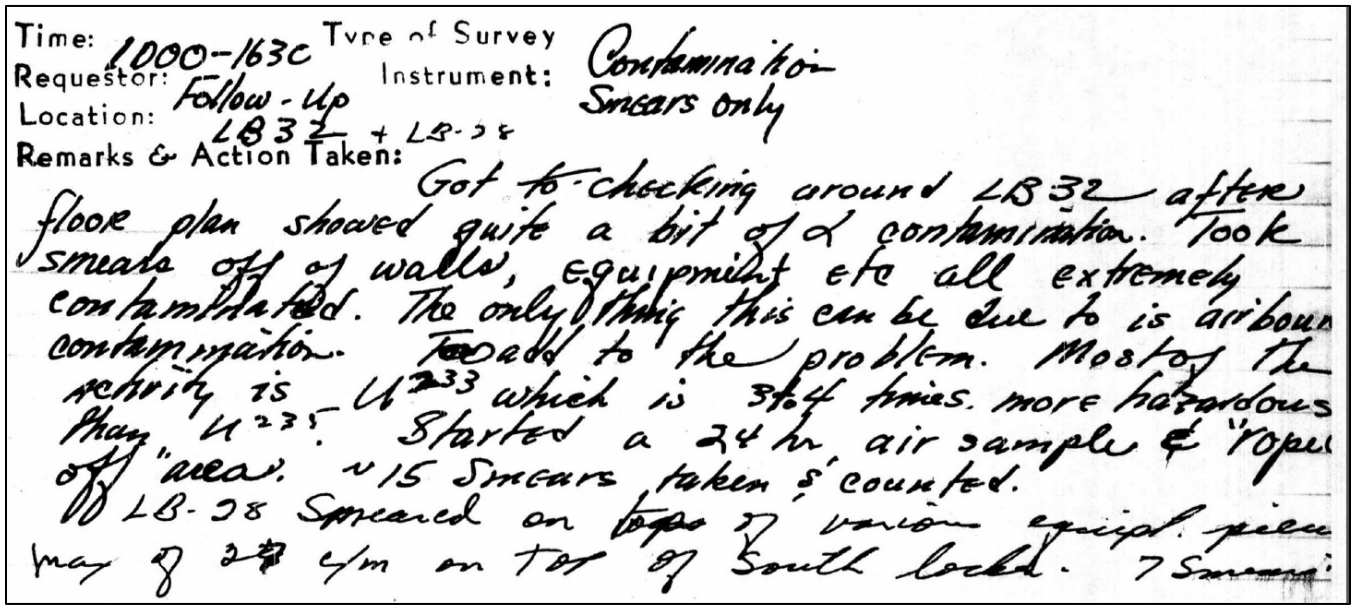
Ex. #	Date	Shift (Military Time)	Origin of Job Request	Remarks and Explanations from Logbooks (Direct Quotes)	Actions Taken	Area	Instrument	Additional SC&A Notes
15	12/13/1954	1600–2400	Operations	"Alpha Activity (Final Product Bottle)"	Contamination Survey, Consultation or Special Services, Samples or Smears Taken (2)	Product Rm	Not Listed	—
16	12/19/1954	1600–2400	Maintenance	"Surveyed clothing for α Surveyed tools for α"	Direct Radiation Survey, Consultation or Special Services, Clothing or Personnel Monitored	201	Not Listed	—
17	12/30/1954	1600–2400	Health Physics	"α cont survey"	Samples and Smears (13)	212-216	Not Listed	Later in the shift the area was rechecked after mopping with 7 additional smears taken.
18	1/8/1955	1600–2400	Chemistry	"Explosion Incident"	Direct Radiation Survey, Contamination Survey, Radiation Tag Issued, Consultation and Special Services, Clothing or Personnel Monitored, Incident Report Completed	207	Samson, Geiger Mueller	There was a decontamination survey the following day shift using only the Samson radiation meter. SC&A was unable to locate a corresponding incident report.
19	1/9/1955	800–1600	Chemistry	"α survey"	Contamination Survey, Samples or Smears Taken (6)	204	Not Listed	—
20	1/10/1955	1600–2400	Chemistry	"Wall contamination (α), floor contamination (α)"	Contamination Survey, Consultation or Special Surveys, Samples or Smears Taken (14)	207	Samson	The first shift on 1/10/1955 (0000-0800) indicated that 2 drawers in Area 207 were checked for alpha contamination. Follow-up surveys occurred later in the shift in Area 207, noting alpha contamination and floor contamination.
21	1/10/1955	0000–0800	Health Physics	"Alpha contamination (207)"	Incident Report Completed	L-01	Not Listed	SC&A was unable to locate a corresponding incident report.

Ex. #	Date	Shift (Military Time)	Origin of Job Request	Remarks and Explanations from Logbooks (Direct Quotes)	Actions Taken	Area	Instrument	Additional SC&A Notes
22	10/12/1953	0000–0800	Health Physics	"Proportional α counter not operating"	Instruments Calibrated, Instruments Inspected or Other Instrument Work	LB-13	Not Listed	—
23	12/6/1953	0000–0800	Health Physics	"α cont"	Samples and Smears Taken (8)	LC-12	Not Listed	Two other α contamination surveys were made in the LC-12 area during this shift.
24	12/6/1953	0000–0800	Operations	"α cont"	Direct Radiation Surveys, Contamination Surveys	Q-Cell	"UV"	—
25	11/26/1953	1600–2400	Operations	"Possible α spill"	Direct Radiation Surveys, Contamination Surveys	E Cell	UV	—
26	12/27/1953	800–1600	Maintenance	"Floor α contaminated"	Contamination Survey, Samples and Smears Taken (5)	LB-12	Not Listed	A second survey occurred during the same shift in LB-12 with 4 more smears taken. Remarks and Explanations also indicate "Floor α contaminated"

In addition to the general shift log entries shown in Figure 1 and described in Table 1, SC&A identified available HP records that contained handwritten logs of individual activities with additional detail (CPP HP 1954a, b). One such example is the surveys performed in LB-32, which are shown in Figure 2. Although such entries have difficult legibility, Figure 2 shows a contamination survey occurring in LB-32 and LB-28 between 1000 and 1630 hours (the specific date is not provided but the logbook itself was dated January of 1954). The remarks and actions taken appear to read:

> *Got to checking around LB32 after* ***floor plan showed quite a bit of α contamination****. Took smears off of walls, equipment etc* ***all extremely contaminated****. The only thing this can be* ***due to is airborne contamination.*** *To add to the problem.* ***Most of the activity is*** U^{233} ***which is 3 to 4 times more hazardous than*** U^{235}*. Started a 24 hr air sample & 'roped off' area. ~15 smears taken & counted. LB-28 smeared on tops of various equipt pieces max 28* [legibility issues] *c/m on top of south locks. 7 smears* [emphasis added]

Figure 2. Example of Handwritten Health Physics Logs Detailing a Specific Activity in 1954 (CPP HP 1954a)



Additional logbook entry examples are summarized in Table 2. The entries were numbered for ease of reference to the reader. Many of the example entries shown in Table 2 involve alpha contamination issues in particular laboratory areas. Lab-32, which was also the subject of the activity shown in Figure 2, had noted alpha contamination issues shown in examples 4 and 7. Example 7, in particular, noted: "*Found α cont. in LB-32 again*" (CPP HP 1954b). Additionally, an air sample that was taken in the north sampling corridor (see Example 6) showed airborne alpha contamination that was comparable to the maximum permissible concentration (MPC) and would require respiratory protection (NIOSH 2010). The logbook entry for this event notes that no significant beta-gamma airborne activity was measured at that location.

Table 2. Additional Examples of Health Physics Logbook Entries with Detailed Handwritten Notes from January and February 1954 (CPP HP 1954a, b)

Ex. #	Type of Survey, Instrument	Requestor	Location	Quotes Labelled as "Remarks and Action Taken"*
1	α Cont., Smears	Chem.	LB-12	"*Checked desk tops, etc. in LB-12 request of radio-chem lab personnel. Found furniture tops cont. up to 100 c/m α. Since* [name redacted] *will be out of lab by today, advised thorough cleaning tomorrow.*"
2	Cont., Smear	[Name Redacted]	PM Area	"*7 smears taken behind barrel area on R, Q & S platform. Found max 27 c/m alpha on floor excluding area under small tables. Advised to scrub area with citric or dilute solution of nitric. Subsequent survey to be made… contamination (α) survey of P, Q, S platform area after decontamination work with nitric. 5 smears taken. All count to ~35 c/m. Advised more scrubbing… 4 smears taken on P, Q, &S platform after repeated nitric scrub. Max 10c/m alpha. Advised O.K. to remove barricade.*"
3	Cont., Samson	[Name Redacted]	LB-1	"*Survey made on* [illegible] *which had been juiced by metal joint apparatus used to siphon material. Significant alpha contamination found.*"
4	Cont., GM – Juno - Scaler - Counter	Routine	LB Area	"*Made routine area surveys 3 labs – LB-28, LB-32, LB-44. α cont to 250 c/m found. Mostly on desk and bench tops. Marked all plainly for Monday A.M. cleanup. Floor plans completed + distributed – 26 smears counted. 3 tags issued.*"
5	Cont., Counter	[Name Redacted]	LB-28A	"*Made smear survey of previously α cont area now scrubbed. 2 c/m α max found – O.K.ed floor plan.*"
6	Air Sample, Hudson	[Name Redacted]	N. Sample Corr.	"*10-min air sample taken near vicinity of K plug openings. Air blowing from these openings into corridor. Calculated concentration* 4.4×10^{-11} *μc/cc (alpha). No significant βγ counts Alpha concentrations appear to be approx. allowable level (40 hr/wk).*"
7	Rad. and Cont., GM and Smears	Routine	LB-2, 4, 11, 12, 13, 28, 32, 31	"*Routine Area Surveys. Found several hot pots. Reported same. 41 smears taken and counted for αβγ. Found α cont. in LB-32 again.*" [note: underline appears in original record]

* The quotes presented in the "Remarks and Action Taken" column were transcribed to the best of the author's ability.

SC&A found multiple examples in available HP logbooks in which alpha contamination was detected at various locations at CPP including hot cells and laboratory/product room areas. The logbook examples did not necessarily indicate that beta/gamma contamination was also present in these same areas during the identified shift. However, there was evidence that areas were resurveyed during the same shift, which is likely indicative of cleanup efforts (see examples 4, 7, 17, 18, 20, 23 and 26 in Table 1 and examples 1, 2, 4 and 5 in Table 2).

Finding 1: SC&A found multiple examples in sampled HP logbooks that indicate alpha contamination was detected without corresponding indications that beta/gamma contamination was also present. This is indicative that there were certain situations and locations at CPP in which alpha contamination may have existed that was not comingled with FAP material.

3.0 ALPHA MONITORING IN THE CPP PRODUCT BOTTLE ROOM DURING 1955

The Product Bottle Room at CPP is of particular interest to potential alpha exposures as this would be the final stage in which purified highly enriched uranium (HEU) would be encountered without the fission product component. Figure 3 shows an example of alpha smears taken on product bottles in the product bottle room. The figure notes that certain product bottles had been identified as requiring decontamination and other bottles had been cleaned and rechecked after decontamination.

Figure 4 shows a similar decontamination survey log[1] in which bird cages (assumed to be used for movement of materials) were checked for alpha contamination. The figure indicates that bird cage numbers "101" and "155" had checkmarks which are assumed to indicate an unacceptable level of alpha contamination. Later in the same day, they were rechecked for alpha contamination (presumably after cleaning) and found to be at acceptable levels. Finally, Figure 5 shows an example alpha air sample from 1954 in the product bottle room. The record seems to indicate that the units are in "microcurie," however this would not be consistent with other observed air sampling records, which were all given in units of "microcurie/ml" or "microcurie/cc." It is possible that the record was partially cut off and the activity units were actually normalized per unit volume.

Finding 2: SC&A found examples of alpha monitoring taking place in the Product Bottle Room, including smear surveys of product bottles and bird cages, as well as air monitoring for alpha. This is evidence that alpha contamination, including airborne contamination, was of concern to the HP staff for this area. Given the nature of routine work activities encountered in the Product Bottle Room, it is unlikely that workers in this area would also encounter FAP that are comingled with the enriched uranium.

[1] Figure 4 is actually the combination of two successive survey logs, rather than a single survey logsheet.

Figure 3. 1955 Example of Alpha Smears Taken on Uranium Product Bottles Showing Decontamination Was Required on Three of the Bottles (CPP HP Various Dates-b)

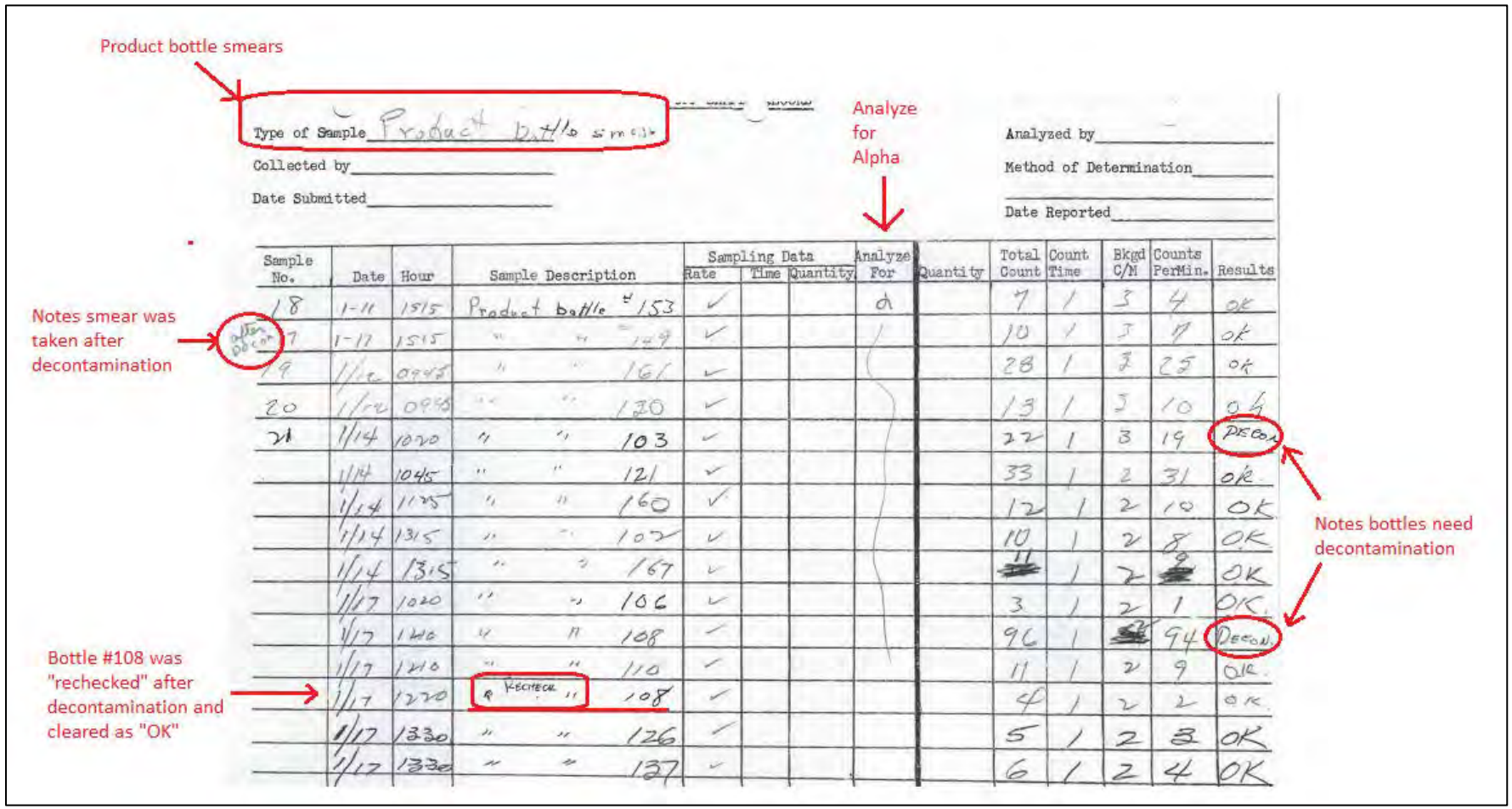


Figure 4. 1955 Example of Alpha Smears Taken from Product Bottle Room Bird Cages – Shows Bird Cages Marked for Resurvey Likely after Appropriate Decontamination (CPP HP Various Dates-b)

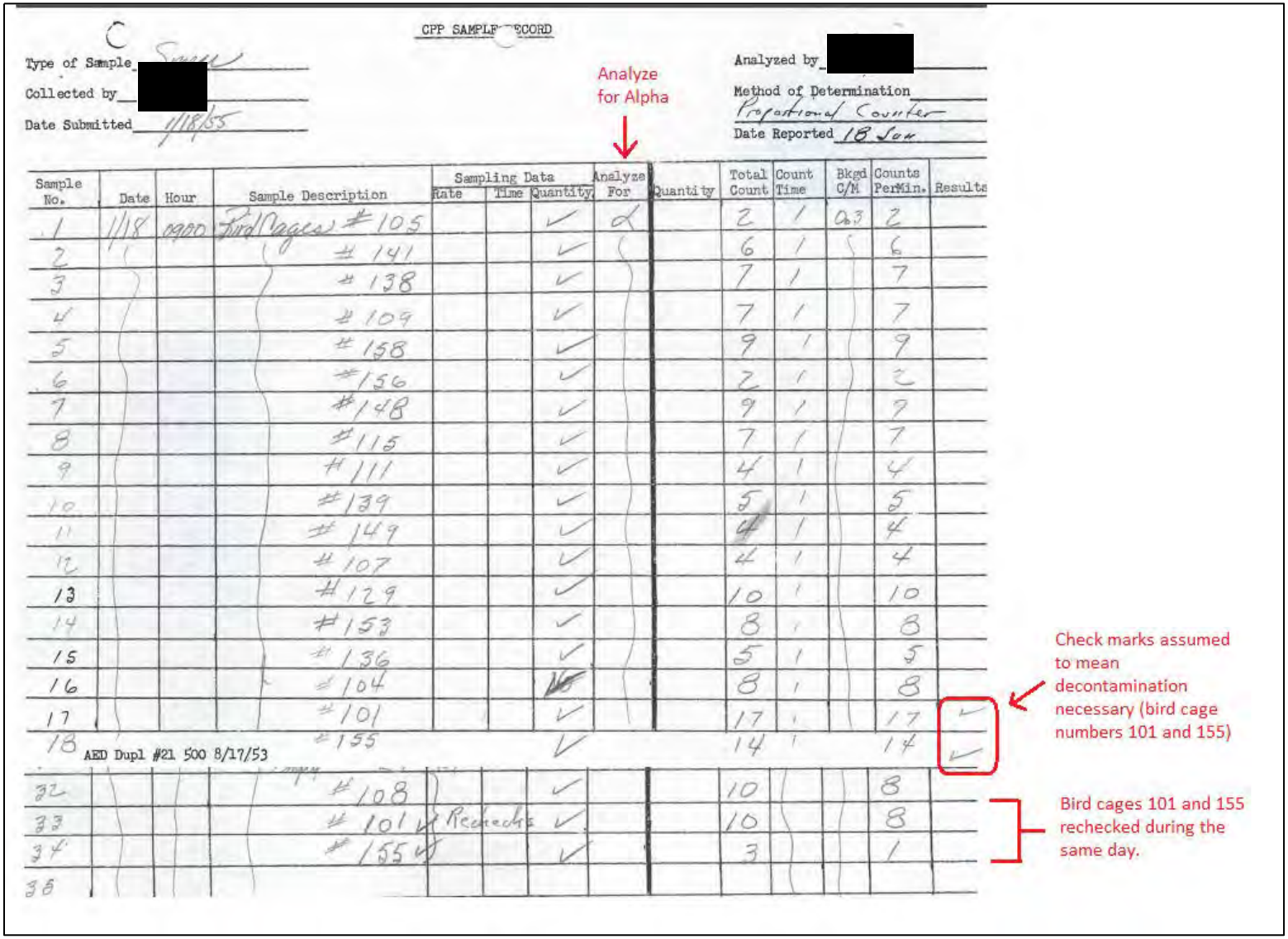
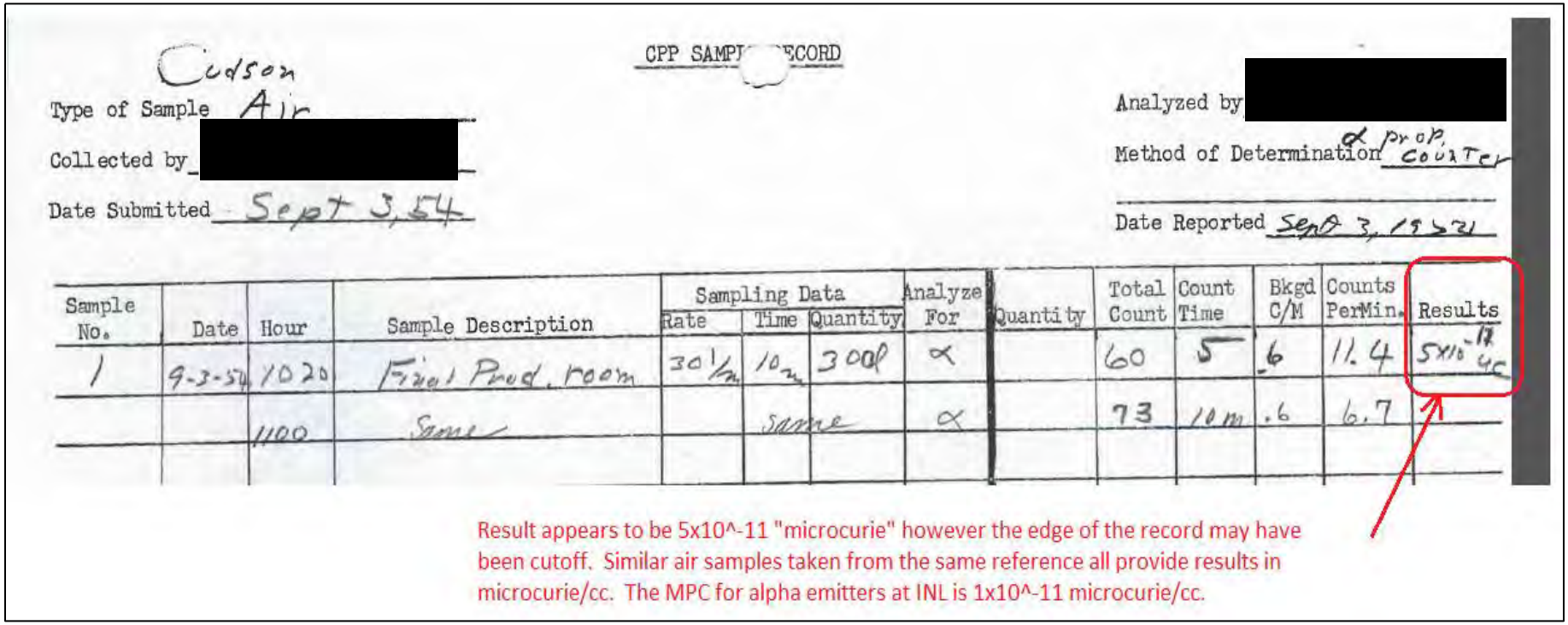


Figure 5. Alpha Air Sample Taken in the Product Bottle Room in 1954 Showing Positive Alpha Air Activity (CPP HP Various Dates-b)



CPP SAMPLE RECORD

Cudson

Type of Sample Air

Collected by [redacted]

Date Submitted Sept 3, 54

Analyzed by [redacted]

Method of Determination α prop. counter

Date Reported Sept 3, 1954

Sample No.	Date	Hour	Sample Description	Sampling Data Rate	Time	Quantity	Analyze For	Quantity	Total Count	Count Time	Bkgd C/M	Counts PerMin.	Results
1	9-3-54	1020	Final Prod. room	30 l/m	10 m	300l	α		60	5	.6	11.4	5×10^{-11} uc
		1100	Same		Same		α		73	10 m	.6	6.7	

Result appears to be 5x10^-11 "microcurie" however the edge of the record may have been cutoff. Similar air samples taken from the same reference all provide results in microcurie/cc. The MPC for alpha emitters at INL is 1x10^-11 microcurie/cc.

4.0 EXAMPLES OF ALPHA AREA SURVEY MAPS FROM 1954, 1955, 1957, 1960, AND 1961

SC&A identified several examples of HP area survey maps that either solely or primarily indicated alpha contamination. Figures 6–8 show routine radiation and contamination surveys in Room 216. Figure 6 shows a routine "rad & cont." survey from December of 1961. The survey found alpha contamination in a sink, on a chair, and inside a hood and a glovebox. A fifth area of alpha contamination was not specifically identified in the survey floor plan, but it appears to be a bench or desk. The survey notes that these areas should be decontaminated with the entry: *"Cleaning of shaded areas recommend*." No beta/gamma contamination was noted in the survey.

Figure 7 shows a specific alpha contamination survey of Room 216 in May of 1955 and identifies a significantly contaminated hood. Figure 8 displays a magnified image of the hood area of the survey floor plan. This figure shows contamination inside the hood as 1,500 disintegrations per minute per 100 square centimeters (dpm/100cm^2) which is 75 times the radiation control guideline (RCG) for alpha contamination (NIOSH 2010). The contamination survey notes that the blotter paper should be changed in this area.

Figure 6. Example Alpha Survey of Rooms 212 and 216 in 1961 (CPP HP 1961)

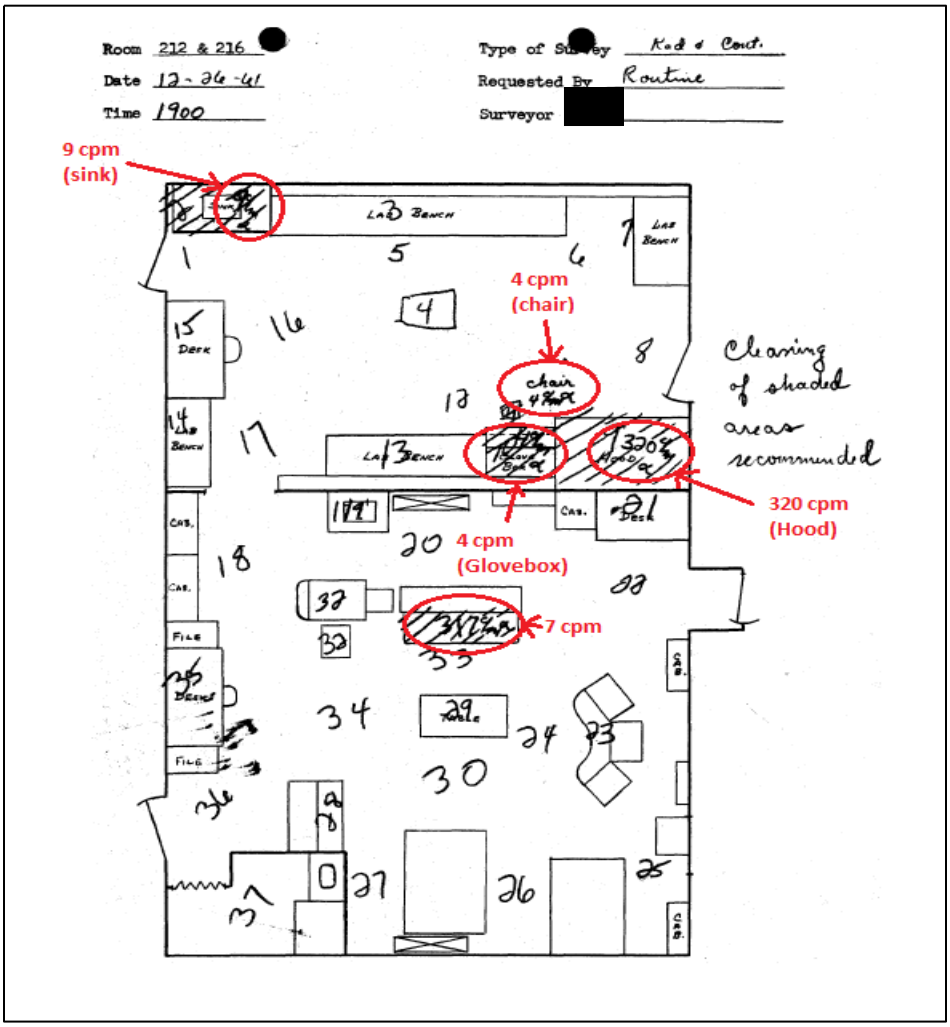


Figure 7. Example Alpha Survey of Room 216 in 1955 (CPP HP 1955)

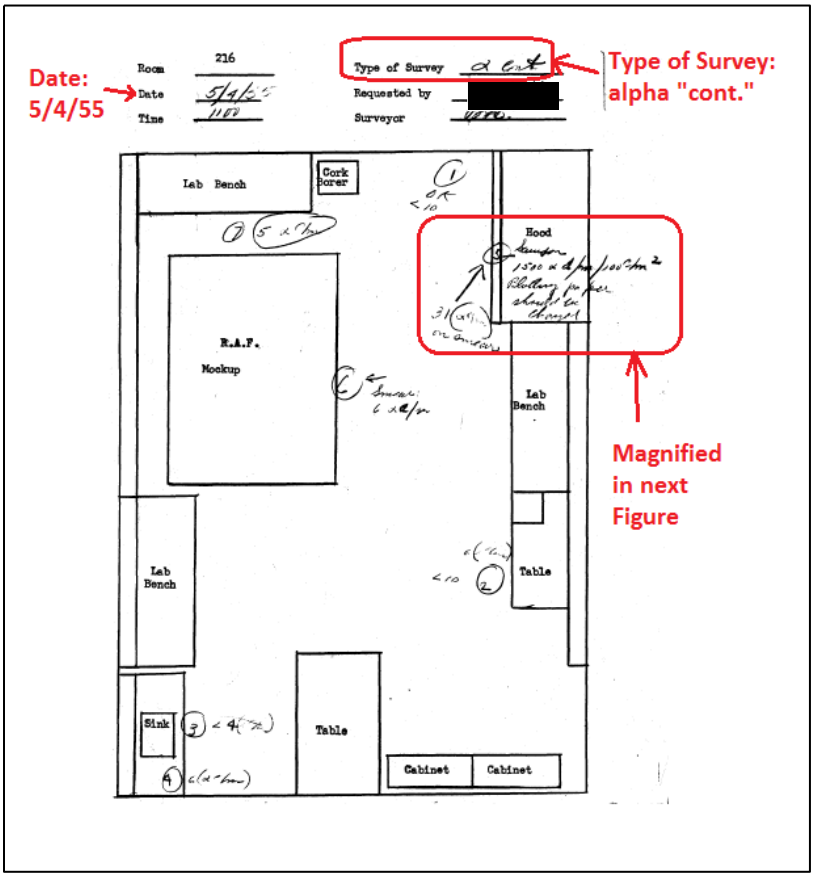


Figure 8. Close Up of Hood in Figure 7 Showing Alpha Contamination Prompting Clean-up Action (CPP HP 1955)

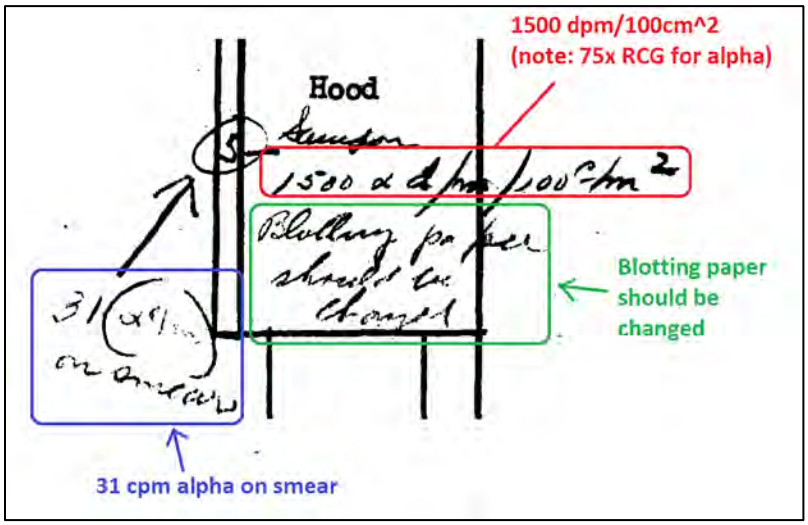


Figure 9 shows an alpha/beta/gamma contamination survey of the X-Cell which occurred in October 1961. As the figure shows, alpha contamination was found in several locations within the cell (sink, desk, bench, hood, table, and floor). Only one location within the X-Cell was noted to have beta/gamma

contamination (bottom left of the figure). Another location on the floor noted contamination to 5 counts per minute (cpm), but does not specify the type of contamination.

Figure 9. 1961 Alpha/Beta/Gamma Contamination Survey in X-Cell Showing Single Labelled Beta/Gamma Result (CPP HP 1961)

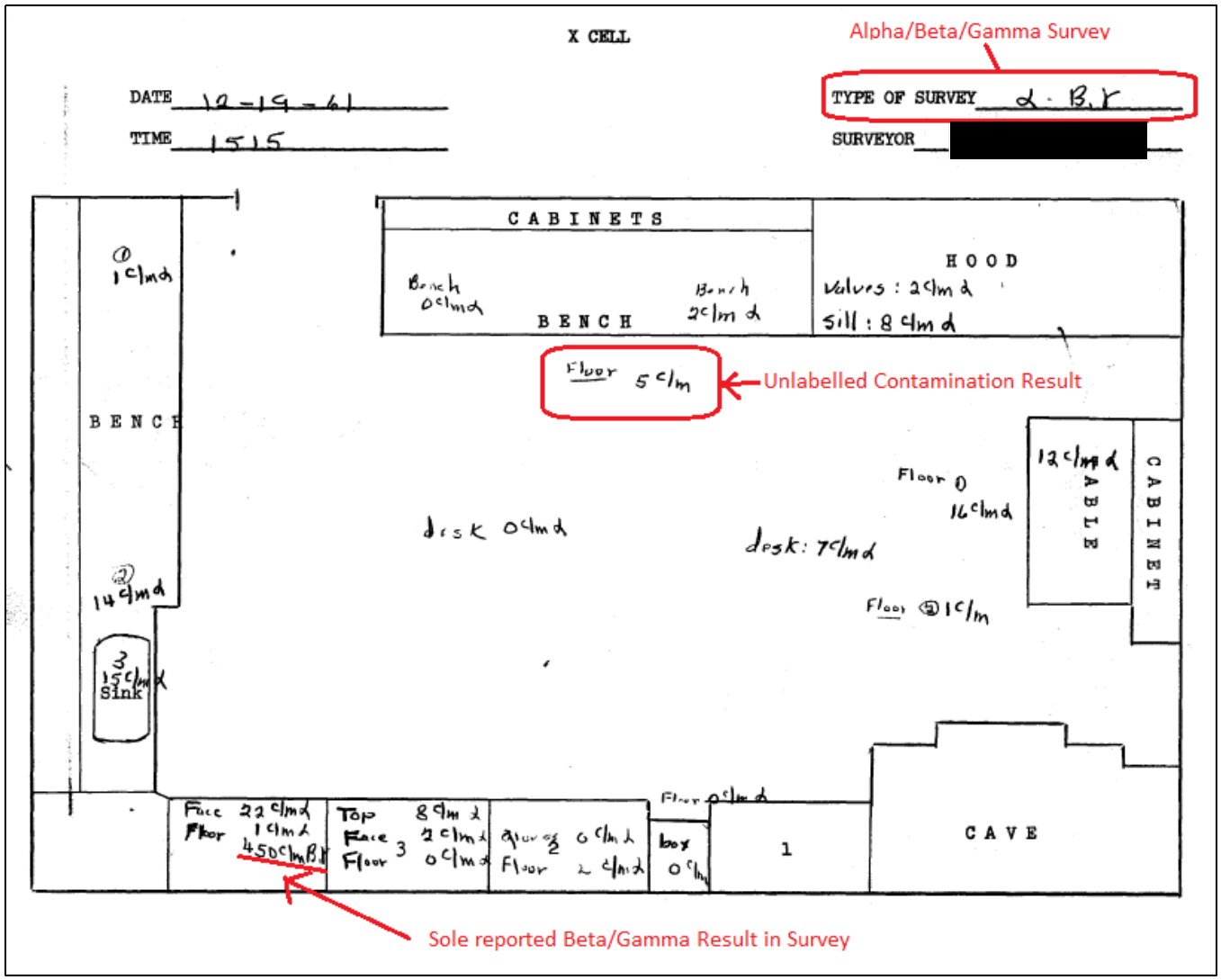


Figure 10 shows a routine "Cont. + Rad" smear survey of Rooms 204 and 207 that occurred in July of 1961. Two shaded areas of the map show alpha contamination on a table and a sink. A note on the contamination survey floor plan suggests that those areas be cleaned. No beta or gamma contamination is noted on the survey map.

Figure 10. Example of a Routine 1961 Radiation and Contamination Survey in Rooms 204 and 207 (CPP HP 1961)

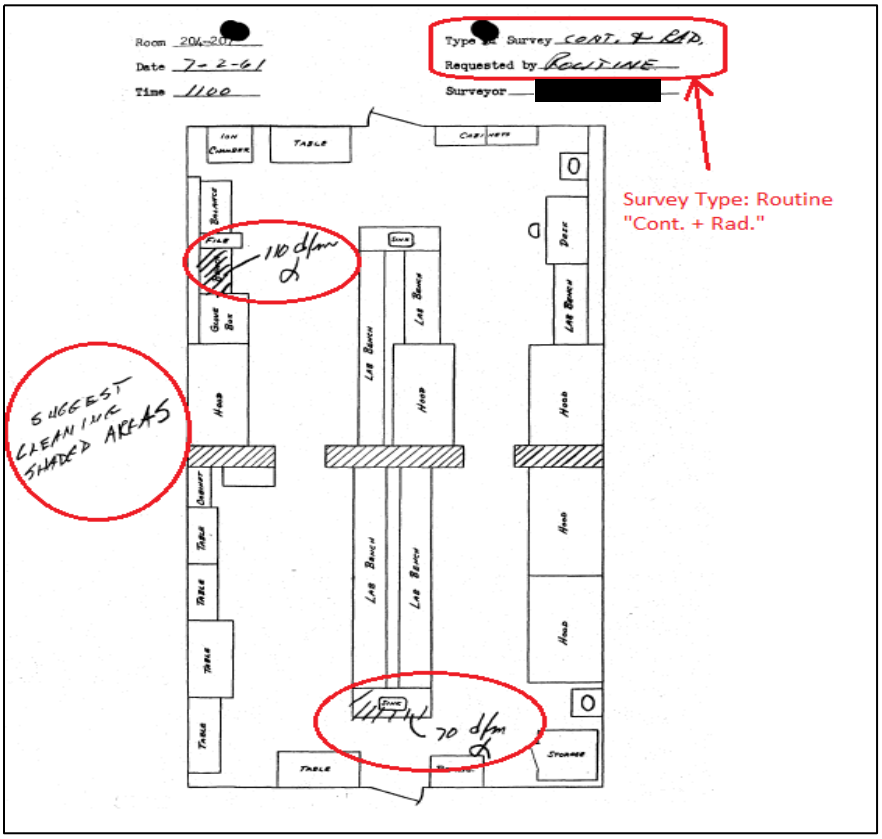
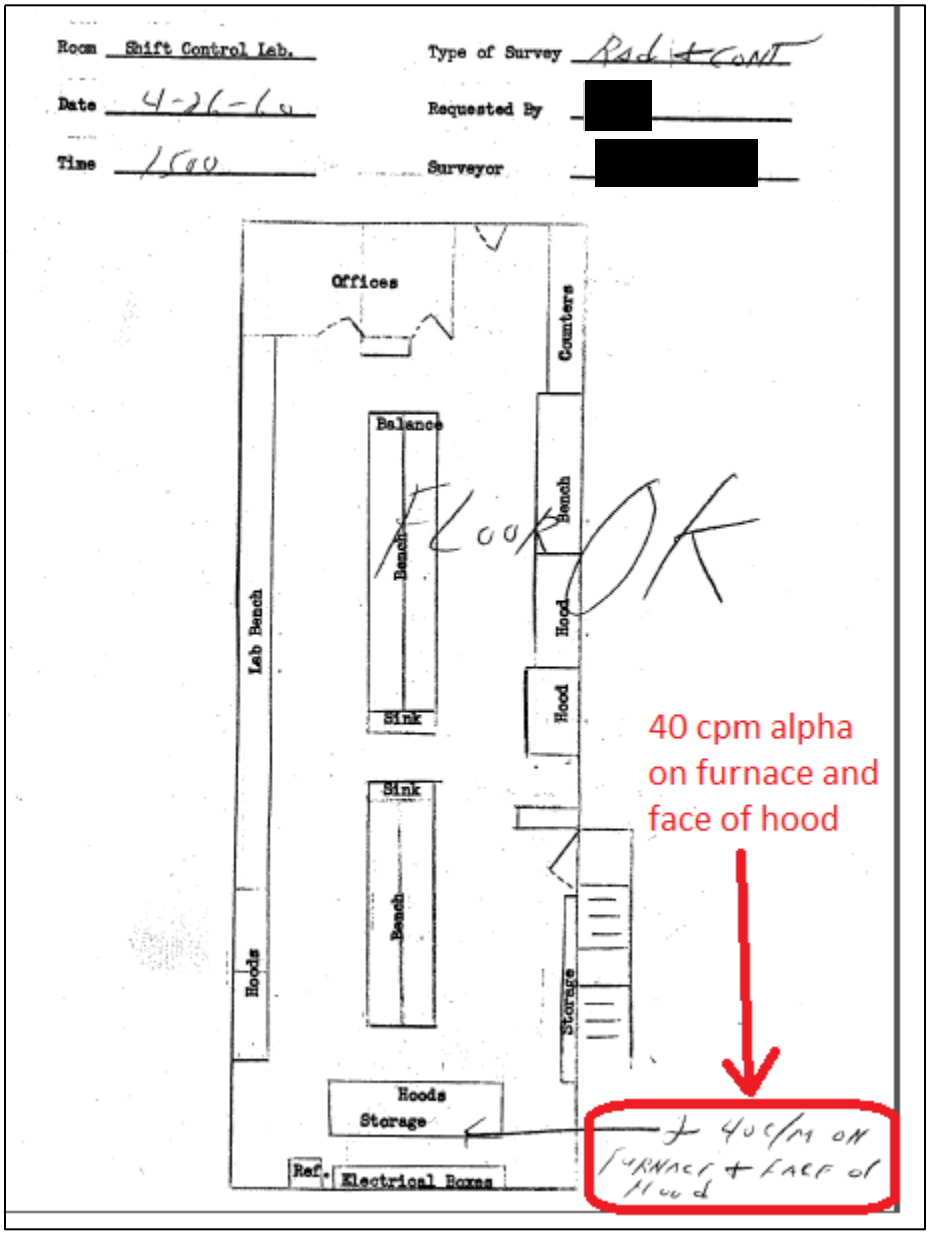


Figure 11 shows a survey floor plan of the shift control laboratory from April of 1960. The survey notes that the floor is “OK” but that alpha contamination was found on the furnace and face of a hood. The type of survey was “Rad + Cont” and so it is assumed to be an “alpha/beta/gamma” contamination survey.

Figure 11. Example of a Shift Lab Floor Plan from 1960 Showing Alpha Contamination (CPP HP 1960)



Figures 12 and 13 contain “radiation and control” surveys of Rooms 100, 102, and 104 in 1960 and Rooms 102 and 106 in 1957. Figure 12 notes that alpha contamination was found in several places in Room 102, including apparent spots on the floor and on a stool. Figure 12 also notes that all beta/gamma smears were less than 50 cpm for all three rooms. Figure 13 notes that a hood in Room 102 contained levels of alpha and beta contamination. Although units are not specified in the radiation survey, the numerical values assigned for alpha are over an order of magnitude higher than the numerical values assigned for beta. Also shown in Figure 13 is an area of Room 106 that indicated alpha contamination and also notes that a portion of the floor needs to be mopped.

Figure 12. Example of a General Contamination Survey in 1957 for Rooms 100, 102, and 104 That Shows Alpha Contamination on the Floor but All Beta/Gamma Contamination Swipes Were Less Than 50 cpm (CPP HP Various Dates-c)

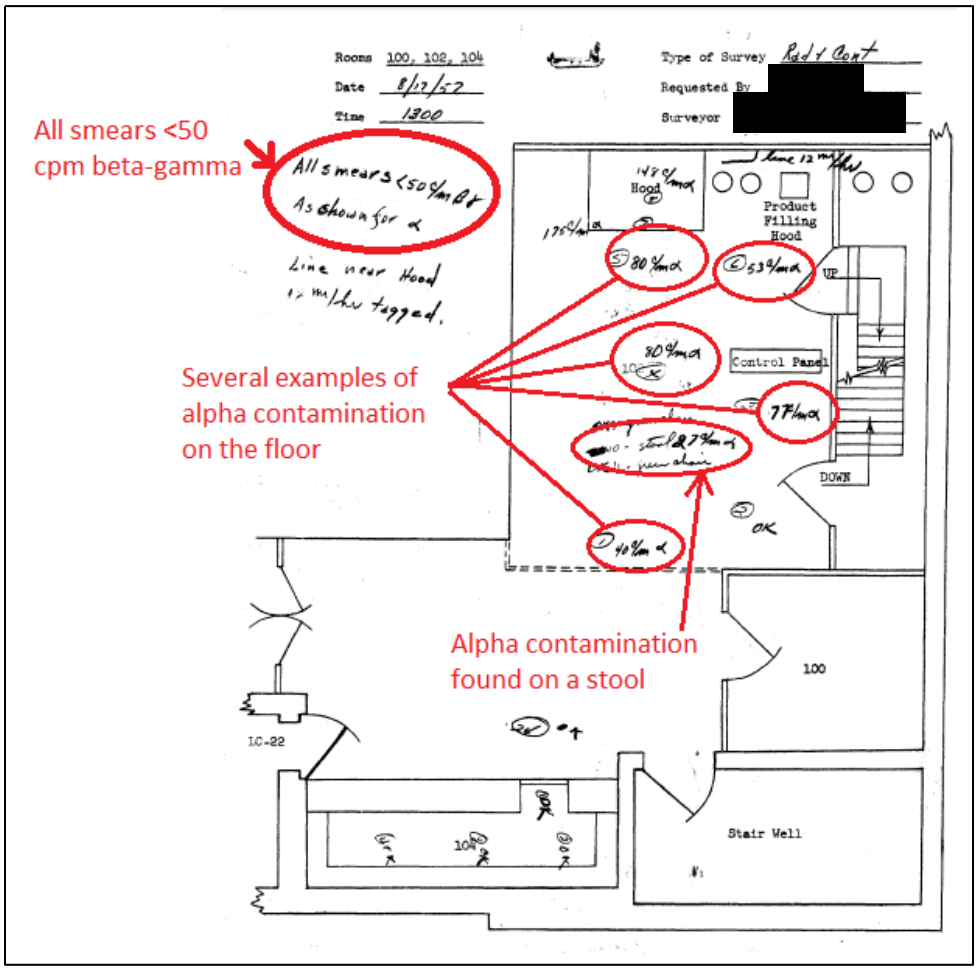
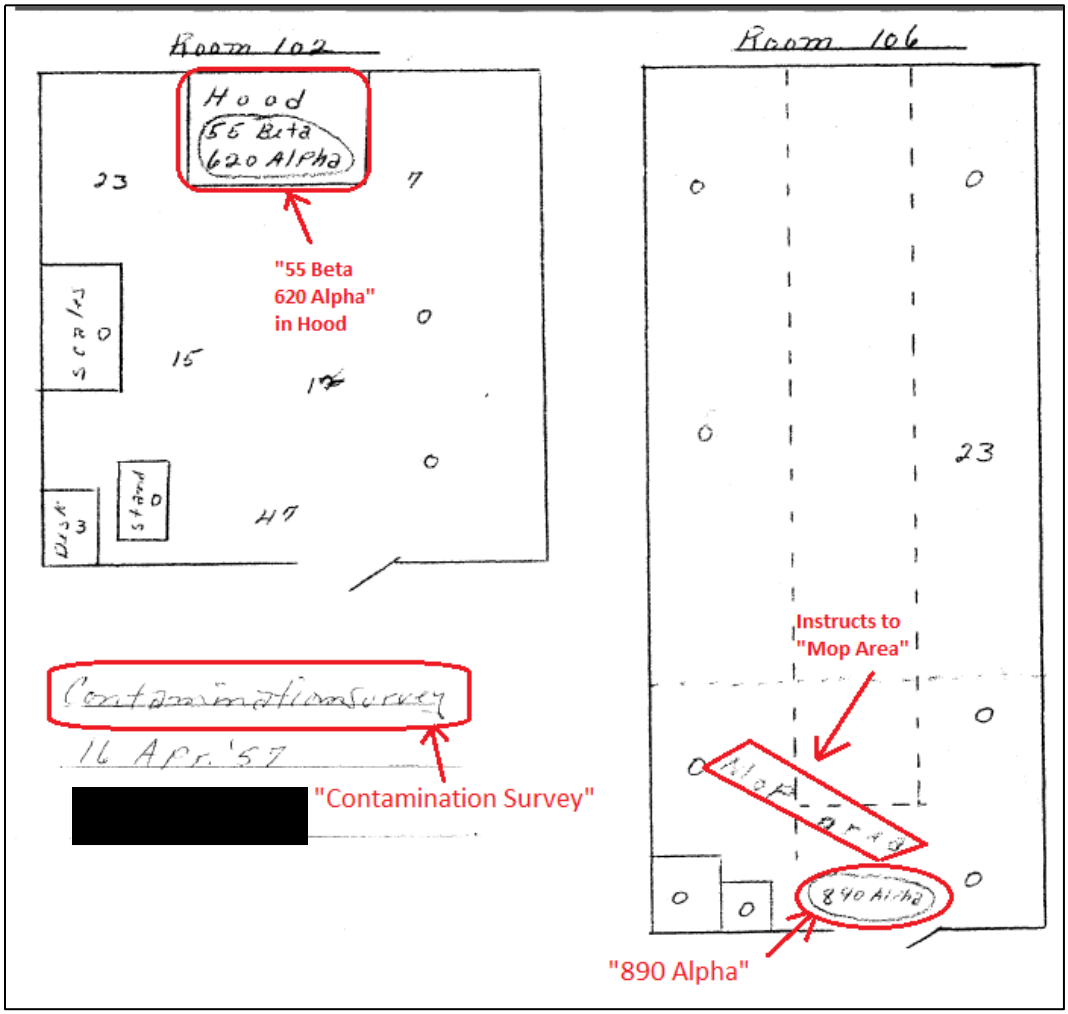


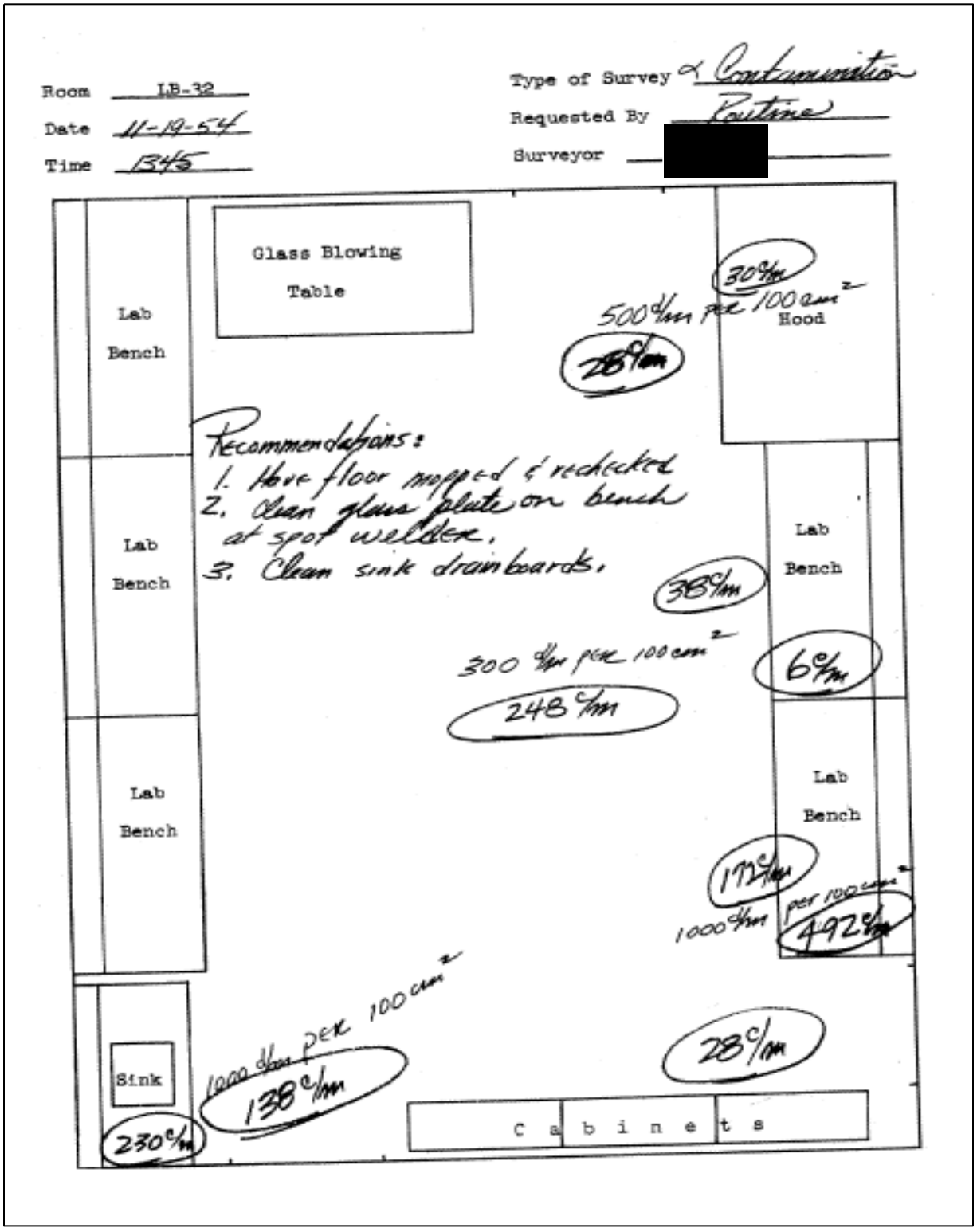
Figure 13. Contamination Survey Map from 1957 in Rooms 102 and 106 (CPP HP Various Dates-c)



Finally, Figure 14 shows an alpha contamination survey report from Lab 32 in November of 1954. The survey shows that alpha contamination was found on the floors, in a hood, on lab benches, and in a sink. As a result of the survey, it was recommended that the floor be mopped and rechecked. Also, it was recommended that a glass plate on the bench at the spot welder be cleaned, as well as the sink drain boards.

Finding 3: SC&A identified several area contamination survey maps from 1954, 1955, 1957, 1960, and 1961 that indicate that alpha contamination may have been the primary radiological concern for certain locations at the time of the survey. In many cases, the survey is a general contamination survey that did not detect beta/gamma activity, but directed that the identified locations with alpha contamination be cleaned up.

Figure 14. Contamination Survey of Lab-32 from 1954 Indicating Alpha Contamination with Instructions on which Spots Needed Decontamination (CPP HP Various Dates-c)



5.0 AIR MONITORING DATA FROM ROOM 216

SC&A identified a set of air sampling records for Room 216 that was intended to quantify long-lived airborne activity in November of 1954. Figures 15 and 16 were analyzed only for long-lived alpha emitters, and it was determined that there was airborne uranium-233 (U-233) present in the room. Figure 15 also contains a note which states that the material is likely U_3O_8.

Figures 17–19 contain measurements of both long-lived beta emitters and long-lived alpha emitters, but do not identify a specific isotope. Figure 17 shows that long-lived alpha emitters were measured while there were no long-lived beta emitters present. In Figure 18, both long-lived beta and alpha emitters were detected. It is not clear from the record whether the alpha air concentration is 9.6×10^{-12} microcurie per cubic centimeter (µCi/cc) or 9.6×10^{-13} µCi/cc. However, in either case the airborne alpha activity is higher than the airborne beta activity. Finally, Figure 19 shows alpha and beta air concentrations of 1.2×10^{-13} and 6.7×10^{-13} µCi/cc, respectively. In this last case, the beta air activity is higher than the alpha activity, however they are of the same general order of magnitude.

Finding 4: Based on a limited set of air samples in Room 216 from November of 1954, it is apparent that there was airborne alpha activity present. Evidence suggests the airborne alpha activity was U-233 in the form of U_3O_8. In two of the three examples, the airborne long-lived alpha activity bounded the airborne beta activity.

Figure 15. Air Sample Taken in Room 216 and Analyzed for Both Long-Lived Beta and Alpha Activity on November 5, 1954 (CPP HP Various Dates-b)

CPP SAMPLE RECORD

Type of Sample: Filtron Air Sample
Collected by: [redacted]
Date Submitted: 11/5
Analyzed by: [redacted]
Method of Determination: Filtron 2 column 30.8%
Date Reported: 11/5

Sample No.	Date	Hour	Sample Description	Sampling Data Rate	Sampling Data Time	Sampling Data Quantity	Analyze For	Quantity	Total Count	Count Time	Bkgd C/M	Counts PerMin.	d/m Results
2	11/5	1345	216 Lab. off at 0825 C_4	5 cfm	24h	C	α		2652	10m	1.5	264	857
118	0915		C_3 for CLL determinations				α		977	21	2.7	10	22
			C_{LL} = 12 d/m		at this it is not	significant							
			C_{LL} 12 ± 2 d/m										
			Results:										
			12 d/m				=	2.4×10^{-12} μc/cc					
			$2.22 \times 10^6 \times 0.7 \times 1.2 \times 10^{-12} \times 2.83 \times 10^{-2}$										
			U^{233} conc. = 2.4 ±	0.4		$\times 10^{-12}$ μc/cc							
			prob. as U_3O_8										

Identifies the contaminant as U-233 that is likely in the form of U3O8

Figure 16. Air Sample Taken in Room 216 and Analyzed for Both Long-Lived Beta and Alpha Activity on November 9, 1954 (CPP HP Various Dates-b)

CPP SAMPLE RECORD

Type of Sample Filtron

Collected by [redacted]

Date Submitted 11/9

Analyzed by [redacted]

Method of Determination prop. chg.

Date Reported 11/9

Sample No.	Date	Hour	Sample Description	Sampling Data Rate	Time	Quantity	Analyze For	Geo Quantity	Total Count	Count Time	Bkgd C/M	Counts PerMin.	d/m Results
4	11/9	1600	0900 11/8 to 0820 11/9	5 cfm	23:20	7000 ft³	α	24.4%	955	6m	3.3	156	640
			C_1					16.8%					
	11/11	1100	C_2 for C_{11} determ.				α	16.8%	274	12m	8.4	15	89
			$C_1 = 89$ $C_2 = 640$										
			$\alpha t = 43$ hr										
			$C_{11} = \frac{89 - 640\,e^{-0.0655 \times 43}}{1 - e^{-0.0655 \times 43}}$				=	89-4 = 84					
			$C_{11} = 90$ d/m										
			Results: U^{233} conc. =	2.1	$\times 10^{-13}$		μc/cc						

Figure 17. Air Sample Taken in Room 216 and Analyzed for Both Long-Lived Beta and Alpha Activity on November 16, 1954 (CPP HP Various Dates-b)

CPP SAM[illegible]ECORD

Type of Sample Air

Collected by [redacted]

Date Submitted 11/16/54

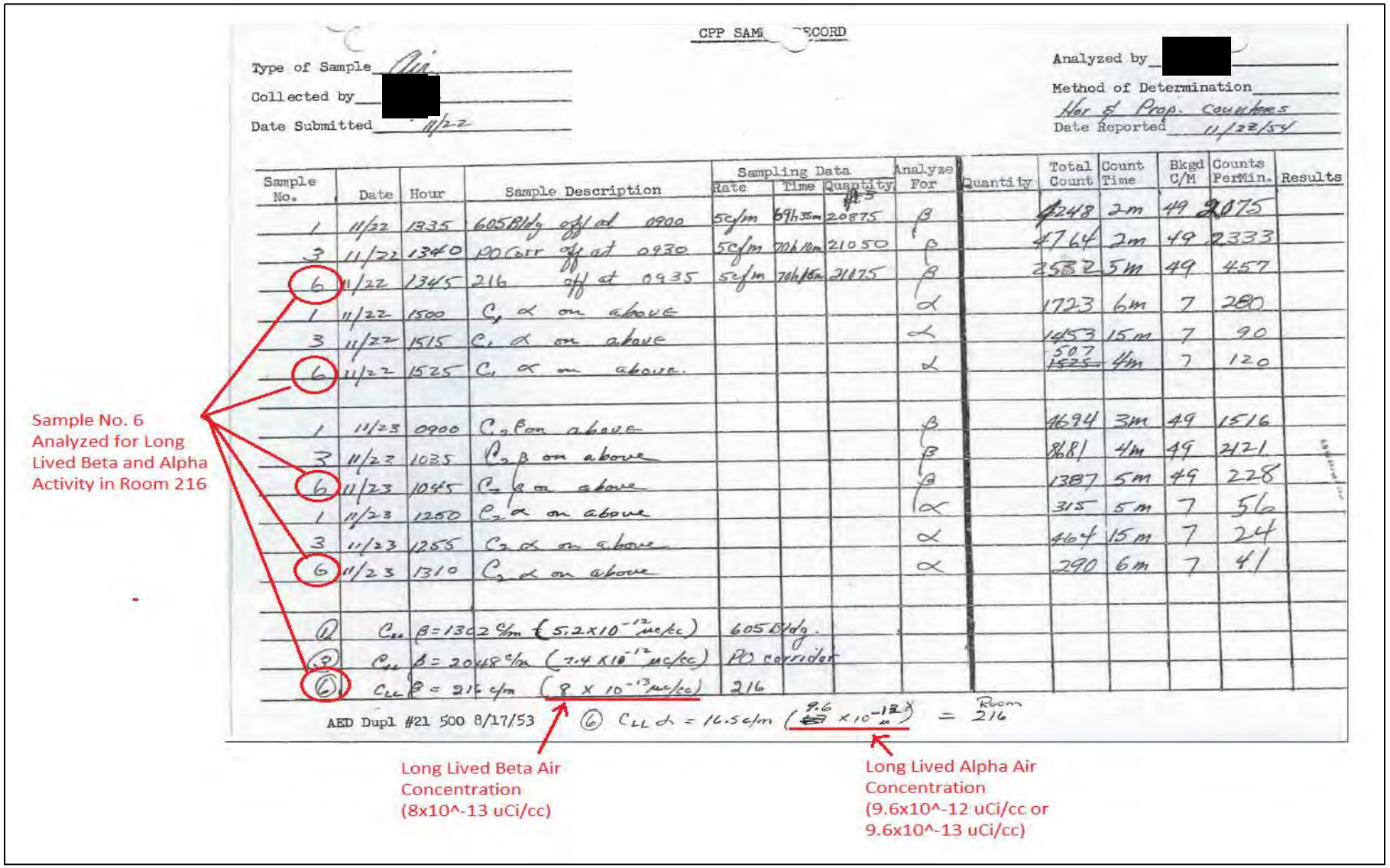
Analyzed by [redacted]

Method of Determination Alpha & β Filters Etc

Date Reported 11/16/54

Sample No.	Date	Hour	Sample Description	Sampling Data Rate	Sampling Data Time	Sampling Data Quantity	Analyze For	Quantity	Total Count	Count Time	Bkgd C/M	Counts PerMin.	Results
9	11/16		216 1035 to 0835	5cfm	22hr.	6600 ft³	α						
		1000	Same				β		1673	4m	48	370	
	11/16	1540	C_1				β		714	2m	48	311	
		1550					α		492	5m	12	86	
	11/17	0840	C_2				α		673	7m	12	84	
		0910	C_2				β		1581	11	48	96	
			C_{net} = 82 c/m = 234 d/m										
			Long Life Alpha concentration = 5.6×10^{-13}					μc/cc					
			C_{net} = 0										

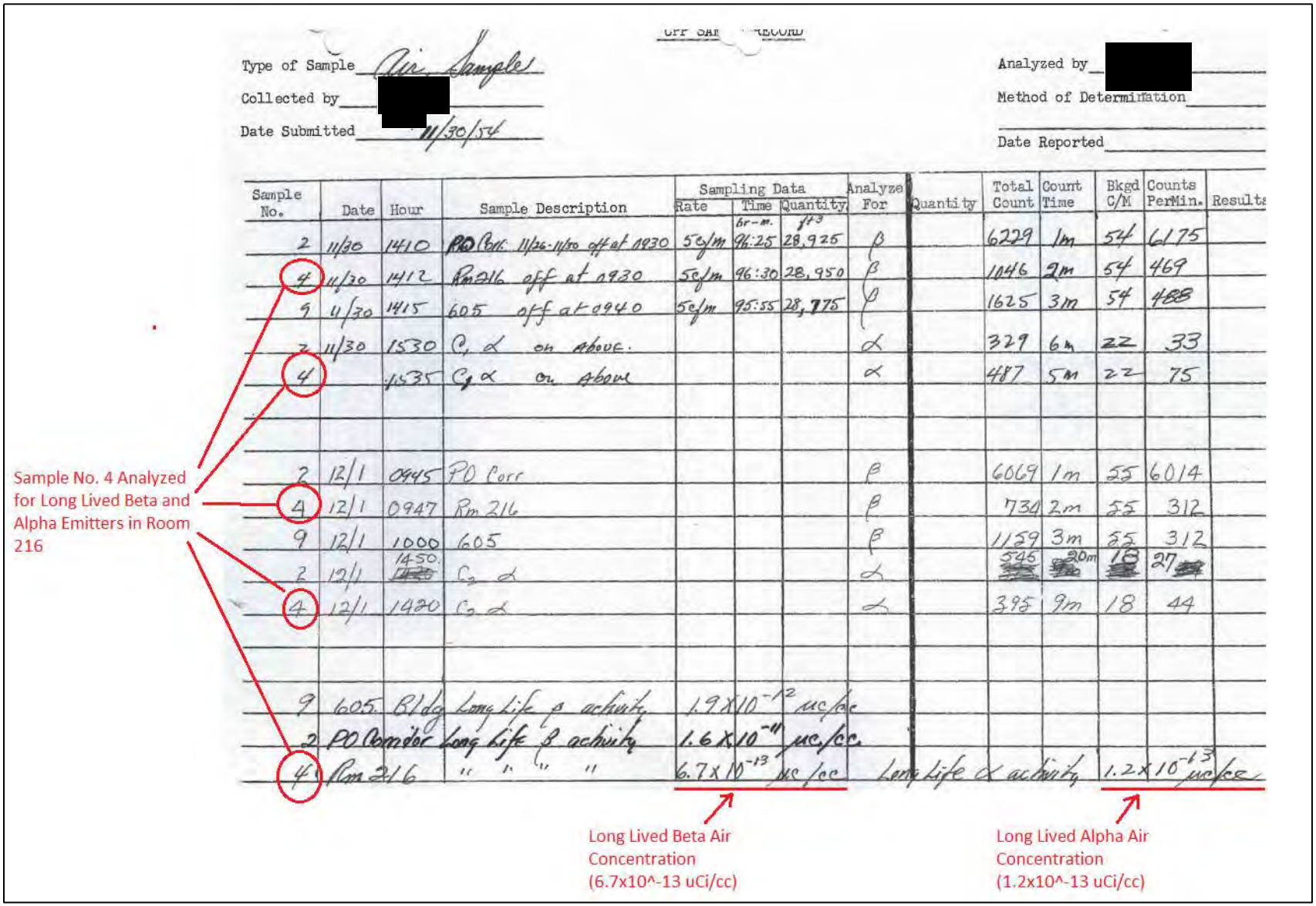
Figure 18. Air Sample Taken in Room 216 and Analyzed for Both Long-Lived Beta and Alpha Activity on November 22, 1954 (CPP HP Various Dates-b)



Sample No.	Date	Hour	Sample Description	Sampling Data Rate	Time	Quantity	Analyze For	Quantity	Total Count	Count Time	Bkgd C/M	Counts PerMin.	Results
1	11/22	1335	605 Bldg off at 0900	5cfm	69h35m	20875	β		2248	2m	49	2075	
3	11/22	1340	PO Corr off at 0930	5cfm	70h10m	21050	β		2764	2m	49	2333	
6	11/22	1345	216 off at 0935	5cfm	70h15m	21075	β		2582	5m	49	457	
1	11/22	1500	C_1 α on above				α		1723	6m	7	280	
3	11/22	1515	C_3 α on above				α		1453	15m	7	90	
6	11/22	1525	C_6 α on above.				α		507 1525	4m	7	120	
1	11/23	0900	C_1 β on above				β		4694	3m	49	1516	
3	11/23	1035	C_3 β on above				β		868	4m	49	2121	
6	11/23	1045	C_6 β on above				β		1387	5m	49	228	
1	11/23	1250	C_1 α on above				α		315	5m	7	56	
3	11/23	1255	C_3 α on above				α		464	15m	7	24	
6	11/23	1310	C_6 α on above				α		290	6m	7	41	
①	C_{LL}	β = 1302 c/m (5.2×10^{-12} uc/cc)		605 Bldg.									
③	C_{LL}	β = 2048 c/m (7.4×10^{-12} uc/cc)		PO corridor									
⑥	C_{LL}	β = 217 c/m (8×10^{-13} uc/cc)		216									

AED Dupl #21 500 8/17/53 ⑥ C_{LL} α = 16.5 c/m ($\frac{9.6}{} \times 10^{-12}$ uc/cc) = Room 216

Figure 19. Air Sample Taken in Room 216 and Analyzed for Both Long-Lived Beta and Alpha Activity on November 30, 1954 (CPP HP Various Dates-b)



6.0 SC&A INTERVIEWS WITH INL WORKERS

As part of its review, SC&A participated in interviews with former workers who might have knowledge of radiological conditions (specifically those related to alpha-emitting material) at the CPP prior to 1963. These interviews were conducted jointly with NIOSH/ Division of Compensation Analysis & Support, ORAUT, and members of the ABRWH INL WG. While the interview effort is obviously complicated by both the timeframe in question (work performed more than 50 years in the past), as well as the highly technical nature of the information sought as part of this review, five interviewees were identified who provided information that is germane to this investigation. These five interviews are discussed in Sections 6.1 through 6.5. Section 6.6 contains a brief overview and characterization of the five interviews.

6.1 DOCUMENTED COMMUNICATION WITH EE 1

EE 1 ([redacted]) was interviewed on at least two separate occasions in which information germane to radiological conditions at CPP was discussed: September 10, 2015 (ORAUT 2014a), and December 11, 2014 (ORAUT 2014b). [redacted] worked as an [redacted] at CPP from [redacted] when he was transferred to another INL site area. [redacted] describes the routine HP monitoring program of the 1950s as very comprehensive and disciplined.

With regard to possible alpha-emitting material, [redacted] stated that plutonium-238 (Pu-238) was never extracted at CPP during that time because there was never enough of it to make it worthwhile. However, the interview notes from ORAUT 2014a also state:

> *The analytical lab did U and Pu separations on 3rd cycle process samples in the 1950s for process control. The lab was surveyed at every shift. Pu-238 contamination was found on a lab bench – it was found, reported, and cleaned up because of the shift surveys.… When alpha contamination was discovered in the lab (1950s), the entire crew was sent for urine bioassay – looking for U and Pu. Alpha bioassay was done when conditions indicated; alpha contamination was not seen often.… Alpha bioassay would be done if alpha uptakes were suspected, mostly for lab personnel. The highest potential for internal alpha exposure was the 3rd cycle extraction.*

In a separate interview, [redacted] reiterated the HP practices of surveying the laboratory areas. ORAUT 2014b states:

> [redacted] *informed us that the lab had benches, hoods, and gloveboxes and that it was surveyed every shift. He noted that if plutonium contamination was found in the lab, it was immediately cleaned up and plutonium bioassay was implemented as needed. The sample analysis in the Analytical Labs looked for alpha and beta/gamma. If alpha was detected on a sample then an isotopic analysis was performed to determine the radioactive contributor. He also noted that filters from CAMS and other air monitors were counted for alpha and beta/gamma. Occasionally, alpha contamination was found in the laboratory areas.*

As indicated in both statements, CPP locations where unmingled alpha contamination was possible were routinely surveyed, and urinalysis specific to alpha emitters was performed on an "incident" type basis when contamination or uptakes were suspected. This is confirmed in ORAUT 2014a:

> *At ICPP in the 1950s, bioassays were conducted for suspected uptakes. Workers were sent to RESL for bioassay if they had any facial contamination or if they worked in an area where airborne contamination was detected. When alpha contamination was discovered in the lab (1950s), the entire crew was sent for urine bioassay – looking for U and Pu. Alpha bioassay was done when conditions indicated; alpha contamination was not seen often.… Alpha bioassay would be done if alpha uptakes were suspected, mostly for lab personnel. The highest potential for internal alpha exposure was the 3rd cycle extraction.*

Finally, [redacted] indicated that there was a concern over alpha emitters (specifically plutonium) at CPP. ORAUT 2014a states:

> [redacted] *tried to make management and workers aware of Pu. He gave the interview team a copy of a document titled, "*[redacted]*" This was a presentation he gave to* [redacted] *staff in the* [redacted]*. It was not well understood. Fission products were the controlling dose issue. The technical staff believed the controls were adequate for alpha contamination, and the survey equipment was capable of detecting alpha contamination. Pu was only present in small amounts, but it was recognized that it doesn't take much to create a problem.*

Although a presentation on plutonium at CPP was provided by the interviewee, evidence suggests this presentation was not given in [redacted], but sometime later (possibly [redacted]). It is not known if a different presentation was given in [redacted], or if there was a typo in the interview notes when it was noted there was a presentation in [redacted]. At this time, it is not known if the original handwritten interview notes were available. However, given that worker interviews are documented by multiple individuals, and the summaries of those notes are reviewed by the interviewee prior to finalization, it is likely the statements are at least partially accurate.

6.2 DOCUMENTED COMMUNICATION WITH EE 2

EE 2 ([redacted]) worked at CPP from [redacted] as a [redacted] in the [redacted]. [redacted] describes his day to day activities as follows:

> *He performed analyses on the* [redacted]*. An example of an analysis was a "FLOSSIE." This was a test of uranium content that was done by dropping process liquid onto a chalk-like pellet. The uranium analyses were important for criticality control.*[ORAUT 2015]

[redacted] also described the use of anti-contamination measures during lab work:

> *In the Shift Lab, blotter paper would be placed on benches and floors. Even the interior of the hoods would be papered down. All of this was done to control contamination and keep the work surfaces as clean as possible. Health Physics did smears at the end of the shift. They (analytical lab) always prepared blotter paper for the next shift as directed by the HPs. Papering was done quite frequently.* [ORAUT 2015]

In general, [redacted] described the HPs at CPP as doing a "*good job*" and mentioned that they would monitor transfers and cleanup activities. [redacted] stated that while HP was around for many activities, sometimes the workers would self-monitor and then report their results to the HP Department.

6.3 DOCUMENTED COMMUNICATION WITH EE 3

EE 3 ([redacted]) started work in [redacted] as a [redacted] until moving to the [redacted], which developed techniques to analyze the chemical constituents of various CPP waste streams. [redacted] was transferred to another INL facility in [redacted]. With regard to the presence of alpha-emitting radioactive material, [redacted] stated the following:

> *HPs did their job. They took smears with filter paper for alpha monitoring. He doesn't know the results, but they were taking samples routinely.* [ORAUT 2016a]

The former worker also described a project at CPP which involved developing a method to dissolve and analyze Naval Reactors Facility fuel rods which likely involved fuel that had not yet been irradiated (i.e., did not yet contain significant FAP).

6.4 DOCUMENTED COMMUNICATION WITH EE 4

EE 4 ([redacted]) began full-time work as a [redacted] in the [redacted] at CPP beginning in [redacted] was specifically asked about the presence of alpha material at CPP and the interview notes include the following:

> *He wasn't very knowledgeable of HP instrumentation. He recalls taking a sample of the end product, which contained uranium. Several people were there. Security had to open the door/vault to access the sampling area. He doesn't specifically recall HP monitoring, but they were probably there.* [ORAUT 2016b]

6.5 DOCUMENTED COMMUNICATION WITH EE 5

EE 5 ([redacted]) began employment as an [redacted] at CPP in [redacted] and continued as a [redacted] until [redacted]. [redacted] indicated that the highest priority for HPs was exposure control because high exposures were common; however, the EE also indicates that contamination within the plant was more of a concern than direct radiation. In particular, the interviewee mentions concern over strontium-90 (Sr-90) due to its relative insolubility and tendency to migrate to the bone. [redacted] described the use of the HP logbooks (see Section 2.0 for examples) but does not recall using survey maps (examples shown in Section 4.0).

ORAUT 2016c describes the regular contamination control measures, as recalled by [redacted], as follows:

> *HPs were very concerned about contamination. They assumed contamination was present everywhere, and they took precautions to protect the workers.*
>
> - *Upon entering CPP, workers changed into anti-contamination clothing. On the way out, they showered, put on clothes, and walked through a monitor. Anyone who set off an alarm was expected to report to HP office for follow-up.*

- *Floors were cleaned every day.*
- *Air samples and smears were taken to determine contamination levels. A certain number of smears had to be taken during each shift.*
- *Blotter paper was used a lot at CPP for contamination control. HPs typically put it down.*
- *Operations workers helped police and keep the area clean, and they had to help clean up when contamination occurred.*

With regard to the bioassay program, [redacted] noted that HPs were not directly involved in the routine monitoring program but that they could send a worker to get a "special" sample if an intake was suspected. Specific to potential alpha contamination, the interview notes state:

> *"[redacted] was aware of one location at CPP where alpha contamination was a concern. He is not certain of the specific location now; it may have been the uranium packaging area or an analytical laboratory. He only recalls alpha contamination events happening about 3-4 times during his [redacted] years at CPP; he doesn't recall details clearly.* [ORAUT 2016c]

6.6 DISCUSSION CONCERNING RELEVANT CLAIMANT INTERVIEWS

Based on the limited interviews performed with EEs who worked at CPP prior to 1963 and who had knowledge of radiological source terms and operations, it is apparent that the presence of alpha contamination was of concern to the HP staff in certain areas of the plant. The HP staff performed daily or even shift-specific contamination surveys in lab areas where alpha contamination may have occurred (see Sections 6.1, 6.2, 6.3, and 6.5) and also often used blotter paper on the floor and on potentially contaminated surfaces to try and limit exposures (see Sections 6.2 and 6.5).

Exposure to alpha emitters was primarily of concern with the laboratories and "end product" locations (see Sections 6.1 and 6.5). The interviewees in Sections 6.2 and 6.4 describe taking uranium samples out of the product stream for analysis. Internal monitoring for alpha emitters was characterized as "incident"-based, in that special bioassay for alpha emitters could be requested at the behest of the HP staff (see Sections 6.1 and 6.5). Such incidents would involve contamination or other events in which an uptake of alpha emitting material was suspected. However, the actual threshold levels for conducting "non-routine" or "special" bioassay were not provided, and it is not clear what would constitute a significant enough contamination event to require internal monitoring for alpha contamination. For example, somewhat regular contamination events might be not be considered "incidents" for the purposes of conducting special internal monitoring and simply would require that the area be cleaned up or existing blotter paper be removed and replaced (see Section 4.0 for examples where HP surveys directed such activities).

Observation 1: Based on five identified interviews with former CPP workers having some knowledge of radiological operations, it is apparent that the HP staff were aware of, and took steps to control, alpha contamination in certain areas of the plant. These areas include the laboratories and other "product" areas. While the interviews indicate that an "incident"-based internal monitoring program was employed for alpha emitters, it is unclear what levels of alpha contamination would actually trigger "special bioassay" samples versus more common decontamination activities.

7.0 EXAMINATION OF CLAIMANT MONITORING RECORDS

SC&A acknowledges that internal monitoring at CPP was overwhelmingly driven by beta/gamma bioassay monitoring during the period of interest. However, in order to characterize the less common monitoring practices associated with uranium and other alpha emitters, SC&A reviewed the monitoring files for claimants who may have worked in laboratory areas or who had job types that could have potentially exposed them to source terms which did not contain alpha emitters comingled with FAP material at CPP during the period of interest.

Specifically, SC&A examined the records of claims with job titles that generally included: laboratory technicians, chemists/chemical engineers, research engineers, and scientists. SC&A identified 62 claimants who fit this job criteria prior to 1963, with 32 of them assigned for some or all of their employment at CPP.

Of the 32 claimants who matched SC&A's job type and location criteria, only [redacted] result was observed for uranium (Claim [redacted]). This EE worked at [redacted] continuously from [redacted]. The EE's computer-assisted telephone interview (CATI) report lists the following job titles: "[redacted]," as well as the following work locations: "[redacted]

The EE describes their routine duties in the CATI as follows:

> *For the first five years as a [redacted], he [redacted]. In [redacted], he [redacted] the plant.*

Additionally, the EE described the use of Radiation Work Permits (RWPs):

> *Radiation work permits were required when he worked with [redacted] He did not work under one routinely.*

On [redacted], the EE submitted a [redacted] which was not labelled as either being routine or special. A second [redacted]) was collected on [redacted]. Both [redacted] were [redacted] and can be seen in Figure 20. Examination of the claimant's "Chronological Record of Medical Care" provided in the Department of Labor files shows that a [redacted] was taken on [redacted], and that [redacted] were provided on [redacted] (see Figure 21). The latter [redacted] taken in [redacted] were not provided in the claimant records supplied by the U.S. Department of Energy (DOE).

One of those [redacted] was identified via the NIOSH process known to SC&A as "optical recognition imaging." While the [redacted] is dated [redacted], for [redacted], this is likely when the [redacted] was collected, rather than when the [redacted] was provided by HP. That record contained a handwritten note stating that the [redacted] was found to be [redacted] but does not provide further information. There was no incident report observed that was associated with the series of [redacted].

Figure 20. [redacted]

Figure 21. [redacted]

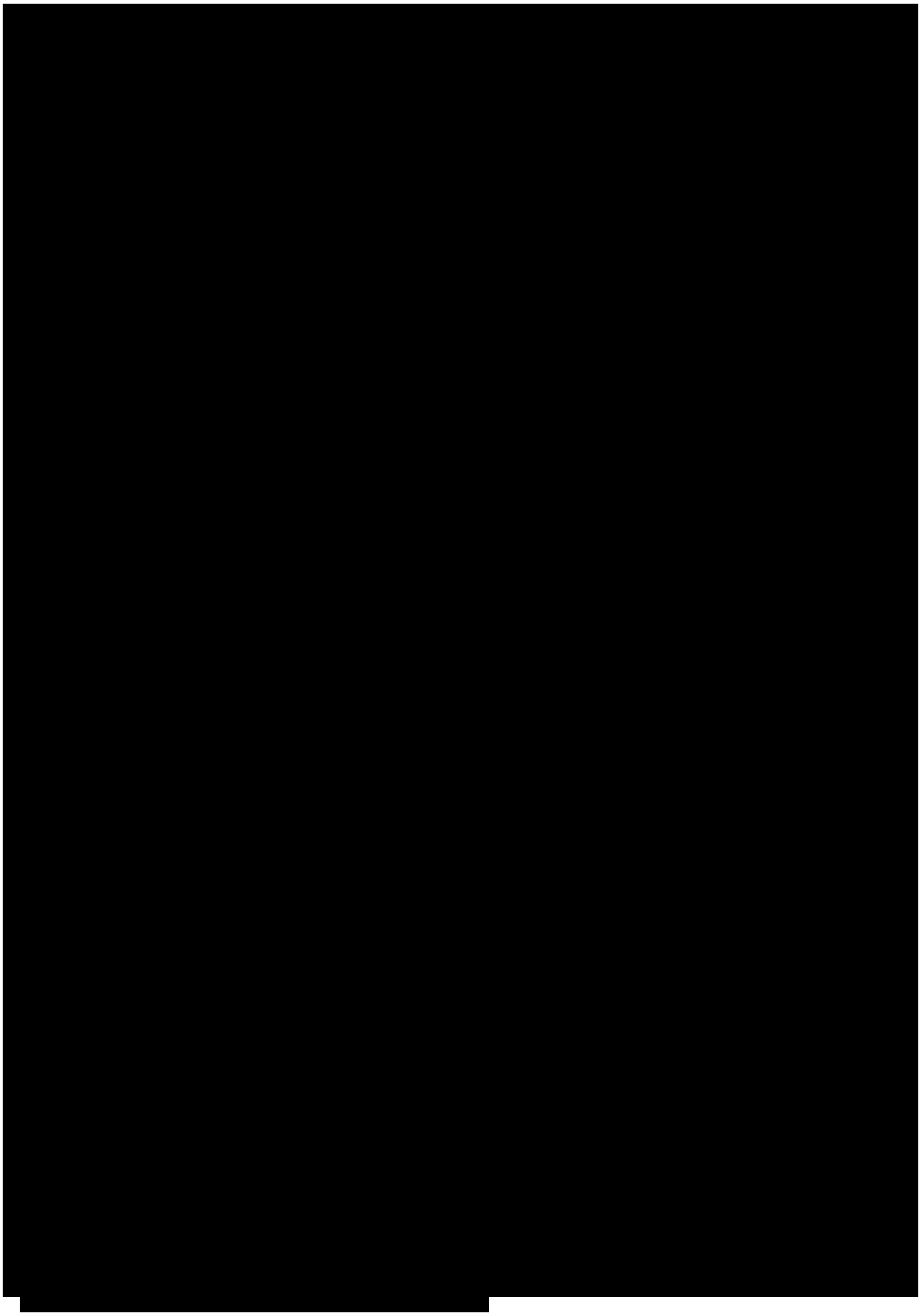
Finding 5: SC&A identified a single example in which [redacted] (specifically U-[redacted]) occurred out of the 32 reviewed claims who held job titles with the potential for laboratory work at CPP. [redacted] were provided in [redacted] monitoring record; however, a log of all medical treatment indicates that [redacted] occurred, which are missing from the dosimetry records supplied by DOE. [redacted] was located via the NIOSH process known as "optical recognition imaging." The disposition and availability of the [redacted] is unknown.

The remaining 31 claimants who did not have evidence of any [redacted] are described in Appendix A. Inspection of Appendix A shows that this subset of CPP workers generally had extensive [redacted].

Observation 2: [redacted] who worked at CPP prior to [redacted] and had job types most likely to be associated with laboratory work did not have any [redacted]. It cannot be inferred from available [redacted] files whether these workers should have been monitored and were not, were monitored and the records are unavailable, or did not experience any exposure potential to [redacted] warranting routine monitoring.

During SC&A's review of the [redacted] records described in Appendix A, SC&A observed several [redacted] who were on a routine [redacted] schedule for [redacted]. These [redacted] workers are listed in alphabetical order in Table 3 with an example number assigned for ease of reference. It is important to remember that the routine [redacted] in Table 3 likely do not represent the extent to which these workers were routinely [redacted]. These workers and their monitoring records were simply observed as a byproduct of the claimant study discussed previously.

Table 3. Listing of Observed Workers with Routine Urinalysis Results



As seen in Table 3, [redacted] results in [redacted] were labelled as "special" though the same worker would later submit [redacted]. The majority of observed routine samples fell between [redacted]. For certain examples, it appears that the EE may have been on a routine monitoring schedule as frequent as [redacted] (see Examples 2, 8, 9, 11, 12, and 13). Other monitoring intervals observed in Table 3 were on the order of [redacted]; however, this may simply be the result of this dataset representing only a sampling of the internal monitoring records for these workers. The fact that certain workers appear to be on a routine, and not a "special" or

incident-driven, monitoring schedule for [redacted] is logically indicative that there were groups of workers who had the potential for chronic exposure.

Observation 3: During its review of claimants who may have worked in the [redacted] areas of CPP, SC&A identified several non-claimants who appear to have been part of a regular routine monitoring program for [redacted]. This is logically indicative that a group of workers existed at CPP who had the potential for [redacted] that was of radiological concern to the health and safety staff.

8.0 DOCUMENTED INCIDENTS INVOLVING URANIUM PRIOR TO 1963

SC&A identified two incident reports which specifically involved exposure to uranium solutions at CPP during [redacted]. These two incidents are described in the following sections with the full incident reports reproduced in Appendices B and C.

8.1 [redacted] IN [redacted]

In [redacted], there was a documented contamination incident in which [redacted] was detected as a vapor that was emanating from the sump in [redacted] ([redacted]). This incident is also briefly described in Section 5.4.2 of NIOSH 2015b. SC&A examined the available incident reports for further information on the circumstances and radiological response. NIOSH 2015a describes the area where the incident occurred ([redacted]) as follows:

> [redacted] *was the last stop for* [redacted]. *For a time, the* [redacted] *was stored and packaged for shipment in* [redacted] *at a facility set up within* [redacted].

An air sample taken in [redacted] using an alpha proportional counter indicated an air concentration of 2×10^{-6} µCi/cc which was 10,000 times the MPC at the time. Three smears that were taken also showed positive alpha contamination on the floor near the sump, the stairs that lead to the bottom of the cell, and the in the product room near the exit from the cell.

Nasal smears taken at the time of the incident showed no detectable contamination. However, [redacted] samples collected the day after the incident for [redacted] workers who had been present in the cell were positive for [redacted]. The [redacted] sample results are shown in Table 4.

Table 4. [redacted] Samples Collected 1 Day after Documented [redacted] Contamination Incident

[redacted]

The [redacted] workers were resampled four days and again ten days after the incident, and all the samples were below the detection limit of 1×10^{-5} grams/liter.

A memo documenting the incident can be found in Appendix B and states the following:

> *The vapors from the sump were very heavy and did not seem to disperse into the air but settled to the floor immediately. Exposures to the activity concentration reported above in the vapor itself was not probable. In fact, the vapor was visible and was reported as soon as detected such that exposure to even low-level activity was improbable.* [redacted]

Using what the memo referred to as *"gross over-estimates,"* the maximum possible body burden was calculated to be approximately one-half of the maximum permissible amount. However, the memo also notes that expected dose to the limiting organ (bone) would only be a few millirem. The memo concludes:

> *The consequences of this particular incident are not especially alarming except that the situation could very well have been more serious. Perhaps operational procedures with respect to this area of work should be reviewed to avoid future like incidents, since hazards from ingested and/or inhaled uranium are present.* [redacted]

A follow-up report to the incident indicates that the following changes were made as a result of the airborne contamination ([redacted]):

1. *A rotameter was instilled on* [redacted] *to measure the amount of air to the spargers and prevent excessive sparging.*
2. *The flow of air was increased in the* [redacted].
3. *The procedure for any further mixing experiments was changed to pull only one sample at a time while the* [redacted] *are in operation.*

Observation 4: A documented [redacted] incident involving airborne [redacted] activity in the [redacted] indicates that HP was notified immediately and appropriate actions were taken, including air sampling, area swipe contamination surveys, and worker nasal swipes. Multiple [redacted] samples were collected in the days immediately following the incident. Analysis of the available [redacted] related to the incident indicates that exposures were likely minimal. This incident was also discussed in NIOSH 2015b.

8.2 [redacted] IN [redacted])

On [redacted], there was a maintenance activity on a [redacted] where a [redacted] had been identified. The maintenance activity involved cutting into the [redacted] and replacing approximately [redacted]. Due to an [redacted] that had been unexpectedly [redacted], approximately [redacted] ([redacted]). This incident is documented in two follow-up reports: [redacted] (shown in Appendix C). The spill was described as follows:

> *Most of* [redacted]. [redacted] *outer*

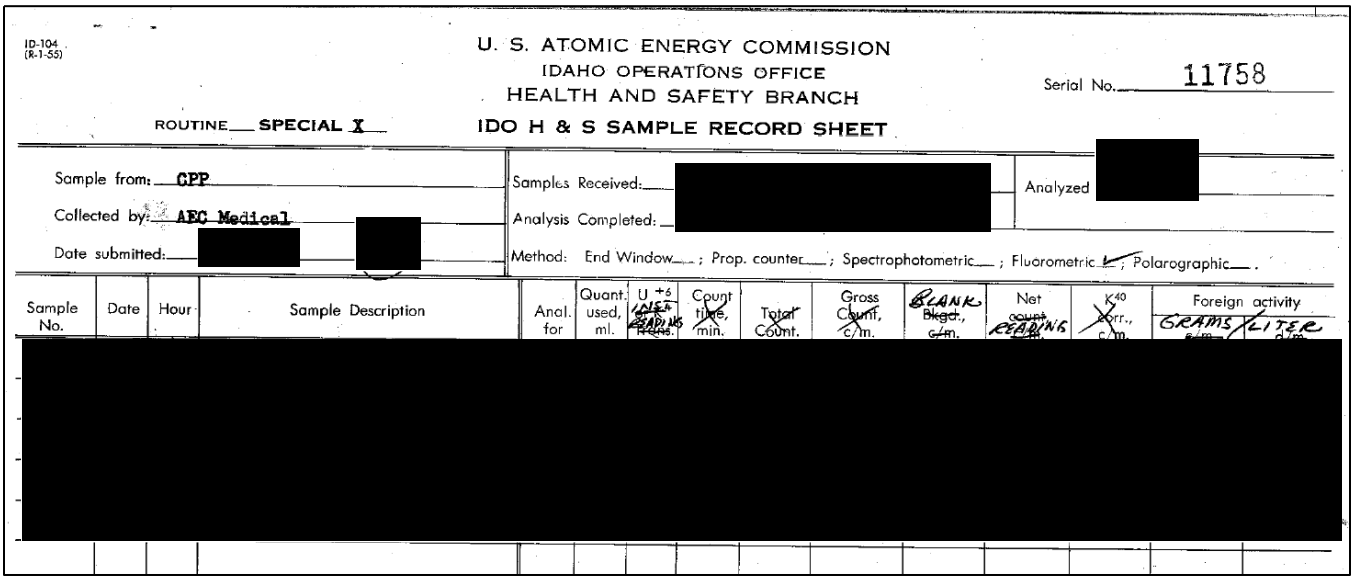
[redacted] *were gathered up in a* [redacted] *and the* [redacted] *was cleaned up and all were taken to the* [redacted] *for further recovery.* [redacted]

The incident indicates that a Safe Work Permit was issued and also an "HP Permit," which is assumed to be the equivalent of an RWP. In addition, [redacted] indicates a member of the [redacted] was present in at least one of the two [redacted] locations of the [redacted]. Subsequent to the incident, the following recommendations were stated in [redacted]:

1. *Don't start a critical job without having the written work request in the hands of the maintenance foreman.*
2. *All work requests contain written precautions. (If to be checked back by operations, approvals by safety, safeguards, etc. when special hazards exist)*
3. *If there are critical hazards, maintenance should be advised how to do the job safely.*
4. *Add details of HP and safety procedures on the HP and safety permits.*
5. *Adhere strictly to the tag out procedure.*

Although neither [redacted] nor [redacted] specify what follow-up internal monitoring was requested, SC&A observed that one of the [redacted] involved in the incident ([redacted]) submitted a [redacted] on the day of the [redacted] (see Figure 22). It is unknown, at this time, if all workers involved in the [redacted] were likewise monitored internally for [redacted].

Figure 22. Special Follow-Up [redacted] for [redacted] Involved in [redacted]



ID-104 (R-1-55)

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

Serial No. 11758

ROUTINE SPECIAL X — IDO H & S SAMPLE RECORD SHEET

Sample from: CPP
Collected by: AEC Medical
Date submitted: [redacted]

Samples Received: [redacted]
Analysis Completed: [redacted]
Analyzed [redacted]
Method: End Window ___; Prop. counter ___; Spectrophotometric ___; Fluorometric ✓; Polarographic ___.

Sample No.	Date	Hour	Sample Description	Anal. for	Quant. used, ml.	U +6	Count time, min.	Total Count.	Gross Count, c/m.	BLANK Blkgd., c/m.	Net count READING	K40 Corr., c/m.	Foreign activity GRAMS/LITER
[redacted]													

Observation 5: A documented incident in [redacted] describes a [redacted] maintenance activity that resulted in a [redacted] in the [redacted]. The activity involved an [redacted]" and also had an HP presence in at least [redacted] maintenance locations. Follow-up reports indicate HP and safety permits required more detail to avoid future incidents. Although not specified in the incident

report, SC&A located at least one [redacted] sample that was taken for a [redacted] involved in the [redacted].

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APPENDIX A: [REDACTED IN FULL]

[Appendix A is withheld in its entirety to prevent the disclosure of Privacy Act protected information.]

APPENDIX B: [REDACTED IN FULL]

[Appendix B is withheld in its entirety to prevent the disclosure of Privacy Act protected information.]

APPENDIX C: [REDACTED IN FULL]

[Appendix C is withheld in its entirety to prevent the disclosure of Privacy Act protected information.]