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Dose Reconstruction
Project for NIOSH**

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Review of Potential Exposure to Exotic Radionuclides Using Radiological Work Permit Data at Los Alamos National Laboratory

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08/15/2022	00	New report to address an issue from the Advisory Board on Radiation Worker Health regarding the ability to bound dose for exotic radionuclides for Los Alamos National Laboratory energy employees from 1996 through 2005. This report is supplemental to ORAUT-RPRT-0101 and reviews radiological work permit information to ensure that RCT monitoring was appropriately performed. Incorporates formal internal and NIOSH review comments. Training is not required. Initiated by Pat McCloskey and authored by James M. Mahathy.

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ACRONYMS AND ABBREVIATIONS

1LSA	service area in MPF-7, Room 200
ALARA	as low as is reasonably achievable
anti-Cs	anti-contamination clothing
APT	accelerator production of tritium
CAM	continuous air monitor
CED	committed effective dose
C.F.R.	<i>Code of Federal Regulations</i>
cm	centimeter
CMR	Chemistry and Metallurgy Research
CTRWP	Changes to the RWP
DAC	derived air concentration
DOE	U.S. Department of Energy
dpm	disintegrations per minute
DU	depleted uranium
EPD	Electronic Personal Dosimeter
FP	fission product
hr	hour
ICRP	International Commission on Radiological Protection
LANL	Los Alamos National Laboratory
LAS	large area swipe
m	meter
MAPs	mixed activation products
MDA	minimum detectable activity
MFPs	mixed fission products
mrem	millirem
NDA	no detectable activity
NIOSH	National Institute for Occupational Safety and Health
ORAU	Oak Ridge Associated Universities
ORAUT	ORAU Team
PCM	personnel contamination monitor
PPE	personal protective equipment
RCT	radiological control technician
RIR	Radiological Incident Report
RWP	radiological work permit
SEC	Special Exposure Cohort
SRDB Ref ID	Site Research Database Reference Identification (number)
SWP	Special Work Permit

TA Technical Area
TLD thermoluminescent dosimeter

WB whole body

yr year

§ section or sections

1.0 INTRODUCTION

On April 3, 2008, the National Institute for Occupational Safety and Health (NIOSH) received a Special Exposure Cohort (SEC) petition for the Los Alamos National Laboratory (LANL) in Los Alamos, New Mexico. The petition, SEC-00109, requested that a class be added to the SEC for service support workers (which includes but is not limited to security guards, firefighters, laborers, custodians, carpenters, plumbers, electricians, pipefitters, sheet metal workers, ironworkers, welders, maintenance workers, truck drivers, delivery persons, radiation technicians, and area work coordinators) who worked in any operational Technical Area (TA) with a history of radioactive material use at LANL from January 1, 1976, through December 31, 2005 [NIOSH 2012].

In Revision 1 of the SEC-00109 petition evaluation report, NIOSH defined a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy. The class included [NIOSH 2012, p. 2]:

All employees of the Department of Energy, its predecessor agencies, and their contractors and subcontractors who worked at the Los Alamos National Laboratory in Los Alamos, New Mexico from January 1, 1976 through December 31, 1995, for a number of work days aggregating at least 250 work days, occurring either solely under this employment or in combination with work days within the parameters established for one or more other classes of employees in the Special Exposure Cohort.

The dose reconstruction limitations identified for the specified class period included the inability to bound unmonitored intakes of exotic alpha emitters, fission products (FPs), and activation products. NIOSH [2012] defined "exotic radionuclides" as being everything other than $^{234/235/238}\text{U}$, $^{238/239}\text{Pu}$, ^3H , ^{241}Am , and ^{137}Cs .

NIOSH selected the December 31, 1995, end date for the class based on its presumption that by January 1, 1996, LANL would have been in full compliance with 10 *Code of Federal Regulations* (C.F.R.) Part 835, Occupational Radiation Protection, § 402 and 702, which stated in 1993 [U.S. Department of Energy (DOE) 1993, pp. 35, 37]:

§ 835.402 Individual monitoring.

(c) For the purpose of monitoring individual exposures to internal radiation, internal dose evaluation programs (including routine bioassay programs) shall be conducted for:
(1) Radiological workers who, under typical conditions, are likely to receive 0.1 rem (0.001 sievert) or more committed effective dose equivalent, and/or 5 rems (0.05 sievert) or more committed dose equivalent to any organ or tissue, from all occupational radionuclide intakes in a year.

§ 835.702 Individual monitoring records.

(a) Records shall be maintained to document doses received by all individuals for whom monitoring was required pursuant to § 835.402 and doses received during planned special exposures, accidents, and emergency conditions.

The 10 C.F.R. Part 835 rule became effective on January 13, 1994, and required full compliance by January 1, 1996 [DOE 1993, p. 9].

The 1993 edition of 10 C.F.R. Part 835 [DOE 1993] incorporated the recommendations of International Commission on Radiological Protection (ICRP) Publications 26 and 30 for the calculation of doses [ICRP 1977, 1979]. In 2007, DOE revised the rule to incorporate the newer

recommendations of ICRP Publications 60 and 68 [ICRP 1991, 1995]. With this update to the calculated dose came a change in terminology: the dose of interest became committed effective dose (CED). The Energy Employees Occupational Illness Compensation Program Act of 2000 applies this later system of dose assessment; therefore it is used for all calculations in this document. Unless specified otherwise, the term “dose” in this document refers to the CED.

1.1 PURPOSE

This report supplements ORAUT-RPRT-0101, *Bounding Intakes of Exotic Radionuclides at Los Alamos National Laboratory* [RPRT-0101; Oak Ridge Associated Universities (ORAU) Team (ORAUT) 2022], which addressed an issue from the Advisory Board on Radiation Worker Health about the ability to bound dose for exotic (which for the purpose of this report will also include mixed fission and activation products) radionuclides [NIOSH 2018, pp. 11–16; 2019, pp. 18–25] for LANL workers from 1996 through 2005 using surface contamination survey data, air monitoring data, and personnel contamination monitoring to comply with 10 C.F.R. Part 835 [DOE 1993]. In RPRT-0101, the ORAU Team evaluated surface contamination and air monitoring data and derived values to bound dose at 100 mrem CED per year. For surface contamination, results exceeding 400 dpm/100 cm² alpha and 3,200,000 dpm/100 cm² beta were derived. For air monitoring, results exceeding 0.04 dpm/m³ alpha and 320 dpm/m³ beta were derived. For this assessment, ²²⁷Ac type F was assumed to represent the worst-case alpha emitter and ⁹⁰Sr type S was assumed to represent the worst-case beta emitter.

Cesium-137 is assumed in this report to be an indicator radionuclide for mixed fission products (MFPs) when present. This report will show examples of radiological work permit (RWP) packages to support the premise given in RPRT-0101 that LANL monitored work so they could determine which workers to monitor by bioassay. LANL issued RWPs to establish radiological controls for intended work activities. RWPs inform workers of area radiological conditions and as low as is reasonably achievable (ALARA) requirements and provide a mechanism to relate worker exposure to specific work activities [DOE 1998]. Conclusions made in the report are subjective and not intended to provide a degree of statistical confidence. No dose assessment is performed for any worker identified in these RWP packages.

The ORAU Team notes the LANL Health Physics group only monitored by bioassay those workers thought to have the potential to receive more than 100 mrem CED per year in the period January 1, 1996, through December 31, 2005. This report examines RWPs for evidence to support the premise that LANL Health Physics performed radiological work in a disciplined manner that minimized inadvertent intakes of radioactive material.

Internal Dosimetry Technical Basis HSR-12-03-TB.0 describes LANL internal dosimetry processes. Sections 2.2.1 through 2.2.5 of that document describe the typical routine monitoring for the majority of radionuclides handled at LANL, which are plutonium, americium, uranium, and tritium [Archuleta 2021a].

The ORAU Team queried LANL Health Physics for information regarding dosimetry thresholds for some exotic radionuclides and received the following information [Archuleta 2021b, p. 5]:

During the period January 1, 1996 through December 31, 2005, LANL had no routine bioassay monitoring programs for the following isotopes:

- *Ac-227*
- *Cm-244*

- *Np-237*
- *Pa-231*
- *Sr-90*

Routine monitoring programs for these isotopes would only have been established if there was routine work with associated materials likely to result in intakes of 100 mrem committed effective dose or greater. Consequently, no bioassay enrollment criteria for these radionuclides were adopted or promulgated.

A question posed to LANL Health Physics related specifically to ⁹⁹Tc received the following response [Archuleta 2021a, p. 5]:

During the period January 1, 1996 through December 31, 2005, LANL did not establish a routine bioassay monitoring program for Tc-99. Routine monitoring programs for this radionuclide would only have been established if there was routine work with associated materials likely to result in intakes of 100 mrem committed effective dose or greater. As this was not the case, no bioassay enrollment criteria for Tc-99 were adopted or promulgated. Any nonroutine work with, or events involving, Tc-99 during this time period would have been evaluated for bioassay monitoring on a case-by-case basis. This method was demonstrated following a LANL contamination event in 2012 involving Tc-99; based on the potential for intakes, LANL collected urine bioassay samples from involved workers, subcontracted analysis by an outside laboratory, and performed dose assessments. There were no such cases during the period January 1, 1996 through December 31, 2005.

Workers at LANL were enrolled in routine dosimetry programs commensurate with their work location, activity, and associated radiological hazards using the Health Physics Checklist process. Radiological work involving the potential for intakes was identified by operational health physics based on knowledge of ongoing activities and associated hazards, workplace monitoring data, and experience with contamination conditions. For radionuclides where in vivo measurements were deemed effective, workers were enrolled in the routine in vivo monitoring program. For-cause bioassay measurements were initiated when field indicators suggested the potential for intake in unusual or upset conditions. Based on the nature of planned nonroutine work, RWPs prescribed bioassay measurements when the work could result in radioactive material intakes. Workers were provided Radiological Worker training to understand their responsibilities regarding participation in prescribed dosimetry programs. Work covered by RWPs was initiated with prejob briefings during which all RWP requirements were covered, and all attendees were accountable for following those requirements. This included individuals verifying they were on the prescribed dosimetry program [Archuleta 2020].

1.2 METHODOLOGY OF REPORT

The ORAU Team selected RWPs from the Site Research Database (SRDB) for the same technical areas used in RPRT-0101, TA-3, TA-48, and TA-53, and during the period from January 1, 1996, through December 31, 2005. These areas were selected based on documented evidence that exotic radionuclides were processed in them. Selected RWPs involved work with radionuclides other than plutonium, americium, and uranium. The ORAU Team cannot conclude that it has captured all such RWPs. Additionally, LANL Health Physics stated to the ORAU Team that there was no general intent to provide in process surveys in all RWP packages. LANL planned and prepared for nonroutine hot jobs which includes characterizing the as is conditions, commonly established with a pre job survey, potential changes in radiological hazards due to the activity, such as breaching containment devices, and established boundaries, hold points, electronic personal dosimeter (EPD) alarm settings,

maximum expected levels of contamination, dose rates and/or airborne contamination. During the work execution phase, conditions are monitored against limits. Radiological control technicians (RCTs) providing coverage monitor for applicable radiological conditions and direct the work team. Often in higher contamination areas, RCTs perform qualitative “go/no-go” direct monitoring, with no need to pause for quantitative measurements. Often, high contamination techniques are developed which do not require monitoring as it is safely assumed that involved materials are contaminated. Monitoring such materials increases the risk for spreading contamination, including contaminating survey instruments, rendering them useless, and causing immediate suspension of work [Archuleta 2022].

In consideration of these factors, in process hot job surveys are not documented. While supporting the work, RCTs are regularly monitoring and directing actions to manage conditions within established suspension limits. There is no occupational radiation protection benefit to stopping, recording, documenting, reviewing, filing, tracking, and archiving such survey results. Furthermore, it would not be consistent with ALARA principles to add cumbersome, unnecessary steps to an already higher-hazard activity. In rare circumstances, there may be an external request or unusual driver to provide such data, such as a customer need to characterize radioactive waste; NIOSH/ORAU Team requestors should not expect such surveys to be documented via typical RWP protocols. If conditions exceed suspension limits, work is paused and the condition is remediated, or the RWP is revised with updated hazard analysis and commensurate controls [Archuleta 2022].

Finally, upon completion of the hot job and cleanup activities, a post job survey is typically called for. If conditions indicate residual contamination, a second post job survey may be included following additional decontamination [Archuleta 2022].

To summarize, the ORAU Team should expect to see pre job and post job surveys for applicable RWPs. Requestors should not expect to see in process hot job surveys, as RCT monitoring during hot jobs is typically not formally documented. These statements represent current expectations and those during the time period under review [Archuleta 2022].

Archuleta [2022] states that LANL does not require documented in process surveys to be conducted during work under RWPs and the ORAU Team should not expect find such surveys. However, some of these in process surveys are provided in RWP packages and examples are included. Therefore, the ORAU Team was tasked by NIOSH to perform a qualitative review of some RWPs that identified exotic radionuclides to check for the inclusion of survey information.

The initial search used the “notable” RWPs referenced in Section 5.6 of ORAUT-RPRT-0102 [ORAUT 2021]. Notable RWPs were targeted for capture, where a “notable” RWP is defined as an RWP that:

- Occurred within the study period (January 1, 1996, to December 31, 2001);
- Required urinalysis as noted on the RWP by having “Special Urinalysis” or “Pu Access List” checked or contained other equivalent terminology or notation indicating urinalysis was required; and
- Contained an associated roster (acknowledgment sheet) with names of personnel acknowledging the RWP.

These “notable” RWPs consisted of 316 references and 2,252 RWPs. These documents cover the period from January 1, 1996, to December 31, 2001, and contained no TA-53 information. Therefore, additional RWP information to cover the years 2002 through 2005 and TA-53 were needed, so nine additional references containing 311 RWPs were selected from the SRDB and reviewed. Sections

2.1.8, 2.2.2, 2.2.5 through 2.2.8, and all of 2.3 contain these references. All other Subsections in Section 2.0 are from the “notable” references mentioned above.

Thus, the ORAU Team subjectively selected 24 RWPs by manually reviewing those that:

- Occurred within the period January 1, 1996, through December 31, 2005, from TA-3, TA-48, and TA-53;
- Listed exotic and/or mixed fission and activation products as expected radionuclides; and
- Appear to be properly monitored by containing prejob, in process (which can include prejob, postjob, hotjob, routine, and nonroutine, smear, large area swipe (LAS), nasal smears, direct reading and external radiation), postjob surveys, and prejob briefing logs with names of personnel acknowledging the RWP.

As a result of the selection of the 24 RWPs, the ORAU Team identified one or more radionuclides of interest in each of the RWPs including ^{137}Cs (indicator radionuclide), ^{237}Np , ^{57}Co , ^{58}Co , ^{60}Co , ^{82}Sr , $^{90}\text{Sr/Y}$, ^{91}Nb , ^{92}Nb , ^{93}Nb -metastable, ^{232}Th , ^{248}Cm , $^{88}\text{Zr/Y}$, $^{68}\text{Ga/Ge}$, ^{22}Na , ^{54}Mn , ^7Be , ^{172}Hf , ^{175}Hf , ^{171}Lu , ^{172}Lu , and ^{148}Gd . From January 1, 1996, to the December 31, 2005, evaluation period LANL had no routine bioassay monitoring programs for some of these radionuclides. A bioassay method would have been established only if there was to be work with associated materials likely to result in intakes of greater than 100 mrem CED/yr. No bioassay enrollment criteria for these radionuclides were adopted or promulgated, but LANL had the capacity to perform bioassay for these radionuclides if warranted [Hoover 2008, 2021].

2.0 REVIEW OF RADIOLOGICAL WORK PERMITS

This section presents data recorded in and discussions of work and radiological monitoring for RWPs by technical area in order to demonstrate LANL Health Physics monitored workers for conditions of work that could lead to intakes of exotic radionuclides.

The ORAU Team reviewed the 24 RWPs qualitatively to ensure that the jobs specified were monitored appropriately by comparing prejob radiological protection requirements such as protective clothing, respiratory, dosimetry, and monitoring requirements to the final post job review to ensure that the associated reports were included. No detailed analyses of any of the air monitoring, surface contamination smear surveys, nasal smears, direct or external reading data presented in these RWP packages were performed by the ORAU Team. Primary information such as location, work to be performed, dates of work, radionuclide(s), airborne radioactivity, prejob surveys, postjob surveys, in process surveys, personal protective equipment (PPE) requirements, and prejob briefing logs (Prejob Briefing Acknowledgment Log and/or Radiological Work Permit Acknowledgment Log depending on form) are summarized and reviewed in Sections 2.1, 2.2, and 2.3.

The prejob briefing logs are required rosters signed by workers before performing work under an RWP and indicate that the worker understands the radiological conditions, protection requirements, and monitoring requirements [DOE 1998]. Note that a worker could have signed an acknowledgment sheet and never performed work under that RWP; it is not a sign-in sheet. The dates of these logs were compared to dates of the survey data in the RWP packages to ensure they are consistent.

The survey information and associated reports provided in the RWP packages was reviewed by the ORAU Team and compared to the review section of the RWP to ascertain that LANL Health Physics appropriately monitored work performed under the RWP. Table A-1 in Attachment A provides a brief summary of the RWP information.

2.1 TA-3

During the time of evaluation, TA-3 has conducted a mixture of LANL activities that include experimental sciences, work with special nuclear materials, administrative work, public and corporate access, theoretical studies and computations, and physical support operations. Many of the major facilities for providing physical support such as utilities and maintenance are in TA-3. Much like a university campus, research facilities are scattered throughout the area. These range from small laboratories with bench-scale operations to activities involving radioactive materials in the Chemistry and Metallurgy Research (CMR) facility in Building 29 [Romero and Faust 1992a; LANL 1998a]. LANL staff at TA-3 were potentially exposed to both alpha materials and exotic radionuclides, primarily FPs.

2.1.1 RWP 96-3-29-9030-106

LANL issued RWP 96-3-29-9030-106 (effective March 8, 1996, expiration June 28, 1996). The permit authorized replacing shaft bearings and a motor at FE-40, FE-41, and FE-42 in Room 9030 in Building 29 of TA-3 [LANL 1996, pp. 12-37].

Cesium-137 was recorded as the anticipated radionuclide. The anticipated prejob airborne radioactivity was reported as less than 10% of the derived air concentration (DAC). Measured prejob surface contamination levels for direct readings were reported as no detectable activity (NDA) for alpha activity and a maximum of 50,000 disintegrations per minute (dpm)/100 cm² for beta/gamma. The smear surveys were reported as NDA for alpha and beta contamination. The LAS survey was reported as NDA for alpha and a maximum of 4,000 dpm/100 cm² for beta/gamma. These values are below the limits stated in RPRT-0101.

The RWP required Level 1 (coveralls, 2 pairs of surgeon's gloves, and booties) protective clothing with skull cap and taped openings, whole body (WB) dosimeter, intermittent RCT coverage, notifying RCT before job starts and ends, monitoring equipment and tools before removal, and self-frisking. LANL Form 107-02-3, Changes to the RWP (CTRWP), was initiated for workers to work inside the fan housing due to a bent shaft and required an upgrade to Level 2 (2 coveralls, 2 pairs of surgeon's gloves, and 2 pairs of booties) protective clothing with hood, full face respirator, job-specific air monitoring, nasal smears, continuous RCT coverage, and RCT monitoring doffing of anti-contamination clothing (anti-Cs). The estimated airborne radioactivity was updated and reported as greater than 10% DAC.

Twelve workers signed the Radiological Work Permit Acknowledgment Log with dates ranging from June 11, 1996, through June 14, 1996. Nasal smears were collected as part of a routine procedure, rather than a diagnostic procedure taken in response to suspected intakes, and were used as an indicator for potential intakes for five workers obtained June 11, 1996, and three obtained June 14, 1996, all reported as NDA for both alpha and beta activity.

Eight surveys consisting of prejob, postjob, hotjob, nonroutine item release smear, LAS, external radiation, and direct surveys covering March 13, 1996, through June 20, 1996, were provided. The surveys coincide with the dates on the acknowledgment logs except for the three prejob smears, LAS, and direct surveys from March 13, 1996.

No postjob airborne radioactivity was recorded on the RWP. However, the job-specific air sample activity from June 11, 1996 to June 14, 1996 was reported as NDA for alpha and 0.07 dpm/m³ with an uncertainty of 17.69 dpm/m³ for beta. The postjob surface contamination direct alpha measurements and LAS survey were reported as NDA for the highest and general area. Direct measurements for beta/gamma identified fixed contamination reported as 50,000 dpm/100 cm² for the highest area and as NDA for the general area. The LAS beta/gamma survey was reported as NDA. These values are below the limits stated in RPRT-0101. There were no postjob smears for this RWP. The checkboxes

in the review section for job-specific air monitoring, prejob survey data, postjob survey data, nasal smear data, and RWP acknowledgment log were checked and included in this RWP package. No personnel were contaminated above applicable limits. Review of this RWP indicates that LANL RCTs monitored this job appropriately.

2.1.2 RWP 96-3-29-9030B-423

LANL issued RWP 96-3-29-9030B-423 (effective November 7, 1996, expiration February 5, 1997). The permit authorized the installation of vibration pickups and thermocouples for filter banks located in Room 9030B in Building 29 of TA-3 [LANL 1996–1997, pp. 10–31].

Cesium-137 was recorded as the anticipated radionuclide. The anticipated prejob airborne radioactivity was reported as greater than 10% DAC. Measured prejob radiological conditions for surface contamination LAS were reported as NDA for alpha activity, and as 5,500 dpm beta/gamma activity for the highest area. These values are below the limits stated in RPRT-0101.

For work performed on the filter banks FE-44 through 46, the RWP required Level 2 protective clothing, full-face respirator, WB dosimeter, continuous RCT coverage, monitoring personnel before leaving job, monitoring equipment and tools before removal, RCT monitoring of personnel doffing anti-Cs, and notifying RCT at job end. For work outside of the filter banks FE-44 through 46, the RWP reduced the requirement for protective clothing to Level 1, no respirator, and intermittent RCT coverage. Contacting an RCT before entering the fan area was an additional requirement.

Twenty-two workers signed the Radiological Work Permit Acknowledgment Log with dates ranging from November 14, 1996, through November 22, 1996. Nineteen nasal smears used as an indicator for potential intakes were obtained on November 21, 1996 and three were obtained on November 22, 1996. Results for all 22 samples were reported as NDA for both alpha and beta activity.

Eight surveys consisting of prejob, postjob, hotjob, and routine were obtained via LAS, nasal smears, and fixed air samplers. These surveys were obtained with dates ranging from November 13, 1996, to January 7, 1997 and coincide with dates from the acknowledgment log.

The postjob review of the RWP estimated airborne radioactivity was reported as less than 10% DAC. Measured postjob radiological conditions for surface contamination for alpha direct readings were reported as less than 200 dpm/100 cm² for the highest area and as NDA for the general area. For beta/gamma the direct result was reported as less than 10,000 dpm/100 cm² for the highest area and as NDA for the general area. Smears were marked as not applicable. The LAS survey was NDA for alpha and the highest beta/gamma result was reported as 4,000 dpm/100 cm² and the general area as NDA. These values are below the limits stated in RPRT-0101. The checkboxes in the review section for prejob survey data, postjob survey data, FAS filters, nasal smear data, and RWP acknowledgment logs were checked and were included in the package. The postjob section of the RWP indicates that no personnel were contaminated above applicable limits. Review of this RWP indicates that LANL RCTs monitored this job appropriately.

2.1.3 RWP 97-3-29-9030-99

LANL issued RWP 97-3-29-9030-99 (effective February 7, 1997, expiration December 24, 1997) to check, troubleshoot, and repair if required, the limit switches on the hot cell doors in Room 9030 in Building 29 of TA-3 [LANL 1997a, pp. 30–43].

Cesium-137 was recorded as the anticipated radionuclide. The measured prejob airborne radioactivity was reported as less than 10% DAC. There was one survey form with four LAS results considered as the prejob and postjob surveys for the hotjob work performed, which indicates no change in

radiological conditions, and an associated contamination area map on June 12, 1997. The alpha results were reported as NDA, and the beta/gamma results ranged from 3,000 dpm to 5,000 dpm. No surface area was provided. These values are below the limits stated in RPRT-0101. There was also one radiation area survey map from June 12, 1997.

The RWP required Level 2 protective clothing with hood, full face respirator, WB dosimeter, supplemental dosimeter, nasal smears, continuous RCT coverage, monitoring of personnel before leaving job, monitoring equipment and tools before removal, RCT monitoring of personnel doffing anti-Cs, and notifying RCT before and after job.

Special instructions written on the RWP stated that an RCT would monitor the worker(s) for hot particles every 15 minutes via WB frisk while they were working in the door cavity. If hot particles were identified, they were to be removed before continuing. If levels exceeded greater than 100 times LANL Radiological Control Table 2-2 values [Hoover 2021, p. 4] and could not be removed, work was to be stopped and reevaluated.

Four workers signed the RWP Acknowledgment Log, all dated June 13, 1997. Two workers submitted nasal smears used as an indicator for potential intakes in the morning and afternoon on June 13, 1997; results were reported as NDA for both alpha and beta activity. Both workers were wearing respirators and signed the RWP Acknowledgment Log.

One air sample result was included for June 13, 1997, the same day that nasal smears were acquired. Note that these were collected one day after LAS and radiation area measurements were taken.

The postjob review of the RWP measured airborne radioactivity was reported as less than 10% DAC. Measured postjob radiological conditions for surface contamination were reported as the same as the prejob. The checkboxes in the review section for prejob, postjob, nasal smears, and RWP acknowledgment log were checked and included in the package. No personnel were contaminated above applicable limits. Review of this RWP indicates that LANL RCTs monitored this job appropriately.

2.1.4 RWP 97-3-29-Wing 9-162

LANL issued RWP 97-3-29-Wing 9-162 (effective March 24, 1997, expiration December 24, 1997) to inspect, maintain, and repair as needed bridge cranes and hoists in Building 29, Wing 9 of TA-3 [LANL 1997b, pp. 114–129].

Cesium-137 was recorded as the anticipated radionuclide. The measured prejob airborne radioactivity was reported as less than 10% DAC. Prejob/postjob surface contamination results from an LAS survey were reported as NDA for alpha activity and as NDA to 15,000 dpm for beta/gamma activity. No surface area was provided. These values are below the limits stated in RPRT-0101.

The RWP required Level 1 with skull cap, no respirator, WB dosimeter, intermittent RCT coverage, monitoring of personnel before leaving job, monitoring equipment and tools before removal, and notifying an RCT before start and end of job.

This RWP had two RWP Acknowledgment Logs. Eleven workers signed one with dates ranging from April 14, 1997, through July 22, 1997. Twelve workers signed the second one with dates ranging from October 7, 1997 to November 21, 1997.

The RWP notes prejob surveys will be performed as the job progresses. Four crane inspections with associated smear surveys were performed on October 7, 1997, November 20, 1997, November 21,

1997, and December 8, 1997. Two of the surveys on November 20, and 21, 1997, indicated contamination was identified but was decontaminated to NDA. The November 20, 1997, survey indicated that the CTO-8 rail had 25 dpm/100cm² alpha and 1,500 dpm/100cm² beta contamination, and the CTO-6 rail had 48 dpm/100cm² alpha contamination. The November 21, 1997, survey indicated the CTO-4 Trolley had 1,456 dpm/100cm² beta contamination. These dates cover the ranges of the acknowledgment logs.

The postjob review of the RWP measured airborne radioactivity was reported as less than 10% DAC. Measured postjob radiological conditions for surface contamination were the same as the prejob. The checkboxes in the review section for prejob, postjob, and RWP acknowledgment log were checked and included in the package. No personnel were contaminated above applicable limits. Review of this RWP indicates that LANL RCTs monitored this job appropriately.

2.1.5 RWP 99-3-29-1117-47

LANL issued RWP 99-3-29-1117-47 (effective December 12, 1998, expiration February 26, 2000) to decontaminate Rooms 1117, 1117A, and 1119 in Building 29 of TA-3 [LANL 1998–2000, pp. 2–853].

Technetium-99 and uranium were recorded as the anticipated radionuclides. The expected prejob airborne radioactivity was reported as less than 10% DAC. Measured prejob radiological conditions for both direct and smear surveys ranged from NDA to 1,000,000 dpm/100 cm² and were from the August, 1991 surveys referred to on page 1 of the RWP [LANL 1998–2000, pp. 8, 73–75]. This value exceeds the alpha limit derived in RPRT-0101 but the RWP prescribes adequate protection requirements as described in the paragraphs below. The ORAU Team assumes this is the last time work was performed in that room because it could find no evidence to the contrary.

The RWP required Level 2 protective clothing, full face respirator, WB dosimetry, nasal smears, continuous RCT coverage, monitoring of personnel before leaving job, monitoring equipment and tools before removal, and RCT monitoring of personnel doffing anti-Cs. Subsequent requirement reductions due to three CTRWPs explained below.

Two additional RWPs were included in the package to support work done under RWP 99-3-29-1117-47. RWP 99-3-29-1117/1119-406 (effective August 18, 1999, expiration November 16, 1999) was initiated for tours and inspections with all activity restricted to walk-ins and visual inspection of room conditions, and RCT direct and smear surveys of non-intrusive items. The RWP required Level 1 skull cap, WB dosimeter, notifying RCT at start and finish of job, continuous RCT coverage, and RCT monitoring of doffing anti-Cs [LANL 1998–2000, pp. 46–53].

RWP 99-3-29-1117/1119-383 (effective July 16, 1999, expiration October 14, 1999) was initiated to install a high efficiency particulate air filter holder and filter on the inside corridor door to Room 1117A. The same radiological protective requirements for RWP 99-3-29-1117-47 were required.

Sixteen workers signed the RWP 99-3-29-1117-47 Prejob Briefing Acknowledgment Log with dates ranging from February 8, 1999, through November 22, 1999. Subsequently, there were three CTRWP forms with dates for change number 1 of August 24, 1999, through November 29, 1999, signed by 17 workers, change number 2 of January 3, 2000, through January 5, 2000, signed by six workers, and change number 3 of January 4, 2000, through January 5, 2000, signed by five workers [LANL 1998–2000, p. 24].

CTRWP Number 1 for RWP 99-3-29-1117-47 stated that airborne contamination levels did not justify respirators. Additionally, protective clothing requirements were reduced from Level 2 to Level 1 with skull cap. Job-specific air monitoring and a beta continuous air monitor (CAM) set for 1 DAC was added as a requirement. Radiological conditions were updated and direct surface contamination

levels for alpha were reported as less than the minimum detectable count rate; the highest direct for beta/gamma was reported as 320,000 dpm/100 cm²; and the beta/gamma general area was reported as 750 dpm/100 cm². Updated smear surface contamination levels for alpha was reported as 81 dpm/100 cm² for the highest area and as NDA for the general area. For beta/gamma the highest area smear was reported as 3,256 dpm/100 cm² and the general area was reported as 100 dpm/100 cm². The measured airborne radioactivity was reported as <10% DAC for ⁹⁹Tc [LANL 1998–2000, p. 26].

CTRWP Number 2 for RWP 99-3-29-1117-47 extended the expiration date to February 26, 2000. Radiological conditions were updated and direct surface contamination levels for alpha were reported as less than the minimum detectable activity (MDA). The highest direct for beta/gamma was reported as 26,000 dpm/100 cm² and the beta/gamma general area was reported as 1,000 dpm/100 cm². Updated smear surface contamination levels for alpha were reported as less than the MDA; the highest beta/gamma was reported as 2,000 dpm/100 cm²; and the general area was reported as less than the MDA. The measured airborne radioactivity was reported as <10% DAC for ⁹⁹Tc [LANL 1998–2000, p. 28].

CTRWP Number 3 for RWP 99-3-29-1117-47 stated that air sampling results justify the discontinued use of CAM instruments. The updated radiological conditions were reported as the same as CTRWP Number 2 in the preceding paragraph [LANL 1998–2000, p. 30].

CTRWP Number 1 for RWP 99-3-29-1117/1119-406 relaxes the PPE to lab coat, skull cap, gloves, and booties. Updated radiological conditions for a tent enclosure indicated surface contamination levels for direct for both alpha and beta/gamma were less than the minimum detectable count rate. Smear levels were reported as NDA. The measured airborne radioactivity was reported as <10% DAC for ⁹⁹Tc and ²³⁸U [LANL 1998–2000, p. 47].

Ten workers signed the RWP 3-29-1117/1119-406 Prejob Briefing Acknowledgment Log with dates ranging from August 18, 1999, through January 10, 2000. Seventeen workers signed one CTRWP form with dates ranging from August 26, 1999, through December 9, 1999 [LANL 1998–2000 pp. 48–49]. Five workers signed the RWP 3-29-1117/1119-383 Prejob Briefing Acknowledgment Log with dates ranging from July 26, 1999, through August 12, 1999 [LANL 1998–2000, p. 59].

Nasal smears used as an indicator for potential intakes were required after jobs involving cutting of metal and/or wood, removal of ductwork, trash cleanup and size reduction, working around contaminated drain lines, and hammer drilling operations to remove floor contamination. Results of 15 nasal survey forms with 65 individual results were obtained with dates ranging from February 8, 1999, through January 5, 2000, and reported as NDA.

RWP 99-3-29-1117-47 was a large job containing 213 surveys consisting of prejob, postjob, routine, nonroutine, hotjob, item release, nasal smears, and air monitoring surveys throughout its duration. These surveys consisted of smears, LAS, direct readings, external radiation surveys, nasal smears, and air monitoring using giraffe samplers, CAMs, and a lapel sampler. The dates of the surveys ranged from February 8, 1999, to March 30, 2000, and coincide with dates from the acknowledgment logs. The rooms were kept under negative air pressure to prevent contamination spread. In many cases when an RCT determined values were high, the area was decontaminated. One positive smear of 624 dpm/100cm² beta contamination (which did not exceed the limit of 1,000 dpm/100cm²) was identified on a scaffold wheel and decontaminated. This reinforces that LANL RCTs were monitoring and reviewing results against regulatory limits. In addition, a Work Package was embedded in the RWP with craftwork instructions detailing how the remediation of Rooms 1117, 1117A, and 1119 will be performed [LANL 1998–2000, pp. 117–147].

The postjob review of the RWP measured airborne radioactivity was reported as less than 10% DAC. Measured postjob radiological conditions for surface contamination direct readings were reported as less than the MDA for alpha activity and as less than 5,000 dpm/100 cm² for beta/gamma activity for the highest and general area, with the exception of two items, a sprinkler head and an emergency light that were reported as greater than 5,000 dpm. Smears were reported as less than the MDA for alpha activity and as less than 1,000 dpm/100 cm² for the highest location and general area for beta/gamma. LAS were reported as less than the MDA for alpha and beta/gamma activity. These values are below the limits stated in RPRT-0101. The checkboxes in the review section for CAMs, job specific, prejob, postjob, nasal smears, changes in radiological protection requirements, and other prejob survey were checked and included in the package. They also stated that no problems were encountered. No skin contaminations occurred. Review of this RWP indicates that LANL RCTs monitored this job appropriately.

2.1.6 RWP 99-3-29-9030, 9060-144

LANL issued RWP 99-3-29-9030, 9060-144 (effective January 16, 1999, expiration December 31, 1999) to decontaminate under cell door numbers 10 and 12 in Rooms 9030 and 9060 in Building 29 of TA-3. Temporary enclosures to contain hot particles were designed and fabricated [LANL 1999a, pp. 17–37].

Cesium-137 was recorded as the anticipated radionuclide. The anticipated prejob airborne radioactivity was reported as less than 10% DAC. The prejob radiological conditions for surface contamination with direct readings were reported as 20,000 dpm/100 cm² for the highest alpha activity and as NDA for the general area. Direct readings for beta/gamma were reported as greater than 1,000,000 dpm/100 cm² for the highest area and as 1,000 dpm/100 cm² for the general area. The surface contamination for the highest and general area alpha smear activity was reported as NDA; the beta/gamma highest activity was reported as 56,000 dpm/100 cm²; and the general area was reported as 1,000 dpm/100 cm². LAS activity for the highest area for alpha activity was reported as 5,000 dpm/100 cm² and the general area was reported as NDA. LAS for beta/gamma activity was reported as 100,000 dpm/100 cm² for the highest area and the general area was reported as 10,000 dpm/100 cm². Some of these values exceed the alpha limit derived in RPRT-0101 but the RWP prescribes adequate protection requirements as described in the paragraphs below.

The RWP required Level 2 protective clothing with hood and taped openings, full face respirator, WB dosimeter, supplemental dosimeter, continuous RCT coverage, monitoring personnel before leaving job, and monitoring of equipment and tools before removal. A CTRWP was initiated as radiological conditions reduced. Level 1 protective clothing with skull cap and taped openings, no respirator, intermittent RCT coverage, and notifying RCT before job starts and ends was required. Radiological conditions were updated to not applicable for direct alpha and beta/gamma activity, NDA for the highest and general area alpha smears, 4,322 dpm/100 cm² for the highest area for beta/gamma activity, and NDA for the general area. LAS for alpha activity was reported as NDA for the highest and general area for alpha activity and as 500 dpm/100 cm² for the highest beta/gamma activity with NDA for the general area.

Two workers signed the Prejob Briefing Acknowledgment Log on January 21, 1999. Eight workers signed the CTRWP acknowledgment form with dates ranging from January 25, 1999, through February 9, 1999. One nasal smear used as an indicator for potential intakes obtained for a worker on January 22, 1999, was reported as NDA for alpha and beta activity.

Seven prejob, hotjob nonroutine, nasal smears, and postjob smear and LAS surveys were obtained from January 19, 1999, to February 9, 1999. These dates coincide with dates from the acknowledgment log.

The postjob review of the RWP airborne radioactivity was determined to be not applicable. Measured postjob radiological conditions for surface contamination direct readings for alpha activity were reported as 20,000 dpm/100 cm² for the highest area and as NDA for the general area. Direct readings for beta/gamma were reported as greater than 7,000,000 dpm/100 cm² for the highest area and as 1,000 dpm/100 cm² for the general area. Smears were reported as NDA for the highest and general area for alpha activity; as 56,000 dpm/100 cm² for the highest beta/gamma smear; and as 1,000 dpm/100 cm² for the general area. LAS surveys were reported as NDA for alpha activity; as 13,000 dpm/100 cm² for the highest beta/gamma area; and as NDA for the general area. These values are below the limits stated in RPRT-0101. The checkboxes in the review section for prejob survey data, postjob survey data, nasal smear data, and prejob briefing log were checked and included in the RWP package. A nonroutine LAS floor survey annotated as during job was also included. No skin contaminations occurred. Review of this RWP indicates that LANL RCTs monitored this job appropriately.

2.1.7 RWP 99-3-29-4064-361

LANL issued RWP 99-3-29-4064-361 (effective July 6, 1999, expiration December 24, 1999) to decontaminate Room 4064 in Building 29 of TA-3 [LANL 1999b, pp. 17–61].

Technetium-99 and uranium were recorded as the anticipated radionuclides. The anticipated prejob airborne radioactivity was reported as less than 10% DAC. The measured prejob radiological conditions for surface contamination with direct readings were reported as 1,000 dpm/100 cm² for the highest alpha activity and as NDA for the general area. Direct readings for beta/gamma were reported as 1,000,000 dpm/100 cm² for the highest area and as NDA for the general area. The measured surface contamination for the highest alpha smear activity was reported as 2,000 dpm/100 cm² and the general area was reported as less than the MDA. This value exceeds the alpha limit derived in RPRT-0101 but the RWP prescribes adequate protection requirements as described in the paragraphs below. For beta/gamma smears, the highest result was reported as 1,000,000 dpm/100 cm² and the general area was reported as less than the MDA.

The RWP required Level 2 protective clothing with hood and taped openings, full face respirator, WB dosimetry, continuous RCT coverage, monitoring of equipment and tools before removal, RCT monitoring of personnel doffing anti-Cs, and notifying RCT before job starting. The RWP included an additional stipulation for inspections with no hands-on work and called for Level 1 protective clothing with no respirator requirement.

Twelve workers signed the RWP Acknowledgment Log with dates ranging from July 7, 1999 to August 27, 1999. There were six CTRWP forms and they are summarized below.

A CTRWP was initiated on July 28, 1999, due to a change in radiological conditions. The monitoring requirements changed from continuous RCT coverage to intermittent RCT coverage. Radiological conditions were updated and surface contamination levels for alpha smears were reported as 525 dpm/100 cm² for the highest location and as less than the MDA for the general area. Seventeen workers signed the acknowledgment form with dates ranging from July 28, 1999, to August 24, 1999.

A second CTRWP was initiated on August 18, 1999, due to possible contamination in a high efficiency particulate air inlet filter for a hood. The monitoring requirement for this work required continuous RCT coverage and Level 1 protective clothing with plastic or paper sleeves. Prejob and postjob smears were reported as less than the MDA for alpha and beta/gamma. Five workers signed the acknowledgment form with dates ranging from August 18, 1999, to August 27, 1999.

A third CTRWP was initiated on August 25, 1999, due to decontamination and associated activities in Rooms 4066 and 4068. This was associated with Radiological Incident Report (RIR) 99-29-4064-102.

The highest alpha surface contamination smear obtained was reported as 200 dpm/100 cm² and the general area was reported as NDA. The beta/gamma smears were reported as less than the MDA. LAS floor surveys were reported as NDA for both alpha and beta/gamma. Five workers signed the acknowledgment form with dates ranging from August 20, 1999, to August 30, 1999.

A fourth CTRWP was initiated on August 31, 1999, due to the need to add a smoke test to the RWP. A Special Work Permit (SWP) was initiated on August 31, 1999, to address this smoke test. A glove on a glovebox was lost and this smoke test was initiated to determine the turbulence and air movement pattern in Room 4064. The updated radiological conditions were reported as less than 250 dpm/100 cm² for the highest alpha smear and as NDA for the general area. For the beta/gamma smears the highest result was reported as less than 1,000 dpm/100 cm² and the general area as NDA. Nine workers signed the acknowledgment form with dates ranging from September 2, 1999, to September 7, 1999.

A fifth CTRWP was initiated on September 7, 1999, to add a sprayer to the insides of the gloveboxes in Room 4064. The updated radiological conditions were reported as less than 100 dpm/100 cm² for the highest alpha smear and as NDA for the general area. For the beta/gamma smears, the highest result was reported as less than 231 dpm/100 cm² and the general area was reported as NDA. LAS floor surveys were reported as NDA for alpha and beta/gamma. Seven workers signed the acknowledgment form with dates ranging from September 9, 1999, to October 6, 1999.

A sixth and final CTRWP initiated on October 7, 1999, reduced the requirement for tours and normal work to lab coat with gloves and booties with taped openings, no respirator, and intermittent RCT coverage with the requirement to notify an RCT before the start and at the end of a job. The updated radiological conditions for surface contamination smears were reported as less than 400 dpm/100 cm² for the highest location and as NDA for the general area for alpha and beta/gamma. LAS floor surveys were reported as NDA. Fourteen workers signed the acknowledgment form with dates ranging from October 7, 1999, to November 3, 1999.

Eight surveys were provided in this RWP package consisting of prejob, postjob, hotjob, and nonroutine smear, LAS, and external radiation surveys. The dates ranged from August 1, 1999, to September 7, 1999, and coincide with dates from the acknowledgment log.

There were several smear surveys identified as greater than LANL Radiological Control Table 2-2 limits [Hoover 2021, p. 4] in this RWP package. One survey obtained on the north wall of a glovebox exceeded the beta/gamma limit of 1,000 dpm/100cm². It was noted as decontaminated to NDA. This reinforces that LANL RCTs were monitoring and reviewing results against regulatory limits.

The postjob review of the RWP measured airborne radioactivity was reported as less than 10% DAC. Measured postjob radiological conditions for surface contamination smears were reported as less than 400 dpm/100 cm² for the highest location and as NDA for the general area for alpha and beta/gamma. LAS surveys were reported as NDA for alpha and beta/gamma. These values are below the limits stated in RPRT-0101. The checkboxes in the review section for prejob and postjob were checked and included in the RWP package. The RWP acknowledgment log and six CTRWPs were also included. No skin contaminations occurred. Review of this RWP indicates that LANL RCTs monitored this job appropriately.

2.1.8 RWP 04-03-29-4064-275

LANL issued RWP 04-03-29-4064-275 (effective January 5, 2004, expiration December 31, 2004) to perform an initial survey for contamination assessment, decontaminate affected areas, and investigate cause and repair as needed if contamination was found for Room 4064 in Building 29 of TA-3 [LANL 2004–2005, pp. 12–73].

Techneium-99 and uranium were recorded as the anticipated radionuclides. The expected prejob airborne radioactivity was reported as less than 10% DAC. The measured prejob radiological conditions for surface contamination smears for alpha activity was reported as 63 dpm/100 cm² for the highest area and as NDA for the general area. Beta/gamma smears were reported as 83,000 dpm/100 cm² for the highest area and as NDA for the general area. LAS for alpha was reported as NDA for the highest and general area. LAS for beta/gamma was reported as 33,000 dpm/100 cm² for the highest area and as 1,000 dpm/100 cm² for the general area. These values are below the limits stated in RPRT-0101. Direct readings were determined to be not applicable.

The RWP required Level 1 protective clothing without respirator for work in the buffer area around the high contamination area during decontamination efforts and Level 2 protective clothing if working in the high contamination area, with hood, taped openings, anti-C gloves, and booties, full face respirator, job-specific air monitoring, WB dosimeter, continuous RCT coverage, monitoring of equipment and tools before removal, RCT monitoring personnel before leaving job, RCT monitoring of personnel doffing anti-Cs, and notifying RCT before job starts and ends.

Two workers signed the Prejob Briefing Log on April 28 and 29, 2004.

Eleven surveys were performed for this RWP, and the types were prejob, routine, and nonroutine LAS, and nonroutine and postjob for smears. Three of the surveys were from a previous 2003 RWP 03-03-29-4064-275 and were used as the initial assessment for work to be performed for this RWP. The other surveys dates ranged from May 3, 2004, to October 4, 2004, and coincide with dates from the acknowledgment log.

There were several LAS and smear surveys identified as greater than LANL Radiological Control Table 2-2 limits [Hoover 2021, p. 4] in this RWP package. These surveys were of the floor below gloveboxes. The RWP noted areas that could not effectively be decontaminated because leaching from the glovebox leg pads had been painted over to seal the contamination. This reinforces that LANL RCTs were monitoring and reviewing results against regulatory limits.

The postjob review of the RWP measured airborne radioactivity was reported as NDA. Measured postjob radiological conditions for surface contamination alpha activity was reported as 49 dpm/100 cm² for the highest area and as NDA for the general area. For beta/gamma smears the highest area was reported as 83,185 dpm/100 cm² and as 1,480 dpm/100 cm² for the general area. LAS surveys were all reported as NDA for alpha and beta/gamma for the highest and general area. These values are below the limits stated in RPRT-0101. Direct readings were determined to be not applicable. The checkboxes in the review section for prejob survey data, postjob survey data, and prejob briefing log were checked and included in the RWP package. Nonroutine surveys were also included. No skin contaminations occurred. Review of this RWP indicates that LANL RCTs monitored this job appropriately.

2.2 TA-48

TA-48 is known as the Radiochemistry Site. The facilities at TA-48 supported research and development in nuclear and radiochemistry. Some measurements of radioactive substances were taken in hot cells equipped for remote handling. Although radiochemical operations were conducted primarily in Buildings 1, 8, 28, 45, and 107, only Building 1 contained sufficient radioactive materials to be considered hazardous. During the period of evaluation, the RC-1 building was divided into an office wing, light chemistry laboratories for performing low-level radiochemistry, a hot cell complex to produce medical radioisotopes, an alpha wing for processing alpha-emitting radioactive and toxic materials, a "counting room" complex, and a secure data wing with a classified computer and vault containing historical data [LANL 1998a]. Activities at Building RC-1 included small-scale

radiochemistry in the laboratories area, chemical research of high alpha activity materials in the alpha facility, final analysis of samples in the counting room, and small-scale production of medical radioisotopes in the hot cells area. The dissolution area housed a high-activity chemistry area. The activities conducted there involved the largest amounts of beta/gamma radioactivity outside of the hot cells area. Both alpha materials and FPs were handled and separated in this building [LANL 1998a].

2.2.1 RWP TA-48-98-46

LANL issued RWP TA-48-98-46 (effective July 22, 1998, expiration July 22, 1999) to cover general maintenance and decontamination of all acid line plumbing in RC-1 of TA-48 [LANL 1998b, pp. 172–244].

All radionuclides used at TA-48 were recorded as the anticipated radionuclides. The anticipated prejob DAC was reported as NDA. Prejob surface contamination levels were reported as 16,500 dpm/100 cm² for the highest direct alpha reading and less than the MDA for the general area. The highest direct reading for beta/gamma was reported as 36,000 dpm/100 cm² and less than the MDA for the general area. The highest result of alpha smear surface contamination was reported as 5,000 dpm/100 cm² and less than the MDA was reported for the general area. This value exceeds the alpha limit derived in RPRT-0101 but the RWP prescribes adequate protection requirements as described in the paragraphs below. For beta/gamma the highest smear was reported as 35,000 dpm/100 cm² and the general area as less than the MDA.

The RWP required Level 2 protective clothing, waterproof if systems breached, full face respirator which can be removed if removable contamination is less than 50,000 dpm beta/gamma or less than 5,000 dpm alpha, WB thermoluminescent dosimeter (TLD), supplemental dosimeter, nasal smears, intermittent RCT coverage, notifying RCT before job starts and ends, self-frisking, monitoring of equipment and tools before removal, monitoring personnel before leaving job, and Job Specific air monitoring via a giraffe sampler.

Eleven workers signed the Prejob Briefing Acknowledgment Log with dates ranging from October 10, 1998, through October 20, 1998. Five workers had positive beta nasal smears that did not exceed the limit of 500 dpm sum of both nostrils from a hotjob on October 17, 1998, which would not require a followup bioassay sample [LANL 1998c, p. 2]. The alpha results were reported as NDA. The job-specific air sample results covering this job were reported as NDA. Three of the five were wearing respirators [LANL 1998b, p. 225].

A Special Work Procedure titled Acid Waste Line Repair TA-48, B-001, C1 Basement provided a procedure for decontaminating and patching leaks [LANL 1998b, pp. 176–178].

Fourteen prejob, postjob, hotjob, and nonroutine surveys consisting of smears, LAS, direct, nasal, job-specific air monitoring, and a liquid sample were performed with dates ranging from September 4, 1998 to December 7, 1998. The maintenance started on October 16, 1998, which covers the acknowledgment log dates. Six surveys performed had an RIR number 48-98-40 written on their associated forms. This RIR occurred on July 15, 1998, a week before the initiation of this RWP [LANL 1998c, pp. 128–134].

There were several direct and smear surveys identified as greater than LANL Radiological Control Table 2-2 limits [Hoover 2021, p. 4] in this RWP package. The samples were from the floor area below a leaking pipe and were successfully decontaminated. This reinforces that LANL RCTs were monitoring and reviewing results against regulatory limits.

The postjob review of the RWP measured airborne radioactivity was reported as less than MDA. Measured postjob radiological conditions were all reported as NDA. These values are below the limits

stated in RPRT-0101. The checkboxes in the review section for job specific, prejob, postjob, nasal smears and RWP acknowledgment log were checked and included in the package. There was a lessons learned statement that all personnel involved in decontaminating and repair of acid line plumbing need to be actively involved in the planning process to address all potential hazards. No skin contaminations occurred. Review of this RWP indicates that LANL RCTs monitored this job appropriately.

2.2.2 RWP TA-48-98-62

LANL issued RWP TA-48-98-62 (effective November 10, 1998, expiration November 10, 1999) to offload targets in the warm corridor of RC-1 Hot Cell of TA-48 [LANL 1998–1999, pp. 8–37].

Mixed activation products (MAPs) were recorded as the anticipated radionuclides. The anticipated prejob airborne radioactivity was reported as NDA. Anticipated surface contamination values were reported as not applicable for alpha direct and as NDA for beta/gamma direct. Anticipated alpha smears and LAS were reported as NDA and beta/gamma highest anticipated value was reported as greater than 1,000 dpm/100 cm². Anticipated beta/gamma LAS was reported as NDA. These values are below the limits stated in RPRT-0101.

The RWP required Level 1 protective clothing with hood, WB dosimeter, supplemental dosimeter, continuous RCT coverage, notifying RCT before job starts and ends, self-frisking, monitoring of equipment and tools before removal, and monitoring personnel before leaving job.

Ten workers signed the Prejob Briefing Acknowledgment Log with dates ranging from November 30, 1998, through December 21, 1998.

Eleven surveys consisting of prejob, hotjob, routine, nonroutine, postjob, and item release smear and LAS surveys were performed from December 1, 1998, to November 30, 1999. These dates cover the acknowledgment dates. Posting and Area Sweep Checklists for CST-SOP-326 covering several days were included, and mention of SOP-326 is in the hold point or special instructions portion of the RWP that provides individual dose limits, collective dose limits, contamination limits, and other instructions. Hot Cell dose rate maps were also included with this RWP.

The postjob review of the RWP measured airborne radioactivity was reported as less than MDA. Measured postjob radiological conditions were all marked as not applicable for direct, NDA for alpha smear and LAS (including beta/gamma), and 5,000 dpm/100 cm² for the highest beta/gamma smear and 1,000 dpm/100 cm² for the general area. These values are below the limits stated in RPRT-0101. The checkboxes in the review section for prejob, postjob, and RWP acknowledgment log were checked and included in the package. Additionally, there were in process routine and hotjob surveys. A lessons learned statement indicates there are no beta/gamma direct reading surveys because the warm corridor background is too high and there has been no airborne radioactivity. No skin contaminations occurred. Review of this RWP indicates that LANL RCTs monitored this job appropriately.

2.2.3 RWP TA-48-98-47

LANL issued RWP TA-48-98-47 (effective July 24, 1998, expiration December 30, 1998) for the removal of gloveboxes in Room 430 in RC-1 of TA-48 [LANL 1998b, pp. 245–261].

All radionuclides associated with shot debris (uranium, transuranic, MAP, MFP) were recorded as the anticipated radionuclides [ORAUT 2004, p. 15]. The measured prejob airborne radioactivity was reported as NDA. Measured surface contamination results for alpha were reported as less than the MDA for direct surveys for the highest and general area and as 59.5 dpm/100 cm² for the highest

area; less than the MDA for the general area for smears; and less than the MDA for LAS surveys for the highest and general area. Measured surface contamination results for beta/gamma were reported as less than the MDA for direct surveys for the highest and general area; as 243.3 dpm/100 cm² for the highest area; less than the MDA for the general area for smears, and less than the MDA for LAS surveys for the highest and general area. These values are below the limits stated in RPRT-0101.

The RWP required Level 1 protective clothing with hood and taped openings, full-face respirator, WB dosimeter, intermittent RCT coverage, notifying RCT before job starts and ends, self-frisking, monitoring of equipment and tools before removal, and monitoring personnel before leaving job. Additional special instructions were that respirators may be removed if removable contamination is less than 50,000 dpm beta/gamma or less than 5,000 dpm for alpha. Lab coat and gloves with taped openings may be worn if prejob survey results are less than respirator requirements. Gloveboxes were to be wiped down before starting the job. The surrounding area was to be masked with plastic to minimize spread of contamination, and an RCT will perform a postjob survey to ensure surrounding area is less than MDA.

Three workers signed the Prejob Briefing Acknowledgment Log on August 24, 1998.

Two prejob surveys and one postjob smear survey were provided in this RWP package. There is evidence that other in process surveys were performed and not included in the RWP package. There were lessons learned stating that the greatest amount of contamination was located under the gloveboxes as they were lifted. This contamination was due to spills over the years seeping under the gloveboxes and there was no way to clean without lifting the glovebox. On the surveys provided there were no locations identified as under a glovebox. This reinforces an answer LANL Health Physics staff provided the ORAU Team on a January 26, 2022, conference call. The ORAU Team asked about in process surveys because some RWPs typically lasted for approximately a year and there appeared to be gaps. LANL Health Physics staff stated that it was the nature of their work to decontaminate and perform surveys as work progressed, they did not generally include those surveys in the RWP packages, and the ORAU Team should not necessarily expect to see them [Archuleta 2022].

Six smears from inside of the gloveboxes had maximum results of 45 dpm/100cm² alpha contamination and 341 dpm/100cm² beta contamination. The ORAU Team assumes the respiratory requirements stated in the above paragraph likely were removed due to these low levels of contamination inside the gloveboxes. Based on survey data in various sections of this report, it is evident that LANL RCTs were vigilant and were monitoring and reviewing results against regulatory limits. If the respiratory requirement was removed, it is unlikely that further work would have caused contamination limits to be exceeded.

No airborne radioactivity was measured on the postjob review of the RWP. Measured postjob radiological conditions for surface contamination for alpha direct survey was reported as 57 dpm/100 cm² for the highest area and as 8 dpm/100 cm² for the general area. Alpha smears were reported as 52 dpm/100 cm² for the highest area and as not applicable for the general area. The LAS surveys were reported as less than the MDA for the highest and general area. Measured post job radiological conditions for surface contamination for beta/gamma direct survey were reported as 2,000 dpm/100 cm² for the highest area and as 400 dpm/100 cm² for the general area. Beta/gamma smears were reported as 2,000 dpm/100 cm² for the highest area and as not applicable for the general area. The LAS surveys were reported as less than the MDA for the highest and general area. These values are below the limits stated in RPRT-0101. The checkboxes in the review section for prejob survey data, postjob survey data, and prejob briefing log were checked and included in the package in addition to a lessons learned statement. No skin contaminations occurred. Review of this RWP indicates that LANL RCTs monitored this job appropriately.

2.2.4 RWP TA-48-98-50

LANL issued RWP TA-48-98-50 (effective August 6, 1998, expiration August 6, 1999) to transport accelerator production of tritium (APT) foil stacks from CMR in steel containers to Building 311 of TA-48 [LANL 1998b, pp. 383–404].

MAPs were recorded as the anticipated radionuclides. The anticipated prejob airborne radioactivity was reported as NDA. Prejob measured surface contamination values were reported as NDA for direct and smear, and LAS alpha and beta/gamma for both the highest area and the general area. These values are below the limits stated in RPRT-0101.

The RWP required a lab coat with taped openings and gloves, WB dosimeter, supplemental dosimeter, TLD finger rings, intermittent RCT coverage, monitoring personnel before leaving job, monitoring equipment and tools before removal, and notifying RCT before job starts and ends. There were hold point or special instructions as follows:

- 40 mrem hold point per person.
- RCT will dose rate and monitor incoming APT foil shipment.
- Proper postings and ALARA safeguards such as minimizing time, distance, and shielding.
- RCT will perform a prejob and postjob LAS to ensure outer hood and surrounding area remains less than MDA.
- During initial unpacking, RCT will check for radiation streaming and ensure adequate shielding is in place.
- All APT foils will be remotely handled.
- RCT coverage is not required once APT foils are taped to counting plate and sent to Room 24 for analysis. When analysis is complete, operators will wipe down equipment and ensure area is free from contamination.
- Operator will ensure APT foils are properly stored in RAD safe or hood and dose rate remains less than 5 mrem/hr at 30 cm.
- All APT foil handling will be performed in an operational hood in Room 311 except during analysis in Room 24.
- Finger rings and supplemental dosimeter will be worn at all times while working with APT foils.

Nine workers signed the Prejob Briefing Acknowledgment Log with dates ranging from August 12, 1998, through December 17, 1998. There was one CTRWP issued stating that continuous coverage is only required to unpack APT foils. Safety glasses were added as a requirement to be worn. Measured radiological conditions for surface contamination remained unchanged from the prejob surveys. An updated measured airborne radioactivity was reported as NDA. Six workers signed the form with dates ranging from December 17, 1998, to May 11, 1999.

Twenty surveys consisting of prejob and postjob smears, LAS, and external radiation surveys were obtained from May 11, 1998, to May 11, 1999. The dates are consistent with the acknowledgment logs. An annotation for lessons learned indicated additional postjob surveys are contained in monthly and quarterly routine monitoring instructions for Room 311. ALARA actions included placing additional

shielding in the hood to minimize streaming. The RWP package included a foil activation analysis status/progress memo relevant to this RWP from RWP TA-48-98-11 dated March 30, 1998.

The postjob review of the RWP estimated airborne radioactivity was reported as NDA. Measured surface contamination was NDA for direct, smear, and LAS surveys for alpha and beta/gamma activity for the highest area and general area. These values are below the limits stated in RPRT-0101. The checkboxes in the review section for job-specific air monitoring and postjob survey data were checked. However, no job-specific results were included or required according to the RWP, but as mentioned above on the CTRWP form, the airborne activity was marked as measured. Additionally, prejob surveys and a lessons learned statement were included. No skin contaminations occurred. Review of this RWP indicates that LANL RCTs monitored this job appropriately.

2.2.5 RWP TA-48-03-01

LANL issued RWP TA-48-03-01 (effective January 10, 2003, expiration December 31, 2003) to inspect the radiological inventory in hot cell pits in RC-1, Room 322 of TA-48 [LANL 2003a, pp. 322–331].

MAPs were recorded as the anticipated radionuclides. The expected prejob airborne radioactivity was reported as less than 10% DAC. Prejob anticipated radiological conditions for surface contamination for direct alpha readings were reported as NDA for the highest area and general area and the beta/gamma direct survey was marked as not applicable. The smear surveys were reported as less than the MDA for alpha and beta/gamma for both the highest area and general area. LAS surveys were reported as NDA for alpha and beta/gamma for both the highest area and general area. These values are below the limits stated in RPRT-0101.

The RWP required a lab coat with anti-Cs gloves and booties, WB dosimeter, supplemental dosimeter, extremity dosimeter, continuous RCT coverage, monitoring personnel before leaving job, monitoring equipment and tools before removal, and notifying RCT before job starts. If surface contamination levels exceeded 10 times the Appendix A level of the LANL Radiation Protection Program, work was to be stopped and reevaluated. If radiation levels exceed 40 mrem/hr at 30 cm, work will stop to reevaluate implementation of engineering controls. Only the inventory verifier is required to wear extremity and supplemental dosimetry if the dose rate of 40 mrem/hr at 30 cm is exceeded.

Thirteen workers signed the Prejob Briefing Log with dates ranging from January 17, 2003, to March 20, 2003.

Four surveys consisting of prejob, hotjob and postjob smears and an external radiation survey were obtained on March 20, 2003, which covers the dates of the Prejob Briefing Log. A Supplemental Dosimetry Issue Sheet for one worker was included as well.

The postjob review of the RWP measured airborne radioactivity was marked as not applicable. Measured postjob radiological conditions for surface contamination for alpha direct surveys were reported as NDA for the highest area and general area and as not applicable for beta/gamma. The smear surveys were reported as less than MDA for alpha and beta/gamma for the highest area and general area. LAS surveys were reported as NDA for alpha and beta/gamma for the highest and general areas. These values are below the limits stated in RPRT-0101. The checkboxes in the review section for prejob survey data, postjob survey data, dose tracking report, and prejob briefing log were checked and included in this RWP package. No skin contaminations occurred. Review of this RWP indicates that LANL RCTs monitored this job appropriately.

2.2.6 RWP TA-48-03-08

LANL issued RWP TA-48-03-08 (effective January 13, 2003, expiration December 31, 2003) to perform warm corridor and hot cell entries for health physics, waste, maintenance, and shipping operations in Building 1, Room 332 at TA-48 [LANL 2003a, pp. 221–249].

MAPs were recorded as the anticipated radionuclides. The anticipated prejob airborne activity was reported as less than 10% of the DAC. Prejob measured surface contamination values were reported as NDA for direct, smear, and LAS alpha surveys. Measured beta/gamma smears were reported as 80,000 dpm/100 cm² for the highest area and as 10,000 dpm/100 cm² for the general area. These values are below the limits stated in RPRT-0101. Direct and LAS surveys for beta/gamma were marked as not applicable.

The RWP required Level 1 protective clothing with hood with taped openings, WB dosimeter, supplemental dosimeter, intermittent RCT coverage, notifying RCT before job starts and ends, monitoring of equipment and tools before removal, and monitoring personnel before leaving job. Additional hold point/special instructions called for respiratory protection for hot cell entry where volatile radionuclides or chemicals have been processed.

Eight workers signed the Prejob Briefing Log with dates ranging from February 3, 2003, through April 9, 2003.

Twenty-four surveys consisting of routine smear surveys and radiation surveys occurred on an approximate monthly basis throughout the duration of this RWP. Both types of surveys were performed on the same day. Twelve of each type were included in this RWP package and they cover the dates of the acknowledgment logs. On the review section of the RWP under lessons learned, it was noted that monthly mopping of the warm corridor greatly reduced contamination and dose levels from previous years. There was a recommendation to maintain the monthly mopping schedule for future similar jobs.

The postjob review of the RWP measured airborne radioactivity was reported as less than 10% DAC. Measured postjob radiological conditions for surface contamination for alpha smears were reported as less than MDA for the highest and general area. For beta/gamma smears the highest result was reported as 6,000 dpm/100 cm² and 3,000 dpm/100 cm² for the general area. These values are below the limits stated in RPRT-0101. Direct and LAS surveys were marked as not applicable. The checkbox in the review section for monthly surveys was checked and the surveys were included in the RWP package in addition to a lessons learned statement. No skin contaminations occurred. Review of this RWP indicates that LANL RCTs monitored this job appropriately.

2.2.7 RWP TA-48-03-09

LANL issued RWP TA-48-03-23 (effective February 10, 2003, expiration March 7, 2003) to decontaminate Room 413 in RC-1 of TA-48 [LANL 2003b, pp. 2–42].

Strontium/yttrium-90 were recorded as the anticipated radionuclides. The measured prejob airborne radioactivity was reported as less than 10% DAC. Prejob measured surface contamination values for smears were reported as less than the MDA for the highest and general area and as not applicable for direct and LAS. Measured beta/gamma smears was reported as 340,000 dpm/100 cm² for the highest area and as not applicable for the general area. An LAS survey of the highest area was reported as 500,000 dpm/100 cm² and as not applicable for the general area. These values are below the limits stated in RPRT-0101. Direct surveys were marked as not applicable. An ALARA review checklist was also provided for this RWP.

The RWP required Level 2 protective clothing, full-face respirator WB dosimeter, supplemental dosimeter, extremity dosimeter, continuous RCT coverage, and notifying RCT before job starts. A hold point was required for torn PPE. If EPDs alarm, the job and dose exposure minimization techniques would be reevaluated.

Seven workers signed the Prejob Briefing Log with dates ranging from February 10, 2003, through February 11, 2003.

Nine surveys consisting of prejob, postjob, hotjob, and nonroutine smear, external radiation surveys, and job-specific air sampling results covering February 10, 2003, through February 13, 2003, were included. There were two accompanying survey maps. The surveys cover the dates on the acknowledgment logs. A worker dose tracking report and extremity exposure results were also included in this RWP.

The postjob review of the RWP measured airborne radioactivity was reported as less than 10% DAC. Measured postjob radiological conditions for surface contamination for alpha and beta/gamma direct surveys were reported as less than the MDA for the highest and general area. The smears and LAS surveys were reported as NDA for the highest and general area. These values are below the limits stated in RPRT-0101. The checkboxes in the review section for job-specific air monitoring, prejob survey data, postjob survey data, dose tracking report, prejob briefing log, and ALARA review checklist were checked and included in the RWP package. No skin contaminations occurred. Review of this RWP indicates that LANL RCTs monitored this job appropriately.

2.2.8 RWP TA-48-03-23

LANL issued RWP TA-48-03-23 (effective September 10, 2003, expiration December 31, 2003) to clean up hoods in RC-1 of TA-48 [LANL 2003a, pp. 85–99].

A mixture of ^{91}Nb , ^{92}Nb , ^{93}Nb -metastable, ^{94}Nb , depleted uranium (DU), ^{232}Th , ^{239}Pu , ^{242}Pu , ^{243}Am , ^{248}Cm , ^{237}Np , $^{88}\text{Zr/Y}$, ^{83}Rh , ^{75}Se , $^{68}\text{Ga/Ge}$, and ^{22}Na were recorded as the anticipated radionuclides. The expected prejob airborne radioactivity was reported as less than 10% DAC. Prejob measured radiological conditions for surface contamination for alpha were reported as NDA for direct, less than MDA for smears, and not applicable for LAS. For beta/gamma the direct readings were reported as NDA, the smears were reported as less than the MDA, and as not applicable for LAS. These values are below the limits stated in RPRT-0101.

The RWP required Level 1 protective clothing, WB dosimeter, intermittent RCT coverage, notifying RCT before job starts, and RCT monitoring of bagged items leaving hoods. Additional hold point/special instructions were for torn PPE, contamination found outside of the hoods, and contamination or dose rates exceeding expected levels.

Six workers signed the Prejob Briefing Log with dates ranging from September 10, 2003, through September 25, 2003.

Fifteen surveys consisting of prejob, hotjob, and postjob smear, direct, and radiation surveys were performed covering September 10, 2003, through September 25, 2003. These dates coincide with the acknowledgment logs.

There were several smear surveys identified as greater than LANL Radiological Control Table 2-2 limits [Hoover 2021, p. 4] inside the hoods in this RWP package. This is expected because the purpose of this RWP was to decontaminate hoods. This reinforces that LANL RCTs were monitoring and reviewing results against regulatory limits.

The postjob review of the RWP estimated airborne radioactivity was reported as less than 10% DAC. Measured postjob radiological conditions for surface contamination for alpha direct surveys were reported as NDA for the highest and general area and the smears were reported as less than MDA for the highest and general area. These values are below the limits stated in RPRT-0101. LAS surveys were marked as not applicable. The checkboxes in the review section for prejob, postjob, and prejob briefing log were checked and included in this RWP package. No skin contaminations occurred. Review of this RWP indicates that LANL RCTs monitored this job appropriately.

2.3 TA-53

TA-53 housed the Los Alamos Neutron Science Center. During the period of this evaluation, TA-53 had approximately 400 buildings and other structures. Site workers were protected by shielding, fencing, access controls, sweep procedures, beam shutoff mechanisms, monitoring devices, dosimetry, posted safety information, training, administrative controls, and emergency response mechanisms [LANL 1998a]. LANL staff at TA-53 were potentially exposed to both alpha materials and exotic radionuclides that were chiefly activation and spallation products, some with short half-lives.

2.3.1 RWP 1999-122-01

LANL issued RWP 1999-122-01 (effective June 7, 1999, expiration September 30, 1999) to set up an area in and around A-East for removal of inserts in the A-6 pit and culvert area of Sector M of Building 3 of TA-53 [LANL 1999c, pp. 290–384].

Cobalt-60, ^{57}Co , ^{58}Co , ^{54}Mn , ^7Be , and ^{22}Na were recorded as the anticipated radionuclides. The anticipated prejob airborne radioactivity was reported as less than 10% DAC. Prejob measured radiological conditions for surface contamination for beta/gamma smear and LAS surveys were reported as greater than 100,000 dpm/100 cm². This value could potentially exceed the limit stated in RPRT-0101. All other prejob surveys were marked as not applicable.

The RWP required Level 1 protective clothing with skull cap and taped openings with RCT authority to upgrade or downgrade based on current surveys, WB TLD, EPD, notifying RCT before job starts, monitoring personnel before leaving job, monitoring equipment and tools before removal, continuous RCT coverage, and RCT monitoring doffing of anti-Cs. After setup of this job, operations were to be done remotely and personnel will only make entries to change tools on monitor in a low exposure area. This RWP package contained an SWP titled *Special Work Permit for Cutting Experiments from their A6 Inserts* to aid operators in preventing accidents and releases of radioactive material, as well as four cask radiation surveys. The SWP states contamination levels up to several million dpm/100cm² can be expected. The highest result noted in this RWP package was an LAS beta survey of a landing and tool change area with 115,500 dpm. No surface area given.

Twenty-two workers signed the Prejob Briefing Acknowledgment Log with dates ranging from June 8, 1999, to September 20, 1999. Thirty nasal smears used as an indicator for potential intakes were obtained and all were reported as NDA. No forms were associated with these individual workers.

Twenty surveys of routine smear and LAS, nonroutine LAS, offsite item release, radiation surveys, and nasal smears were provided in this RWP package. Additionally, 125 air sample analyses of job-specific and CAMs were provided. Eleven air samples had positive results and combined radionuclides such as ^7Be , ^{56}Co , ^{57}Co , ^{58}Co , ^{60}Co , ^{54}Mn , ^{22}Na , ^{83}Rb , ^{46}Sc , and ^{75}Se were identified. The date ranges for these surveys covered July 22, 1999, to September 24, 1999. The surveys are consistent with the dates on the acknowledgment logs. A table with weekly exposures from July 19, 1999, to September 26, 1999 was included. Prejob radiological conditions did not require air sampling or respirators initially; there was a caveat for an RCT to upgrade requirements, which was done, showing RCTs reacted to changing conditions during the job.

The postjob review of the RWP measured airborne radioactivity was reported as less than 10% DAC. The measured postjob radiological conditions for surface contamination was reported as less than 100,000 dpm/100 cm² for beta/gamma smears and as 684 dpm/100 cm² for beta/gamma LAS. These values are below the limits stated in RPRT-0101. All other postjob surface contamination surveys were marked as not applicable. The checkboxes in the review section for CAM results, job-specific air monitoring, prejob survey data, postjob survey data, nasal smear data, dose tracking report, and RWP acknowledgment log were checked and included in this RWP package. No personnel were contaminated above applicable limits. Review of this RWP indicates that LANL RCTs monitored this job appropriately.

2.3.2 RWP 2001-035-01

LANL issued RWP 2001-035-01 (effective February 14, 2001, expiration May 31, 2001) to replace target system Culligan bottles in the Service Area, Target 1L in Building 7 of TA-53 [LANL 2001, pp. 86–154].

Cobalt-57, ⁶⁰Co, ¹⁷⁵Hf, ¹⁷¹Lu, ⁵⁴Mn, and ²²Na were recorded as the expected radionuclides. The anticipated prejob airborne radioactivity was reported as less than 10% DAC. Prejob measured radiological conditions for surface contamination for beta/gamma were reported as 2,100 dpm/100 cm² from a LAS survey. These values are below the limits stated in RPRT-0101. All other prejob surveys were marked as not applicable.

The RWP required Level 2 protective clothing with skull cap and taped openings with RCT authority to change pending contamination levels, splash anti-Cs with face shield recommended if water is present, full face respirator with RCT having authority to change respiratory requirements pending contamination levels, job-specific air monitoring via giraffe sampler, WB TLD, EPD, notifying RCT before job starts, self-frisking, monitoring personnel before leaving job, monitoring equipment and tools before removal, and continuous RCT coverage.

Twelve workers signed the Prejob Briefing Acknowledgment Log with dates ranging from February 20, 2001, through May 23, 2001. Nasal smears used as an indicator for potential intakes were obtained for two workers and both workers signed the RWP acknowledgment log. However, no results were included in this RWP package. An RWP worksheet mentions them being processed [LANL 2001, p. 97].

Twenty-four surveys consisting of prejob, postjob, hotjob, routine, and nonroutine smear, LAS, job-specific air sampling, and external radiation surveys covering February 5, 2001, through June 16, 2001, were provided. Many have accompanying maps. The surveys are consistent with the dates on the acknowledgment logs. Also included were RWP worksheets summarizing activities performed for the duration of this RWP and worker EPD goals for the RWP.

There were several LAS and smear surveys identified as greater than LANL Radiological Control Table 2-2 limits [Hoover 2021, p. 4] in this RWP package. This reinforces that LANL RCTs were monitoring and reviewing results against regulatory limits.

The postjob review of the RWP estimated airborne radioactivity was reported as less than 10% DAC. Measured postjob radiological conditions for beta/gamma smears was reported as 25,155 dpm/100 cm² and as 15,300 dpm/100 cm² for beta/gamma LAS. These values are below the limits stated in RPRT-0101. All other prejob surface contamination values were marked as not applicable. The checkboxes in the review section for job specific air monitoring, prejob survey data, postjob survey data, dose tracking report, and RWP acknowledgment log were checked and included in the package. No personnel were contaminated above applicable limits and there were no

annotations of lessons learned. Review of this RWP indicates that LANL RCTs monitored this job appropriately.

2.3.3 RWP 2002-006-01

LANL issued RWP 2002-006-01 (effective January 7, 2002, expiration March 31, 2002) for the installation of traps in three radioactive liquid waste lines in Experimental Area Room 1 on the lower floor in Building 7 of TA-53 [LANL 2002, pp. 406–442].

Cobalt-57, ⁶⁰Co, ¹⁷²Hf, ¹⁷²Lu, ⁵⁴Mn, and ²²Na were recorded as the expected radionuclides. The estimated prejob airborne radioactivity was reported as less than 10% DAC. Prejob anticipated radiological conditions for alpha surface contamination for LAS were reported as less than 20 dpm/100 cm² and as 500,000 dpm/100 cm² for beta/gamma. These values are below the limits stated in RPRT-0101. Direct and smear surveys were marked as not applicable.

The RWP required Level 2 protective clothing with outer pair of waterproof coveralls if water is present, full face respirator, WB TLD, alarming dosimeter, i.e., EPD if working in target cell only, continuous RCT coverage, notifying RCT before job starts, self-frisking, monitoring of equipment and tools before removal, RCT monitoring of doffing anti-Cs, frisking through the personnel contamination monitor (PCM) in Experimental Area Room 2, and job specific air monitoring via a giraffe sampler. Water lines were to be flushed before commencing this job and plastic was to be laid down.

Seven workers signed the Prejob Briefing Acknowledgment Log with dates ranging from January 14, 2002, through January 19, 2002. Nasal smears used as an indicator for potential intakes were taken for six workers and all results were NDA for alpha and beta radioactivity. Nasal smears were not a requirement of this RWP, and a postjob survey included six respirator smear results that were less than MDA. This reinforces that LANL RCTs were monitoring and reviewing results against regulatory limits and were taking conservative steps to ensure worker safety. All of the workers signed the RWP acknowledgment log.

Twelve surveys consisting of prejob and postjob smear, LAS, nasal smears, and job-specific air sampling radiation survey from January 5, 2002, to February 7, 2002, were provided. One job-specific air sample analyzed via gamma spectroscopy identified ⁷Be, ¹⁷²Lu, ¹⁷⁵Hf, and ¹⁷³Lu, and the reported levels were below the limits stated in RPRT-0101. The surveys are consistent with the dates on the acknowledgment logs.

The postjob review of the RWP estimated airborne radioactivity was reported as less than 10% DAC. Measured postjob radiological conditions for surface contamination were marked as not applicable for direct, less than LANL Radiological Control Table 2-2 limits [Hoover 2021, p. 4] for smears, and as less than 1,000 dpm/100 cm² for beta/gamma LAS. These values are below the limits stated in RPRT-0101. The checkboxes in the review section for job specific, prejob, postjob, nasal smears, and RWP acknowledgment log were checked and included in the package. No personnel were contaminated above applicable limits. Review of this RWP indicates that LANL RCTs monitored this job appropriately.

2.3.4 RWP 2002-007-01

LANL issued RWP 2002-007-01 (effective January 7, 2002, expiration July 31, 2002) to open the 1L hydrogen system cold box following a move from a service area in MPF-7, Room 200 (1LSA) to repair and rebuild for reinstallation in Building 3 of TA-53 [LANL 2002, pp. 443–498].

Cobalt-57, ⁶⁰Co, ¹⁷²Hf, ¹⁷²Lu, ⁵⁴Mn, and ²²Na were recorded as the expected radionuclides. The estimated prejob airborne radioactivity was reported as less than 10% DAC. Prejob measured

radiological conditions for surface contamination were marked as not applicable except for a reported result of 2,000 dpm/100 cm² for beta/gamma LAS. This value is below the limit stated in RPRT-0101.

The RWP required Level 2 protective clothing with RCT authority to change pending contamination levels, full face respirator with RCT having authority to change respiratory requirements pending contamination levels, WB TLD, notifying RCT before job starts, self-frisking via PCM-1B, monitoring of equipment and tools before removal, continuous RCT coverage, and job specific air monitoring via a giraffe sampler if contamination exceeds 100,000 dpm.

Fourteen workers signed the RWP 2002-007-01 Prejob Briefing Acknowledgment Log with dates ranging from February 1, 2002, through February 27, 2002.

Twenty-three surveys consisting of prejob, postjob, hotjob, routine, nonroutine, and offsite shipments for smear, LAS, external radiation, direct, and job-specific air samples were provided. The surveys were performed from January 23, 2002, to March 5, 2002. These dates are consistent with the signed acknowledgment logs. A *Special Work Permit for Repair of Components Inside the Hydrogen Moderator System Cold Box* was included in this RWP package (LANL 2002 pp. 453–465). It lists detailed procedures for accessing and repairing the unit.

There were several beta/gamma LAS and smear surveys identified as greater than LANL Radiological Control Table 2-2 limits [Hoover 2021, p. 4] in this RWP package; the highest was 18,600 dpm/100cm². This reinforces that LANL RCTs were monitoring and reviewing results against regulatory limits.

The postjob review of the RWP measured airborne radioactivity was reported as less than MDA. Measured postjob radiological conditions for surface contamination were marked as not applicable except for reported results of beta/gamma less than Table 2-2 limits [Hoover 2021 p.4] for smears and less than background for beta/gamma LAS. These values are below the limits stated in RPRT-0101. The checkboxes in the review section for job specific, prejob, postjob, and RWP acknowledgment log were checked and included. No personnel were contaminated above applicable limits. Review of this RWP indicates that LANL RCTs monitored this job appropriately.

2.3.5 RWP 2003-001-01

LANL issued RWP 2003-001-01 (effective January 2, 2003, expiration December 24, 2003) to operate the 1L Target systems in the Building 7 Service Area of TA-53 [LANL 2003c, pp. 2–101].

Cobalt-60, ⁵⁹Fe, ¹⁷²Lu, and ⁵⁴Mn were recorded as the expected radionuclides. The anticipated prejob airborne radioactivity was reported as less than 10% DAC. The prejob surface contamination smear for beta/gamma provided was reported as 50,000 dpm/100 cm². This value is below the limit stated in RPRT-0101.

The RWP required Level 2 protective clothing with RCT authority to adjust PPE, splash anti-Cs with face shield if free liquids are present, WB TLD, EPD turned in daily, notifying RCT before job starts and ends, monitoring equipment and tools before removal, self-frisking via PCM, and continuous RCT coverage.

Seventeen workers signed the RWP Prejob Briefing Acknowledgment Log with dates ranging from January 27, 2003, through August 12, 2003.

Forty-two surveys consisting of prejob, postjob, hotjob, routine, and nonroutine smear, LAS, external radiation, and direct surveys were provided. The surveys covered dates from January 2, 2003, through June 24, 2003. Many have accompanying maps. The surveys are consistent with the dates

on the acknowledgment logs. RWP worksheets summarizing activities performed for the duration of this RWP were included. Prejob and postjob LAS surveys performed on August 20, 2003, were not included in this RWP package. They did record the results as less than MDA on an RWP worksheet and this appears to be the last day work was performed under this RWP. Worker EPD goals and actual dose for this RWP were included.

There were several beta/gamma LAS and smear surveys identified as greater than LANL Radiological Control Table 2-2 limits [Hoover 2021, p. 4] in this RWP package; the highest was 547,000 dpm/100cm². This reinforces that LANL RCTs were monitoring and reviewing results against regulatory limits.

The postjob review of the RWP estimated airborne radioactivity was recorded as less than 10% DAC. The postjob beta/gamma smear was recorded as 9,000 dpm/100 cm² and the LAS was reported as 500,000 dpm/100 cm². These values are below the limits stated in RPRT-0101. Alpha surface contamination surveys were marked as not applicable. The radionuclides differed from page 1 of the RWP and they are recorded as measured for ⁵⁷Co, ⁵⁸Co, and ⁶⁰Co. There is no information in this RWP package as to why these changed. The checkboxes in the review section for prejob, postjob, special dosimetry results, formal ALARA review, and RWP acknowledgment log were checked and included in this RWP package. RWP worksheets were also included. No personnel were contaminated above applicable limits. Review of this RWP indicates that LANL RCTs monitored this job appropriately.

2.3.6 RWP 2003-022-01

LANL issued RWP 2003-022-01 (effective January 28, 2003, expiration July 20, 2003) to perform maintenance and upgrades to 1L water, hydrogen and instrumentation control systems located in the Target Cell and Pump Alcove in support of a 2003 outage at 1L Target systems in the Building 7 Service Area of TA-53 [LANL 2003c, pp. 102–276].

Cobalt-60, ⁵⁹Fe, ¹⁷²Lu, and ⁵⁴Mn were recorded as the expected radionuclides. The anticipated prejob airborne radioactivity was reported as less than 10% DAC. The measured prejob surface contamination LAS for beta/gamma was recorded as 20,000 dpm/100 cm². This value is below the limit stated in RPRT-0101. All other prejob surface contamination values were marked as not applicable.

The RWP required Level 2 protective clothing, full-face respirator until RCT gives approval to remove, WB TLD, EPD turned in daily, notifying RCT before job starts and ends, monitoring equipment and tools before removal, monitoring personnel before leaving job, monitor EPDs, continuous RCT coverage, all items released by RCT, and personnel exit via PCM.

Twenty-four workers signed the RWP Prejob Briefing Acknowledgment Log with dates ranging from February 10, 2003, through June 11, 2003.

Seventy-four surveys consisting of prejob, postjob, hotjob, routine, and nonroutine smear, LAS, and external radiation surveys were provided. The dates ranged from January 28, 2003, through June 16, 2003. Many have accompanying maps. The surveys are consistent with the dates on the acknowledgment logs. RWP worksheets summarizing activities performed for the duration of this RWP, EPD tracking records, and worker goals and actual dose were included for this RWP.

There were several LAS and smear surveys identified as greater than LANL Radiological Control Table 2-2 limits [Hoover 2021, p. 4] in this RWP package. One smear survey from inside a cask exceeded the beta/gamma limit of 1,000 dpm/100cm². This reinforces that LANL RCTs were monitoring and reviewing results against regulatory limits.

The postjob review of the RWP estimated airborne radioactivity was recorded as less than 10% DAC. The postjob surface contamination LAS for beta/gamma provided was recorded as 230 dpm/100 cm². This value is below the limit stated in RPRT-0101. All other postjob surface contamination values were marked as not applicable. The checkboxes in the review section for prejob, postjob, special dosimetry results, dose tracking report, formal ALARA review, and acknowledgment log were checked and included in this RWP package. No personnel were contaminated above applicable limits. Review of this RWP indicates that LANL RCTs monitored this job appropriately.

2.3.7 RWP 2004-054-01

LANL issued RWP 2004-054-01 (effective April 27, 2004, expiration May 20, 2004) for a target shipment from the New Isotope Production Facility Building 984 in TA-53 [LANL 2004, pp. 346–366].

Strontium-82 was recorded as the expected radionuclide. The anticipated prejob airborne radioactivity was reported as less than 10% DAC. Prejob anticipated surface contamination levels were reported as less than 20 dpm/100 cm² for alpha and reported as less than 1,000 dpm/100 cm² for beta/gamma. These values are below the limits stated in RPRT-0101.

The RWP required Level 1 protective clothing, monthly TLD, continuous RCT coverage, notifying RCT before job starts and ends, self-frisking, and monitoring of equipment and tools before removal.

Eight workers signed the Prejob Briefing Acknowledgment Log with dates ranging from April 20, 2004, through May 12, 2004.

Eleven surveys consisting of consisting of prejob, postjob, hotjob, and nonroutine smear, LAS, and external radiation, and direct surveys were provided. The dates ranged from April 20, 2004 to May 14, 2004. These surveys are consistent with the dates on the acknowledgment logs. RWP worksheets summarizing activities performed for the duration of this RWP and EPD dose tracking records were included.

One LAS survey result of 1,110 dpm/100cm² beta/gamma exceeded the LANL Radiological Control Table 2-2 limits [Hoover 2021, p. 4] value of 1,000 dpm/100cm². The location was decontaminated. This reinforces that LANL RCTs were monitoring and reviewing results against regulatory limits.

The postjob review estimated airborne radioactivity was reported as less than 10% DAC. Measured postjob radiological conditions surface contamination were marked as not applicable except for LAS beta/gamma reported as less than 1,000 dpm/100 cm². This value is below the limit stated in RPRT-0101. The checkboxes in the review section for prejob, postjob, RWP acknowledgment log, dose tracking, and RWP worksheets were checked and included in the package. No personnel were contaminated above applicable limits and there were no annotations of lessons learned. Review of this RWP indicates that LANL RCTs monitored this job appropriately.

2.3.8 RWP 2004-128-01

LANL issued RWP 2004-128-01 (effective December 9, 2004, expiration December 31, 2004) to perform contamination surveys to characterize, post, establish controls, and establish the decontamination efforts required for the Building 7 Service Area and Crypt, Target 1L and 1LSA in TA-53 [LANL 2004 pp. 367–414].

Gadolinium-148, ⁶⁰Co, ⁵⁷Co, ²²Na, ⁵⁴Mn, and ¹⁷²Lu were recorded as the expected radionuclides. The anticipated prejob airborne radioactivity was reported as less than 10% DAC. The prejob measured LAS surface contamination level for beta/gamma was reported as 33,304 dpm/100 cm² and noted as not applicable for alpha. This value is below the limit stated in RPRT-0101.

The RWP required Level 2 protective clothing, monthly TLD, EPD, continuous RCT coverage, notifying RCT before job starts and ends, self-frisking, monitoring of personnel before leaving job, job specific air monitoring via a giraffe sampler, monitoring of equipment and tools before removal, shoe survey, RCT monitoring for doffing anti-Cs, and frisking.

Four workers signed the Prejob Briefing Acknowledgment Log on December 9, 2004.

Eight surveys consisting of prejob, postjob, hotjob, routine, and nonroutine smear, LAS, external radiation, and job-specific air samples were provided. The dates ranges from October 26, 2004 to February 1, 2005. Several of these surveys were outside of the date ranges for this RWP. They were recorded on a review of reports sheet provided. They were a monthly smear survey used as prejob from October 26, 2004, two postjob smear surveys acquired on January 6, 2005 and January 31, 2005, a postjob direct survey from January 31, 2005, and a postjob LAS from February 1, 2005. A gamma spectroscopy analysis of the job-specific air sample filter positively identified ^{173}Lu . The surveys coincide with the dates on the acknowledgment logs. RWP worksheets summarizing activities performed for the duration of this RWP were included as were EPD tracking records.

Many hotjob characterization smear surveys not held to any LANL Radiological Control Table 2-2 limits [Hoover 2021, p. 4] had positive results for alpha and beta/gamma. One other hot job smear survey had several results exceeding Table 2-2 alpha and beta/gamma limits. This reinforces that LANL RCTs were monitoring and reviewing results against regulatory limits.

The postjob measured airborne radioactivity was reported as less than 10% DAC. Measured postjob radiological conditions for alpha surface contamination levels were reported as 6.34 dpm/100 cm² for the highest area and as less than the MDA for the general area. The highest beta/gamma level was reported as 508.19 dpm/100 cm² and the general area was reported as 200 dpm/100 cm². LAS levels for beta/gamma were reported as 5.2 dpm/100 cm² and as 3.46 dpm/100 cm² for the general area. These values are below the limits stated in RPRT-0101. The checkboxes in the review section for job-specific air monitoring, prejob, postjob, special dosimetry, dose tracking report, and RWP acknowledgment log were checked and included in the package. No personnel were contaminated above applicable limits. Review of this RWP indicates that LANL RCTs monitored this job appropriately.

3.0 SUMMARY AND CONCLUSION

In this report that supplements information and conclusions presented in RPRT-0101, the ORAU Team subjectively reviewed 24 RWP packages from LANL for areas TA-3, TA-48, and TA-53 where the primary anticipated radionuclides were other than plutonium, americium and uranium. Prejob surveys, in process surveys, postjob surveys, and radiological conditions were reviewed to ensure that RCT monitoring was appropriately performed to ensure worker safety. RWP requirements for PPE, dosimetry, respiratory protection, and prejob acknowledgment logs indicating the worker understood the monitoring requirements were reviewed. Nasal smears were included in nine of the RWPs and were used to indicate potential intakes.

The ORAU Team review of RWPs in Sections 2.1, 2.2, and 2.3 concludes that LANL Health Physics, via intermittent RCT and/or continuous RCT coverage, appropriately monitored jobs covered by RWPs. The ORAU Team examined monitoring data around the dates recorded by workers on the prejob briefing logs to assess if Health Physics personnel monitored the job and work conditions. Instances presented by CTRWP Form and/or hold point and special instructions show that LANL RCTs reacted to changing radiological conditions to protect worker safety. The review of these RWP packages supports the premise that LANL Health Physics personnel monitored workers for nonroutine radiological work conditions and radiological situations, reinforcing the conclusion in RPRT-0101 that could have led to LANL workers receiving intakes of exotic radionuclides in excess of 100 mrem

CED/yr. LANL maintained the capacity to perform bioassay for these radionuclides if that had been warranted [Hoover 2008, 2021].

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**ATTACHMENT A
SUMMARY OF RWP INFORMATION**

Table A-1. Summary of RWP information.

RWP number	TA	Radionuclide(s)	Number of signatures signed logs	Nasal smears (Y-#/N)	RCT coverage	Number of surveys provided
96-3-29-9030B-423	3	Cs-137	22	Y-22	Continuous and intermittent	8
96-3-29-9030-106	3	Cs-137	12	Y-8	Continuous and intermittent	8
99-3-29-1117-47	3	Tc-99, U	44	Y-65	Continuous	213
97-3-29-9030-99	3	Cs-137	4	Y-2	Continuous	4
97-3-29-Wing 9-162	3	Cs-137	22	N	Intermittent	6
99-3-29-4064-361	3	Tc-99, U	69	N	Continuous and intermittent	8
01-03-29-4064-275	3	Tc-99, U	2	N	Continuous	11
99-3-29-9030, 9060-144	3	Cs-137	10	Y-1	Continuous and intermittent	7
TA-48-98-46	48	All used at TA-48	11	Y-5	Intermittent	14
TA-48-98-62	48	MAP	10	N	Continuous	11
TA-48-98-47	48	All associated with shot debris	3	N	Intermittent	3
TA-48-98-50	48	MAP	15	N	Intermittent	20
TA-48-03-08	48	MAP	8	N	Intermittent	24
TA-48-03-23	48	Nb-91, Nb-92, Nb-93m, Nb-94, DU, Th-232, Pu-239, Pu-242, Am-243, Cm-248, Np-237, Zr/Y-88, Rh-83, Se-75, Ga/Ge-68, Na-22	8	N	Intermittent	15
TA-48-03-01	48	MAP	13	N	Continuous	4
TA-48-03-09	48	Sr/Y-90	7	N	Continuous	9
1999-122-01	53	Co-60, Co-57, Co-58, Mn-54, Be-7, Na-22	22	Y-30	Continuous	20
2001-035-01	53	Co-57, Co-60, Hf-175, Lu-171, Mn-54, Na-22	12	Y-2	Continuous	24
2002-006-01	53	Co-57, Co-60, Hf-172, Lu-172, Mn-54, Na-22	7	Y-6	Continuous	12
2002-07-01	53	Co-57, Co-60, Hf-172, Lu-172, Mn-54, Na-22	14	N	Continuous	23
2003-001-01	53	Co-60, Fe-59, Lu-172, Mn-54	17	N	Continuous	42
2003-022-01	53	Co-60, Fe-59, Lu-172, Mn-54	24	N	Continuous	74
2004-054-01	53	Sr-82	8	N	Continuous	11
2004-128-01	53	Gd-148, Co-60, Co-57, Na-22, Mn-54, Lu-172	4	N	Continuous	8