Sigma-Aldrich Company

US NRC License 24-16607-03

Decontamination and Decommissioning Plan

3300 South Second Street

St. Louis, MO

&

2909 Laclede Avenue

St. Louis, MO

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July 12, 2017

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ACRONYM LIST

ALARA	As Low As Reasonably Achievable
D&D	Decontamination and Decommissioning
$DCGL_{EMC}$	Derived Concentration Guideline Level – Elevated Measurement Comparison
$DCGL_W$	Derived Concentration Guideline Level – Average Area Concentration
DQO	Data Quality Objective
DSV	Default Screening Value
GSF	Gross Square Feet
HSA	Historical Site Assessment
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	Minimum Detectable Concentration
NRC	U.S. Nuclear Regulatory Commission
QAPP	Quality Assurance Project Plan
RSO	Radiation Safety Officer
TEDE	Total Effective Dose Equivalent

1.0 Introduction

Sigma-Aldrich Company (Sigma) is planning to perform decontamination and decommissioning (D&D) to terminate its United States Nuclear Regulatory Commission (NRC) License 24-16607-03. This Decontamination and Decommissioning (D&D) Plan will demonstrate the techniques used to evaluate the interior laboratories of the 3300 S Second Street & 2909 Laclede Avenue facilities will fall well below the annual total effective dose equivalent (TEDE) of twenty-five (25) millirem above background to an individual member of the public. The goal of this decommissioning is to achieve unrestricted release of the facility and termination of license 24-16607-03.

This plan was developed using the guidance provided in NUREG 1727, "NMSS Decommissioning Standard Review Plan"; NUREG 1757, "Consolidated NMSS Decommissioning Guidance"; and NUREG 1575, "Multi-Agency Radiation Survey and Site Investigation Manual" (MARSSIM). It provides the approach, methods, and techniques for the radiological D&D of impacted areas of each facility. Final status surveys are designed to implement the protocols and guidance provided in MARSSIM to demonstrate compliance with the default screening values generated using the default scenarios and parameters of the DandD Code v.2.1. These methods ensure technically defensible data is generated to aid in determining whether these facilities meet the release criteria for unrestricted use.

D&D activities will be performed in accordance with this Plan and Sigma Aldrich Radiation Protection Program. Decontamination Decommissioning and Environmental Services, LLC (DDES) will be performing this scope of work under DDES' Massachusetts Radioactive Materials License 56-0623, via reciprocity.

2.0 Site Description

<u>3300 S Second Street Facility</u>

The R&D facility located at 3300 S Second Street confined restricted areas for possession and use of radioactive materials to three laboratories. These radioactive material use laboratories are N1111, N1143 and N340.

Lab N1111 is used for radio-assays, and has been in operation since the initial license issue in 1986. This lab is currently active. Isotopes used in this lab have been limited to 3H, 14C, 32P, 33P, 35S, 57Co, and 125I. Use has been limited to small quantities (less than 1 mCi) for each assay.

Lab N1143 was used for radio-assays and was in operation from 1986 until September of 2005. The lab has been inactive since. Isotopes used in this lab have been limited to 3H, 32P, and 33P. Use was limited to small quantities (less than 1 mCi) for each assay. The radiation safety committee released this lab for unrestricted use in July of 2011.

Lab N340 was used for radio-assays and was in operation from 1986 until April of 2002. The lab has been inactive since. Isotope use was limited to 32P in small quantities (less than 1 mCi) for each assay during operation. The radiation safety committee released the lab for general use in November of 2005.

No significant spills or incidents were reported that had an impact on decommissioning activities. This is consistent with the small scale, analytical type of work, and historical area surveys only rarely showing activity levels above background measurements.

2909 Laclede Avenue Facility

The restricted area for possession and use at the 2909 Laclede Avenue facility is Lab G109, which is located on the ground floor of the building. Isotopes in this lab have been limited to 32P and 33P. Use is limited to small quantities (less than 1 mCi) for each assay. No significant spills or incidents have been reported. This is consistent with the small scale, analytical type of work, and historical area surveys consistently showing no activity levels above background.

3.0 Site History

3.1 Potential Contaminants

Based on discussions with Sigma management and data obtained from review of the current NRC Radioactive Materials License # 24-16607-03, the nuclides of concern (NOC) for this project are ^{14}C, ^{3}H,^{125}I, ^{32}P, ^{35}S. A historical site assessment was performed in July of 2017.

Previous scoping surveys performed by DDES, LLC, indicate that there is minor radiological contamination present within a few fume hoods and the associated ventilation system.

Nuclides were evaluated by utilizing Default Screening Values (DSV's) generated from a screening analysis using the default parameters contained in the DandD Code v.2.1.

4.0 Impacted Room Descriptions

The laboratory spaces identified above have tile and vinyl tile floors and epoxy-painted walls. These laboratories also contain bio-safety cabinets and fume hoods where the use of radioactive material was permitted. Ventilation in these areas is designed to provide between 6 and 12 room air changes per hour.

Laboratory areas are protected by sprinkler systems. The facility's smoke detectors are hardwired into the buildings fire alarm system, which is linked to the St. Louis Fire Department.

Sinks within these areas were not permitted for disposal of radioactive materials, but will

be evaluated.

Any work with radioactive material that could cause any airborne activity (e.g., volatile compounds) was done in properly functioning fume hoods or glove boxes. The ventilation flow rates for enclosures in which licensed materials were used was verified at least annually. At a minimum, face velocity of fume hoods was maintained at 100 feet/minute.

Sigma employs full-time on-site security. In addition, cameras are installed at all perimeter doors and facility door access is controlled through the use of key-card readers. Only properly trained and authorized individuals are granted access to areas where licensed radioactive materials are being used and/or stored. Radioactive stock solutions have been transferred or disposed of as radioactive waste prior to assembling this decommissioning plan.

5.0 Radiological Status of Facility

The radiological status of the facility has been determined by a combination of historical records and interviews with the Radiation Safety Officer and Site Management. A characterization survey shall be performed to determine the current status of each potentially impacted area.

5.1 Characterization Survey

Typically, the survey protocol for building surfaces will consist of performing the scanning portion of the final status survey protocol, with judgmental smears and static measurements on the highest probability areas for residual radioactivity. Judgmental static measurements and smears shall also be taken, as needed, on vertical surfaces as part of potentially modified Class 2 and Class 3 final status survey protocols.

The purpose of scanning is to identify locations of elevated activity. Where elevated activity is identified, a static measurement and smear will be taken at the location of highest activity identified during the scan. Where elevated activity is identified, the boundary of the elevated area will be marked to aid in locating the area for remedial actions.

If the initial characterization survey results indicate that contamination is not present in excess of the release criteria, then data from the survey may be used as part of the final status survey. For areas that are partially contaminated, the characterization survey data may be used as part of the final status survey measurements provided that 1) the data used is only from areas with contamination levels below the release criteria, and 2) decontamination work is controlled such that the survey location could not have become cross-contaminated.

Each survey unit will have an independent survey package that has specific survey

instructions. The survey package will contain, at a minimum:

- Survey Unit number (e.g., Building and Room Number, System Number, etc.)
- Percentage of surface requiring scan surveys
- Number of removable contamination measurements
- Instrumentation to be used with static count times and scan rates
- Any additional specific survey instruction
- Maps of the survey unit surfaces

6.0 Release Criteria

Guidance provided in NUREG 1727, "NMSS Decommissioning Standard Review Plan", NUREG 1757, V.2., "Characterization, Survey and Determination of Radiological Criteria", and NUREG 1575, "Multi-Agency Radiation Survey and Site Investigation Manual" (MARSSIM) will be used for the radiological release criteria for decommissioning these rooms. Specifically the rooms being released under this decommissioning effort will be surveyed in accordance with the guidance and protocols contained in MARSSIM to demonstrate compliance with the release criteria. The criteria are that residual radioactivity results in a TEDE to an average member of the critical group that does not exceed 25 mrem per year and that the residual radioactivity has been released to levels that are as low as reasonably achievable (ALARA). Additionally, the TEDE during decommissioning activities shall not exceed 25 mrem per year.

7.0 Derived Concentration Guideline Levels

The NRC has published default screening values in NUREG 1757 for commonly used radionuclides. DandD v.2.1 software was used to determine default screening values for isotopes not listed in NUREG 1757. Surface contamination limits were derived using the Building Occupancy scenario together with default parameter values. Screening values were selected such that the 0.9 quantile of projected doses was less than or equal to 25 mrem/y (i.e., when probabilistic dose assessment calculations were performed, there was a 90% probability the calculated dose would be less than 25 mrem/y).

The nuclides of concern (NOC) have been limited to ^{14}C, ^{3}H, ^{125}I, ^{32}P, ^{35}S based on the last recorded use of radioactive materials in each area. The NOC screening values for surfaces under default conditions (generic screening levels) from the NRC DandD code v.2.1 are provided in Table 7.1, while Sigma Project Administrative Limits are provided in Table 7.2.

Table 7.1: Established DCGLw's for Survey (25mrem)

Radionuclide	Total (DPM/100 cm^2)	Removable (DPM/100 cm^2)
^{14}C	3.7×10^6	3.7×10^5
^{3}H	N/A	1.2×10^7

^{125}I	6.8×10^5	6.8×10^4
^{32}P	9.5×10^6	9.5×10^5
^{35}S	1.3×10^7	1.3×10^6

Table 7.2: Established Sigma Aldrich Administrative Limit's for Survey

Radionuclide	Total (DPM/100 cm^2)	Removable (DPM/100 cm^2)
^{14}C	5×10^3	1×10^3
^{3}H	N/A	1×10^3
^{125}I	5×10^3	1×10^3
^{32}P	5×10^3	1×10^3
^{35}S	5×10^3	1×10^3

The default screening values are the basis for developing the derived concentration guideline levels (DCGL's) for the project. The DCGL is the radionuclide specific surface area concentration that could result in a dose equal to the release criterion. $DCGL_W$ is the concentration limit if the residual activity is essentially evenly distributed over a large area. For this project, $DCGL_W$ is equal to the DSV.

In the case of non-uniform contamination, higher levels of activity are permissible over small areas. The $DCGL_{EMC}$ is derived separately for these small areas. The $DCGL_{EMC}$ is the $DCGL_W$ increased by an area factor depending on the size of the elevated area. For the Sigma Aldrich decommissioning project, $DCGL_{EMC}$ is not expected to be used since contamination levels in the facility are a small percentage of the DSV.

Additionally, a reasonable effort shall be made to decontaminate any detectable contamination in support of the ALARA principle. If simple hand wipe/scrub techniques are unsuccessful at removal of the residual contamination, then the RSO may perform a cost vs. risk analysis prior to any aggressive decontamination methods.

8.0 ALARA Analysis

Due to the extremely low doses associated with the release criteria used for this D&D project, a quantitative ALARA analysis is not required. Default screening values are being used to establish DCGLs.

NUREG 1727 states in part: "In light of the conservatism in the building surface and surface soil generic screening levels developed by the NRC staff, the staff presumes, absent information to the contrary, that licensees or responsible parties that remediate building surfaces or soil to the generic screening levels do not need to demonstrate that these levels are ALARA. However, licensees or responsible parties should remediate their

facility below these levels through practices such as good housekeeping. In addition, licensees or responsible parties should provide a description in the final status survey report of how these practices were employed to achieve the final activity levels."

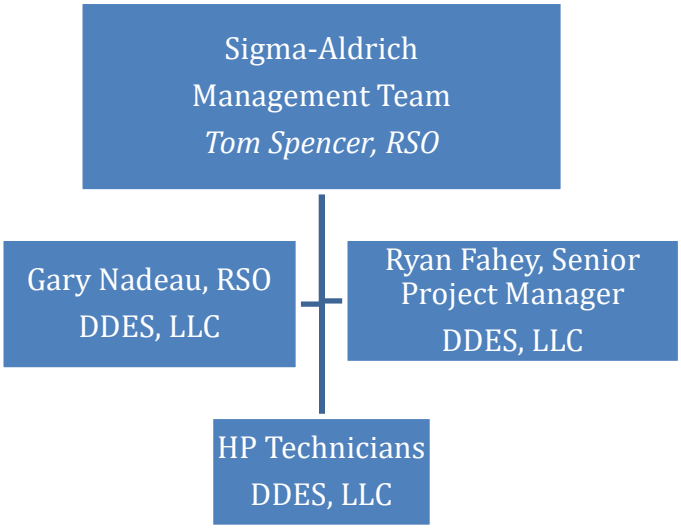
Based on interviews with Sigma-Aldrich management and personnel, it is anticipated that minor remediation activities will need to be performed in several fume hoods and associated ventilation. As an additional ALARA measure, other locations with residual detectable contamination that is below the release criteria will be at least hand-wiped to attempt to further remove contamination.

9.0 Planned Decommissioning Activities

If required, remediation methods that will be used include simple decontamination (i.e. wet wiping with a mild detergent) and removal of contaminated material by dismantling systems and structures and/or cutting contaminated sections from the material. Cutting may consist of the use reciprocating saws, band saws, high leverage shears, electric snips, tin snips and/or ratcheting cable cutters. High Efficiency Particulate Air (HEPA) filtered vacuums may be used to remove loose dry material from surfaces during remediation activities. All remediation activities will be conducted to control the spread of contamination and to maintain personnel exposures ALARA.

10.0 Project Management and Organization

Due to the limited scope of remedial actions required and the relative simplicity of the final status survey design, a complex management organization is not required. Decommissioning tasks will be performed according to written plans and procedures approved by Sigma-Aldrich management.



11.0 Radiation Safety and Health Program

Radiological work will be performed according to DDES' Radiation Safety Program under the management and supervision of the Project Radiation Safety Officer.

12.0 Radioactive Waste Management

It is anticipated that there will be a small amount of waste generated in the form of dry active waste (DAW) resulting from the removal of fume hoods and the associated ventilation system. It is estimated that one 40 foot seavan container of material will be shipped of site as DAW during the course of this project.

13.0 Quality Assurance Program

DDES LLC will develop a Quality Assurance Project Plan (QAPP) utilizing the guidelines of MARSSIM Section 9 for the Final Status Survey Report. The QAPP will incorporate at a minimum, the following:

- Description of the Quality Assurance and Quality Control goals, Data Quality Objectives (DQO), procedures, and plans to be implemented for all D&D activities.
- Description of the methodology to ensure that all radiological survey data meet the 95% confidence level.
- The QAPP will be developed and organized with emphasis given to maximizing worker safety, minimizing/eliminating off-site releases and minimizing overall project costs. The quality control program will control all quality documents during the performance of D&D operations. Quality documents include, but are not limited to:
- Training Records
- Survey Records
- Instrument Records
- Shipping Records
- Work Procedures and Plans

14.0 Survey Instrumentation

14.1 Instrument Calibration

Laboratory and portable field instruments will be calibrated at least annually with National Institute of Standards and Technology (NIST) traceable sources, where feasible, and to radiation emission types and energies that will provide detection capabilities similar to the nuclides of concern.

14.2 Functional Checks

Functional checks will be performed at least daily when in use. The background, source

check, and field measurement count times for radiation detection instrumentation will be specified by procedure to ensure measurements are statistically valid. Background readings will be taken as part of the daily instrument check and compared with the acceptance range for instrument and site conditions. If an instrument fails a functional check, all data obtained with the instrument since the last satisfactory check will be invalidated.

14.3 Determination of Counting Times and Minimum Detectable Concentrations

Minimum counting times for background determinations and counting times for measurement of total and removable contamination will be chosen to provide a minimum detectable concentration (MDC) that meets the criteria specified in this Plan. MARSSIM equations relative to building surfaces have been modified to convert to units of dpm/100cm^2. Count times and scanning rates are determined using the following equations:

14.3.1 Static Counting

Static counting Minimum Detectable Concentration at a 95% confidence level is calculated using the following equation, which is an expansion of NUREG 1507, "Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions", Table 3.1 (Strom & Stansbury, 1992):

$$MDC_{Static} = \frac{3 + 3.29\sqrt{B_r \cdot t_s \cdot \left(1 + \frac{t_s}{t_b}\right)}}{E_{tot} \cdot \frac{A}{100\,cm^2}}$$

Where:

MDC_{Static}	=	Minimum detectable concentration level in dpm/100 cm^2
Br	=	background count rate in counts per minute
t_b	=	Background count time in minutes
t_s	=	Sample count time in minutes
E_{tot}	=	Total detector efficiency for radionuclide emission of interest (includes combination of instrument survey 2π efficiency and 0.25 surface efficiency)
A	=	Detector probe area in cm^2

14.3.2 Ratemeter Scanning

Scanning Minimum Detectable Concentration at a 95% confidence level is calculated using the following equation that is a combination of MARSSIM equations 6-8, 6-9, and 6-10:

$$MDC_{scan} = \frac{d'\sqrt{b_i}\left(\frac{60}{i}\right)}{\sqrt{p}\cdot E_{tot}\cdot\frac{A}{100cm^2}}$$

Where:

MDC_{scan}	=	minimum detectable concentration level in dpm/100 cm^2
d'	=	desired performance variable (1.38)
bi	=	background counts during the residence interval
i	=	residence interval
p	=	surveyor efficiency (0.5)
E_{tot}	=	total detector efficiency for radionuclide emission of interest (includes combination of instrument efficiency and 0.25 surface efficiency)
A	=	detector probe area in cm^2

14.3.3 Smear Counting

Smear counting Minimum Detectable Concentration at a 95% confidence level is calculated using the following equation, which is NUREG 1507, "Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions", Table 3.1 (Strom & Stansbury, 1992):

$$MDC_{smear} = \frac{3 + 3.29\sqrt{B_r\cdot t_s\cdot(1+\frac{t_s}{t_b})}}{t_s\cdot E}$$

Where:

MDC_{smear} = minimum detectable concentration level in dpm/smear

Br = background count rate in counts per minute

tb = background count time in minutes

ts = sample count time in minutes

14.4 Instrumentation Specifications

The instrumentation, or equivalent, used for facility decommissioning surveys is summarized in the following tables. Table 14.1 lists the standard features of each instrument such as probe size and efficiency. Table 14.2 lists the typical operational parameters such as scan rate, count time, and the associated Minimum Detectable Concentrations (MDC). Alternate or additional instrumentation with similar detection capabilities may be utilized as needed for survey requirements with DDES LLC Project RSO approval.

Table 14.1 Instrumentation Specifications

Detector Model	Detector Type	Detector Area	Meter Model	Window Thickness	Typical Total Efficiency
Ludlum 43-68	Beta Scintillation	100 cm^2	Ludlum 2224	0.8 mg/cm^2	12 % (C-14)
Ludlum 43-37 Floor Monitor	Gas Flow Proportional	582 cm^2	Ludlum 2221	0.4 mg/cm^2	13 % (C-14)
Perkin Elmer	LSC	N/A	Tri-Carb	N/A	92% (C-14) 55% (H-3)
Ludlum 43-93	Alpha Beta Scintillation	100 cm^2	Ludlum 2224	0.8 mg/cm^2	10% - ^{14}C
Ludlum 19	Gamma Scintillation	1" x 1"	Ludlum	N/A	N/A

Table 14.2 Typical Instrument Operating Parameters and Sensitivities

Measurement Type	Detector Model	Meter Model	Scan Rate	Count Time	Background (cpm)	MDC ($dpm/100cm^2$)
Surface Scans	Ludlum 43-68B	Ludlum 2221	2 in./sec.	N/A	285	1,284 (^{14}C)
Surface Scans	Ludlum 43-37B Floor Monitor	Ludlum 2221	4 in./sec.	N/A	740	441 (^{14}C)
Surface Scans	Ludlum 43-93	Ludlum 2224	2 in./sec.	N/A	235	2,317 (^{14}C)
Total Surface Activity	Ludlum 43-68B	Ludlum 2221	N/A	1 Min	285	582 (^{14}C)
Total Surface Activity	Ludlum 43-93	Ludlum 2224	N/A	1 Min	235	558(^{14}C)
Removable Activity	Perkin Elmer Tri-Carb	N/A	N/A	60 sec.	10 (^{3}H) 15 (^{14}C)	22 (^{3}H) 17 (^{14}C)

15.0 Characterization Surveys

Scanning will be performed in each survey unit to verify that the presence of the other

authorized licensed materials are not present.

Typically, the survey protocol for building surfaces will consist of performing the scanning portion of the final status survey protocol, with judgmental smears and static measurements on the highest probability areas for residual radioactivity. Judgmental static measurements and smears shall also be taken on vertical surfaces as part of the modified Class 2 and Class 3 final status survey protocols.

The purpose of scanning is to identify locations of elevated activity. Where elevated activity is identified, a static measurement and smear will be taken at the location of highest activity identified during the scan. Where elevated activity is identified, the boundary of the elevated area will be marked to aid in locating the area for remedial actions.

If the initial characterization survey results indicate that contamination is not present in excess of the release criteria, then data from the survey may be used as part of the final status survey. For areas that are partially contaminated, the characterization survey data may be used as part of the final status survey measurements provided that 1) the data used is only from areas with contamination levels below the release criteria, and 2) decontamination work is controlled such that the survey location could not have become cross-contaminated.

Each survey unit will have an independent survey package that has specific survey instructions. The survey package will contain, at a minimum:

- Survey Unit number (e.g., Building and Room Number, System Number, etc.)
- Percentage of surface requiring scan surveys
- Number of removable contamination measurements
- Instrumentation to be used with static count times and scan rates
- Any additional specific survey instruction
- Maps of the survey unit surfaces

16.0 Remedial Action Surveys

If necessary, remediation will be conducted to control the spread of contamination and keep personnel exposures ALARA. Remedial action surveys are conducted in support of remediation activities to help determine when the area is ready for a final status survey and to provide updated estimates for final status survey planning. Remedial action surveys serve to monitor the effectiveness of decontamination efforts and ensure that surrounding areas are not cross-contaminated from remediation actions.

Remedial action surveys will consist of scan surveys, direct measurements and removable contamination measurements. These will be conducted following remediation activities to establish the success or failure of the efforts to decontaminate the applicable survey

area. Results of the survey will be the decision basis for continued remediation or conduct of final status surveys.

Remedial action surveys will be designed to meet the objectives of the final status surveys. To the extent allowed by MARSSIM, the results of the remedial action surveys will be used to supplement the final status survey.

17.0 Design and Performance of Final Status Surveys

Final status surveys are performed to demonstrate that residual radioactivity in each survey unit satisfies the predetermined criteria for release for unrestricted use. The final status survey will be conducted using the Data Quality Objective (DQO) process. Characterization and remedial action survey data will be used as final status survey data to the maximum extent possible in order to minimize overall project costs.

Final status surveys will be conducted by performing required scan surveys, total direct surveys, removable contamination measurements and solid sampling as discussed further in this section. All survey data shall be documented on survey maps and associated data information sheets.

17.1 Background Determination

The use of reference background areas or paired background comparisons is not necessary for the purposes of this plan. Material and ambient background values are not expected to be present at a significant level in comparison to the DCGLs. Surface background will be determined for each survey to calculate the actual survey MDCs and associated count errors.

17.2 Area Classifications

Based on the results of the historical site assessment and previous survey results, facility areas have been classified as impacted areas or non-impacted areas.

17.2.1 Non-Impacted Area

Non-impacted areas are areas without residual radioactivity from licensed activities and are not surveyed during final status surveys. The following areas are classified as non-impacted:

- Surfaces above a two-meter height.

17.2.2 Impacted Areas

Impacted areas are those areas that have potential residual radioactivity from licensed activities. Impacted areas are subdivided into Class 1, Class 2 or Class 3 areas. Class 1 areas

have the greatest potential for contamination and therefore receive the highest degree of survey effort for the final status survey using a graded approach, followed by Class 2, and then by Class 3. Impacted sub-classifications are defined, for the purposes of this plan are as follows:

17.2.3 Class 1 Area

Areas with the highest potential for contamination, and meet the following criteria: (1) impacted; (2) potential for delivering a dose above the release criterion; (3) potential for small areas of elevated activity; and (4) insufficient evidence to support classification as Class 2 or Class 3.

17.2.4 Class 2 Area

Areas that meet the following criteria: (1) impacted; (2) low potential for delivering a dose above the release criterion; and (3) little or no potential for small areas of elevated activity.

17.2. Class 3 Area

Areas that meet the following criteria: (1) impacted; (2) little or no potential for delivering a dose above the release criterion; and (3) little or no potential for small areas of elevated activity.

17.3 Survey Units

A survey unit is a geographical area of specified size and shape for which a separate decision will be made whether or not that area meets the release criteria. A survey unit is normally a portion of a building or site that is surveyed, evaluated, and released as a single unit. For the purposes of this plan, areas of similar construction and composition will be grouped together as survey units and tested individually against the DCGLs and the null hypothesis to show compliance with the release criteria. Survey units will be homogeneous in construction, contamination potential, and contamination distribution.

The number of discrete sampling locations needed to determine if a uniform level of residual radioactivity exists within a survey unit does not depend on the survey unit size. However, the sampling density should reflect the potential for small-elevated areas of residual radioactivity. Survey units will be sized according to the potential for small-elevated areas of residual radioactivity.

Survey units will be established to meet MARSSIM recommendations.

Table 17.1 MARSSIM Recommended Maximum Survey Unit Sizes

Type of Survey Unit	Class 1	Class 2	Class 3
Structures*	Up to 100 m^2	100 m^2 to 1,000 m^2	No limit

Table 17.2 below summarized the initial classifications of each survey unit at Sigma-Aldrich based upon the site meeting and historical use.

Table 17.2 Initial Area Classifications

Building	Laboratory	Isotope(s)	Class
3300 S Second St	N1111	H-3, C-14, I-125, P-32, S-35	1
3300 S Second St	N1143	H-3, C-14, I-125, P-32, S-35	1
3300 S Second St	N340	H-3, C-14, I-125, P-32, S-35	1
3300 S Second St	Hallways & Connecting Offices	H-3, C-14, I-125, P-32, S-35	3
2909 Laclede Ave	G109	32P	1
2909 Laclede Ave	Hallways & Connecting Offices	32P	3

*A minimum number fourteen (14) survey locations will be met for each survey unit. The survey points only account for horizontal surfaces only. Survey points for each survey unit will increase when vertical surface area (up to 2.0 meters in height) are added to obtain the total area for each survey unit. The amount of survey points are based on a 1.0 meter grid for each survey unit and are subject to change.

17.4 Surface Scans

Due to the low energies of ^{3}H, scanning is not required for this isotope; however, scanning for ^{14}C, ^{125}I, ^{32}P, and ^{35}S will be performed to verify that the presence these nuclides, and of the other authorized license materials, does not exist.

Typically, scanning is used to identify locations within the survey unit that exceed the investigation level. These locations are marked and receive additional investigations to determine the concentration, area, and extent of the contamination. Scanning surveys are designed to detect small areas of elevated activity that are not detected by the

measurements using the systematic pattern. Table 17.3 summarizes the percentage of accessible building structural surfaces to be scanned based on classification.

Table 17.3 Scan Survey Coverage by Classification

Classification	Percentage of Surface Area Requiring Scan Coverage (MARSSIM)	Sigma-Aldrich Surface Area Scan Coverage
1	100%	100%
2	10 – 100% (Judgmental)	50%
3	Judgmental	20%

The percentage of survey area scan surveyed may be increased based on suspected elevated activity. For Class 2 and Class 3 areas, the surfaces to be scan surveyed will be those with the highest potential to contain residual contamination.

Floor areas near entrances and exits will receive a 100% scan survey regardless of the area classification. These surveys will provide indications of potential migration of residual contamination to outside areas.

If elevated activity is detected during the scan surveys, then the location shall be marked and total and removable surface activity measurements will be taken to quantify the activity. However, total surface activity measurements are in addition to the static measurements required for the statistical test.

17.5 Total Surface Activity Measurements

Direct surveys (static measurements) will be performed if during the scan survey if elevated activity is detected. If elevated measurements are detected, static measurements will be taken on surfaces to the extent practical in impacted areas utilizing instrumentation of the best geometry based on the surface at the survey location. Additionally, locations of elevated activity identified and marked during the scan survey will require direct survey measurements.

17.5.1 Determining the Number of Samples

A minimum number of samples are needed to obtain sufficient statistical confidence that the conclusions drawn from the samples are correct. The number of samples will depend on the Relative Shift (the ratio of the concentration to be measured relative to the statistical variability of the contaminant concentration).

The minimum number of samples is obtained from MARSSIM tables or calculated using equations in Section 5 of MARSSIM.

17.5.2 Determination of the Relative Shift

The number of required samples will depend on the ratio involving the activity level to be measured relative to the variability in the concentration. The ratio to be used is called the Relative Shift and is defined in MARSSIM as:

σ_s= An estimate of the standard deviation of the residual radioactivity in the survey unit.

$$\Delta / \sigma_S = \frac{DCGL - LBGR}{\sigma_S}$$

Where:

DCGL = Derived concentration guideline level

LBGR = Concentration at the lower bound of the gray region. The LBGR is the average concentration to which the survey unit should be cleaned in order to have an acceptable probability of passing the test.

17.5.3 Determination of Acceptable Decision Errors

A decision error is the probability of making an error in the decision on a survey unit by failing a unit that should pass (ß decision error) or passing a unit that should fail (α decision error). MARSSIM uses the terminology α and ß decision errors; this is the same as the more common terminology of Type I and Type II errors, respectively. The decision errors are 0.05 for Type I errors and 0.05 for Type II errors.

17.5.4 Determination of Number of Data Points (Sign Test)

The number of direct measurements for a particular survey unit, employing the Sign Test, is determined from MARSSIM Table 5.5, which is based on the following equation (MARSSIM equation 5-2):

$$N = \frac{\left(Z_{1-\alpha} + Z_{1-\beta}\right)^2}{4\left(Sign\ p - 0.5\right)^2}$$

Where:

N = number of samples needed in the survey unit

Z1-□□= percentile represented by the decision error □□

Z1-□□= percentile represented by the decision error □□

SignP = estimated probability that a random measurement will be less than the DCGL when the survey unit median is actually at the LBGR

Note: SignP is determined from MARSSIM Table 5.4

MARSSIM recommends increasing the calculated number of measurements by 20% to ensure sufficient power of the statistical tests and to allow for possible data losses. MARSSIM Table 5.5 values include an increase of 20% of the calculated value.

17.5.5 Determination of Sample Locations

Determination of Class 1 survey unit sample locations is accomplished by first determining sample spacing and then systematically plotting the sample locations from a randomly generated start location. The random starting point of the grid provides an unbiased method for obtaining measurement locations to be used in the statistical tests. Class 1 survey units have the highest potential for small areas of elevated activity, so the areas between measurement locations may be adjusted to ensure that these areas can be detected by scanning techniques.

Similar systematic spacing methods are used for Class 2 survey units because there is an increased probability of small areas of elevated activity. The use of a systematic grid allows the decision-maker to draw conclusions about the size of the potential areas of elevated activity based on the area between measurement locations.

Class 3 survey locations are determined from computer selected randomly generated x and y coordinates. Survey protocols for all areas are summarized in Table 17.4

Table 17.4 Survey Sample Placement Overview

Survey Unit Classification		**$DCGL_w$ Comparison**	**Elevated Measurement Comparison**	**Measurement Locations**
Impacted	Class 1	Yes	N/A	Systematic random
	Class 2	Yes	N/A	Systematic random
	Class 3	Yes	N/A	Random
Non-Impacted		None	None	None

Permanent counter tops and other horizontal surfaces, which block floor surfaces, will be included as a replacement to the blocked floor surface. Likewise, fixed cabinetry faces and other permanent equipment will replace blocked wall surfaces. Permanent equipment, which does not actually block floor or wall surfaces, will be folded out 2-dimensionally

and attached to the room overview so as to be included in the grid plot.

Internal surfaces of permanent furnishings (i.e., drawer or cabinetry interior surfaces) are not included in the systematic measurement location placement. However, these surfaces will be included in the scan surveys and judgmental measurements may be taken.

Additional total surface activity measurements will be collected at each area of elevated activity identified during the scan surveys.

17.5.5.1 Determining Class 1 Sample Locations

For this survey, all impacted areas (below 2 meter elevation) will be considered Class 1. In Class 1 survey units, the sampling locations are established in a unique pattern beginning with the random start location and the determined sample spacing. After determining the number of samples needed in the survey unit, sample spacing is determined from MARSSIM equation 5-8:

$$L = \sqrt{\frac{A}{N}} \quad \text{for a square grid}$$

Where:

N = number of samples needed in the survey unit
L = sample spacing interval
A = the survey unit area

Maps will be generated of the survey unit's permanent surfaces included in the statistical tests (floors, walls, ceilings, fixed cabinetry, etc.) and folded out in a 2-dimensional view. A random starting point is determined using computer-generated random numbers coinciding with the x and y coordinates of the total survey unit. A grid is plotted across the survey unit surfaces based on the random start point and the determined sample spacing. A measurement location is plotted at each intersection of the grid plot.

17.5.5.2 Determining Class 2 Sample Locations

In Class 2 survey units, the sampling locations are established in a unique pattern beginning with the random start location and the determined sample spacing. After determining the number of samples needed in the survey unit, sample spacing is determined from MARSSIM equation 5-8:

$$L = \sqrt{\frac{A}{N}} \quad \text{for a square grid}$$

Where:

L = sample spacing interval

A = the survey unit floor area

N = number of samples needed in the survey unit

Maps will be generated of the survey unit's permanent surfaces included in the statistical tests. A random starting point is determined using computer-generated random numbers coinciding with the x and y coordinates of the total survey unit. A grid is plotted across the survey unit surfaces based on the random start point and the determined sample spacing. A measurement location is plotted at each intersection of the grid plot.

17.5.5.2 Determining Class 3 Sample Locations

For Class 3 areas, maps will be generated of the survey unit floor surfaces and applicable permanent equipment and/or furnishings. Sample locations will be chosen on floor, lower wall (<2m) and permanent equipment surfaces at the discretion of the survey technician. Measurement locations will be biased towards areas with the highest potential of residual contamination. Each chosen location will be plotted on the applicable survey map.

17.6 Removable Contamination Measurements

Removable contamination measurements (smears) will be collected on surfaces at each sample location. Additionally, removable contamination measurements will be collected for building system internals. An area of approximately 100 cm^2 shall be wiped if possible. If an area of less than 100 cm^2 is wiped, a comment shall be added to the survey data sheet estimating the surface area wiped to allow for area correction of the results. Swabs may be used when system or component access points are not large enough to allow for a wipe of a 100 cm^2 surface area.

17.7 Survey Documentation

A survey package will be developed for each survey unit containing the following:

- Survey Instruction Sheets
- General survey requirements
- Instrument requirements with associated MDCs, count times and scan rates
- Survey Maps
- Overview maps detailing survey locations and placement methodology
- Survey sub-unit maps with additional sample location information, as needed
- Survey Data Sheets

- Signature of Data Collector and Reviewer

17.8 Data Validation

Field data will be reviewed and validated to ensure:

- Completeness of forms and that the type of survey has correctly been assigned to the survey unit.
- The MDCs for measurements meet the established data quality objectives; independent calculations will be performed for a representative sample of data sheets and survey areas.
- Instrument calibrations and daily functional checks have been performed accurately and at the required frequency.

18.0 Data Quality Assessment (DQA) and Interpretation of Survey Results

The statistical guidance contained in Section 8 of MARSSIM will be used to determine if areas are acceptable for unrestricted release, and whether additional surveys or sample measurements are needed.

18.1 Preliminary Data Review

A preliminary data review will be performed for each survey unit to identify any patterns, relationships or potential anomalies. Additionally, measurement data is reviewed and compared with the DCGLs and investigation levels to identify areas of elevated activity and confirm the correct classification of survey units. If an area is misclassified with a less restrictive classification, the area will be upgraded and surveyed accordingly.

The following preliminary data reviews will be performed for each survey unit:

- Calculations of the survey unit mean, median, maximum, minimum, and standard deviation for each type of reading.
- Comparison of the actual standard deviation to the assumed standard deviation used for calculating the number of measurements. If the actual standard deviation is greater than estimated, the minimum number of samples shall be calculated using the actual standard deviation to ensure a sufficient number of samples have been obtained.
- Comparison of survey data with applicable investigation levels.

18.2 Determining Compliance

For Class 1 areas, if it is determined that all total activity results are less than the applicable DCGL, then no further statistical tests are required. If any of the total activity

measurements are greater than the DCGLW, then the survey unit fails and the null hypothesis is not rejected. The survey unit is determined to meet the release criterion provided that the application of any unity rules result in values less than 1.

The Sign test is used to determine the minimum number of sample locations. However, the Sign test is not performed in this survey design because the total activity DCGL is used as a maximum. If all measurements are less than the DCGL, performance of the Sign test is not necessary because the survey unit will pass the Sign test by definition.

Removable contamination measurements will be compared directly to the applicable DCGL. No contingency is established for elevated removable contamination. Therefore, if any removable contamination is detected which exceeds the removable contamination DCGL, the survey unit is determined not to meet the release criterion. However, if all removable contamination measurements are less than the removable contamination DCGL, then compliance shall be determined based on total activity measurements.

Compliance will be determined for each applicable type of total activity measurement performed in each survey unit (i.e., gross beta total activity measurements and gross gamma total activity measurements). Locations with multiple isotopes present will be evaluated by the unity rule.

A Final Report summarizing D&D activities performed at Sigma-Aldrich in St. Louis, MO shall be prepared and submitted to Sigma-Aldrich for final submission to the NRC. The guidance provided in NUREG 1727 will be used to prepare the final report.

19.0 References

- NUREG-1575, “Multi-Agency Radiation Survey and Site Investigation Manual” (MARSSIM)
- NUREG-1505, “A Nonparametric Statistical Methodology for the Design and Analysis of Final Decommissioning Surveys"
- NUREG 1507, “Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions”
- NUREG 1727, “NMSS Decommissioning Standard Review Plan,” September 2000.
- NUREG 1757, Volume 1 “Consolidated NMSS Decommissioning Guidance,” September, 2002
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