Final Status Survey Plan
DNSC, Somerville Depot, Hillsborough, NJ

February 2006

Glossary of Terms, Acronyms and Abbreviations

αdm	alpha decays per minute
CEDE	Committed Effective Dose Equivalent
CHPPM	US Army Center for Health Promotion and Preventive Medicine
cm^2	square centimeter
cpm	counts per minute
DandD	NRC Dose Modeling Code, Version 2.1.
DCGL	Derived Concentration Guideline Level
DLA	Defense Logistic Agency
DNSC	Defense National Stockpile Center
DoD	Department of Defense
dpm	disintegrations per minute
DQO	data quality objective
EPA	Environmental Protection Agency
FSS	final status survey
ft^2	square feet
GSA	General Services Administration
HSA	historical site assessment
in^2	square inches
LBGR	lower bound of the gray region
m^2	square meter
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDA	minimum detectable activity
MDC	minimum detectable count
MDCR	minimum detectable count rate
mrem/yr	millirem per year
NRC	Nuclear Regulatory Commission
NUREG	NRC nuclear regulation document
ORPP	Occupational Radiation Protection Program
SU	survey unit
Th	thorium
U	uranium
WRS	Wilcoxon Rank Sum
ZnS(Ag)	Zinc Sulfide with silver doping, a scintillator

Executive Summary

Chesapeake Nuclear Services, Inc. (ChesNuc) has developed this Final Status Survey Plan (FSSP) for the DNSC, 8725 John J. Kingman Rd, Fort Belvoir, VA 22060-6223. Work will be performed at the DNSC Somerville Depot, 152 US Highway 206 South, Hillsborough, NJ 08844-4135. This FSSP addresses each of the following subtasks and defines the proposed approach:

- Develop a Final Status Survey Plan (FSSP) consistent with the guidance contained in MARSSIM and conduct discussions with the NRC as necessary;
- Select survey techniques appropriate to develop adequate data and survey instrumentation based on their detection sensitivity to the radiations of concern;
- Develop data quality objectives, a Radiological Survey and Sampling Plan, and Derived Concentration Guideline Levels;
- Perform the Final Status Survey; and
- Submit a Final Status Survey Report (FSSR) and recommendation to the NRC and DNSC Occupational Radiation Protection Program Manager regarding unrestricted release.

An Historical Site Assessment (HSA) was conducted by ChesNuc during November 2005. Warehouses impacted from storage or sampling of radioactive materials at the depot are Warehouses 1, 3, and 4. The Decontamination Trailer is also considered impacted as it was potentially used for showering following operations with radioactive materials. These areas are listed in the following table.

Warehouse	Section	Bays	Purpose
1	C	9,10,17,18	Sampling
1	D	12,15,21	Storage
3	A	1,2,3, 4,5,6,7,11, 12,13,14,15,19	Storage
3	E-1	All	Storage
3	E-4	All	Sampling
4	A	20	Storage
4	C	31, 32	Storage
Decon Trailer			Sampling

A small part of Warehouse 3, Section A, Bay 5 is considered a MARSSIM Class 1 survey area. In keeping with MARSSIM criteria, a larger Class 2 area surrounds it. All other areas in the table above are considered Class 3.

Sampling and repackaging appear to be the only operations which would provide any opportunity for building surface contamination. Since this process was performed under well-documented, controlled conditions, the likelihood of residual contamination, if any, is minimal.

ChesNuc has designed this Work Plan with several innovative ideas which are necessary as the release criteria for naturally occurring radioactive material (NORM) that emit alpha particles is predictably low and difficult to measure. The application of these concepts will provide the best use of survey resources while increasing the probability of meeting the statistical requirements.

- The US Nuclear Regulatory Commission (NRC) has generally agreed that through the license amendment process higher release criteria could be made based upon metabolic data recently published as FGR-13. Application for a license amendment has been made to use this scientific development. Taking advantage of multiple alpha emissions for both thorium and uranium decay with application of FGR-13, the expected DCGLs of 6 and 12 dpm/100 cm^2 may be increased to about 224 and 448 dpm/100 cm^2 as alpha emissions, respectively. These relationships are presented in the following table.

Reference	DCGL (dpm/100cm^2)	
	Th-nat	U-Nat*
DandD*	5.9	11.6
Alpha Based w DandD	36	97
FGR-13*	37	54
Alpha Based w FGR-13	224	448

*DandD and FGR-13 line values are for U-238; lines for Alpha Based include U-235+C.

- The licensed commodities contained varying concentrations of thorium and uranium. With application of the NRC's fractional rule, a commodity may have an even higher DCGL. For example Tungsten metal scrap may have a DCGL$_{alpha}$ of 224 dpm/100 cm^2 while Tantalum concentrates may be as high as 1524 dpm/100 cm^2. Both are more appealing as release criteria than NRC's screening values; these add to the concept that any residual contamination is a small fraction of the DCGL.

- Lower walls (2 m high) within 25 feet of a storage bay or area will be Class 3 survey units. The survey unit length will be extended by 10 feet on both sides of the impacted floor bays. Upper walls and ceiling structures will receive bias sampling only and not be considered as an independent survey unit.

- Although thorium and uranium and their progeny emit alpha, beta and gamma radiation, radiation measurements for alpha radiation only will be performed. The type of instrumentation to be used will be of sufficient sensitivity to meet the DCGL$_{alpha}$ for the site and provide enough proof that the survey units are releasable. Therefore, there is no need to duplicate the alpha survey effort with beta surveys. No gamma scans will be performed as the DCGLs and levels of anticipated radioactivity are well below the minimum detectable concentrations even with a shielded NaI probe.

- In keeping with MARSSIM, areas which are identified as never having had radioactive material present need not be surveyed; this approach will be taken down to the bay size area. Records of storage throughout the years were defined by lots in specific Warehouses and Bays.

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1.0   BACKGROUND INFORMATION

As a result of the recent removal of all Nuclear Regulatory Commission (NRC) licensed radioactive material, the Defense National Stockpile Center (DNSC) has directed that an investigation be performed at the Somerville Depot to ensure that former storage locations are suitable for unrestricted release as specified by the NRC.

Chesapeake Nuclear Services, Inc. (ChesNuc) has developed this Final Status Survey Plan (FSSP) for the DNSC, 8725 John J. Kingman Rd, Fort Belvoir, VA 22060-6223. Work will be performed at the DNSC Somerville Depot, Hoyt Avenue, Hillsborough, NJ 08844-4135. This FSSP addresses each of the following subtasks and defines the proposed approach:

- Develop a Final Status Survey Plan (FSSP) consistent with the guidance contained in MARSSIM and conduct discussions with the NRC as necessary;
- Select survey techniques appropriate to develop adequate data and survey instrumentation based on their detection sensitivity to the radiations of concern;
- Develop data quality objectives, a Radiological Survey and Sampling Plan, and Derived Concentration Guideline Levels;
- Perform the Final Status Survey; and
- Submit a Final Status Survey Report (FSSR) and recommendation to the NRC and DNSC Occupational Radiation Protection Program Manager regarding unrestricted release.

1.1   General

Currently, the Somerville Depot consists of approximately 77 acres of land. The entrance to the Depot is through Veterans Administration property on the western side of Route 206, approximately two and one half miles (4.0 km) south of Somerville, New Jersey. The Depot can be reached by following Interstate 287 to the Route 206 exit, and by following Route 206 South to the main Depot entrance west of the highway. Entrance is through the main gate through the portion of the former Depot which is owned by the Veterans Administration (VA). The current Depot is located approximately 0.75 miles west of the main gate.

The Somerville Depot is currently owned by the Federal Government (GSA) and operated by the Department of Defense (DoD), Defense Logistics Agency (DLA). The Somerville Depot stored columbium/tantalum and tungsten in various forms (ores and concentrates, metal scrap, natural minerals) which contain naturally occurring radioactive materials in the form of uranium and thorium. Some of these commodities contained sufficient quantities of these two naturally occurring radionuclides as to require licensing by the NRC. Radiological operations at the Somerville Depot are authorized under NRC license STC-133 issued to the DNSC which expires on February 28, 2010. The license authorizes the storage, sampling, repackaging, and transfer of natural uranium and thorium ores, concentrates and solids. The total authorized quantity is 2,000,000 kilograms (~4,410,000 pounds).

1.2   Historical Site Assessment (HSA)

An HSA was conducted by ChesNuc during November 2005 and the results are identified in Reference 7-1. The HSA report was completed in December 2005, which provides the basis for area classifications in this FSSP.

Impacted warehouses from storage of radioactive materials at the depot consisted of Warehouses 1, 3, and 4. The Decon Trailer is also considered impacted as it was potentially used for showering following operations with radioactive materials.   These areas are listed in the following table.

Table 1-1 Somerville Impacted Areas

Warehouse	Section	Bays	Purpose
1	C	9,10,17,18	Sampling
1	D	12,15,21	Storage
3	A	1,2,3, 4,5,6,7,11, 12,13,14,15,19	Storage
3	E-1	All	Storage
3	E-4	All	Sampling
4	A	20	Storage
4	C	31, 32	Storage
Decon Trailer			Sampling

Sampling and repackaging appear to be the only operations which would provide any opportunity for building surface contamination. Since this process was performed under well-documented, controlled conditions, the likelihood of residual contamination, if any, is minimal. Records of storage throughout the years were defined by lots in specific Warehouses and Bays.

2.0   SITE INFORMATION

2.1   Site Description

Warehouse storage at the Depot consists of four ground-level concrete-block buildings as shown in Figure 2. Outdoor open storage areas cover approximately 455,000 square feet. The facility also includes the following support buildings: administration building, maintenance building, decontamination trailer, pump house, scale house, switch gear house, and vault.

2.2   Site Conditions at Time of Final Survey

All bulk NRC-licensed material has been removed from the Somerville Depot. Radiological operations at the Depot are authorized under NRC license STC-133, issued to the DNSC, and which expires on February 28, 2010. The license authorizes the storage, sampling, repackaging, and transfer of natural uranium and thorium ores,

concentrates, and solids. The total authorized quantity is 2,000,000 kilograms (~4,410,000 pounds).

Access to all impacted areas is to be available during the HSA. Access to wall areas extending to 10 feet on both sides of impacted is planned also.

The following figure illustrates the various impacted buildings and floor areas. The highlighted areas represent the impacted floor areas and they are about proportional to the actual floor areas to be surveyed.
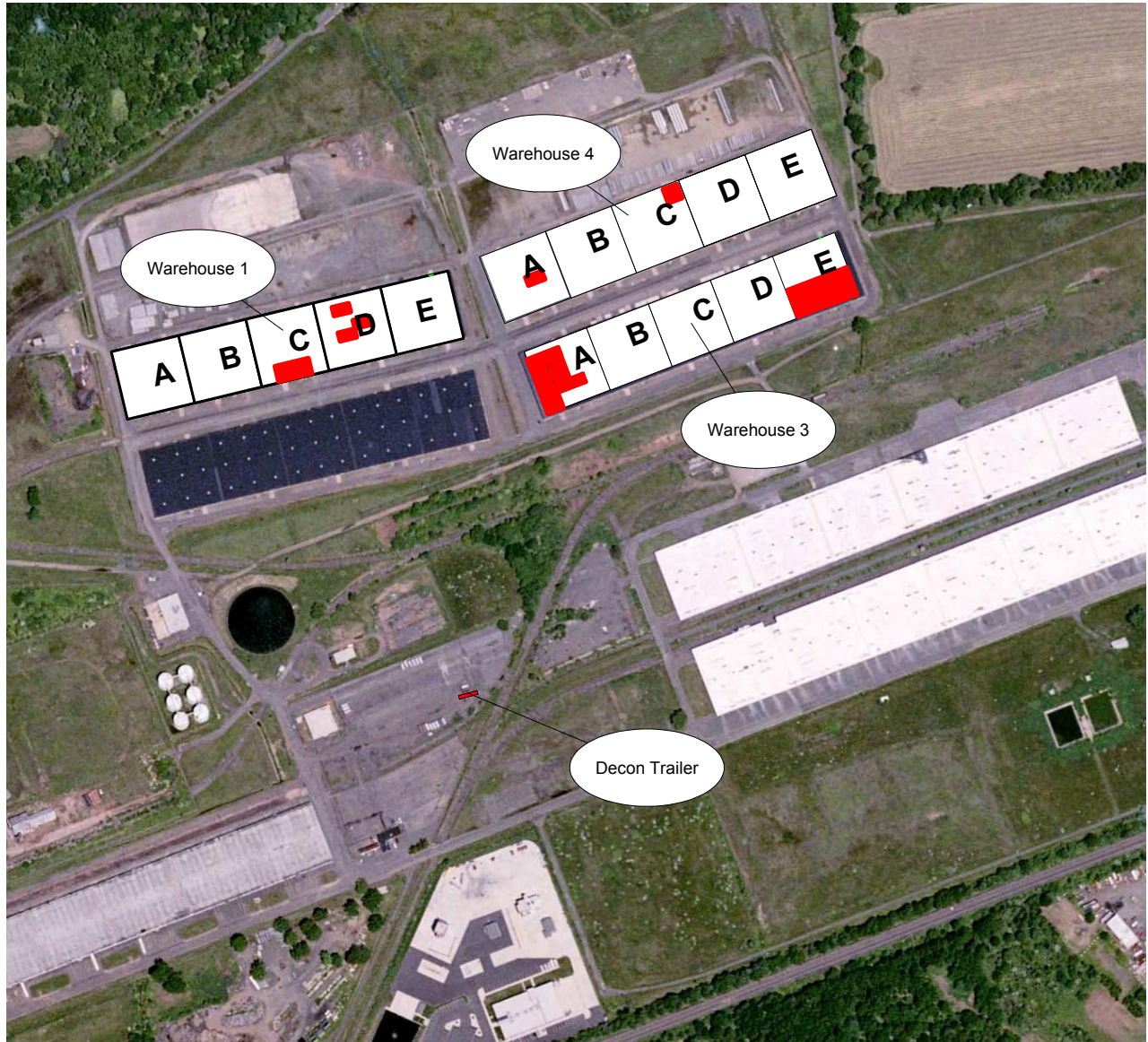

Figure 1. Somerville Depot Layout

3.0   FINAL STATUS SURVEY OVERVIEW

3.1   Survey Objectives

The final status survey is used to demonstrate compliance with regulations. The primary objectives of the final status survey are to:

- select/verify survey unit classification;
- demonstrate that the potential dose or risk from residual contamination is below the release criterion for each survey unit ; and
- demonstrate that the potential dose or risk from small areas of elevated activity is below the release criterion for each survey unit.

The final status survey provides data to demonstrate that all radiological parameters satisfy the established guideline values and conditions.

Professional judgment and biased sampling are important for locating contamination and characterizing the extent of contamination at a site. However, the MARSSIM focus is on planning the final status survey, which utilizes a more systematic approach to sampling. Systematic sampling is based on rules that endeavor to achieve the representativeness in sampling consistent with the application of statistical tests.

The Final Status Survey for release of areas will be conducted in accordance with guidance given in NUREG 1575, Multi-Agency Radiation Site Survey and Investigation Manual (MARSSIM). MARSSIM provides guidance on classifying areas and survey requirements based on potential level of residual radioactive material contamination relative to the established release criteria. MARSSIM also provides the following guidance as an aid in conducting surveys, which are incorporated into this proposal.

- Determine background activity for building interior surfaces. Only interior building surfaces are a concern per the HSA; exterior building parts and outdoor areas are not.

- Perform systematic and judgmental alpha surface scan measurements.

- If elevated areas of contamination are identified (>50% of DCGLs), perform selective direct measurements and sampling of areas of elevated activity of residual radioactivity to provide data on upper ranges of residual contamination levels. Note that locations of high scan values should be used.

- Document survey and sampling locations. Establish a reference coordinate system. Prepare scale drawings.

- Maintain chain of custody of samples.

3.2 Identity of Contaminants and DCGLs

3.2.1 Natural Thorium and Uranium

The radionuclides stored at this facility were thorium and uranium contained as a constituent of tungsten or columbium/tantalum. The HSA concluded that the chemical/isotopic analysis and storage time (50 years plus) indicated that any residual quantities of natural uranium and thorium would be in equilibrium with their progeny. The HSA also contains a listing of the various material received and the lot analysis by weight percent for Th and U. Table 3-1 provides a review of the types and kinds. The bulk weight of the material sampled is given as well as the weight percentages of Th and U for average and high values of sample lots.

Table 3-1. Th and U Weight Percentages for Commodities

Material	Lot	Weight (lbs)	Weight % U	Weight % Th
Tungsten Metal Scrap	Code 1	6,784	< MDL*	0.300
	Code 2	21,121	< MDL	2.280
	Code 6	1,015	< MDL	2.750
Tantalum Natural Minerals	A	41,600	0.153	0.026
	B	38,400	0.144	0.035
	C	41,600	0.161	0.026
	D	38,400	0.144	0.026
	E	45,528	0.127	0.024
	F	45,528	0.127	0.027
	G	45,528	0.136	0.035

The Tantalum Natural Minerals were in a granular form; however, the tungsten metal scrap had various physical configurations. Code 1 was a wire material. Code 2 was rods, bits, spring and other various shapes. Code 6 consisted of die cores.

3.2.2 Development of DCGLs

To complete the final status survey, this plan focuses on the evaluation of alpha emissions. The NRC has released DandD version 2.1 for use by licensees which includes the ability to calculate DCGLs for natural thorium and natural uranium. For this evaluation reverse engineering was applied and the number of simulations was 10,000 to assure that the estimated DCGLs would not exceed 25.0 mrem/yr. As DandD provides estimates in terms of dpm, these estimates were converted to αpm for use at this site.

3.2.2.1 DandD Code Evaluations

For natural thorium, the estimated DCGL for the Building Occupancy Scenario was 5.9 dpm/100cm^2. To obtain a DCGL for natural uranium, a mixture of U-238+C and U-235+C was used and 11.6 and 0.556 dpm/100cm^2, respectively, were determined as the

combined activity for the DCGL. The U-235 activity of 0.556 dpm/100cm^2 is the natural abundance at 2.34% of the total activity (Table 3.1.1 of Reference 7.13) for natural uranium.   Results of the DandD computer runs are in Appendix B. These DCGL values are developed into DCGLs based on alpha emissions as follows.

Reference 7.14 was used to establish the number of alpha emissions per parent decay in each chain.

- As Th-232 is in equilibrium with its progeny, there are six alpha emissions for each decay of a Th-232 atom. The alpha emissions are one each from Th-232, Th-228, Ra-224, Rn-220, Po-216 while Bi-212 and Po-212 combined emissions yield one from both.   The alpha based DCGL for 5.9 dpm/100cm^2 is then six times that or ~36 αpm/100cm^2.

- As natural uranium consists of U-238, U-234 and U-235, the number of alphas emitted per decay of a U-238 atom requires consideration of the activity abundance of each found in nature, 48.83%, 48.83%, and 2.34%.

  U-238 and U-234 are considered in the same decay chain with a total of eight alpha emissions for each decay of a U-238 atom. The alpha emissions are counted as one each from U-238, U-234, Th-230, Ra-226, Rn-222, Po-218, Po-214, and Po-210. Credit was not taken for the insignificant alpha emission fractions of At-218, Pb-210, and Bi-210. The contribution to the natural uranium alpha based DCGL from U-238+C at 11.6 dpm/100cm^2 is eight times that or 92.8 αpm/100cm^2.

  For the U-235 series, the alpha emissions total seven for each decay of a U-235 atom with one each from U-235, Pa-231, Th-227, Ra-223, Rn-219, Po-215, and Bi-211. Credit was not taken for the insignificant alpha emission fractions of Ac-227, Fr-223, At-215, and Po-211. The contribution to the natural uranium alpha based DCGL from U-235+C at 0.556 dpm/100cm^2 is seven times that or 3.9 αpm/100cm^2.

  The combined alpha DCGL from U-238+C and U-235+C at 11.6 and 0.556 dpm/100cm^2, respectively, is 96.7 αpm/100cm^2.

3.2.2.2 Dose Multiples of Federal Guidance Report No.13

Multiples of individual radionuclide dose factors of FGR-11 to FGR-13 were then applied to determine the dose that would be calculated if the DandD code used FGR-13 dose factors. This was done for both the ingestion and inhalation pathways holding the external pathway as constant. The dose was reduced by a factor of 6.36 and 4.63 for natural thorium and natural uranium, respectively.

Simple ratios were applied to obtain the increased DCGLS based on the dose reductions.

- For natural thorium, the estimated FGR-13 DCGL for the Building Occupancy Scenario was 37.3 dpm/100cm^2. The alpha based DCGL for 37.3 dpm/100cm^2 is then six times that or about 224 αpm/100cm^2.

- The values calculated for a combined radionuclide FGR-13 DCGL for natural uranium from a mixture of U-238+C and U-235+C were 53.7 and 2.57 dpm/100cm^2, respectively. The U-235 activity of 2.57 dpm/100cm^2 is the natural abundance at 2.34% of the total activity for natural uranium.

  The contribution to the natural uranium alpha based FGR-13 DCGL from U-238+C at 53.7 dpm/100cm^2 is eight times that or about 430 αpm/100cm^2. The contribution to the natural uranium alpha based DCGL from U-235+C at 2.57 dpm/100cm^2 is seven times that or about 18 αpm/100cm^2. The combined alpha FGR-13 DCGL for natural uranium from U-238+C and U-235+C at 53.7 and 2.57 dpm/100cm^2, respectively, is 448 αpm/100cm^2.

The following table summarizes the DCGLs and their reference source developed in this paragraph.

Table 3-2. DCGL Comparisons

Reference	DCGL (dpm/100cm^2)	
	Th-nat	U-Nat*
DandD*	5.9	11.6
Alpha Based w DandD	36	97
FGR-13*	37	54
Alpha Based w FGR-13	224	448

* DandD and FGR-13 line values are for U-238; lines for Alpha Based include U-235+C.

Note that Table 3-2 reflects 6 alpha emissions per dpm for thorium and about 8.3 alpha emissions per dpm of U-238.

3.2.2.3 Commodity Specific DCGLs

From the concentrations listed per lot given in Appendix A, a dpm per gram ratio was established and then alpha emission rates were calculated.
As an example, the weight percentages for the Tantalum Natural Minerals Lot A from Table 3-1 are given as 0.153% and 0.026% for uranium and thorium respectively. The activity/mass relationship is defined by the US Department of Transportation (DOT), 10 CFR Part 49 (Reference 8.15). The alpha rate per gram is then calculated individually for natural uranium and natural thorium; a ratio is then made of alphas from natural uranium to natural thorium. The following equation is used.

$$AlphaRate/gram = WgtFraction * A/Mass * Nuclide_{fraction} * CF * Alphas/Element$$

where:

Wgt Fraction = Respective % converted to fraction from Table 3-1.

A/Mass = Activity to mass relationship established by DOT as 7.

Nuclide$_{fraction}$ = Fraction of activity abundance for the tracking nuclide; 0.4883 for U-238 and 1.0 for natural thorium.

CF = Conversion factor; 2.22E12 dpm/Ci.

    Alphas/Element   = The number of alpha emissions per natural thorium or natural uranium expected for the nuclide fraction; 6 for natural thorium and 8.3 for U-238.

Continuing with the Tantalum Natural Minerals Lot A example, and substituting the values for <u>uranium</u> into the above equation:

    AlphaRate/gram = 0.00153 * 7.1E-7 Ci/g *0.4883* 2.22E12 *8.3
    AlphaRate/gram = 9,773 alphas/gram

Similarly for <u>thorium</u>:

    AlphaRate/gram = 0.00026 * 2.2E-7 Ci/g *1.0* 2.22E12 *6
    AlphaRate/gram = 762 alphas/gram

The ratio of uranium to thorium alphas is the ratio of the above two rates: 9,773/762 or 12.8 alphas from uranium to 1 alpha from thorium.

An alpha emission ratio was established per lot (shown in Table 3-3) and the gross activity DCGL$_{alpha}$ was determined per the following equation.

$$GrossActivityDCGL_{alpha} = \frac{1}{\left(\dfrac{fi}{DCGL_1} + \dfrac{f_2}{DCGL_2}\right)}$$

Where: f_1 is the alpha fraction for natural thorium
                    f_2 is the alpha fraction for natural uranium
                    DCGL$_1$ is the alpha DCGL for natural thorium
                    DCGL$_2$ is the alpha DCGL for natural uranium

As an example, the calculation is shown for the FGR-13 value for the Ferberite Commodity Lot 1 as indicated in Table 3-3. The calculation uses the emissions ratio indicated in Table 3-3 with the DCGLs from Table 3-2. Per Table 3-3, the alphas from thorium represent a fraction of 42.7/43.7 of the total emissions and those from uranium are about 1/43.7 of the total. These values are entered into the above equation.

$$GrossActivityDCGL_{alpha} = \frac{1}{\left(\dfrac{0.9771}{224} + \dfrac{0.0229}{448}\right)} \; \alpha pm/100cm^2$$

$$GrossActivityDCGL_{alpha} = 227 \; \alpha pm/100cm^2$$

A DCGL$_{alpha}$ value for each lot of the Tungsten Metal Scrap and Tantalum Natural Minerals are shown in Table 3-3. For the Tungsten Metal Scrap, all reported weight percentages were reported as less than MDL and the conservative DCGL for 100% thorium is listed for this material. As expected in that Tantalum Natural Minerals contain some quantity amount of thorium, the DCGL$_{alpha}$(s) are somewhat lesser than that for natural uranium.

Table 3-3. Surface Gross Activity DCGLs

Commodity	Lot	Ratio of U/Th Alphas	FGR-13 DCGL (αpm/100cm2)
Tungsten Metal Scrap	1	NA*	224
	2	NA	224
	6	NA	224
Tantalum Natural Minerals	A	12.8	418
	B	9.0	407
	C	13.5	419
	D	12.1	416
	E	11.5	415
	F	10.3	411
	G	8.5	405

*NA- Not applicable as all material was considered as thorium.

For those areas for which sampling and testing was not performed on the stored materials, a conservative approach would be to use the lowest DCGL (that for the Tungsten Metal Scrap).

A specific release criteria for activity identified by swipes is not set; however, data for any area with a swipe indicating greater than 10% of a DCGL will be specifically reviewed. This is consistent with the NRC's position (Reference 7.17) that the fraction of removable surface contamination not exceed 0.1 of a DCGL and that swipes are a semi-quantitative evaluation of removable contamination per MARSSIM.

As all commodities contain a mixture of natural thorium and natural uranium, the approach is to identify each area where a particular commodity was stored and to apply a particular DCGL to that area. DCGLs will be selected from the above table and applied depending upon exactly where a particular commodity was stored or used. HSA and scoping survey data is used for determining the appropriate application as shown in Table 3-4 below. In Table 3-4, the historical storage locations containing the various commodities are listed with the conservative DCGL for the area given in the last column. The areas are identified with a Survey Unit alphanumeric code in the first column. The survey unit code lists the building identifier first (1, 3, 4, and DT for the Decon Trailer.) The next sequences are for the building section (A-E) followed by either "FL" or "WL"; floor or wall, respectively. The numeric values at the end represent the individual survey units within that section. For example, 1CFL1 represents the first floor survey unit on the floor of Warehouse 1 Section C. Another example, DTWL1 represents the wall survey unit in the Decon Trailer.

Table 3-4. Historical Storage Locations and DCGLs

Survey Unit	Bays or Partial Bays	Material	DCGL$_{alpha}$ αpm/100cm^2
1CFL1	9,10,17,18	Tungsten Metal Scrap	224
1CWL1	1,9,17,25 (walls)	Tungsten Metal Scrap	224
1DFL1	12	Miscellaneous	224
1DFL2	15	Miscellaneous	224
1DFL3	21	Miscellaneous	224
3AFL0	5 (partial)	Miscellaneous	224
3AFL1	5,12,13 (partial)	Miscellaneous	224
3AFL2	4,5,6,11,12,13,14,19	Miscellaneous	224
3AFL3	1,2,3	Miscellaneous	224
3AFL4	7,15	Miscellaneous	224
3AWL1	9,1,2,3 (walls)	Miscellaneous	224
3AWL2	4,5,6,7,8 (walls)	Miscellaneous	224
3AWL3	8,16,24 (walls)	Miscellaneous	224
3EFL1	All	Tantalum Natural Minerals	405
3EWL1	All (walls)	Tantalum Natural Minerals	405
3EFL4	All	Non-Licensed Material	405
3EWL4	All (walls)	Non-Licensed Materials	405
4AFL1	20	Miscellaneous	224
4CFL1	31,32	Tungsten Metal Scrap	224
4CWL1	24,32,31,30 (walls)	Tungsten Metal Scrap	224
DTFL1	All floors	Miscellaneous	224
DTWL1	Walls	Miscellaneous	224

3.3   Organization and Responsibilities

The survey will be performed by a team composed of qualified personnel currently employed by ChesNuc. This is the same organizational structure which conducted the characterization survey activities. Figure 2 is an organizational chart for the survey activities.

The ChesNuc team will operate under the supervision of Claude Wiblin, CHP. Mr. Wiblin will have the authority to make appropriate changes to the survey plan (subject to the established QA/QC program) as deemed necessary as the survey progresses.

Field measurements of radiological parameters and sample collection will be under the direction of Mr. Jamie K. Doan. Mr. Doan will also direct laboratory services for in-house analyses.

QA/QC responsibilities will be handled by a QA officer whose work responsibilities are otherwise separate from those on the survey team. Mr. J. Stewart Bland, CHP, will serve as the QA officer and will, in that capacity, coordinate all interface requirements during the survey process. Applicable ChesNuc QA procedures are developed from guidelines presented in ANSI/ASTM NQA-1, Quality Assurance Program Requirements for Nuclear Facilities (1989). Any changes or alterations to these procedures will be handled in the same manner as changes to survey procedures. All changes from procedures will be documented and become part of the final report submitted to the NRC.

Mr. Michel J. Pecullan is the DNSC Deputy Manager Occupational Radiation Protection Program and is the DNSC Project Manager for this survey. Mr. James M. Farley is the Somerville Depot Manager and Mary Davidson is the Somerville Depot Radiation Safety Officer. All survey activities will be coordinated with these individuals.

Mr. Farley and Ms. Davidson will also provide expertise on Health and Safety (H&S) issues for the survey process. Somerville Depot has its own H&S Plan which is identifiable through their "I Am the Key" website, (https://www.dnsc.dla.mil/iamthekey/default.htm)".   ChesNuc has developed a project specific H&S Plan for this effort. The ChesNuc H&S Plan incorporates considerations for workers and the general pubic. A safety briefing will be part of every Plan-of-the-Day meeting held daily. All survey team members are required to sign an attendance roster for these meetings; Mr. Wiblin or Mr. Doan will hold these meetings.
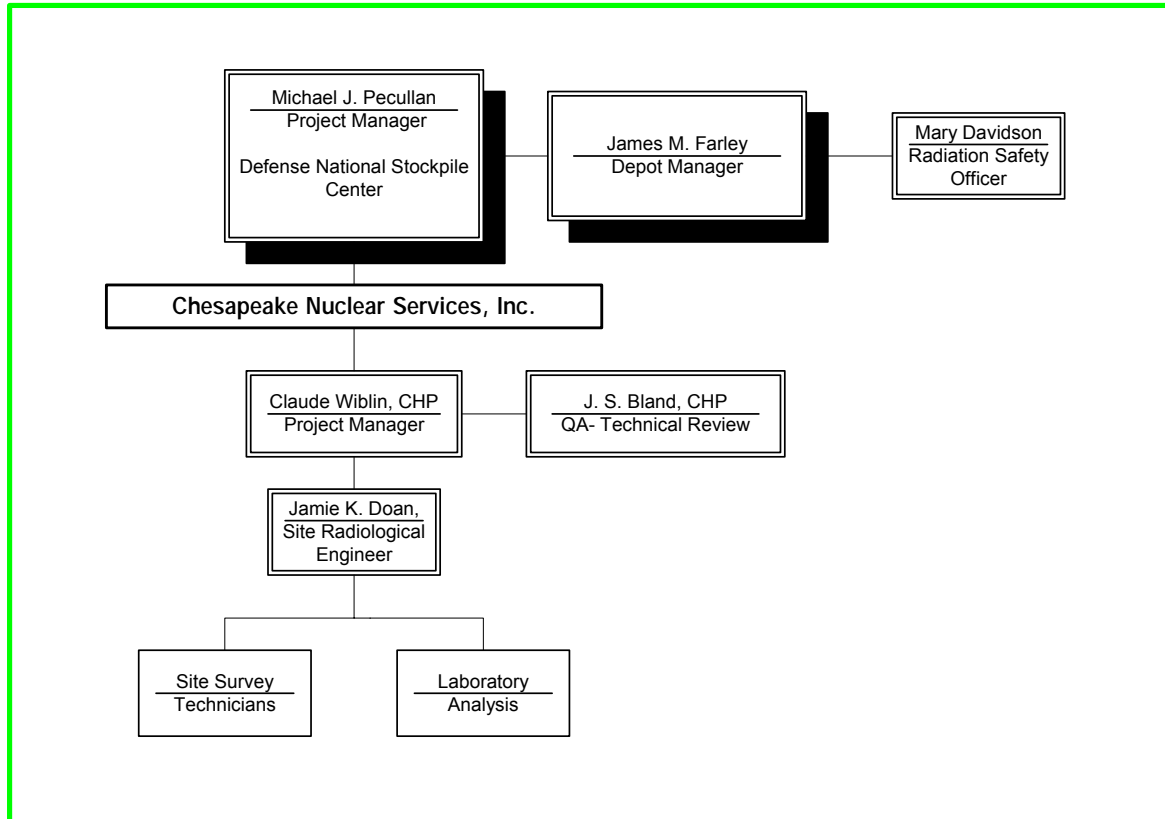
Figure 2. Organization Chart for Final Status Survey Activities

3.4   Training

ChesNuc provides continuing training for its survey personnel and other workers who may be exposed to radioactive materials. Training varies according to potential exposure and the nature of the employee's job duties which is consistent with 10 CFR Part 19.12, "Instruction to Workers," Reference 7.18. In addition to the regular training, special training will be provided on equipment, special techniques, and practices relative to the survey activities for those employees who will be involved in taking radiological measurements and samples. All members of the final status survey team will attend an in-house training session regarding radiation protection, survey procedures, and quality assurance activities. Documentation of training participation will be retained in the ChesNuc training files.

3.5   Laboratory Services

Use of outside laboratories is not planned. All smears will be analyzed by ChesNuc personnel either onsite or offsite depending upon the amount of natural radon interference at the Depot.

3.6   General Survey Plan

This survey plan consists of systematic processes and procedures that have been deemed acceptable by industry practices and the NRC. MARSSIM methodology and its graded approach were afforded particular attention. Activities (organized units of work needed to complete a function) have been defined and tasks (specific work assignments within a specific activity) have been delegated to the appropriate team members. Table 3-4 provides a breakdown of activities and tasks that are currently a part of the FSSP.

Table 3-5. Overview of Major Activities and Tasks

Activities	Tasks
Evaluate contamination potential	1. Review radiological data from scoping and characterization surveys.
	2. Identify radionuclides of concern and determine DCGLs.
	3. Identify boundaries of survey units and classes.
Establish grid reference system	1. Determine frequency and locations of measurements to meet criteria.
	2. Prepare facility survey maps and work packages.
Determine background levels	1. Review characterization survey data.
	2. Measure indoor alpha levels.
Perform measurements	1. Remove any loose debris and dirt.
	2. Perform surface scans.
	3. Perform direct alpha measurements.
	4. Collect smears.
Analyze samples	1. Count smears
Interpret data	1. Convert data to standard units.
	2. Calculate average levels.
	3. Compare data with criteria.
Prepare report	1. Construct data tables.
	2. Develop graphics.
	3. Prepare text.
	4. Submit report to NRC.

A work process flow chart is shown in Figure 3.
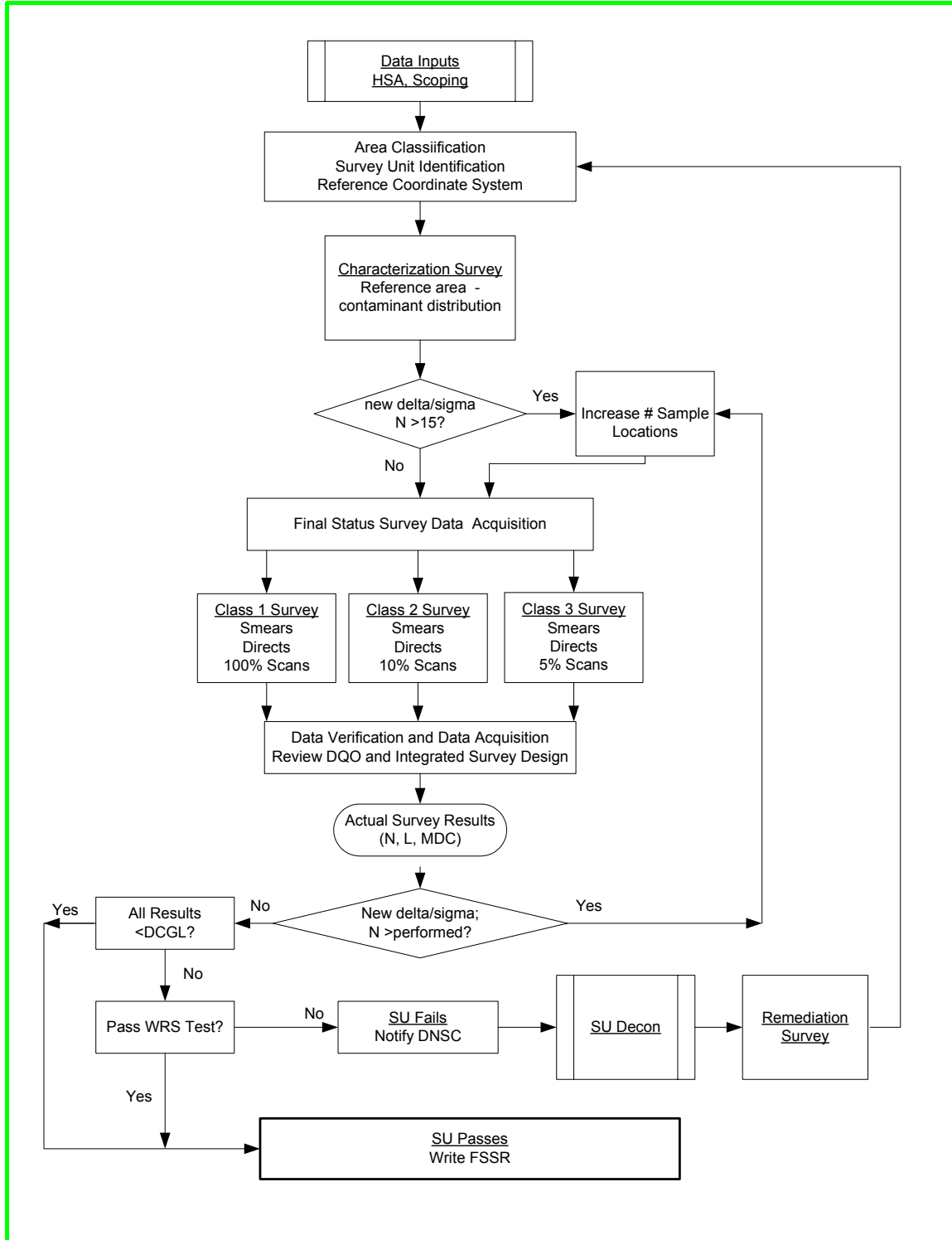
Figure 3. Work Process Flow Chart

3.7 Tentative Schedule

The FSS is scheduled to begin within 60 days of the NRC approval of this plan and completed within one month. An example project schedule is shown in Figure 4 which depicts the project being completed before the end of June 2006.

Task Name	Duration	1st Half
		Jan Feb Mar Apr May Jun
⊟ **FSS Performance**	**15 days**	
Mobilization	1 day	
⊟ **Somerville Depot FSS Activities**	**14 days**	
Training	1 day	
⊟ **Conduct Reference Area Measurements**	**2 days**	
Warehouse 3 Section E Cube 2	1 day	
Decon Trailer	1 day	
⊟ **Conduct Measurements and Physical Sampling**	**11 days**	
Warehouse 1 Sections C and D	3 days	
Warehouse 3 Sections A, E-1, and E-4	5 days	
Warehouse 4 Sections A and C	1 day	
Decon Trailer	1 day	
Demobilization	1 day	
⊟ **FSS Report**	**10 days**	
Analyze data & prepare draft report	10 days	
Submit draft to DNSC	1 day	
Meet with DNSC to resolve comments	3 days	

Figure 4. FSS Schedule

3.8 Survey Report

A report describing the survey procedures and findings, will be prepared and submitted to the NRC. Report format and content will follow the recommendations contained in *Consolidated NMSS Decommissioning Guidance*, NUREG-1757.

4.0   SURVEY PLAN AND PROCEDURES

4.1   FSS Data Quality Objectives

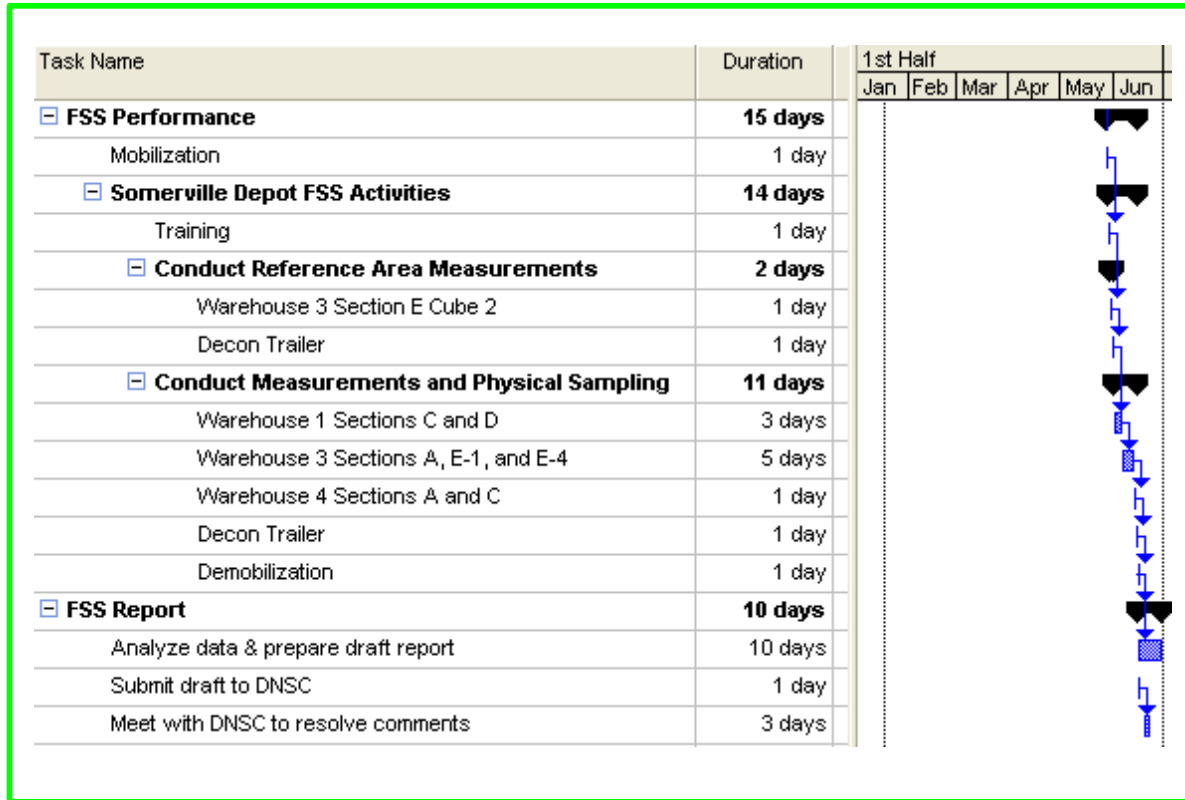Data Quality Objectives (DQOs) are fundamental components for planning. These will be considered during the scoping surveys, become formal elements of the FSSP, and integrated/implemented during the FSS performance. The following DQOs are quantitative and qualitative statements derived from the output of the DQO process. These are typical of those which will be used in the final listing, but may not be limited to these.

- The objective of the FSS is to prove that the residual radioactivity levels in the survey units within the facility are at or below the release criteria.
- The background reference area or materials will be located in an area that has similar construction materials to those located in the facility.
- The null hypothesis (H_o) will be: The residual radioactivity in the survey unit exceeds the release criteria.
- A decision error occurs when the decision maker rejects the null hypothesis when it is true, or accepts the null hypothesis when it is false; these two types of decision errors are classified as Type I and Type II decision errors respectively. The Type I and Type II decision error probabilities will both be 5%.
- The upper bound of the gray region is defined as the release criteria and the lower bound of the gray region (LBGR) is defined initially as one-half of the DCGL. The LBGR may be adjusted for an acceptable relative shift as described in MARSSIM.
- For the Class 1 and 2 Areas, fixed-point measurements will be determined for the survey unit using a systematic, random-start method.
- For the Class 3 and Reference Areas, all fixed-point measurements locations will be determined for the survey units using a random selection method.
- For fixed-point measurements, instrument MDCs will be less than 50% of the total surface activity release criteria.
- For smear measurements, instrument MDCs will be less than 10% of the total surface activity release criteria.
- For alpha scanning, MDCs may be greater than the DCGL, not to exceed a multiple of 3.
- Quality control (QC) measurements will be made to evaluate instrument and operator precision.
- Survey measurements will be documented and controlled.
- The scanning investigation level (IL) in the Class 1 area is >$DCGL_{EMC}$. For Class 2 areas the IL is measurements > DCGL; for Class 3 areas the IL is > Minimum Detectable Concentration (MDC).
- A response check form or instrument control log will be used to keep track of background counts and response checks.

4.2   Instrumentation

ChesNuc will perform the specified radiation scan and measurements using its proprietary Mapping and Radiation Survey System (MARSS-Surveyor). MARSS - Surveyor is an integrated radiation survey system. It was specifically designed to plan, perform, and coordinate radiological surveys coupled with management, evaluation, and reporting of radiation measurement data. Its survey planning and data collection capability support MARSSIM site characterization and final status surveys. Scan measurements are continually recorded on a hand-held personal data assistant (PDA) on a user-defined frequency, typically set at about once every second. Static measurements are collected and recorded directly into the system data management system, linking the location, survey unit, and instrument data for automated data evaluation and reporting. This approach provides automated survey records, and does not have to rely on the user alone for identifying elevated measurements.

The Base Unit is designed to manage the overall radiological survey project data. At the initiation of a project, survey requirements are established in the Base Unit for use in guiding the overall survey performance and evaluation. The Surveyor field units provide the scan and static measurement devices, collecting the prescribed radiation measurements coupled with other key information, such as survey unit, designated locations, date and time, user selected background, and key instrument information. MARSS-Surveyor has built-in data summary and reporting functions that support timely preparation of the required FSS reports.

The instruments selected for use during the FSS and their applications, which are integral to the MARSS-Surveyor system, are provided in Table 4.1. Alternate instruments and probes of equivalent or better characteristics may be used.

Table 4.1 lists the characteristics and application of the instruments; these instruments or equivalent will be used. All instruments will be calibrated using NIST-traceable standards.   Instruments will be response checked daily to ensure they are operating properly. In keeping with ANSI guidance, an acceptable ± 20% response range is determined *a priori.*

Although thorium and uranium and their progeny emit alpha, beta and gamma radiation, only measurements for alpha radiation will be performed. This is due to the very low DCGL for thorium and the fact that beta measurements are a duplicative effort. The type of instrumentation to be used will be of sufficient sensitivity to meet the static $DCGL_{alpha}$ for the site.

The calibration source which will be used was manufactured by Isotope Product Laboratories (IPL), Valencia CA 91355. The source is 2 inches in diameter with 16.53 nCi of Th-230 electroplated in an active diameter of 44 mm. The source had a total alpha surface emission rate of 17,610 αpm in 2π on 11 Oct 01 (IPL reference No. 762-54).

Instrument records, including dates of use, efficiencies, probe areas, calibration due dates, and source traceability are maintained. These records are integral to the application of the proprietary Mapping and Radiation Survey System (MARSS-Surveyor) for this project.

Although thorium, uranium, and their progeny emit alpha, beta, and gamma radiation, measurements for only alpha radiation will be performed. This is due to the anticipated very low DCGL for thorium, and beta measurements represent a duplicative effort. The type of instrumentation used is industry standard instruments for alpha detection.

For field applications, it is important that the values of the MDC, Investigation Level, and acceptable release criteria are well documented and understood in the field. From a project planning standpoint, these values/criteria are typically expressed in dpm/100cm^2. The MARSS-Surveyor system provides the mechanism for integrating these values/criteria directly to the field surveys. MDCs are verified; Investigation Level alarms are established for the field instruments; and data for documenting compliance with the release criteria are automatically stored and evaluated.

Table 4-1. Instruments

Application	Instrument	Probe Physical Area
Fixed-point measurements	Ludlum 2350-1 data logger with either detector (1) Ludlum 43-1, ZnS (Ag) scintillator, (2) Eberline SHP380AB, ZnS (Ag), *or* (3) Ludlum43-93 ZnS(Ag) scintillator	83 cm^2 100 cm^2 100 cm^2
Alpha scans	Ludlum 2350-1 data logger with either detector (1) Ludlum 43-1, ZnS (Ag) scintillator, (2) Eberline SHP380AB, ZnS (Ag), *or* (3) Ludlum43-93 ZnS(Ag) scintillator	83 cm^2 100 cm^2 100 cm^2
Smears	Ludlum Model 2929 sample counter; Detector Model 43-10-1 Alpha beta sample counter, scintillator is ZnS(Ag)	2" diameter

4.2.1   Instrument backgrounds

Reference 7.5 presents background count rates for various materials and instrument types; however, site specific values were measured. The values for instrument background rates are provided in the HSA as about 1.4 or less cpm for the ZnS detectors. Ambient and material background rates were determined in the site reference areas and varied accordingly for the age and type of material, see Table 4-2.

4.2.2   Alpha Scanning

Scanning MDCs for alpha emitters must be derived differently than scanning for beta and gamma emitters. MARSSIM has formulas and probability concepts for scanning alpha contamination when the background is less than 3 cpm. Abelquist (Reference 7.12) has developed scan MDCs on structure surfaces for alpha radiation by use of Poisson summation statistics.   Appendix J in MARSSIM provides a complete derivation of the formula used to determine the probability of observing a single count:

$$P(n \geq 1) = 1 - e^{-\left(\frac{G\varepsilon t}{60}\right)}$$

Where P(n $\geq$ 1) is the probability of observing a single count; G is the elevated area activity (αpm); ε is the detector efficiency (4π); and t is the residence time of the detector over the activity.

The scan process must be in two stages: continuous monitoring and stationary sampling (pausing). During the continuous monitoring, the surveyor listens to the number of clicks. Because the instrument background is low (<3 cpm), a single count gives the surveyor cause to stop and investigate further by pausing for an additional number of seconds.   The scan MDC for alpha contamination must be based on the continuous monitoring stage which is illustrated as follows.

Per Abelquist's example pages193-197: setting the P(n $\geq$ 1) at the 90% level and solving for G which is now defined as the alpha scan MDC.

$$scanMDC_{alpha} = \frac{[-\ln(1 - P(n \geq 1))]60}{\varepsilon_i \varepsilon_s t}$$

> where:
>> ε_i = Intrinsic instrument efficiency
>>
>> ε_s = Surface efficiency
>>
>> t = residence time (sec), calculated from scan rate

Reference 7.5, Table 5.5 gives a surface material effect for a distributed source on sealed concrete as 0.428 for ZnS detectors. This type of surface and contamination should represent the majority of any impacted areas. Further, per Reference 7.5, Table 5.6, the MDC for a point source on scabbled concrete versus a distributed source on sealed concrete would be higher by about 1.6. Although scabbled areas were not identified, cracks were present and should elevated readings be noted in cracks, the concept of a higher MDC would be included in the review of the data.

Even though the scan process is in two stages, all data is logged and any area with an elevated count may be revisited. The detector meter system logs measurements on an established frequency that is established to be consistent with the scan speed for ensuring complete data collection.

Once a count is recorded and the surveyor stops, the surveyor should wait a sufficient period of time such that, if activity at the MDC were present, it would be noticed. This time period can be estimated from the scan MDC and the time required for about

another count to register.   For example, an alpha activity of about 200 alphas per minute with efficiencies of 0.428 and 0.358, pausing for 2 seconds after the initial count is registered will yield one alpha count:

$$(200 \text{ αpm})(0.428)(0.358)(2 \text{ sec})(1 \text{ min/60sec}) = 1 \text{ count}$$

If no additional counts are observed in the 2 second period, the initial count is either at background levels or less than scan MDC. This process is applied per planned residence time and the individual instrument efficiency; each work package will have a planned survey scan speed.

During the HSA, the survey technicians used a slow scan rate for the single remediated area. For other areas, the scan rate was faster. The data for time are automatically recorded in data loggers and scan rates are calculated with the known area. MDCscan values were obtained ranging from 120 to 751 αpm/100cm^2 as shown I Table 4-2.

<u>These levels of MDCscan are acceptable as MARSSIM does not require them to be lower than the DCGL.</u> MARSSIM page 5-45 is quoted: "In Class 2 or 3 areas, neither measurements above the DCGL$_w$ nor areas of elevated activity are expected. Any measurement at a discrete location exceeding the DCGL$_w$ in these areas should be flagged for further investigation. Because the survey design for Class 2 and Class 3 survey units is not driven by the EMC, the scanning MDC might exceed the DCGL$_w$. In this case, any indication of residual radioactivity during the scan would warrant further investigation." This concept was employed; noting again that all measurements were logged. All characterization data will be reviewed for acceptability for the FSS.

Table 4-2. Instrument Scan Characteristics

Characterization Survey Unit	Material Background* (cpm)	Scan Interval Time (sec)	scanMDC (αpm/100cm2)	Probe
3AFL1	4.7	7.5	120	SHP380AB
3AFL2	4.7	1.2	751	SHP380AB
3EFL2	0.1	1.2	414	L43-1-1
3EFL4	4.7	1.2	414	L43-1-1

* An instrument background is shown for the reference area 3EFL2.

4.2.3   Static and Swipe Minimum Detectable Activities (MDC)

NUREG-1507, Reference 7.5, provides a rigorous derivation of the calculational expression for instrument sensitivity, typically stated as the minimum detectable concentration (MDC). The MDC equations and example values for both static measurements and swipe analysis are presented in this section.

For static measurements, background and indicator measurements are both typically one minute in duration. The following equation for the MDC from Reference 7.5, Equation 3-9, as modified for here applies:

$$MDC = \frac{3 + 4.65 * s_b}{(\varepsilon_s)(\varepsilon_i)\left(\frac{a}{100cm^2}\right)}$$

where:

s_b = standard deviation of background measurements

ε_i = Intrinsic instrument efficiency

ε_s = Surface efficiency

a = probe area in cm^2

As an example, 16 measurements were made in a reference area (Warehouse 3 Section E Cube 3) on the concrete floor and the results show a background rate of 4.8 cpm with a sigma of 2.4 cpm. The physical size of the probe was 100 cm^2. With a total efficiency of 0.153 cpm/αpm (this is the surface efficiency of 0.428 epm/αpm times the instrument efficiency of 0.358 cpm/epm), the MDC is about 93 αpm/100 cm^2.

Background and sample count times used to analyze a swipe are typically twenty minutes and one minute, respectively. When the background count time and the sample count time are different, the following MDC formula, taken from Reference 8.5, Equation 3-11, as modified for here, applies:

$$MDC = \frac{3 + 3.29\sqrt{R_B t_S \left(1 + \frac{t_S}{t_B}\right)}}{(\varepsilon_s)(\varepsilon_i)(t_S)\left(\frac{a}{100cm^2}\right)}$$

where:

R_B = Background count rate (cpm)

t_S = Sample counting time

t_B = Background counting time

ε_i = Intrinsic instrument efficiency

ε_s = Surface efficiency

a = area of surface smear in cm^2, nominally 100 cm^2

Smears will be analyzed using a Ludlum Model 2929 with the MDC calculated using the daily background count time, normally 20 minutes. The total efficiency was determined from the reported emissions per minute (epm) on the calibration trace form of the source and the surface efficiency was set to approximate dirt loading on the smear paper. Per McFarland's data for filter paper, Reference 7.16, alpha particle counting efficiency is lowered by approximately 15% from dirt loading of 5 mg on the paper. As most smears are from "clean" surfaces which would typically contain 1-3 mg of dirt; a reasonable and conservative assumption would be to set the loss at 10%. Conservatively assuming no back-scatter and since alpha emissions are in equal directions (50% in either the up or down direction), a surface efficiency of 0.45 epm/αpm is set to account for the dust loading effect.

A typical MDC for the smear analysis unit, Ludlum 2929, is about 18.5 αpm/100 cm^2. This calculation includes the low background of 0.8 cpm over a 20 minute period and a source efficiency of 0.723 cpm/epm.

Should the need arise to improve (lower) MDC statistics, the formula above for swipes may be used for static measurements with "*a"* being the probe area.   Generally, the sample analysis time could be increased to obtain a desired MDC. The background analysis time could be increased as well.

4.2.4   Surface Activity

A measurement for surface activity is performed over an area, represented by the <u>physical</u> surface area of the detector. To convert instrument counts to conventional surface activity units, the following equation is used:

$$\frac{dpm}{100cm^2} = \frac{\dfrac{C_s}{t_s} - \dfrac{C_b}{t_b}}{(\varepsilon_s)(\varepsilon_i)\left(\dfrac{a}{100cm^2}\right)}$$

where:

C_s = Integrated counts recorded by the instrument

C_b = Background counts recorded by the instrument

t_S = Sample counting time

t_B = Background counting time

ε_i = Intrinsic instrument efficiency

ε_s = Surface efficiency

a = probe area in cm^2, or
    = area of surface smear in cm^2

4.3   Survey Plan

4.3.1   Area Classification

The HSA suggests that classification of impacted areas be into three classes, based on MARSSIM definitions for Class 1, 2 and 3.

- <u>Class 1</u> areas are impacted areas that, prior to remediation, had concentrations of residual radioactivity above the DCGL. Remediated areas will be Class 1 and only one consisting of 36 ft^2 is identified at this Depot.

- <u>Class 2</u> areas have or had prior to remediation, a potential for radioactive contamination or known contamination, but are not expected to exceed the DCGL. No areas have been identified at this site for this classification.

- Class 3 areas are impacted areas that are not expected to contain any residual radioactivity, or are expected to contain levels of residual radioactivity at a small fraction of the DCGL.

- Non-impacted areas: For this Depot, the HSA concludes that potentially impacted areas do not include outdoor areas, railroads, and roadways that may have been used for transport of radioactive or contaminated materials. No contamination is expected to be identified in the storage areas arising from transportation loading and unloading.

A small part of Warehouse 3, Section A, Bay 5 is considered a MARSSIM Class 1 survey area. In keeping with MARSSIM criteria, a larger Class 2 area surrounds it. All other areas are considered Class 3.

4.3.2   Selection and Size of Survey Units

Suggested survey unit sizes from MARSSIM are given in the following table. These areas are suggested in MARSSIM because they give a reasonable sampling density and they are consistent with most commonly used dose modeling codes. However, the size and shape of a particular survey unit may be adjusted to conform to the existing features of the particular site area.

Table 4-3. Suggested Survey Unit Areas

Class	Structures - floor area
1	1,076 ft^2 maximum
2	1,076 to 10,760 ft^2
3	no limit

The contiguous and near contiguous areas used for storage of radioactive commodities are broken down into Survey Units, each classified according to the guidance of MARSSIM. Area classification was based upon information collected during the HSA. Survey units may be further segregated into specific areas to facilitate data collection and processing. The boundaries for these areas will be selected based on certain commonalities, either in terms of contiguous area, natural boundaries (walls), or historical information, such as prior use (i.e., potentially affected or unaffected areas). Planned survey activities at the Depot are described in the following sub-sections. Estimated fixed points and scan area for floors, lower walls and upper walls is provided.

The wall spaces from floor height to a point two meters above the floor will be treated as separate survey units. There will also be random checks on wall surfaces above two meters and at overhead structural members.

Table 4-4 below lists the individual survey unit with related locations and area size while Figures 5-8 give an approximation of where they are found in the Buildings. The reference area for the trailer is not shown but it will be of similar construction at the site.

Table 4-4. Survey Unit Locations and Area Sizes

Survey Unit	Bays or Partial Bays	Comment	Total Area
1CFL1	9,10,17,18		5000
1CWL1	1,9,17,25	10' Partials on 1 & 21	787
1DFL1	12		1250
1DFL2	15		1250
1DFL3	21		1250
3AFL0	5 (Partial)	Class 1	36
3AFL1	4,5,12,13	Encompasses Class 1	1225
3AFL2	4,5,6,11,12,13,14,19	Encompasses Class 1 &2	10000
3AFL3	1,2,3	Road Side	3750
3AFL4	7,15		2500
3AWL1	1, 2, 3, 9	10' partial aisle of 9	886
3AWL2	4,5,6,7,8	No partials	820
3AWL3	8,16	10' partial on 24	722
3EFL1	All	3E Cube 1	10000
3EWL1	All	3E Cube 1	2624
3EFL2	All	Reference Area 3E Cube 2	10000
3EWL2	All	Reference Area 3E Cube 2	2624
3EFL3	All	Reference Area 3E Cube 3	10000
3EFL4	All	3E Cube 4	10000
3EWL4	All	3E Cube 4	2624
4AFL1	20		1250
4CFL1	31,32		2500
4CWL1	24,30,31,32	10' Partials on 24 and 30	787
DTFL1	N/A	Decon Trailer	660
DTWL1	N/A	Decon Trailer	1312
RTFL1	N/A	Reference Area Trailer	660
RTWL1	N/A	Reference Area Trailer	1312
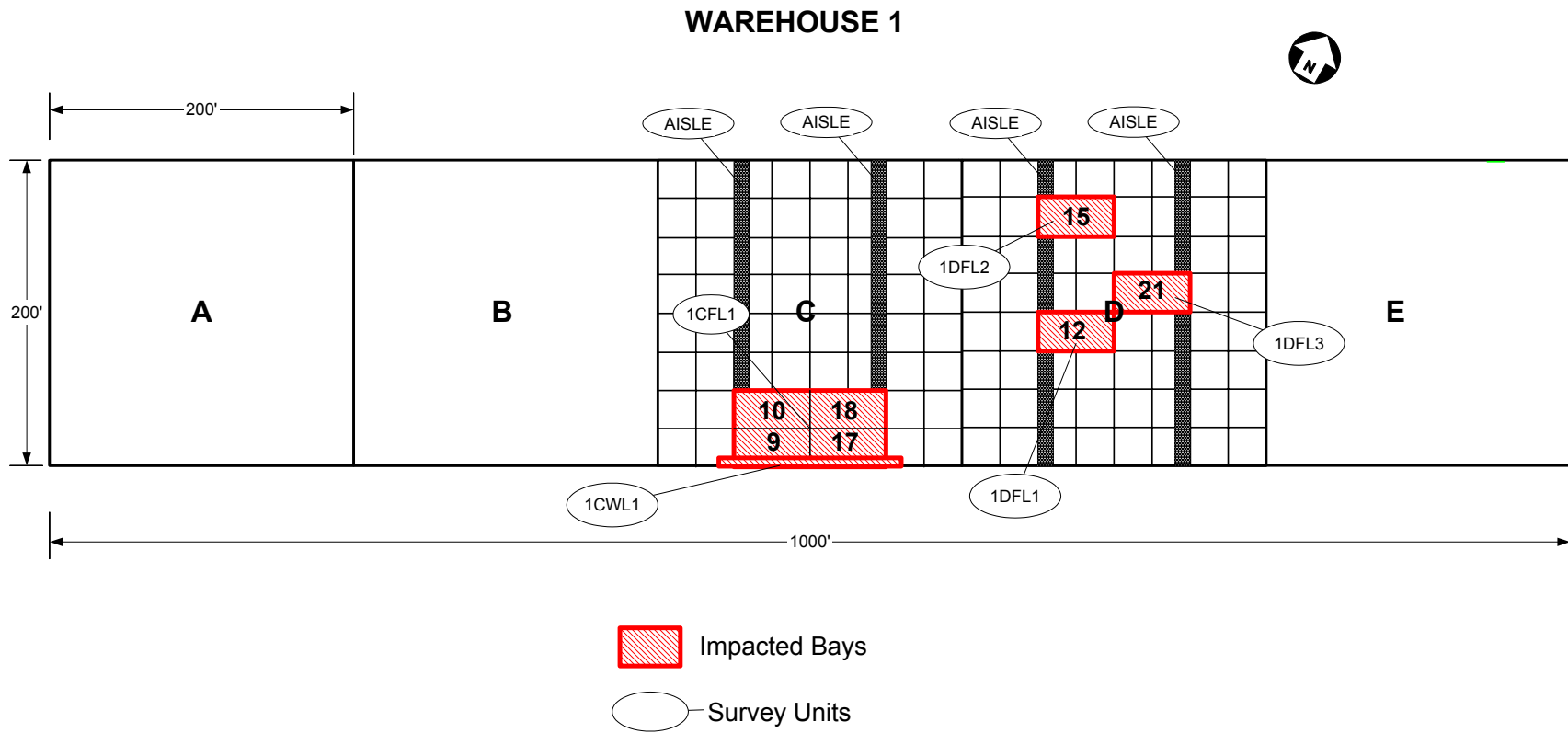
WAREHOUSE 1

Figure 5. Warehouse 1 Survey Units

WAREHOUSE 3

SU 3AFL0 in Section A Bay 5 is a Class 1 Remediated Area of 36 ft^2.

SU 3AFL1 in Section A surrounds the Class 1 Area, covers 1/2 of Bay 5 provides a 10' buffer zone

Reference Area

Impacted Bays or Cubicles

AISLE — Characterization Survey Units
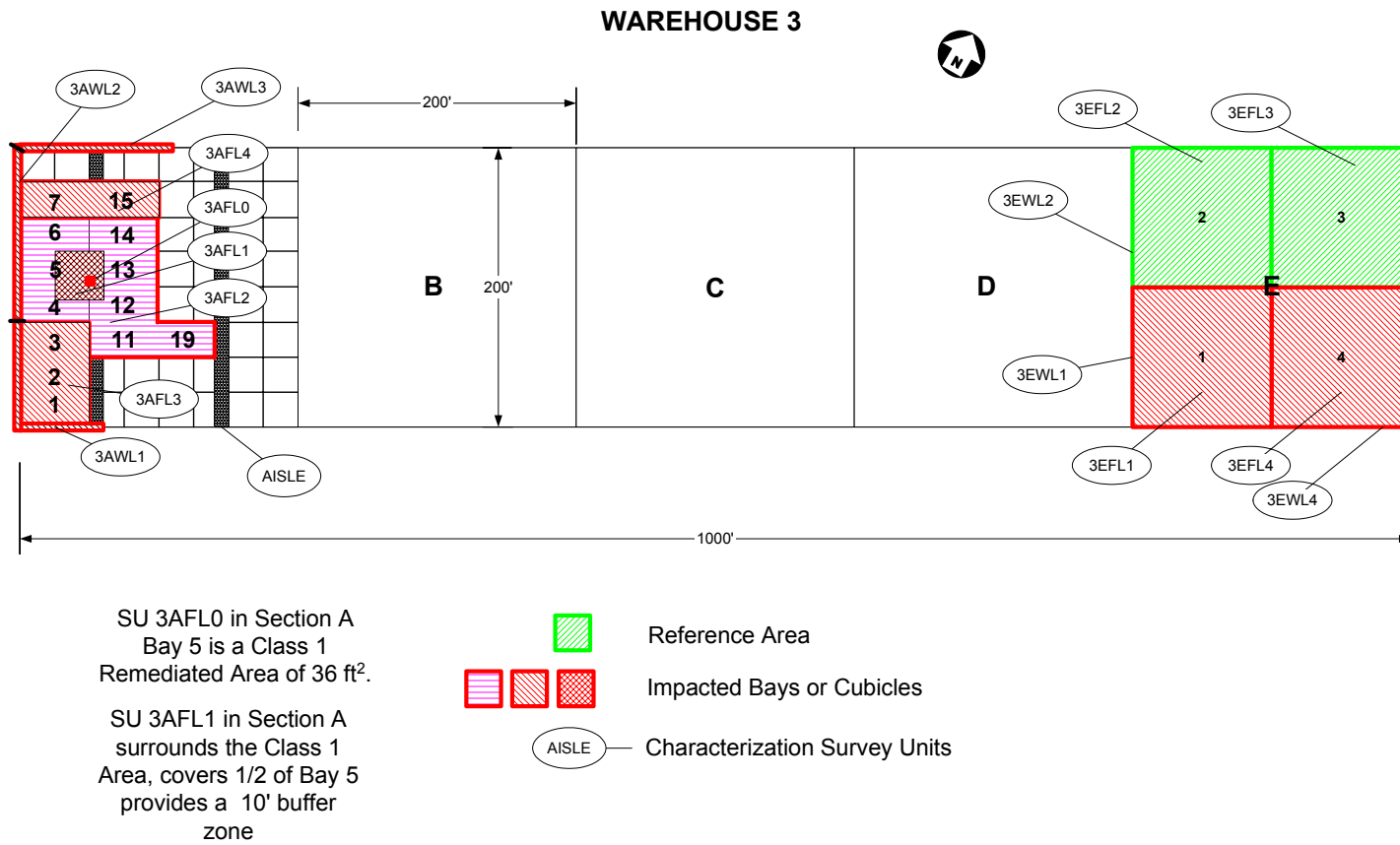
Figure 6. Warehouse 3 Survey Units

WAREHOUSE 4

Figure 7. Warehouse 4 Survey Units

Decontamination Trailer

The wall survey unit will encompass all walls.
The floor survey unit will cover all floors.
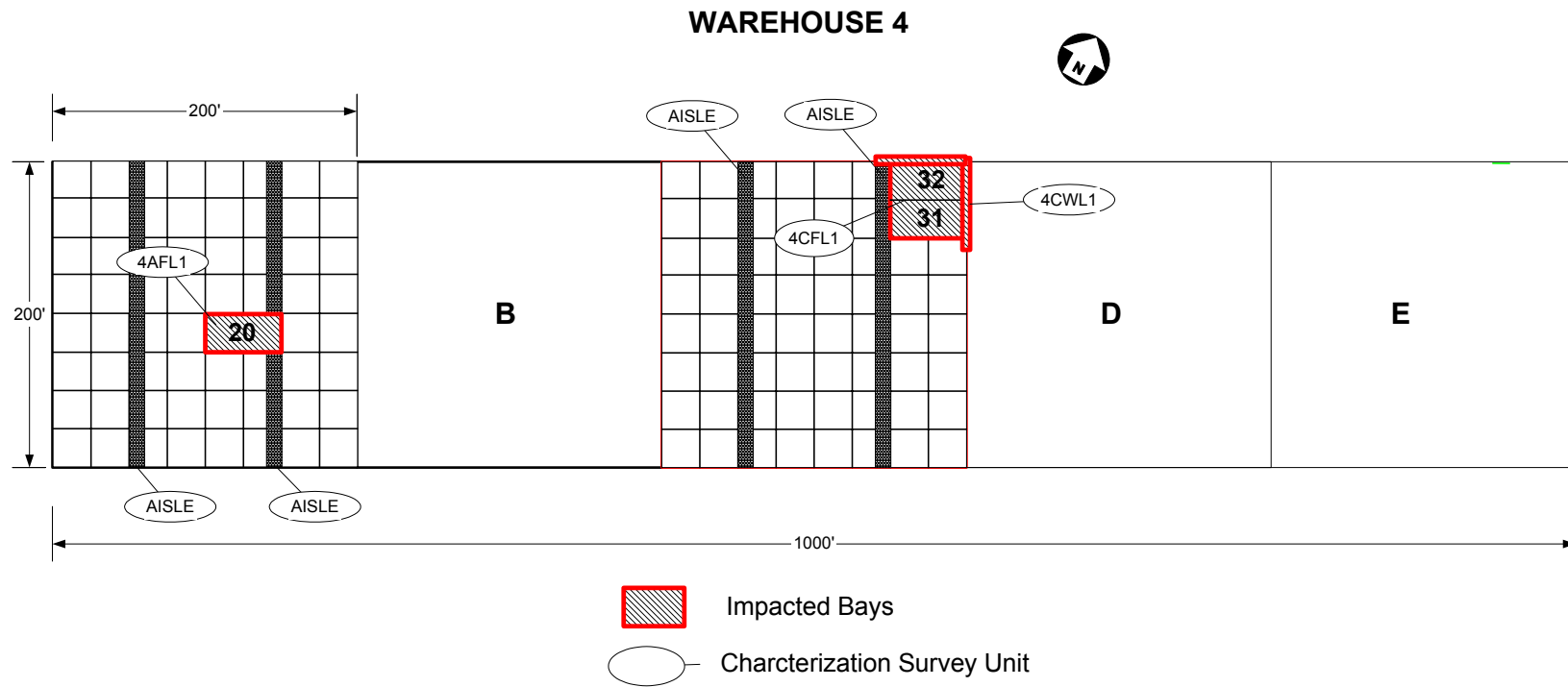
Trailer is ~ 12' x 60' Exterior dimensions. Two sections are given here.
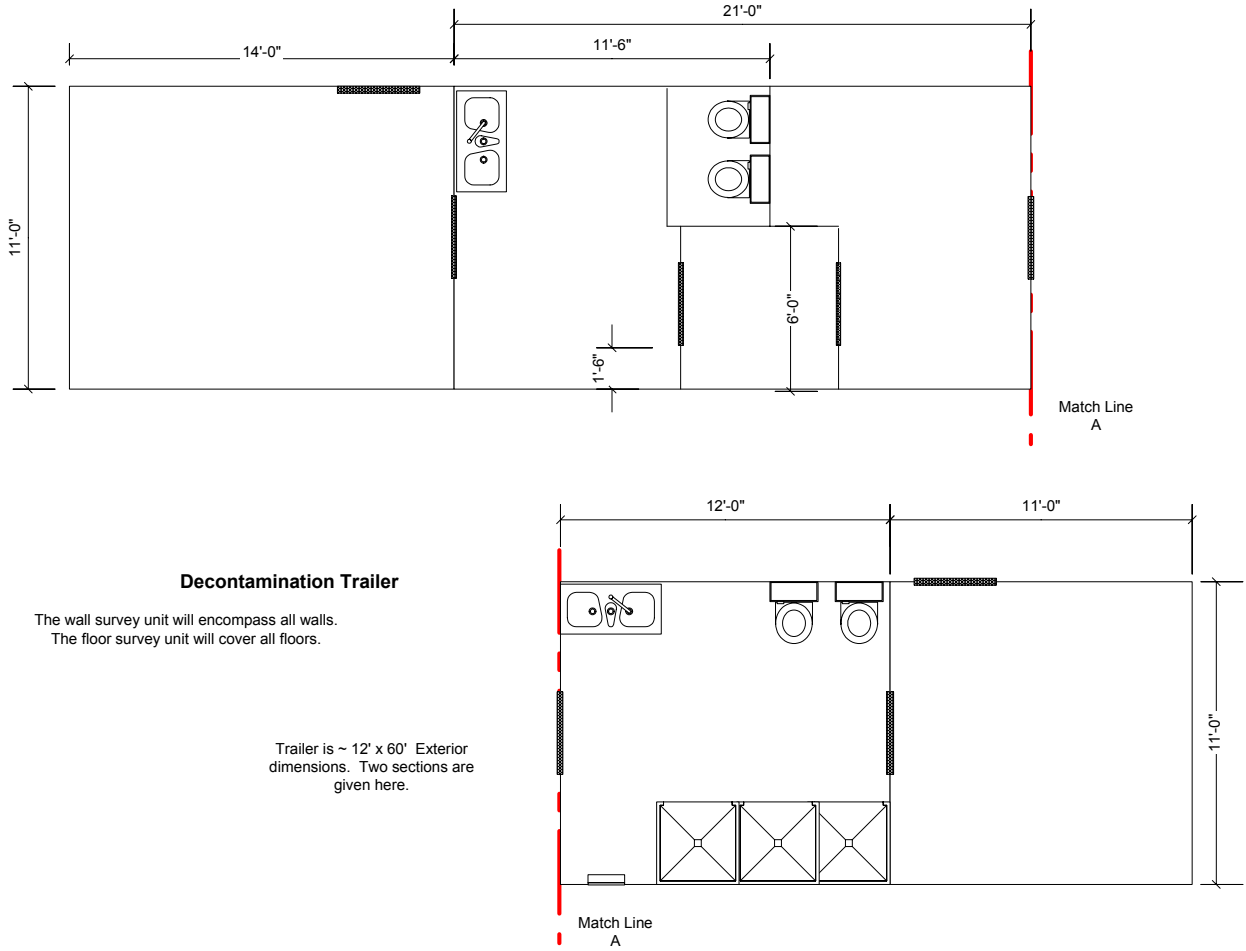
Figure 8. Decon Trailer Survey Units

4.3.3   Determining the Number of Survey Points

The following technique is used for determining the number of samples required. The number of survey points as estimated may be increased, but MARSSIM suggests the value to use should be conservative until all actual values are known. A review will be made post-survey to determine if more samples are required but conservatism is built into the design to preclude this from happening.

Section 5.5.2.2 of MARSSIM describes the process for determining the number of survey measurements necessary to ensure a data set sufficient for statistical analysis. For building and structure surfaces, the Wilcoxon Rank-Sum (WRS) test may be used. The method for determining the combined number of data points (N) for the survey unit and reference area is based on the expected contaminant variability and the predetermined acceptable Type I and Type II error rates.

The project data quality objectives (DQO) established the Type I and Type II error rates (α and β respectively) at 0.05.

The "relative shift" (Δ/σ) is the ratio involving the concentration to be measured (Δ) relative to the expected variability in that concentration sigma (σ), and can be thought of as an expression of the resolution of the measurements. The sigma (σ) is selected from the larger of that found in the survey unit or the reference area. The shift (Δ) is the width of the statistical gray region or difference in the release criterion and the lower bound of the gray region (LBGR). The gray region is the area where the impact of making an incorrect error decision (Type I or Type II error) is small. The LBGR is the concentration at which the type II error rate is set. It is advantageous to set the LBGR at or above the expected median contaminate concentration in the survey unit.

MARSSIM recommends assuming a coefficient of variation of 30% for sigma when preliminary data are not available, an assumption of 0.3 times the DCGL. Routinely the LBGR is set at one-half of the DCGL All of this is summarized in the following formulas:

$$\frac{\Delta}{\sigma} = \frac{DCGL - 0.5 * DCGL}{\sigma}$$

$$\frac{\Delta}{\sigma} = \frac{0.5}{0.3}$$

$$\frac{\Delta}{\sigma} \approx 1.7$$

To determine the number of data points needed in each survey unit and reference area, MARSSIM Table 5.3 is used. <u>For this example,</u> each structure survey unit and the reference area are expected to have a minimum of 15 survey points.   However, from the HSA, preliminary data is available to estimate the relative shift. An issue arose as the known and low levels of contaminate averages and sigmas drove the relative shift to levels (3.5 and higher) which are not useful for an FSS design. A relative shift of this magnitude implies that so few samples are required that statistics would not support the result. MARSSIM recommends that if the relative shift is greater than 3 to adjust the

LBGR until it is between the values of 1 and 3. This adjustment was required the Survey Unit 3EFL4. With the DQOs for α and β at 0.05, the required number of data points needed in each survey unit and reference area, MARSSIM Table 5.3 is used, is 10. However, another DQO is to scan survey 5% of the survey unit with the area surveyed distributed uniformly around each point and a <u>goal</u> is set to apply the scan over 15 data points. Certainly when obstructions exist and a sample point can not be used, the minimum acceptable number of data points is 10. All survey units are designed initially for 15 data points.   Following this process, the FSS Plan should be conservative. The process will be reviewed and adjusted accordingly should any $\Delta > 0.5$ or a $\sigma > 0.3$ be observed in any survey unit.

The following table illustrates the Characterization Survey Units and the respective DCGLs, known contaminate averages, the calculated LBGR, established sigma for the survey unit, and the relative shift "Delta/Sigma" set at 3.

Table 4-5. Contaminate Averages, LBGR, Sigma, & Delta/Sigma for Characterization Surveys

Survey Unit	DCGL$_{alpha}$ αpm/100cm^2	SU Average αpm/100cm^2	LBGR	Sigma*	Delta/Sigma
1CFL1	224	<0	177	11.2	3
3AFL0	224	<0	177	12.2	3
3AFL1	224	<0	177	14.4	3
3EFL1	405	8.9	358	6.9	3
3EFL4	405	<0	358	9.2	3
4CFL1	224	<0	177	12.5	3
DTFL1	224	<0	177	6.6	3

* The background sigma was 15.8 and was used to determine LBGR.

For the Class 1 area, the actual scan MDC used during the HSA is less than the DCGL; detecting small contaminated areas is not a concern and it is not necessary to determine area factors.

4.3.4   Determination of Survey Point Locations

Before the surveys are conducted within a survey unit, a fixed reproducible starting point is selected, such as the southwestern corner of the survey unit at ground level. The survey unit points are based on an X-Y reference-coordinate system that was provided with the FSS maps. Equipment such as tape and laser measurers will be used in the measurement of the survey units for the FSS. SAE units (feet and inches) may be used for measuring the survey units. Visual aids such as paint and/or removable tape can be used to mark survey point locations within the survey unit, other methods can be used when applicable.

Reference area measurements will be taken and recorded in a similar fashion to measurements taken in the survey units. The gross activity measurements (uncorrected for background) in the reference area(s) will be compared to the gross activity measurements in the survey units to determine if the null hypothesis (the survey unit is

contaminant) is accepted or rejected. All reference and Class 3 survey points will be a random selection.

Once the number of data points required for each survey unit is determined, the location of the first survey point in each survey unit is determined using a random number generator to generate an X and Y coordinate in meters from a reference point (0, 0). The (0, 0) point was generally taken as the southwestern corner of the survey unit or survey area at ground level. The reference points are clearly identified on each survey unit map. For an X or Y coordinate to be valid, it has to fall on the survey map within the survey unit.

The survey points for the single Class 1 and the Class 2 survey units will each have a randomly selected starting point. Once the initial randomly selected survey point is determined, the remaining points will be mapped on the survey map using a systematic triangular grid pattern.

Survey unit maps, showing the survey points, their (X, Y) coordinate will be provided in the survey work package.

4.3.5   Surface Scan

The FSS area covered by scan measurement is based on the survey unit classification as shown in Table 4-6 below (derived from MARSSIM Table 2.2). The Class 1 area will receive a 100% scan. A minimum of 10% accessible area scan of the Class 2 survey units is required. Scanning percentage of Class 2 and 3 survey units will be performed on likely areas of contamination based on the likelihood of contamination and the judgment of the radiation survey staff.

Table 4-6. Scan Measurement Requirements

Class 1	Class 2	Class 3
100%	10% Systematic and Judgmental	5% Systematic and Judgmental

As directed by MARSSIM, each survey unit will receive a surface scan using appropriate survey instruments. For surface contamination detectors, scanning at no greater than one detector width per second will ensure that the scan MDC meets the project DQOs. Scan speed may be adjusted as determined by the project Certified Health Physicist (CHP) and per the calculation technique shown above.

Class 2 and 3 survey unit scanning sections are arbitrary sections of the survey unit that can be defined. For example, if there are 15 fixed-point measurements in a 1,000 ft^2 survey unit, the technician should survey 3-4 ft^2 around each fixed-point. For each scanning section, the average and maximum count rates observed by the surveyor (in gross cpm) will be recorded. Judgmental scans will also be performed in areas of highest potential (*e.g.*, corners, seams between concrete pours, or base of support poles) based on professional judgment. This provides a qualitative level of confidence that no areas of elevated activity were missed by the random measurements and that there were no errors made in area classification.

4.3.6   Surface Activity Measurements

Each survey unit and the reference area are initially designed to have a minimum of 15 randomly located survey points. All Class 2 and 3 survey units will have a 5% alpha scan at random locations and also bias scans along cracks and seams in the concrete floors. A smear will be performed at each survey point.

Direct Measurements

Direct measurements of alpha surface activity will be performed at selected locations using instrumentation described in Table 4-1. Unless precluded by surface conditions or physical parameters, measurements will be conducted by integrating counts over a 1 minute period.

Removable Contamination Measurements

A smear for removable contamination will be performed at each measurement location.

No Gamma Scan

The following is presented to demonstrate that gamma scans will not be required and do not provide any useful information concerning surface contamination, which is the overall purpose for specified measurements. For this evaluation, the DCGL activity per 100 cm^2 is considered to be a point source. Gamma exposure rate conversion factors are developed as the sum of all specific gamma ray dose constants in each chain from NUREG-1717, Chapter 3, (Reference 7.13) with application of the inverse square rule. Ludlum manufacturer data indicates that, for a 2"x2" NaI detector, 900 cpm could be expected for each microR/hour. As background is approximately 9-10k cpm for an unshielded probe there is no technical justification to use the NaI detector as the expected responses are so low they could not be discerned from variations in background readings.

Table 4-7. Expected NaI Response for a DCGL Point Source

Radionuclide	DCGL (dpm/100cm^2)	DCGL (µCi/100cm^2)	Γ µRem/h per µCi @ 5 cm	DCGL µR/h @ 5 cm	DCGL (cpm)
Th Natural	37	1.67E-05	864	0.014	13
U-238+C	53.7	2.42E-05	532	0.013	12
U-235+C	2.6	1.17E-06	892	0.001	1

4.4   Background Level Determinations

Reference area measurements can be used for multiple survey units as long as the material being surveyed is similar to that in the reference area.

For comparability of results, survey measurements will be collected from the reference area background survey units using similar instruments and survey techniques to be employed in the survey unit areas. Each background reference area will be surveyed using 15 random static alpha measurements and alpha scanning.   The number of measurements may be increased if necessary due to large site variation in background levels or survey unit levels.

The background survey units are chosen due to their similarity in construction materials, construction date, and no history of storing or handling radioactive materials.
Two background reference area survey units selected were Warehouse 3, Section E, Cubes 2 and 3. A similar trailer at the Depot will be a reference for the Decon Trailer. Background reference areas are shown in Figure 6.

5.0   DATA INTERPRETATION

During the FSS, data will be properly documented so that aspects of the FSS can be referenced in the future if desired. The survey documentation will be of sufficient detail to allow for the recreation of the survey procedure, location, instrumentation used, and results.

All of the data taken including fixed measurements, scanning measurements, removable contamination, dose rates (if necessary) and soil contamination or other media contamination will be documented in detail.

Instrument measurements and analytical results will include the following data:

- Daily background measurements
- Location of the measurement or sample
- Date and time of the measurement or sample
- Gross or net instrument readings. Net instrument readings will often be negative since samples without any added radioactivity will often be below the background count. These numbers should be recorded since they may be necessary for statistical evaluation of the data.
- Measured concentrations in dpm/100 cm^2 for surface contamination
- Name of surveyor, sampler, or analyst
- Instrument specifications and calibration date
- Minimum detectable concentrations or activity
- Name of person reviewing results
- Other relevant information

Any deviations from normal operating survey procedures or procedures specified in the FSSP including equipment selection and use will be documented for future reference with a complete explanation.

If any data is disregarded for any reason, the situation is to be documented with supporting reasons and necessary evidence. Examples of this would include detector malfunction/contamination, reclassification of a survey unit if cross contamination occurred between survey units after decontamination activities, and other such occurrences.

6.0   REPORT

The Final Status Survey Report (FSSR) will restate the intention of the FSSP and provide the results of the FSS. The FSSR should explain any deviations to the FSSP. It will also provide a summary of the survey results and the overall conclusions that demonstrate that the facility and site meet the radiological criteria for unrestricted use. Information such as the number and type of measurements, basic statistical quantities, and statistical analysis results are included in the report. The level of detail is sufficient to clearly describe the FSS program and to certify the results.

Data will be analyzed for completeness and to ensure that no individual static measurement exceeded the investigation level. To assist in this analysis, the Wilcoxon Rank-Sum (WRS) Test may be used as recommended by MARSSIM, if necessary. As part of the data interpretation process, all scanning, static measurement, and swipe sample data collected by the field personnel will be reviewed and approved by the Lead Engineer; follow-up reviews by the Project Manager will also be performed as part of the overall QA process. These reviews will ensure the surveys are performed and the data collected consistent with the approved FSSP. The reviews will also include MDA achieved during the scanning efforts and the scanning data to ensure data of sufficient sensitivity are collected.

Statistical analyses of the FSS data will be performed for evaluating compliance with the approved release criteria. If all measured data are below the DCGL, no further analyses are required. Otherwise, statistical analyses, such as WRS, will be performed. The WRS test is a two-sample test that compares the distribution of a set of measurements in an survey unit to that of a set of measurements in a reference area (SU-0). Because the null hypothesis is to test if the survey unit exceeds the reference area by more than the $DCGL_{alpha}$, the reference area data are first adjusted by adding the $DCGL_{alpha}$ to those measurements from the reference area; the survey unit measurements are left unchanged. Adjustments for detector size may be necessary because not all detectors have an active area of 100 cm^2. The $DCGL_{alpha}$ will be converted from dpm to cpm using the detector counting efficiencies. The gross measurements from both the reference area and the survey unit are used. The data from the survey unit and the adjusted data from the reference area are ranked together in increasing numerical order. The ranks for just the adjusted reference area data are summed and compared to a critical value from MARSSIM Appendix I, Table I.4. If the rank sum of the adjusted reference area data exceeds the critical value, the survey unit demonstrates compliance with the release criterion (i.e. the survey unit results do not exceed the reference area by more than the $DCGL_{alpha}$).

7.0 REFERENCES

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