NMRC Radiological Decontamination and Decommissioning (D&D) Plan

August 1999, Revision 1

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1.0 OVERVIEW

The Overview and Executive Summary sections were prepared so that a reader can get a quick grasp of the extent of the NMRC Decontamination and Decommissioning (D&D) Plan. Additional clarification is provided within the text of the D&D Plan. Collections of documents, floor diagrams, figures, photographs, and tables are provided as Appendices. An abbreviated version of the NMRC Historical Site Assessment (HSA) is provided as Appendix E. The NMRC D&D Plan and the NMRC HSA were prepared using the guidance provided in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM, ref 10.1) and other regulatory documents.

1.1 PURPOSE.

Conduct a final status decommissioning survey to determine the presence and extent of any radiological health hazards in the building used by NMRC at the National Naval Medical Center (NNMC) Bethesda campus and at the Rockville Annex. To take the necessary actions and verify that any residual radioactivity in the vacated NMRC buildings is in compliance with the NRC and State of Maryland guidelines for the decontamination of facilities prior to release for unrestricted use.

1.2 HISTORICAL REVIEW.

A review of the historical records and interviews with personnel who worked in the NMRC facilities were conducted by the NMRC Radiation Safety Officer, LCDR Schleurious L. Gaiter, MSC, USN, NMRC staff to conduct non-human, military medical research during 1942 to 1999 used the facilities at NNMC in Bethesda and the Rockville Annex. Sealed-source use of radioactive materials involved cobalt-60 and cesium-137. Unsealed radioactive materials included a variety of materials. The radionuclides of contaminant concern are Hydrogen-3, Carbon-14, Phosphorus-32, Phosphorus-33, Sulfur-35, Calcium-45, Chromium-51, Cobalt-57, Cobalt-60, Iodine-125, and Barium-133. Tables in Appendix E provide data on the historical use of radionuclides at NMRC. Table E-3 lists the radioisotopes used at NMRC during 1942 through 1999. Table E-4 (sorted by year of use and by isotope) provides a historical review of the use of the radioisotopes. Using the data provided in Tables E-3 and E-4, certain radionuclides that have been used at NMRC will not be

included in the list of radionuclides of concern because more than 10 half lives have elapsed since their last use at NMRC.

The isotopes that are not of contamination concern at NMRC (with year of last use, half life (HL), and approximate number of elapsed half lives) are:

Argon, Ar-41 (1992; HL = 1.83 hours; elapsed HL > 30,000);
Cerium, Ce-141 (1993; HL = 32.5 days; elapsed HL > 60);
Cesium, Cs-137 (sealed sources only and negative leak test results) (1999; HL = 30 years);
Iron, Fe-59 (1992; HL = 44.6 days; elapsed HL > 50);
Iodine, I-123 (1991; HL = 13 hours; elapsed HL > 5,300);
Iodine, I-131 (1991; HL = 8.1 days; elapsed HL > 360);
Indium, In-111 (1990; HL = 2.8 days; elapsed HL > 1,170);
Krypton, Kr-79 (1992; HL = 34.9 days; elapsed HL > 70);
Krypton, Kr-83m (1992; HL = 1.9 hours; elapsed HL > 32,200);
Krypton, Kr-85m (1992; HL = 4.4 hours; elapsed HL > 13,900);
Niobium, Nb-95 (1993; HL = 35 days; elapsed HL > 60);
Ruthenium, Ru-103 (1993; HL = 39.5 days; elapsed HL > 50);
Scandium, Sc-46 (1992; HL = 83.8 days; elapsed HL > 30);
Selenium, Se-75 (1991; HL = 119.8 days; elapsed HL > 20);
Tin, Sn-113 (1992; HL = 115 days; elapsed HL > 20);
Strontium, Sr-85 (1992; HL = 64 days; elapsed HL > 39);
Technetium, Tc-99m (1992; HL = 6.05 hours; elapsed HL > 10,000);
Xenon, Xe-127 (1992; HL = 36.4 days; elapsed HL > 70);
Xenon, Xe-133 (1992; HL = 5.3 days; elapsed HL > 480); and,
Ytterbium, Yb-169 (1986; HL = 31.97 days; elapsed HL > 148).

For a survey unit, any detected radioactivity of nuclides of concern will be considered as residual contamination and not as background radiation; exceptions will be noted. All survey units with residual contamination measurements above the NMRC radionuclide-specific investigational level (a small fraction of the regulatory limit) will be subjected to remedial actions and additional surveys. Radioactive material use in NMRC facilities will cease in December 1999. All leak test results (1981-1999) for the sealed-source, cesium-137 irradiators revealed no residual contamination. Except for possible residual cobalt-60 contamination in and around building 150, it is anticipated that no significant quantity of residual radioactive contamination

above background levels will be found during the final status surveys. Reviews of the records for spills indicate that the only concern involves the 1962 cobalt-60 contamination event at building 150. Surveys will be performed and maintained to clear materials removed from the NMRC rooms and buildings. Of the 603 survey sites considered for final status surveys, 165 were designated as Impacted Class 3. One unit, building 150, was classified as Impacted Class 2. Floors, walls, counter tops, drawers, and sink drains and traps will be surveyed. Because radioactive-material use during the last 10 years have involved the use of small quantities in liquid form or short-lived gases in hoods or workbench areas, only the lower two meters of the walls in Impacted Class 3 areas will be surveyed. In building 50, all wall and ceiling surfaces will be surveyed. Final status surveys will also be conducted on a random selection of the non-impacted survey units.

1.3 RADIATION SURVEY INSTRUMENTATION.

Based on the results of the historical review, it was determined that the NMRC facilities would be surveyed for potential beta and gamma emitting radionuclides. The historical review found only isolated use of a material containing depleted uranium in two laboratories in building 17. All portable instruments will be properly calibrated for the radionuclides of concern. Daily and periodic operational checks using check sources will be performed and documented. Background reference data will be documented. Blank smears will be counted on the liquid scintillation counters and gamma counters.

1.4 PLANNING PHASE

1.4.1 **Decision Statement.** To determine if all survey units satisfy the NRC release criteria for unrestricted use.

1.4.2 **Inputs to the Decision.** A historical site assessment indicated the radionuclides used, stored or disposed of in the survey units. Based on the radionuclides used in each location and the results of routine and periodic survey results, survey units were classified. Representative background measurements will be obtained from similar areas where it is known that there had been no unsealed radionuclide use.

1.4.3 **Boundaries of the Study.** The boundaries of the study is the two-story Rockville Annex building and the fifteen NMRC buildings on the NNMC Bethesda campus. The potential media include building surfaces and soil. Only the grounds surrounding building 150 will be evaluated for potential residual radioactive contamination.

1.4.4 **Decision Rule.** Mean concentration is defined as the average level of radioactivity within a survey unit. This mean concentration is determined by summing the sample data and dividing by the number of samples. Investigational levels are radionuclide specific, locally derived and represent a small fraction of regulatory levels. If the mean concentration in the survey unit is less than the investigational level, then the survey unit will be in compliance with the release criteria. If the difference between the mean concentration in the survey unit and the mean concentration in the reference area is less than the investigational level, then the survey unit is in compliance with the release criteria. If the average level of residual radioactivity within the survey unit exceeds the investigational level (a fraction of the regulatory limit), or if small areas within the survey unit with elevated residual activity exceed the investigational level then the survey unit does not meet the release criteria and will require further remediation before it is in compliance with the release criteria.

1.4.5 **Decision Errors.** The lower bound for the sample distribution is the background level and the upper bound on the sample distribution is the DCGL. DCGLs are radionuclide-specific **D**erived **C**oncentration **G**uideline **L**evels that relate residual radioactivity levels to the regulatory dose-based, release criteria.

1.4.6 **Survey Design.** The design goal will be to minimize the number of false positive measurements, or to release a survey unit containing residual radioactivity above the DCGL (Type I error). NRC screening values will be used as DCGL values. The design goal will also attempt to minimize the number of false negative measurements (Type II error) that would add cost and time to the decommissioning effort. The null hypothesis for this

survey is that the survey unit exceeds the release criteria. The design goal for the relative shift (Δ/σ) value will be to achieve a relative shift of 2 for Class 2 and 3 survey units. The selected values for a Type I decision error (α) and a Type II decision error (β) are equal to 0.025. The calculated sample size (number of survey measurements) using the above design criteria is 21 per survey unit. This sample size value, also available in MARSSIM Table 5.5 (ref 10.1), includes additional measurements to account for loss data or inaccessible survey locations.

For a relative shift (Δ/σ) of 2 and α and β values equal to 0.05, the sample size would be 15.

For a relative shift (Δ/σ) of 3 and α and β values equal to 0.025, the sample size would be 20.

For a relative shift (Δ/σ) of 3 and α and β values equal to 0.05, the sample size would be 14.

1.5 **IMPLEMENTATION PHASE.** The data collected will be reviewed daily to ensure that the daily quality objectives are met and that the data is consistent over the course of the survey. Both random and systematic sampling designs will be incorporated into this survey based on survey unit classification. The schedule for decommissioning is approximately 7 months beginning October 1999. The decommissioning effort for the NMRC sites will not consider using passive controls for releasing a survey unit.

1.6 **RADIATION SURVEY TECHNIQUES.** A rectangular grid system using an alphanumeric designator system will be used. The floor and walls will be divided into grids of approximately one-meter squares. If a grid's survey readings are above the trigger or investigational limits (approximately 2 to 3 times background levels), the area will be promptly decontaminated and re-evaluated. Subsequent measurements of potentially contaminated areas will be made by further dividing the grid into 9 smaller squares. The areas within an impacted site to be surveyed include the floor, lower walls up to 2 meters from the floor, counter tops, drawers, and sink drains and traps. Surveyors will also take judgmental samples in impacted areas

where they believe residual contamination may exist. The results of meter surveys, background measurements, and source-check measurements will be properly recorded. Liquid scintillation and gamma counting for each sample will be for the energy range of concern and for 5-minute cycles.

1.7 **ASSESSMENT PHASE.** The assessment phase includes verification and validation of the survey data and an assessment of the quality of the data to ensure that the data meet the objectives of the survey.

1.7.1 **Data Verification.** The performance of tasks by personnel will be conducted according to the D&D Standard Operating Procedures (SOPs), and will be assessed during inspections and surveillance. The performance of equipment will be monitored daily using control charts.

1.7.2 **Data Validation.** The data qualifier codes that will be used in this survey report are:

- <MDC. The concentration of the radionuclide of interest was below the minimum detectable concentration (MDC). The survey results will also be reported.

- J. The associated value was modified, adjusted or an estimated quantity. This qualifier may be used to identify results based on surrogate measurements or gross activity measurements. The implication is that the estimate may be imprecise or inaccurate, and may be inappropriate for statistical evaluations. The potential uncertainty associated with this qualifier will be included with the results.

- R. The associated value was determined to be an outlier and is excluded in statistical evaluations.

- F. In a Class 2 survey unit, the value exceeds the predetermined investigation level and is flagged for further study.

1.7.3 **Preliminary Data Review.** The survey data from the field and laboratory measurements will be converted to DCGL units. Basic statistical quantities that will be calculated for

each data set are the mean, standard deviation, and median values. Statistical plots and graphs may also be prepared.

1.7.4 **Final Status Survey Report.** The final status survey report will include all survey results, background readings, check-source evaluations, calculations, procedures, problems/deviations from plans, recommendations for survey-site status, and other pertinent information. Periodic progress reports will be provided to management and the Navy Environmental Health Center.

2.0 EXECUTIVE SUMMARY

This document, the NMRC Radiological Decontamination and Decommissioning (D&D) Plan (August 1999, Revision Number 1), was prepared in support of NMRC's decommissioning efforts. This D&D Plan describes the actions and level of effort that NMRC will undertake to demonstrate to regulatory authorities that the vacated NMRC Bethesda and NMRC Rockville Annex sites meet the release criteria for unrestricted future use. To achieve this objective, guidance provided in MARSSIM (ref 10.1) and other regulatory documents (refs 10.4 through 10.14) will be followed and parameters chosen to meet or exceed the release criteria.

The NMRC Historical Site Assessment (HSA) (ref 10.2) will serve as the primary document for information regarding potential contaminants, potential contaminated areas, and potential contaminated media. An abbreviated version of the HSA is provided in this document as Appendix E. A primary source of information for NMRC's HSA was the NMRI Environmental Site Assessment of 1997 (ref 10.3). Photographic reproductions of current NMRC buildings are provided in Appendix C as **Photographs P-01 through P-12.** The abbreviated HSA included in this D&D Plan includes an extensive collection of figures, floor diagrams and tables.

Lists of abbreviations and definition of terms are provided in Sections 9.1 and 9.2, respectively, in this report. Building floor and area plans are provided in Appendix E in the Floor Diagram section.

NMRC's history of military medical research during 1942 to 1999 at the Bethesda site and during 1986 to 1999 at the NMRC Rockville Annex site included the use of sealed and unsealed radioactive materials. **Tables E-01 through E-04 in Appendix E** provide information regarding the locations of use of licensed (radioactive) materials at NMRC during 1942 through 1999. NMRC's sealed-source use involved the use of cobalt-60 during the 1950's and 1960's and the use of cesium-137 in gamma irradiators in the 1980's and 1990's. Residual cobalt-60 contaminants are suspected in and around the remnants of building 150. Required, semi-annual leak test results for the gamma irradiators provide assurance that there is low probability of residual cesium-137 contamination at the NMRC sites. The use of unsealed radioactive materials in more than

150 laboratories, rooms, and areas dictate that some level of decommissioning is required for each area of radioactive material use to ensure and document compliance with the NRC's release criteria for unrestricted use.

The NMRC D&D Supervisor will be the NMRC Radiation Safety Officer (RSO). Currently, the NMRC RSO is LCDR Schleurious L. Gaiter, Medical Service Corps, U.S. Navy. LCDR Gaiter has served as the NMRC RSO since March 1995. **Document D-01** provides training and experience information for the NMRC D&D Supervisor.

Provided in **Table E-05 in Appendix E** are the contaminants of concern: Hydrogen-3, Carbon-14, Phosphorus-32, Phosphorus-33, Sulfur-35, Calcium-45, Chromium-51, Cobalt-57, Cobalt-60, Iodine-125, and Barium-133.

Document D-02 provides a copy of the current NMRC Navy Radioactive Material Permit. **Documents D-03, D-04 and D-05** provide copies of historical documents. **Document D-03** is a copy of NMRC's NRC Materials License for its gamma irradiators. **Document D-04** is a copy of the NRC Materials License for NNMC during the 1980's. Before 1987, the NNMC Radiation Safety Office oversaw most of NMRC's licensed- materials use. **Document D-05** is a copy of the Atomic Energy Commission's (AEC) Byproduct Material License for NMRC's Building 150 Cobalt-60 Irradiator facility. This AEC license expired in 1963.

NMRC's decommissioning efforts will focus on survey sites in the existing NMRC buildings. In the 15 buildings at the Bethesda and Rockville sites, 603 rooms and areas (defined in this report as survey units) were evaluated to determine the level of required radiological decommissioning efforts. Of the total of 603 survey units, 438 (about 73 %) have been classified as non-impacted and will require no decommissioning efforts. The remaining 165 survey units (about 27 %) have been classified as impacted areas and will require examination for potential radioactive contaminants. **Table E-06 in Appendix E** summarizes the locations and periods of radioactive materials use in NMRC buildings. Survey monitoring data for these locations and periods were evaluated for the potential of residual contamination. **Tables E-07 through E-10 in Appendix E** provide lists of all NMRC buildings and survey sites, Impacted Classes 2 and 3 Areas, and Non-impacted Areas.

The examination for potential radioactive contaminants will include surveys, direct measurements, sampling and analysis, and scanning with appropriate instruments and equipment. The examinations may include: (1) all accessible floor space, (2) the lower half of all walls extending up approximately two meters from the floor, and (3) other selected locations. Among the 165 impacted areas, one survey unit was classified as Impacted Class 2 and the remaining survey units were classified as Impacted Class 3. There were no survey sites classified as Impacted Class 1, which is the classification requiring the most extensive decommissioning effort. A randomly selected percentage (numbering approximately 20 to 40 additional survey units) of NMRC common areas, restrooms, and non-impacted areas will be evaluated for potential radioactive contamination. After equipment, materials and wastes are removed from radioactive-materials-use areas, it is anticipated that the residual contamination will be confined to small areas within a small percentage of the survey units. Sink traps and floor drains will be likely areas for detection of elevated activity. **Table E-11 in Appendix E** provides the locations of sinks used for sewer disposal of liquid radioactive wastes. Those liquid wastes were disposed of in accordance with regulatory guidelines. If contamination is found, the survey unit's classification may be revised. Every reasonable effort will be taken to reduce the contamination to background levels, which would be well below the regulatory release criteria.

Significant resources are required to accomplish the actions necessary to satisfy the regulatory release criteria for unrestricted use. The estimated cost of performing the necessary decommissioning efforts is $200,000 to $628,000, depending on the availability of no-cost or low-cost resources (manpower, instruments, materials, services and equipment). **Table E-12 in Appendix E** summarizes cost estimates for NMRC's D&D actions. The anticipated 6- to 12-month decommissioning period will begin in October 1999 and could be concluded as early as April 2000. Decommissioning efforts at the NMRC Rockville Annex site must be completed before the lease expires in November 1999. NMRC Bethesda buildings when vacated in March or April 2000, will revert back to the ownership of NNMC. Future occupants of NMRC Bethesda buildings may include NNMC, the National Institutes of Health (NIH), the Stanley Foundation, and the Uniformed Services University of the Health Sciences (USUHS). Future uses of the NMRC buildings on the NNMC campus

will likely include offices, research laboratories, conference rooms, storage areas, and common areas.

3.0 REASON FOR DECOMMISSIONING.

Base Realignment and Closure (BRAC) legislation passed and signed into law in 1995 mandated that the Naval Medical Research Center (NMRC) relocate some of its programs and research efforts and cease operations at the National Naval Medical Center (NNMC) campus in Bethesda, Maryland by the end of October 1999. NMRC, the Navy's largest medical research facility, opened its doors in Bethesda on October 27, 1942 to conduct research, development, tests, and evaluations to enhance the health, safety, and readiness of Navy and Marine Corps personnel in the effective performance of peacetime and contingency missions. As a Tenant Command on the NNMC campus, NMRC has specific environmental obligations to fulfill before vacating the NNMC buildings it currently occupies. One of those obligations is the radiological decommissioning of those NNMC buildings.

NMRC will be among the first Navy commands to undergo a facility decommissioning using the Nuclear Regulatory Commission's (NRC) criteria for radiological release and the guidance provided in the MARSSIM (Multi-Agency Radiation Survey and Site Investigation Manual, NUREG-1575, December 1997, ref 10.1).

The majority of NMRC's current research activities will be co-located with the Walter Reed Army Institute of Research (WRAIR) at a new facility located at Forest Glen, Maryland. NMRC and WRAIR will be tenants of the Walter Reed Army Medical Center (WRAMC) on the Forest Glen Annex complex. **Table E-13 in Appendix E** summarizes the move schedule of NMRC and WRAIR laboratories and programs to the new facility.

4.0 GUIDANCE FOR DECOMMISSIONING EFFORTS

Regulatory guidance for conducting this decommissioning activity will be obtained from various sources.

The Environmental Protection Agency (EPA), the Nuclear Regulatory Commission (NRC), and the Department of Energy (DOE)

are responsible for the release of sites following cleanup. These responsibilities apply to facilities under the control of Federal agencies, such as the DOE and the Department of Defense (DOD), and to sites licensed by the NRC and its Agreement States. Some States have responsibilities for similar sites under their control.

The NRC requires the radiological decommissioning of sites, buildings and outdoor areas where licensed activities have ceased radiological operations, even while licensed activities continue to be conducted at other site locations. Use of licensed materials at NMRC buildings on the NNMC campus in Bethesda, Maryland and at a leased building in Rockville, Maryland will cease in 1999. These sites must be decommissioned and returned to their respective landlords for unrestricted use.

The detailed guidance provided in the Multi-Agency Survey and Site Investigation Manual (MARSSIM, ref 10.1) will be used for planning, implementing, and evaluating environmental and facility radiological surveys NMRC will conduct to demonstrate compliance with the current dose-based regulation (10CFR20.1402, ref 10.4). Other regulatory documents will be used to provide estimates for derived concentration guideline values, dose modeling, and other necessary information and techniques (refs 10.5 through 10.14). The submission of periodic progress reports will keep the Navy Environmental Health Center apprised of NMRC decommissioning activities.

The MARSSIM provides a nationally consistent consensus approach to conducting radiation surveys and investigations at potentially contaminated sites. The decommissioning that follows remediation will normally require a demonstration to the responsible Federal or State agency that the cleanup effort was successful and that the release criterion was met. In MARSSIM, this demonstration is given the name "final status survey." The MARSSIM assists site personnel and others in performing or assessing such a demonstration.

The demonstration of compliance with respect to conducting surveys is comprised of three interrelated parts:

- Translate: Translating the cleanup/release criteria (e.g., mSv/y, mrem/y, specific risk) into a corresponding derived contaminant concentration level (DCGL)) e.g., Bq/kg or

pCi/g in soil) through the use of environmental pathway modeling.

- Measure: Acquiring scientifically sound and defensible site-specific data on the levels and distribution of residual contamination, as well as levels and distribution of radionuclides present as background, by employing suitable field and/or laboratory measurement techniques.

- Decide: Determining that the data obtained from sampling dose support the assertion that the site meets the release criterion, within an acceptable degree of uncertainty, through application of a statistically based decision rule.

MARSSIM provides comprehensive guidance for the interrelated parts of Measure and Decide for contaminated soil and buildings. This guidance describes a performance-based approach for demonstrating compliance with a dose- or risk-based regulation.

In general, MARSSIM describes generally acceptable approaches for:

- Planning and designing scoping, characterization, remediation-support, and final surveys for sites with surface soil and building surface contamination
- Historical Site Assessment (HSA)
- Quality Assurance/Quality Control in data acquisition and analysis
- Conducting surveys
- Field and laboratory methods and instrumentation, and interfacing with radiation laboratories
- Statistical hypothesis testing, and the interpretation of statistical data
- Documentation

*Unique site-specific cases may arise that require a modified approach beyond what is presently described in MARSSIM.

5.0 CONCEPTUAL MODEL AND SITE INFORMATION

5.1 POTENTIAL CONTAMINANTS

Table E-05 provides a list of potential contaminants in NMRC buildings and was compiled using the radionuclide receipt and disposal logs and inventory records. The potential radioactive contaminants include Hydrogen-3 (tritium), Carbon-14, Phosphorus-32, Phosphorus-33, Sulfur-35, Calcium-45, Chromium-51, Cobalt-57, Cobalt-60, Iodine-125, and Barium-133.

Table E-05. POTENTIAL RADIOACTIVE CONTAMINANTS AT NMRC

BUILDING NUMBER	BUILDING DESCRIPTION OR USE	FLOOR AREA (SQUARE FOOTAGE)	OCCUPANCY OR YEARS OF RAM USE		ISOTOPES OF CONCERN
			Start	Stop	
17 17A 17B	Offices, Labs, Storage, Utility Machinery	84,398 (total)	1942 1946 1956	1999 1999 1999	H3, C14, P32, P33, S35, Ca45, Cr51, Co57, I125, Ba133
18	Animal Facility, Model shops, Offices, Labs, Storage	14,300	1942	1999	H3, C14, P32, S35, Cr51
21	Animal Facility, Offices, Labs, Storage	35,828	1946	1999	H3, C14, P32, S35, Cr51, Co57, I125
28	Machine Shop, Offices, Labs, Storage	5,856	1952	1999	H3, C14 (highly unlikely)
29	Offices, Labs, Storage, X-ray Facility	630	1955	1999	H3, C14 (highly unlikely)
53	Diving Facility, Offices, Labs, Storage	35,000	1976	1999	H3, C14, P32, P33, S35, Ca45, Co57, I125, Ba133
59	Diving Facility	2,695	1989	1999	None
69	H2/O2 Research Facility	805	1992	1999	None
79	Equipment Facility	1,195	1992	1999	None
139	Offices, Labs, Storage	4,343	1944	1999	H3, C14. I125 (very unlikely)
150	Cobalt-60 Irradiator	1100	1950	1963	Co-60
ANNEX	Offices, Labs, Storage	10,657	1986	1999	H3, C14, P32, S35, Cr51

5.2 POTENTIAL CONTAMINATED AREAS

5.2.1 PREVIOUS RADIOLOGICAL SURVEY RESULTS.

All available NMRC daily, weekly, monthly, and quarterly wipe test and survey monitoring results (1979-1999) were reviewed for evidence of residual contamination in NMRC sites. Incident and spills records were also reviewed. A significant spill involving phosphorus-32 (P-32) occurred at the NMRC Rockville Annex in October 1993. No residual radioactivity remains because of the 1993 spill. More than 100 half lives for P-32 have elapsed since that incident. There have been no other incidents of radioactive material spills at the Rockville Annex site. There have been no significant spills or incidents involving radioactive materials at NMRC Bethesda since the 1962 event involving cobalt-60 at and around NMRC building 150. NMRC decommissioning efforts will include final surveys for the Building 150 site and surrounding grounds. With the possible exception of the building 150 site, previous survey data for NMRC sites indicate that there is no reasonable expectation to find residual radioactivity that greatly exceeds background levels. It is anticipated that no NMRC survey unit will have an average residual radioactivity level that exceeds unrestricted-release-criteria guideline values. The NMRC survey locations selected for investigative (scoping) surveys are all sinks and traps and the building and grounds of Building 150. If contamination is found during the course of decommissioning NMRC buildings, characterization surveys, remedial actions, and remedial action surveys will be completed before the final surveys for these sites are initiated.

After review of historical radiological survey monitoring data, NMRC survey units were classified regarding the potential for residual radioactive contamination. **Tables E-07 and E-08 in Appendix E** provide lists of all NMRC buildings and survey sites.

5.2.2 IMPACTED AREAS - KNOWN AND POTENTIAL.

Impacted areas have some potential for residual contamination. Impacted areas are further divided into three classifications. **Tables E-09 and E-10 in Appendix E** provide lists of Impacted Classes 2 and 3 Areas and Non-impacted Areas.

5.2.2.1 **CLASS 1 AREAS.** Class 1 areas are impacted areas that, prior to remediation, are expected to have concentrations of residual radioactivity that exceed the $DCGL_W$ ($DCGL_W$ is defined in MARSSIM). NMRC characterized none of its survey sites as Class 1.

5.2.2.2 **CLASS 2 AREAS.** Class 2 areas are impacted areas that, prior to remediation, are not likely to have concentrations of residual activity that exceed the $DCGL_W$. One of NMRC's survey units has been classified as Impacted Class 2. This survey unit, the ground floor of building 150, was the site for a cobalt-60 contamination event that took place in the early 1960's. **Table E-09** lists Impacted Class 2 and 3 survey units.

5.2.2.3 **CLASS 3 AREAS.** Class 3 areas are impacted that have a low probability of containing residual radioactivity. Of the 154 NMRC survey units that were classified as impacted, all except one was classified as Impacted Class 3. These Impacted Class 3 sites consist of the grounds surrounding building 150 and rooms and laboratories in which radioactive materials were used or stored. **Table E-09** lists Impacted Class 2 and 3 survey units.

5.2.3 **NON-IMPACTED AREAS.** Non-impacted areas have no reasonable potential for residual contamination. **Table E-10** lists NMRC Non-impacted Areas. These non-impacted areas were offices, common areas, and other non-radioactive-material-use areas.

5.3 **POTENTIAL CONTAMINATED MEDIA.** The potential contaminated media are building surfaces and soil.

5.4 CONCEPTUAL MODEL FOR DECOMMISSIONING

For the convenience of scheduling necessary radiological activities and to maximize the use of available resources, NMRC's Decontamination and Decommissioning (D&D) Plan has been divided into four distinct phases. These phases may be completed serially or concurrently.

The NMRC D&D Supervisor will be the NMRC Radiation Safety Officer (RSO). Currently, the NMRC RSO is LCDR Schleurious L. Gaiter, Medical Service Corps, U.S. Navy. LCDR Gaiter has served as the NMRC RSO since March 1995. Document D-01 provides training and experience information for the NMRC D&D Supervisor.

Appendix A, Conceptual Model and Site Diagrams, provides information and diagrams of the NMRC site on the NNMC Bethesda campus. Because only one isolated building is involved, no diagram is provided depicting the NMRC Rockville Annex site. A photograph of the Rockville Annex site is included in this section. **Floor Diagrams FD-01 through FD-38** provide floor and area plans for the NMRC Bethesda and NMRC Rockville Annex sites.

Table E-14 provides a summary of the four phases depicted in the Conceptual Model Diagram in Appendix A. This plan calls for D&D actions to be conducted during the period October 1999 through April 2000 at the NMRC Bethesda and NMRC Rockville Annex sites.

The examination for potential radioactive contaminants will include surveys, direct measurements, sampling and analysis, and scanning with appropriate instruments and equipment. The survey-unit examinations may include: (1) all accessible floor space, (2) the lower half of all walls extending up approximately two meters from the floor, and (3) other selected locations. Among the 165 impacted areas, one survey unit was classified as Impacted Class 2 and the remaining survey units were classified as Impacted Class 3. There were no survey sites classified as Impacted Class 1, which is the classification requiring the most extensive decommissioning effort. A randomly selected percentage (numbering approximately 20 to 40 additional survey units) of NMRC common areas, restrooms, and non-impacted areas will be evaluated for potential radioactive contamination. After equipment, materials and wastes are removed from radioactive-materials-use areas, it is anticipated that the

residual contamination will be confined to small areas within a small percentage of the survey units. Sink traps and floor drains will be likely areas for detection of elevated activity.

TABLE E-14. NMRC D&D CONCEPTUAL MODEL INFORMATION

NMRC D&D Phase	Buildings	Number of Survey Units		Floor Area (square feet)	
		Non-impacted	Class 2 or 3	Non-impacted	Class 2 or 3
1	17, 18, 21, 22, 29, 49, 79, 139, 146, 174, 219	334	117	63,509	32,217
2	Rockville Annex	31	35	4,617	7,595
3	150	0	2	0	2,380
4	28, 53, 59, 69	73	11	21,812	6,902
Totals		438	165	89,938	49,094

6.0 DECOMMISSIONING ACTIVITIES

6.1 **OBJECTIVES.** In order to release certain NRMC sites, the primary objective of this decommissioning effort is to demonstrate that the sites are suitable for unrestricted release in accordance with the criteria for decommissioning in Subpart E, "Radiological Criteria for License Termination," of 10 CFR Part 20, "Standards of Protection Against Radiation." (ref 10.4)

To achieve this objective, guidance provided in MARSSIM and other regulatory documents will be followed. Parameters will be chosen to ensure that following objectives are met:

(1) Identification of the premises and radiological operations;

(2) Demonstration that reasonable efforts are planned to reduce/eliminate residual contamination to as low as practicable;

(3) Documentation of decontamination and decommissioning plan and survey standard operating procedures;

(4) Preparation of the Final Status Survey Report.

6.2 **COST ESTIMATES FOR DECOMMISSIONING ACTIVITIES.** Cost estimates have been prepared to approximate the cost for various decommissioning activities, including labor, materials, equipment, services, shipping expenses, and other related expenses. Estimates have been received regarding some of NMRC's planned decommissioning efforts. In addition, an estimate has been received that provides equipment and instrument prices. One vendor quoted a labor rate of $55.00 per hour for technician support working under NMRC supervision. In summary, estimates of NMRC's radiological decontamination and decommissioning efforts range from $200,000 to $628,000. The actual cost will depend upon the availability of no-cost or low-cost manpower, equipment and other essential resources. **Table E-12 in Appendix E** summarizes D&D cost-estimate information.

6.3 PRE-SURVEY ACTIVITIES

6.3.1 RELEASE LIMITS AND DOSE PATHWAY MODELING

The release limits, which include fixed and loose surface contamination, to satisfy the NRC's criteria for unrestricted release of the survey sites will be based upon the NRC guideline screening values. Dose modeling, if necessary, will be performed using the NRC generic parameters. Site-specific parameters should not be necessary and will not be developed.

6.3.2 CRITERIA FOR LICENSE TERMINATION (NUREG-1549)

The criteria for releasing a site for unrestricted use is listed here; the criteria for releasing a site for

unrestricted and restricted use are summarized in **Table T-1.**

Subpart E, 10 CFR 20, paragraph 20.1402 - Criteria for unrestricted use - a site is considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a Total Effective Dose Equivalent (TEDE) to an average member of the critical group that does not exceed 25 mrem/yr, including that from groundwater sources of drinking water, and the residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA).

Table T-1. Summary of 10 CFR Part 20 Subpart E

	Unrestricted Use	**Restricted Release**	
Dose Criterion	25 mrem TEDE per year peak annual dose to the average member of the critical group	25 mrem TEDE per year peak annual dose to the average member of the critical group while controls are in place	100 mrem or 500 mrem TEDE per year peak annual dose to the average member of the critical group upon failure of controls
Time Frame	1000 years	1000 years	1000 years
Other Requirements	ALARA	ALARA, financial assurance, public participation	ALARA, financial assurance, public participation

6.3.3 **DOSE MODELING (NUREG-1549).** Dose modeling is used to estimate the total effective dose equivalent (TEDE) to an average member of the critical group from residual radioactivity. The critical group means the group of individuals reasonably expected to receive the greatest exposure to residual radioactivity for any applicable set of circumstances. The minimum justification for the use of the default models, scenarios, and parameters would consist

of a statement that no conditions exist at the site, outside those incorporated in the default scenarios and modeling assumptions, that would cause the calculated dose to increase. Examples of site-specific features that may require modeling beyond defaults include (but are not limited to) known groundwater contamination, large quantities of contaminated material (such as slag piles), or buried wastes. It is anticipated that dose modeling will not be required during NMRC's decommissioning efforts because survey data will be compared directly with regulatory screening values. These screening values are dose-based and were derived using default parameters.

6.3.4 DERIVED CONCENTRATION GUIDELINE LEVELS (DCGLs)

6.3.4.1 **DCGLs.** The concentration of residual radioactivity distinguishable from background that, if distributed uniformly throughout a survey unit, would result in a total effective dose equivalent (TEDE) of 25 millirems per year to an average member of the critical group is called the derived concentration guideline (DCGL). Residual levels of radioactive material that correspond to allowable radiation dose standards are calculated (derived) by analysis of various pathways and scenarios (direct radiation, inhalation, ingestion, etc.) through which exposures occur. These derived levels, known as derived concentration guideline levels (DCGLs), usually refer to average levels of radiation or radioactivity above appropriate background levels.

For NMRC, as is the case for the majority of MARSSIM users, the applicable DCGLs were obtained using regulatory agency guidance (screening values) based on default values. Other users may elect to perform site-specific pathway modeling to determine DCGLs. In both cases, the DCGL is based on the spatial distribution of the contaminant, and each derivation can produce different values depending on the specific radionuclide distribution and pathway modeling. Because no contamination is anticipated and because residual activity levels, when found, will be

reduced to background levels, NMRC will compare the DCGLs directly to survey data to demonstrate compliance. It is understood that this simple approach may not be possible when more than one radionuclide is present (in the contaminated area). Residual radioactivity limits for the radionuclides present at the site have been selected. NMRC action limits will be equivalent to a small fraction of D&D Screening values at 90^{th} percentile of the output dose distribution and are set such that the NRC release criteria will be satisfied. **Table E-15 in Appendix E** provides the NRC D&D Screening Values for NMRC isotopes of concern, Action Plan values, and NMRC's residual radioactivity limits. The screening values provided in **Table E-15 in Appendix E** will serve as the DCGLs for NMRC's D&D final-status-survey data analysis. Procedures provided in the MARSSIM will be used if multiple radionuclides are present.

6.3.4.2 DECISION METHODS FOR DOSE ASSESSMENT TO COMPLY WITH RADIOLOGICAL CRITERIA FOR LICENSE TERMINATION (NUREG-1549, Abstract)

The simplest method for calculating dose, generic screening, uses models and default parameters that the NRC developed for compliance screening calculations. The generic models and default parameters are intended to estimate the upper range of the dose that an individual could receive and are expected to overestimate the dose for most sites. The purpose of generic screening is to allow the licensee a simple and cost-effective method to demonstrate compliance with NRC regulations using a minimum amount of site-specific information. Such a screening approach is based on reasonably conservative assumptions since it must provide a reasonable level of assurance and must be applicable to a wide range of licensees, radionuclides, and processes. As such, it is expected to be appropriate for NRC licensees who have relatively simple decommissioning situations. The calculated value under generic screening conditions is simply a marker used to demonstrate compliance and is not intended to be a realistic dose estimate. Generic

screening may not be appropriate for licensees who have complex mixtures of radionuclides, unusual or unique decommissioning situations, or where the use of very conservative assumptions would result in unwarranted costs or inefficient and illogical remediation requirements.

In generic screening, the licensee need only provide site-specific final status survey results that are compared with the generic DCGL. If compliance can be demonstrated by using screening models and parameter values, progression to more site-specific analysis is unnecessary. **Table E-16 in Appendix E** (MARSSIM, Roadmap Table 4) provides guidelines for interpreting sample measurements when no reference area is required. Table 4 in MARSSIM also provides, but is not shown in Table E-16, guidelines for interpreting results when the radionuclide is present in background or when radionuclide non-specific (gross) measurements are made.

6.3.5 **PRE-SURVEY SAFETY ACTIONS**

Pre-survey walk-through inspections will be conducted to identify safety concerns before survey activities begin. Pre-survey safety concerns will be identified, addressed and/or corrected before the designated sites are surveyed.

6.3.6 **BACKGROUND/BASELINE LEVELS**

NMRC's primary contaminants of interest (H-3, C-14, P-32, P-33, S-35, Ca-45, Cr-51, Co-57, Co-60, I-125 and Ba-133) do not occur in background at the survey sites, or the background levels are small fractions of the radionuclide-specific $DCGL_w$ values. Therefore, the survey unit radiological conditions will be compared directly to the specified DCGL. Although unnecessary, reference area background surveys will be conducted. The reference area background survey data will be included in the final status survey report.

From the vicinity of a survey site or group of survey sites, background survey-meter readings will be recorded, and background samples will be collected, analyzed and documented.

NEED FOR BACKGROUND REFERENCE AREAS (NUREG-1549). Background reference areas are not needed when radionuclide-specific measurements will be used to measure concentrations of a radionuclide that is not present in background. Background reference areas are needed for the MARSSIM method if (1) the residual radioactivity contains a radionuclide that occurs in background or (2) the sample measurements to be made are not radionuclide-specific. Multiple reference areas may be used if reference areas have significantly different background levels because of the variability in background between areas. Other references on this topic include MARSSIM (ref 10.1) and NUREG-1505 (ref 10.7).

6.3.7 **SURVEY UNITS**

6.3.7.1 A survey unit is defined as a physical area consisting of structures or land areas of specified size and shape for which a separate decision will be made as to whether or not that area exceeds the release criterion. The survey unit is the primary entity for demonstrating compliance with the release criteria.

Per MARSSIM, survey units should be limited in size based on classification, exposure pathway modeling assumptions, and site-specific conditions. The suggested areas for survey units are provided in **Table T-2** as follows:

Table T-2. Suggested Areas for Survey Units (MARSSIM, Roadmap Table 1)

CLASSIFICATION		SUGGESTED AREA
Class 1	Structures	Up to 100 m^2 floor area
	Land Areas	Up to 2,000 m^2
Class 2	Structures	100 to 1,000 m^2
	Land Areas	2,000 to 10,000 m^2
Class 3	Structures	No limit
	Land Areas	No limit

A NMRC survey unit will be defined as a room or other discrete area. Every room in every NMRC building was first examined for consideration as a survey unit. After review of current and historical survey monitoring results and licensed-material use, NMRC's survey units were classified as either Impacted Class 2 or Impacted Class 3. No NMRC survey unit was classified as Class 1.

The grounds surrounding and immediate adjacent to Building 150 will be treated as one Class 3 survey unit. The Building 150 structure will be treated as one Class-2 survey unit.

All other NMRC laboratories and known licensed-materials-use areas were classified as Class 3 survey units.

Offices, hallways, rest rooms, and other common non-license-material-use areas will be treated as Non-impacted areas. As a QA/QC measure, a random selection of these non-impacted areas will receive the same level of survey effort as impacted class 3 areas.

6.3.7.2 **SELECTION AND SIZE OF SURVEY UNITS (NUREG-1549)**

The licensee should divide the impacted area into survey units based on the "classifications". A survey unit is a portion of a building or site that is surveyed, evaluated, and released as a single unit. The entire unit should be given the same area classification. Section 4.6 of the MARSSIM (ref 10.1) contains a method acceptable for dividing impacted areas into survey units. The important features of this method are summarized here:

For buildings, it is normally appropriate to designate each separate room as either 1 or 2 survey units (e.g., floors with the lower half of walls and upper half of walls with ceiling) based on the pattern of potential of residual radioactivity. It is generally not appropriate to divide rooms of normal size (100 m^2 floor area or less) into more than two survey units because the dose modeling is based on the room being considered as a single unit. However, very large spaces such as warehouses may be divided into multiple survey units.

For soil, survey units should be areas with similar operational history or similar potential for residual radioactivity to the extent practical. Survey units should be formed from areas with the same classification to the extent practical, but if areas with more than one class are combined into one survey unit, the entire survey unit should be given the more restrictive classification. Survey units should have relatively compact shapes. Suggested survey-unit areas from MARSSIM are given in Table T-2.

6.4 **QUALITY ASSURANCE AND QUALITY CONTROL.** A Quality Control (QC) and Quality Assurance (QA) Program will be developed to ensure the security and integrity of the data. Maintenance and calibration of equipment will be key considerations. In addition, daily and weekly quality control checks for all monitoring equipment and operators will be

performed, analyzed and recorded. Periodic training will be provided to maintain a suitable and competent work force. Redundant survey efforts will be planned, completed and documented. Using this D&D Plan as a guide, the Quality Assurance Project Plan (QAPP) and D&D Standard Operating Procedures (SOPs) will be prepared for review before initiating decommissioning actions. Quality control procedures and the QAPP for ensuring the validity of survey results will be included in a D&D Standard Operating Procedures manual. These procedures and plan will ensure (1) properly calibrated instrumentation, (2) necessary replicate, reference and blank measurements, and (3) comparison of field measurement results to laboratory sample analyses.

6.4.1 DATA CONVERSION

The methods described in Chapter 6 of the MARSSIM will be used for converting survey data (surface activity, soil radionuclide concentration and exposure rates) to appropriate units for comparison to radiological criteria. For comparison of survey data to DCGLs, the survey data from field and laboratory measurements will be converted to DCGL units.

6.4.2 DATA VERIFICATION

Data verification will ensure that the requirements stated in our QAPP and SOPs are implemented as prescribed. Data verification means that deficiencies or problems that occur during implementation will be documented and reported. This also means that NMRC D&D efforts are assessed regularly with findings documented and reported to management. Corrective actions undertaken will be reviewed for adequacy and appropriateness and documented in response to findings. Data verification activities will be planned and documented in the QAPP. These assessments may include but are not limited to inspections, QC checks, surveillance, technical reviews, performance evaluations and audits.

To ensure that the conditions requiring corrective actions are identified and addressed promptly, data verification activities will be initiated as part of data collection during the implementation phase of the survey.

The performance of tasks by personnel will be compared to the procedures detailed in the SOPs and will be assessed using inspections, surveillance and audits. Self-assessments and independent assessments will be planned, scheduled and performed as part of the survey. Self-assessment also means that personnel performing work will be required document and report deficiencies or problems that they encounter to the D&D supervisor.

The performance of equipment such as radiation detectors or measurement systems such as an instrument or human operator will be monitored using control charts. Control charts will be used to record the results of quantitative QC checks such as background and daily calibration or performance checks. Control charts will be used to document instrument and measurement system performance on a daily or as-needed basis to identify conditions requiring real-time corrective actions. The use of control charts will be documented in SOPs. Because NMRC will own its survey monitoring equipment, the organization will benefit from the preparation and use of control charts.

Periodic technical reviews may be requested an independent-assessment measure.

SAMPLE TRACKING. In MARSSIM, sample tracking refers to the identification of samples, their location, and the individuals responsible for custody and transfer of custody. In the NMRC D&D SOP, the sample-tracking process will cover the entire process from collection of the samples and remains intact through the analysis and final holding or disposal.

6.4.3 DATA VALIDATION

Data validation activities ensure that the results of data collection activities support the objectives of the survey. Data verification compares the collected data with the investigational levels (action limits) or DCGLs that are documented in the D&D Plan and D&D SOPs. Data validation also compares the collected data to the Data Quality Objectives documented in the QAPP.

Qualified data are any data that have been modified or adjusted as part of a statistical or mathematical evaluation, data validation, or data verification operations. Data may be qualified or rejected as a result of data validation or data verification activities. Data qualifier codes or flags will be used to identify data that has been qualified. All schemes used will be fully explained in the QAPP and survey documentation. Data qualifier codes or flags provide in MARSSIM will be used.

Data validation will be defined by the six data descriptors defined in **Table T-3:** (1) Reports to Decision Maker, (2) Documentation, (3) Data Sources, (4) Analytical Method and Detection Limit, (5) Data review, and (6) Data Quality Indicators. Data collected will be required to meet performance objectives for each data descriptor. Deviations will be noted and necessary corrective actions performed. Corrective actions will be taken to improve data usability when performances fail to meet objectives.

Table T-3. Suggested Content or Consideration, Impact if not Met, And Corrective Actions for Data Descriptors

Data Descriptor	Suggested Content or Consideration	Impact if Not Met	Corrective Action
Reports to Decision Maker	• Site description • Survey design with measurement locations • Analytical methods and detection limit • Background radiation data • Results on per measurement basis, qualified for analytical limitations • Filed conditions for media and environment • Preliminary reports • Filed reports	• Unable to perform a quantitative radiation survey and site inspection	• Request missing information • Perform qualitative or semi-quantitative site investigation
Documentation	• Chain-of-custody records • SOPs • Field and Analytical records • Measurement results related to geographic location	• Unable to identify appropriate concentration for survey unit • Unable to have adequate assurance of measurement results	• Request that locations be identified • Resurveying or resampling • Correct deficiencies
Data Sources	• Historical data used meets Data Quality Objectives (DQOs)	• Potential for Type I and Type II decision errors • Lower confidence of data quality	• Resurveying, resampling, or reanalysis for unsuitable or questionable measurements
Analytical Method and Detection Limit	• Routine methods used to analyze radionuclides of potential concern	• Unquantified precision and accuracy • Potential for Type I and Type II decision errors	• Reanalysis • Resurveying, resampling, or reanalysis • Documented

Data Review	• Defined level of data review for all data	• Potential for Type I and Type II decision errors • Increased variability and bias due to analytical process, calculation errors, or transcription errors	• Perform data review
Data Quality Indicators	• Surveying and sampling variability identified for each radionuclide • QC measurements to identify and quantify precision and accuracy • Surveying, sampling, and analytical precision and accuracy quantified	• Unable to quantify levels for uncertainty • Potential for Type I and Type II decision errors	• Resurveying or resampling • Perform qualitative site investigation • Documented discussion of potential limitations

6.5 FIELD MEASUREMENT METHODS AND INSTRUMENTATION

6.5.1 **FIELD MEASUREMENTS.** Surveys for decommissioning will require the collection of two types of radiological data: (1) direct field measurements using portable instruments and (2) sample analyses using fixed laboratory equipment or systems. For either type of measurement, the selection and proper use of appropriate instruments will be the most critical factors in assuring that the survey accurately determines the radiological status of the site. Radiological instruments consist of two components – a radiation detector and the electronic equipment needed to display or record the radiation events. **Table T-4** provides typical measurement sensitivities for laboratory radiometric procedures (MARSSIM, Chapter 7).

When obtaining direct field measurements, the number of (radiation) events will be accumulated over a preset time period using a digital-scaling device. The resulting information from the scaling device is also events per unit time; however, the scaler provides a definite value whereas the ratemeter will vary with time. Using a digital-scaler device will not require the user to determine the average level on a ratemeter.

Instrument detection sensitivity will be verified and assured. The detection sensitivity of a measurement system refers to the statistically determined quantity of radioactive material or radiation that can be measured or detected at a pre-selected confidence level. This sensitivity is a factor of both the instrumentation and the technique or procedures being used. Typically, detection sensitivity has been defined as that level above which there is less than a 5% probability that radioactivity will be reported present when it is really absent (Type I error) or reported absent when it is really present (Type II error). Two terms used when referring to detection sensitivity are the lower limit of detection and the minimum detectable activity.

Table T-4. Typical Measurement Sensitivities for Laboratory Radiometric Procedures (MARSSIM, Chapter 7)

Sample Type	Radionuclides or Radiation Measured	Procedure	Approximate Measurement Sensitivity
Smears (filter paper)	Gross beta	Gas-flow proportional counter; 5-min count	10 dpm
		End window GM with scaler; 5-min count (unshielded detector)	80 dpm
	Low energy beta (H-3, C-14)	Liquid scintillation spectrometer; 5-min count	30 dpm
Soil Sediment	Co-60	Germanium detector (25% relative efficiency) with multi-channel analyzer; pulse height analyzer; 200-min count	0.04 - 0.1 Bq/g (1-3 pCi/g)
Water	Gross beta	Gas-flow proportional counter; 100-ml sample, 200-min count	0.04 Bq/L (1 pCi/L)
	Co-60	Germanium detector (25% relative efficiency) with multi-channel analyzer; pulse height analyzer; 3.5L sample, 16-hour count	0.4 Bq/L (10 pCi/L)
	H-3	Liquid scintillation spectrometer; 5-min count	100 Bq/L (300 pCi/L)

6.5.2 INSTRUMENTS, EQUIPMENT, MEASUREMENT AND SAMPLING TECHNIQUES

6.5.2.1 Instruments for alpha detection will not be required. Instrumentation and equipment will be selected such that radiation detection procedures (scanning, direct measurements, and sample analyses) can be completed for the radionuclides of interest.

6.5.2.2 For beta radiation detection, the following instruments and equipment will be used: (1) samples will be analyzed using standard procedures and calibrated liquid scintillation counters, (2) direct measurements will obtained using digital-scaler, gas proportional counter with appropriate detectors, and (3) scanning will be performed using appropriate Geiger-Mueller detectors with Pancake probes or digital-scaler, gas proportional counter with appropriate detectors.

6.5.2.3 For gamma radiation detection, the following instruments and equipment will be used: (1) samples will be analyzed using standard procedures and calibrated gamma counters; (2) direct measurements will obtained using digital-scaler, (5 cm by 5 cm) NaI(Tl) scintillator detectors with countrate meters, calibrated for the energies of interest; and (3) scanning will be performed using appropriate Geiger-Mueller detectors with appropriate probes.

6.5.2.4 Exposure rate measurements will be obtained using appropriate instrumentation.

6.5.2.5 A combination of two approaches will be used for scanning Class 3 areas. The two approaches include uniformly scanning for the radionuclides of interest and/or performing scans in areas with the greatest potential for residual contamination based on professional judgment and the objectives of the survey. The investigation level will be set at an elevated activity reading that exceeds 2 to 3 times the background readings.

6.5.2.6 Appropriate calibration check sources will be obtained with which to perform instrument background

and check-source (Quality Assurance and Quality Control) checks.

Instrument response (background and check source) is tested and recorded a minimum of once daily– prior to beginning the day's measurements– to assure continued acceptable operation. If the instrument response does not satisfy the established acceptable range, the instrument is removed from use until the reason for the deviation can be determined and resolved and acceptable response again demonstrated. If repair and/or recalibration are necessary, acceptable response ranges will be reestablished and documented.

6.6 SAMPLING AND PREPARATION FOR LABORATORY MEASUREMENTS

6.6.1 FIELD SAMPLE PREPARATION AND PRESERVATION

Proper sample preparation and preservation are essential part of any radioactivity-sampling program. The sampling objectives will be specified in the D&D Standard Operating Procedures (D&D SOP) before sampling activities begin. Precise records of sample collection and handling will be performed to ensure that data obtained from different locations or timeframes are correctly compared.

Soil and sediment samples will require no special field preparation or application of preservation techniques. Samples will be collected from randomly selected locations, labeled, packaged, tracked, and delivered to the selected counting laboratory for analyses.

According to MARSSIM, Chapter 7, field and preparation of building surfaces, including smear samples, is generally not required. Smear samples will be collected from randomly selected locations and other areas, labeled, packaged, tracked, and delivered to the on-site counting laboratory for analyses.

6.6.2 OTHER MEASUREMENTS AND SAMPLING LOCATIONS

In addition to building and land surface areas, there are numerous other locations where measurements and/or sampling will be performed. Examples include items of equipment and furnishings, building fixtures, drains, ducts, and piping. Many of these items or locations have both internal and external surfaces, requiring evaluation. Each such location classified as impacted will be scanned and individual measurements and/or sampling will be performed. Non-impacted locations will also be surveyed, but at lower frequencies, consistent with contamination potential and findings as the survey progresses.

6.7 **MILESTONE CHART FOR D & D ACTIVITIES.** Decommissioning efforts will be tracked using a milestone chart. Progress and other pertinent details regarding each survey unit will be depicted on the chart. This will also serve as a scheduling tool for clearing equipment and materials from a licensed-material-use area. **Table E-17 in Appendix E** provides a milestone chart that will be used for tracking the progress of D&D efforts.

6.8 **PROGRESS REPORTS.** In addition to the milestone chart for tracking the decommissioning progress of each survey unit, summaries regarding the overall progress of decommissioning efforts will be provided to NMRC management and NEHC. These progress reports may include such information as data reviews/results, problems encountered or anticipated, and anticipated final-survey completion dates.

6.9 **COORDINATE ACCESS TO SURVEY SITES.** To ensure that the NMRC Radiation Safety Office has ready access to all survey units, efforts will be initiated to obtain master keys and/or coordinate access to controlled areas.

7.0 DECONTAMINATION PROCEDURES

If contamination is identified in a survey unit, it will likely be a small area of elevated activity and not a case of uniform contamination over the floor and wall surfaces of the survey unit. Efforts will be taken and documented to remediate the small area of elevated activity to the background level when

possible and practical. Using the guidance, procedures, and checklists provided in the MARSSIM, characterization surveys, reclassification of survey areas, remedial actions, and remedial-action support surveys will be performed and documented, if necessary. **Table E-18 in Appendix E** summarizes the types of radiological surveys that will likely be completed as part of NMRC's D&D actions.

8.0 FINAL STATUS SURVEY

8.1 OVERVIEW

The guidance provided in MARSSIM, Section 5.5, Final Status Surveys, will be closely followed.

The final status survey will be performed to demonstrate that residual radioactivity in each survey unit satisfies the predetermined release criteria for unrestricted future use. The survey will provide data to demonstrate that all radiological conditions do not exceed the established DCGLs.

In demonstrating that the objective is met, the null hypothesis (Ho) tested is that residual contamination exceeds the release criterion; the alternate hypothesis (H_a) is that residual contamination meets the release criterion. Two statistical tests are used to evaluate data from final status surveys. For contaminants that are present in background, the Wilcoxon Rank Sum (WRS) test is used. When contaminants are not present in background, the Sign test is used.

Since contaminants are not present in background in significant amounts at NMRC, the Sign test will be used. Statistical parameters (α and β) will be chosen such that there is less than a 5% probability of Type I (false positive) error and Type II (false negative) error.

8.2 SURVEY PREPARATIONS

8.2.1 Residual radioactivity limits for the radionuclides present at the site have been selected. NMRC action limits or investigational levels will be equivalent to a small fraction of D&D Screening values at 90th percentile of the output dose distribution and is set such that the NRC release criteria will be satisfied. **Table E-15** provides the NRC D&D Screening Values for NMRC isotopes of concern (ref 10.13), Action Plan values, and NMRC's residual radioactivity limits. **Documents D-06 and D-07** provide copies of references 10.13 (NRC Screening Table) and 10.14 (Regulatory Guide 1.86). Guidance in **Table E-16** can be used to interpret the survey results.

Table E-15. Residual Radioactivity Values and Limits ($dpm/100\ cm^2$)

Radio-nuclide	**Emission** α= alpha β= beta γ= gamma	**NRC D&D Screening Values**[1] (equivalent to 25 mrem/y) (same as DCGLs)		**Action Plan Values**[2] (Reg. Guide 1.86 limits)	**NMRC Residual Radioactivity Action Limits** ($dpm/100\ cm^2$)
		90^{th} Percentile of the output dose distribution	**Mean of the output dose distribution**		
H-3	β	1.2E+08	1.9E+08	5,000	1,000
C-14	β	3.7E+06	5.6E+06	5,000	1,000
S-35	β	1.3E+07	2.4E+07	5,000	1,000
Co-60	$\beta\gamma$	7.1E+03	7.5E+03	5,000	1,000
I-125[2]	$\beta\gamma$			100	100
β, γ [2] emitters not α	$\beta\gamma$			5,000	1,000

Notes:

(1) Screening values ($dpm/100\ cm^2$) equivalent to 25 mrem/year. Behavioral parameters are set at the mean of the distribution of the assumed critical group. The Metabolic parameters are set at Standard Man or at the mean of the distribution for an average man. The physical parameters were derived as a set to result in a point dose estimate that would be at the percentile indicated of the output dose distribution, and would not exceed 100 mrem at 95% confidence.

(2) Regulatory Guide 1.86 limits ($dpm/100\ cm^2$); these limits are not explicitly dose-based.

Table E-16. Interpretation of Sample Measurements When No Reference Area Is Used (MARSSIM, Table 2.5)

SURVEY UNIT MEASUREMENT RESULTS	CONCLUSION
All concentrations are less that $DCGL_w$	Survey unit meets release criteria
Average concentration is greater than $DCGL_w$	Survey unit fails
Any concentration is greater than $DCGL_w$ and average concentration is less than $DCGL_w$	Conduct Sign test and elevated measurement comparison

8.2.2 The radionuclides of concern for each survey site have been identified. Each survey site has been classified as non-impacted or Class 2 or Class 3. **See Tables E-07 through E-10 in Appendix E.**

8.2.3 Representative reference (background) areas will be selected for the survey units. Reference areas will be selected from non-impacted areas and will be (1) free of contamination from site operations, (2) exhibit similar physical, chemical, and biological characteristics of the survey unit, and (3) have similar construction, but have no history of radioactive operations.

8.2.4 Survey instruments will be selected based upon the techniques to be employed (scanning, direct measurements, and sampling) and the radionuclides of concern. The selected instruments will be capable of detecting the contamination at 10-50% of the DCGLs.

8.2.5 The survey unit will be prepared before conducting the final survey by clearing and providing access to the areas to be surveyed.

8.2.6 Reference coordinate systems will be established and followed.

8.3 SURVEY DESIGN

8.3.1 Sample collection and analysis procedures will be specified in a D&D Standard Operating Procedures manual. All participants in conducting the final status survey will receive initial and periodic training.

8.3.2 The number of data points for statistical tests will be determined using the assumption that the radionuclides are not present in background. The Sign test will be used. The number of samples for the Class 2 and Class 3 areas will be the same because the same statistical values will be used (Type I error, $\alpha = 0.025$; Type II error, $\beta = 0.025$; and the relative shift, $\Delta/\sigma_s = 2$) will be used. The number of data points, N, is determined to be 21. Per MARSSIM, this N value adds an extra 20% to account for unusable data or uncertainty in the value of N.

For Type I and Type II errors to be 0.05 and $\Delta/\sigma_s = 2$, N = 15. Per MARSSIM, this N value adds an extra 20% to account for unusable data or uncertainty in the value of N.

For Type I and Type II errors to be 0.025 and $\Delta/\sigma_s = 3$, N = 20. Per MARSSIM, this N value adds an extra 20% to account for unusable data or uncertainty in the value of N.

For Type I and Type II errors to be 0.05 and $\Delta/\sigma_s = 3$, N = 14. Per MARSSIM, this N value adds an extra 20% to account for unusable data or uncertainty in the value of N.

The number of data points for each survey unit will be 21. MARSSIM procedures will be followed to conduct the final status survey for the one Class 2 area. Additional samples/measurements will be taken for Quality Control and to allow for possible loss of data. The additional data points will not be used when conducting statistical tests of survey data.

Table T-5 provides recommended survey coverage for structures and land areas (MARSSIM, table 5.9).

Table T-5. Recommended Survey Coverage For Structures And Land Areas

AREA CLASSIFICATION	STRUCTURES		LAND AREAS	
	Surface Scans	Surface Activity Measurements	Surface Scans	Soil Samples
Class 1	100%	Number of data points from statistical tests and additional measurements may be necessary for small areas of elevated activity	100%	Number of data points from statistical tests and additional measurements may be necessary for small areas of elevated
Class 2	10 to 100% (10 to 50% for upper walls and ceilings) Systematic and Judgmental	Number of data points from statistical tests	10 to 100% Systematic and Judgmental	Number of data points from statistical tests
Class 3	Judgmental	Number of data points from statistical tests	Judgmental	Number of data points from statistical tests

8.3.3 Sampling locations will utilize a rectangular grid system that uses a local landmark, such as doors in survey units.

Grid systems will be established for the survey sites to:

- Facilitate systematic selection of measuring/sampling locations,

- Provide a mechanism for referencing a measurement/sample back to a specific location so that the same survey point can be relocated, and

- Provide a convenient means for determining average activity levels.

The grid will consist of a system of intersecting lines, referenced to a fixed site location or benchmark. The grid lines will be arranged in a perpendicular pattern, dividing the survey location into squares or blocks or triangles of equal area. Grid patterns on horizontal surfaces will be identified numerically on one axis and alphabetically on the other axis or in distances in different compass directions from the grid origin. Grids on vertical surfaces include a third designator, indicating a position relative to floor or ground level.

Gridding will be limited to the floor and lower (up to 2 meters height) walls, unless there is a potential for upper wall and ceiling area contamination. Because radioactive-material use during the last 10 years have involved the use of small quantities in liquid form or short-lived gases in hoods or workbench areas, only the lower two meters of the walls in Impacted Class 3 areas will be surveyed. In building 50, all wall and ceiling surfaces will be surveyed. No airborne residual contamination is anticipated.

For surveys of structures and land areas, the basic grid system (distance between data points) for impacted areas will be calculated using MARSSIM guidance.

The survey starting location for each survey unit will be determined using a random number generator. For the Class 2 survey unit, a square grid pattern beginning from a randomly selected starting point will be superimposed on the building 150 floor, wall and ceiling plans. For the Class 3 survey units, the location of the 21 data points will be determined using lists of random numbers. MARSSIM procedures will be used to calculate the grid size (or distance between measurements). A random grid-location starting point will be chosen to initiate the class 2 survey.

- The total number of data points and/or spacing (frequency) of measurement/sampling will be determined using MARSSIM guidance.

8.3.4 Information on survey instrumentation and techniques will be maintained. Documentation requirements will be provided in a D&D Standard Operating Procedures manual.

8.3.5 Methods for data reduction and comparison of survey units to reference areas will be provided in a D&D Standard Operating Procedures manual.

8.3.6 Quality control procedures and the Quality Assurance Procedures Plan (QAPP) for ensuring the validity of survey results will be included in a D&D Standard Operating Procedures manual. These procedures and plan will ensure (1) properly calibrated instrumentation, (2) necessary replicate, reference and blank measurements, and (3) comparison of field measurement results to laboratory sample analyses.

8.4 CONDUCTING SURVEYS

8.4.1 The reference (background) area measurements and sampling will be performed and documented.

8.4.2 Final status survey activities will be conducted to include (1) performing surface scans of Class 2 and Class 3 areas and a percentage of non-impacted areas, (2) conducting surface activity measurements and sampling at previously selected sampling locations, and (3) conducting additional direct measurements and sampling at locations based on professional judgment.

8.4.3 Necessary investigation activities, including survey unit reclassification, remediation, and re-survey, will be performed and documented.

8.4.4 Measurement and sample locations will be documented; information will be provided on the measurement system MDC and measurement errors.

8.4.5 Observations, abnormalities, and deviations from the QAPP and standard operating procedures (SOPs) will be documented.

8.5 EVALUATING AND DOCUMENTATING SURVEY RESULTS

8.5.1 Data Quality Objectives will be reviewed.

8.5.2 Samples will be analyzed using the procedures detailed in the SOP. After data are converted to DCGL units, the process of comparing the results to the DCGLs, conditions and objectives begins. Individual measurements and sample concentrations will first be compared to DCGL levels for evidence of small areas of elevated activity and not to determine if reclassification is necessary. Additional data or additional remediation and resurvey may be necessary. Data will then be evaluated using statistical methods to determine if they exceed the release criterion.

8.5.3 If necessary, data reduction on survey results will be performed and procedures documented.

8.5.4 If necessary, assumptions of statistical tests will be verified. Per MARSSIM, Appendix B, "The results of the survey should be compared to derived concentration guideline levels (DCGLs) using an appropriate statistical test, such as Student's t test or Wilcoxon test. If all measurements are less than the $DCGL_w$, then statistics do not need to be addressed because the conclusions are obvious. If the mean of the measurements exceeds the $DCGL_w$, the survey unit obviously fails to demonstrate compliance and the statistics do not need to be addressed."

8.5.5 Survey results for each survey unit will be compared with NMRC residual radioactivity investigational levels or action levels. These action levels represent small fractions of DCGLs (NRC D&D Screening values). Elevated measurement comparisons will be conducted. If needed, statistical Sign tests will be conducted.

8.5.6 The final status survey report will be prepared. The report will include the standard operating procedures, quality assurance information and procedures, data, results, interpretations, deviations from standard procedures, and other applicable information.

8.5.7 The final status survey report will be submitted to NEHC or other approved source for independent review.

9. GLOSSARY OF TERMS, ACRONYMS AND ABBREVIATIONS

9.1 Acronyms and Abbreviations:

µCi	Micro-Curie
µR/hr	Micro-Roentgens per hour (exposure rate)
AFRRI	Armed Forces Radiobiology Research Institute
Annex	NMRC Rockville Annex Laboratories, Washington Avenue, Rockville, MD
BRAC	Base Realignment and Closure
BUMED	Bureau of Medicine and Surgery
CFR	Code of Federal Regulations
cpm	Counts per minute
D&D	decontamination and decommissioning
DOD	Department of Defense
DOT	Department of Transportation
dpm	Disintegrations per minute
ESA	Environmental Site Assessment
Gy	Gray, SI unit of absorbed dose, 1 Gy = 100 rads
Irradiators	Sealed-source, cesium-137 gamma irradiators
MDA	Minimum detectable activity
NEHC	Navy Environmental Health Center
Nicholson Building	NMRC Bone Marrow Research, Nicholson Building in Rockville, MD
NIH	National Institutes of Health
NMRC	Naval Medical Research Center
NMRI	Naval Medical Research Institute
NNMC	National Naval Medical Center
NRC	U. S. Nuclear Regulatory Commission
NRMP	NMRC's Navy Radioactive Materials Permit
NUREG	Nuclear Regulatory Guide
pCi/L	pico-curies per liter
R, R/hr	Roentgen (exposure), Roentgens per hour
Rad, Rad/hr	Rad (dose), Rads per hour (dose rate)
RAM	Radioactive materials
Rem, Rem/hr	Rem (dose equivalent), Rem per hour
SOP	Standard operating procedure
Sv	Sievert, SI unit of dose equivalent, 1 Sv = 100 rems
US	United States
USN	United States Navy
WSSC	Washington Suburban Sanitary Commission

9.2 Key Terms and Definitions (reference 10.1, MARSSIM)

α, Alpha	The specified maximum probability of a Type I error. In other words, the maximum probability of rejecting the null hypothesis when it is true. Alpha is also referred to as the size of the test. Alpha reflects the amount of evidence the decision-maker would like to see before abandoning the null hypothesis.
Area	A general term referring to any portion of a site, up to and including the entire site.
Background radiation	Radiation from cosmic sources, naturally occurring radioactive material, radon, and global fallout as it exists in the environment from testing of nuclear explosive devices or from nuclear accidents. Background radiation does not include radiation from source, byproduct, or special nuclear materials regulated by the Federal or State agency.
Becquerel (Bq)	The SI unit of radioactivity equivalent to one nuclear transformation per second.
β, Beta	The probability of a Type II error, i.e., the probability of accepting the null hypothesis when it is false. The complement of beta ($1-\beta$) is referred to as the power of the test.
Byproduct material	Licensed or radioactive material regulated by the NRC.
Class 1 areas	Impacted areas with the highest potential for contamination or insufficient evidence to support reclassification as class 2 or 3.
Class 2 areas	Impacted areas with low potential for delivering a dose above the release criterion and little or no potential for small areas of elevated activity.
Class 3 areas	Impacted areas with little or no potential for delivering a dose above the release criterion and little or no potential for small areas of elevated activity.
Classification	The act or result of separating areas or survey units into one of the three designated classes: Class 1 area, Class 2 area, or Class 3 area.
Cleanup standard	A numerical limit set by a regulatory agency as a requirement for releasing a site after cleanup.

Contamination	The presence of residual radioactivity in excess of levels which are acceptable for release of a site or facility for unrestricted use.
Curie	A unit of radioactivity equal to 37 billion becquerels.
DCGL, Derived Concentration Guideline Level	A derived, radionuclide -specific activity concentration within a survey unit corresponding to the release criterion. The DCGL is based on the spatial (uniform) distribution of the contaminant and hence is derived differently for the non-parametric statistical test ($DCGL_W$) and the elevated measurement comparison ($DCGL_{EMC}$). DCGLs are derived from activity/dose relationships through various exposure pathway scenarios.
Decommission	To remove (as a facility) safely from service and reduce residual radioactivity to a level that permits release of the property for unrestricted use and termination of the Nuclear Regulatory Commission license or Navy radioactive material permit.
Decommissioning	The process of removing a facility or site from operation, followed by decontamination, and license termination (or termination of authorization for operation) if appropriate.
Decontamination	The removal of radiological contaminants from persons, objects, or areas to within regulatory levels.
Direct measurement	Radioactivity measurement obtained by placing the detector near the surface or media being surveyed. An indication of the resulting radioactivity level is read out directly.
Final status survey	Measurements and sampling to describe the radiological conditions of a site, following completion of decontamination activities (if warranted) in preparation for release.
Impacted areas	Any area that is not classified as non-impacted. Areas with a possibility of containing residual radioactivity in excess of natural background or fallout levels.
Investigation level	A derived media-specific, radionuclide-specific concentration or activity level of radioactivity that is based on the regulatory

	release criteria and triggers a response that further investigation or action is necessary if exceeded
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual (DOE,DOD, EPA, NRC); provides for conducting decommissioning activities to satisfy regulatory release criteria.
Non-impacted areas	Areas where there is no reasonable possibility (extremely low probability) of residual contamination.
Non-parametric test	A test based on relatively few assumptions about the underlying probability distributions of the measurements. As a consequence, non-parametric tests are generally valid for a fairly broad class of distributions. The Wilcoxon Rank Sum test and the Sign test are examples of non-parametric tests.
Outlier	Measurements that are unusually large or small relative to the rest and therefore are suspect of misrepresenting the population from which they were collected.
Radioactive waste	Solid, liquid or gaseous material that contains radionuclides regulated by the NRC
Release criterion	A regulatory limit expressed in terms of dose or risk; compliance demonstration is simply a decision as to whether or not a survey unit meets the release criterion
Residual radioactivity	Radioactivity in structures, materials, soils, groundwater, and other media at a site resulting from activities under the cognizant organization's control.
Scanning	An evaluation technique performed by moving a detection device over a surface at a specified speed and distance above the surface to detect radiation.
Sign test	A non-parametric statistical test used to demonstrate compliance with the release criterion when the radionuclide of interest is not present in background and the distribution of the data is not symmetric.
Site	Any installation, facility, or discrete, physically separate parcel of land, or any building or structure or portion thereof, that

	is being considered for survey and investigation.
Survey	A systematic evaluation and documentation of radiological measurements with a correctly calibrated instrument or instruments that meet the sensitivity required by the objective of the evaluation.
Survey unit	A geographical area consisting of a room, hallway, structures or land areas of specified size and shape for which a separate decision will be made whether the unit attains the cleanup standard; are established to facilitate the survey process and the statistical analysis of the survey data.
Wilcoxon test	A non-parametric statistical test used to demonstrate compliance with the release criterion when the radionuclide of interest is present in background and the distribution of the data is not symmetric.

10.0 REFERENCES

10.1 **NUREG-1575**, MARSSIM, Multi-Agency Survey and Site Investigation Manual (December 1997).

10.2 **NMRC Historical Site Assessment**, Naval Medical Research Center (NMRC)(formerly NMRI), June 1999.

10.3 **ESA 1997**, Environmental Site Assessment, Naval Medical Research Institute (NMRI), by the Environmental Company, Inc., May 1998.

10.4 **10CFR20.1402**, Title 10, Code of Federal Regulations, Part 20 - Standards for Protection Against Radiation, Subpart E.

10.5 NUREG-1500, Working Draft Regulatory Guide on Release Criteria for Decommissioning: NRC's Staff Draft for comment, August 1994.

10.6 NUREG-1501, Background as a Residual Radioactivity Criterion for Decommissioning, Draft Report for Comment, August 1994.

10.7 NUREG-1505, A Non-parametric Statistical Methodology for Design and Analysis of Final Status Decommissioning Surveys.

10.8 NUREG-1507, Minimum Detectable Concentrations with Typical Radiation Survey Instruments for various Contaminants and Field Conditions, December 1997.

10.9 **NUREG-1549**, Decision Methods for Dose Assessment to Comply With Radiological Criteria for License Termination (Draft, July 1998).

10.10 **NUREG/CR-5512**, Residual radioactive Contamination from Decommissioning (Draft, April 1996).

10.G-1 **NUREG/CR-5849**, manual for Conducting Radiological Surveys in Support of License Termination, Draft for comment June 1992 (superseded by NUREG-1575, MARSSIM).

10.12 **Draft Regulatory Guide DG-4006**, Demonstrating Compliance With the radiological Criteria for License Termination (supersedes NUREG 1500), August 1998.

10.13 **NRC Nuclear Licensing Reports**, Volume 12, Number G-1, D&D Screening Values, November 1998

10.14 Nuclear Regulatory Commission Regulatory Guide 1.86 (circa 1974)

11.0 Appendices

A. Conceptual Model and Site Diagrams

B. Organizational Chart

C. Documents, Figures and Photographs

D. Tables

E. Abbreviated Historical Site Assessment (HSA) (Summary, Figures, Floor Diagrams, Tables)