GENERAL RADIOACTIVE MATERIAL (G-RAM) RADIOLOGICAL FINAL REPORT FOR DECOMMISSIONING CHARLESTON NAVAL BASE VOLUME I CNC CHARLESTON SC
4/1/1996
RADIOLOGICAL ENGINEERING DIVISION

GENERAL RADIOACTIVE MATERIAL (G-RAM) RADIOLOGICAL FINAL REPORT FOR THE DECOMMISSIONING OF NAVAL BASE CHARLESTON

(VOLUME I)

Prepared by
Radiological Engineering Division
Charleston Naval Shipyard
Charleston, South Carolina

April 1, 1996

GENERAL RADIOACTIVE MATERIAL (G-RAM)

RADIOLOGICAL FINAL REPORT

FOR THE DECOMMISSIONING OF

NAVAL BASE CHARLESTON

(VOLUME I)

Prepared by
Radiological Engineering Division
Charleston Naval Shipyard
Charleston, South Carolina
April 1, 1996

TABLE OF CONTENTS

SECTION	DESCRIPTION	PAGE
Table of Contents		i
List of Tables and Figures		iv
Executive Summary		1
	A. Purpose	1
	B. Plan	1
	C. Conclusions	2
I.	History of Radiological Work Associated with Naval Nuclear Propulsion Program at Naval Base Charleston	I-1
	A. General	I-1
	B. G-RAM	I-2
	1. Radioactive Liquids	I-3
	2. Radioactive Gases	I-3
	3. Airborn Radioactivity	I-3
	4. Radioactive Solids	I-4
	5. Low-Level Solid Radioactive Waste	I-4
II.	Summary of Radiological Controls Used While Performing Radiological Work	II-1
	A. Controls for the use of G-RAM	II-1
	B. Environmental Monitoring	II-1
III.	Summary of Radiological Survey Plan	III-1
	A. Introduction	III-1
	B. The Process	III-1
	C. Determination of Natural Background Radiation Levels	III-3
	D. General Radioactive Material Criteria for Naval Base Charleston Decommissioning Surveys	III-5
	E. Significant Radionuclide Considerations of the Survey Plan	III-7
IV.	Surveys and Sampling Techniques and Instrumentation	IV-1
	A. Introduction	IV-1

B. Radiation Equipment Used for Direct Surveys IV-1
1. Gamma-scintillation Surveys Equipment IV-1
2. Beta-gamma Survey Equipment IV-2
3. Gamma-Spectrometry Equipment IV-3
4. Alpha-Beta Counting Systems IV-4
5. Eberline Model E-600 Radiation Monitor IV-5
C. Survey Techniques IV-5
1. Scan Surveys IV-5
2. Walk-Through Surveys IV-6
3. Removable Survey Contamination Surveys IV-7
4. Fixed-Surface Contamination Surveys IV-8
5. Supplemental Surveys IV-8
6. Fluid-System Surveys IV-8
7. Solid (Surface) Material Samples IV-8
8. Solid-Material Core Sample IV-9
D. Sample Control IV-9

V. Radiological Decommissioning Strategy V-1
A. Discussion V-1
B. Personnel Training V-3

VI. Classification and Survey Procedure VI-1
A. Area/Facility Classification and Unrestricted Release Procedures VI-1
1. Class A VI-1
a. Procedure methodology VI-1
b. Typical arrangement VI-3
2. Class B VI-4
a. Procedure methodology VI-4
b. Typical arrangement VI-6
3. Class C VI-7
a. Procedure methodology VI-7
b. Typical arrangement VI-9

4. Class D VI-10
a. Procedure methodology VI-10
b. Typical arrangement VI-12

VII. Areas and Facilities Requiring Radiological Surveys VII-1
A. Release of Facilities and Equipment Previously Used for Radiological Work VII-1

	B.	Areas and Facilities Requiring Radiological Surveys	VII-1
VIII.	Disposition of Radiological Facilities Equipment		VIII-1
	A.	General	VIII-1
	B.	Equipment Disposition	VIII-1
IX.	Solid Radioactive Waste Generated During Radiological Facilities Decommissioning		IX-1
X.	Synopsis of Quality Controls		X-1
	A.	Introduction	X-1
	B.	Training and Qualification of Personnel	X-1
	C.	Work Control	X-2
	D.	Survey Data Review	X-2
	E.	Measuring Equipment Calibration and Checks	X-3
	F.	Audits and Reviews	X-3
Appendix A	Glossary of Acronyms/Abbreviations		A-1

<u>VOLUME II</u> (Books as Necessary - Separately Bound) Individual Release Reports (including narratives, grid maps, and photos)

VOLUME III Decommissioning Survey Report of the Defense Reutilization and Marking Office

LIST OF TABLES AND FIGURES

Table/Figure	Description	Page
Table I-1	History of Installation Operations	I-1
Table III-1	Surface Contamination Limits	III-6
Figure VI.1	Typical Class A Grid System and Scan Survey Scheme	VI-3
Figure VI.2	Typical Class B Grid System and Scan Survey Scheme	VI-6
Figure VI.3	Typical Class C Grid System and Scan Survey Scheme	VI-9
Figure VI.4	Typical Class D Survey Scheme	VI-12
Table VI-1	Surveying and Sampling Requirements According to Class	VI-13
Table VII-1	Radiological Facilities In Use at Beginning of NAVBASE Closure	VII-1
Table VII-2	Radiological Work and Storage Areas (In Use at Beginning of NAVBASE Closure) Requiring Unconditional Release From Radiological Controls	VII-2

EXECUTIVE SUMMARY

A. Purpose

This document is the General Radioactive Material (G-RAM) Radiological Final Report for the Decommissioning of Naval Base Charleston. It has been prepared by the Charleston Naval Shipyard (CNSY) pursuant to the Defense Base Realignment and Closure (BRAC) Act of 1990, as amended, which authorized closure of Naval Base Charleston, Charleston, South Carolina. The purpose of this report is to catalog and present the results of the decommissioning surveys for the Naval Base after experience using G-RAM.

Volume I of this report addresses G-RAM, including all non-Naval Nuclear Propulsion Program (NNPP) applications of radioactivity. These include Radiological Affairs Support Program (RASP) material and unregulated consumer products. Site-related medical applications would be included, except Naval Hospital Charleston has not been included in the Closure process. Also, included are the historical controls and requirements which existed. Volume II addresses the individual area release reports.

B. Plan

The major program goals were to:

- Transfer existing G-RAM equipment to authorized recipients.
- Minimize hazardous and low-level radioactive waste generated.
- Meet State and Federal radiological environmental and safety regulations.
- Control costs and complete closure within the allocated timeframe.

A survey plan was developed to survey over 3,467,570 square feet with portable instrumentation and take and analyze approximately 15,000 solid samples throughout the naval base complex undergoing the closure process. Facilities identified for survey and sampling were identified by their work history and probability of containing any residual G-RAM. The closure operations did not involve any sophisticated technology but used basic engineering principles and common industrial practices. Those areas, and there were relatively few, where low-level radioactivity in excess of permissible limits was detected, were remediated and released for unrestricted use. Portable instrumentations surveys of areas classified as Class D

EXECUTIVE SUMMARY

revealed no detectable radiation level greater than background. Ground water and soil sampling around the perimeter of the landfill area [Soil Waste Management Unit 9 Zone H] provided no evidence of G-RAM migration from that site.

C. Conclusions

- Operations involving G-RAM at Naval Base have had no adverse effect on the human population or the environment of the region.

- The State of South Carolina Department of Health and Environmental Controls, and U.S. Environmental Protection Agency, agree that facilities may be released to the local community for unrestricted use.

HISTORY OF RADIOLOGICAL WORK ASSOCIATED WITH GENERAL RADIOACTIVE MATERIAL (G-RAM) AT NAVAL BASE (NAVBASE) CHARLESTON

A. General

On August 31, 1901, the U.S. Navy took possession of 2,250 acres of land, much of it composed of marsh areas, and established the Charleston Navy Yard. The original mission of the new Navy Yard was to make repairs to smaller vessels of the fleet and supply them with stores. This mission was modified and expanded over the life of the installation in response to American military involvements, as well as additional operational requirements. This resulted in a major increase in industrial operations and ship-support activities. Table I-1 provides a compilation of the history of installation operations to the start of the base closure process.

Table I-1
History of Installation Operations

Period	Type of Operation
1901 - 1910	New Navy Yard construction activities.
1911 - 1920	World War I Era: Activities included major alterations and overhaul of naval vessels, construction of smaller fleet vessels (destroyers).
1920 - 1932	Major reduction in operations, with activities consisting primarily of routine maintenance of fleet vessels.
1932 - 1941	Major increase in Navy Yard operations, with activities including Work Projects, Administration, financial-aid projects and increased vessel support/overhaul activities.
1941 - 1945	World War II Era: Activities included facilities' improvements, logistical support to operating forces, vessel construction, repair, overhaul, alteration, conversion and homeport docking. New expanded Naval hospital constructed (currently houses Commander Naval Base staff).
1945 - 1952	Naval Base Charleston was created and the Navy Yard was redesignated as the Charleston Naval Shipyard--one of the components of the base.
1952 - 1961	Activities included initiation of firefighting training, fleet and mine warfare training, and routine maintenance and overhaul of Naval fleet vessels, including conventional submarines.
1961 - 1993	Nuclear-powered vessel design, overhaul, and support; establishment of Nuclear Engineering Department, and NSC (one of the largest Naval Supply Centers); current Naval Hospital Charleston constructed; Annex acquired.
1993	Naval Base closure determination made by Congress.

HISTORY OF RADIOLOGICAL WORK ASSOCIATED WITH GENERAL RADIOACTIVE MATERIAL (G-RAM) AT NAVAL BASE (NAVBASE) CHARLESTON

The Naval Base served as a comprehensive center for berthing, upkeep and repair of surface combatants and submarines. Additional support functions included supply and logistics support training, health care, food services and lodging for crew and support members. Major commands that occupied areas of the Naval Base included Fleet Ballistic Missile Submarine Training Center, Fleet and Mine Warfare Training, Naval Hospital Charleston, Charleston Naval Station and the Navy Reserve Center.

B. G-RAM

In the specific case of G-RAM work, all of the technical disciplines, trade skills, quality assurance inspectors, and radiological control personnel were available to accomplish work associated with radioactivity.

General radioactive materials were common in shipboard equipment (e.g., radioluminescent dials and radioluminescent markers) and in equipment used at support facilities (e.g., industrial radiography and thoriated welding rods). The use of radiographic sources was essential to the industrial maintenance and repair at the base. Although G-RAM consisted mainly of sealed or encapsulated sources, radioactivity in other forms was used. Radio-pharmaceuticals were used at Naval Base as a means of providing a wide range of medical diagnostic services for military personnel and their dependents. However, these fall under the cognizance of and within the facilities of Naval Hospital Charleston which did not undergo the decommissioning process.

Examples of G-RAM sources used at Naval Base were:

- Encapsulated Iridium-192 radiographic sources.
- Sealed radiation detection instrument calibration and reference sources.
- Sealed sources used in analytical equipment.
- Sources contained in electron tubes.
- Radioluminescent paint. Various gauges, dials, bridge and deck markers on Naval ships were painted to assist night operations.

HISTORY OF RADIOLOGICAL WORK ASSOCIATED WITH GENERAL RADIOACTIVE MATERIAL (G-RAM) AT NAVAL BASE (NAVBASE) CHARLESTON

- Manufactured items containing radioactive material as an enhancement to the material, e.g., lantern mantles, lightweight alloys for small engine parts, high refractive optical devices, fluxes, fire retardents, ionizers to help initiate sparks, welding rods, etc.

1. Radioactive Liquids

The only liquid G-RAM items used at Naval Base were confined to Naval Hospital Charleston--a command that was not included in the decommissioning process. Use of that material was under the terms of a specific NRMP and performed under controls equivalent to or more stringent than those imposed on radioactive material licenses by Title 10 of the Code of Federal Regulations (10 CFR). Those radionuclides administered to patients for diagnostic and/or therapeutic purposes have half-lives of eight days or less and then decay to stable daughter products.

2. Radioactive Gases

No tenant command of Naval Base performed work that by regulation in 10 CFR required filtered and/or monitored exhaust ventilation.

3. Airborn Radioactivity

The likeliest potential for airborne release of G-RAM involved grinding of thoriated welding rods. Controls increased over the years. At time of closure procedures required:

- Isolation of grinding areas.
- Filtered exhaust ventilation.
- Use of a wet belt to contain dust.
- Cleaning of grinding areas after use by vacuum cleaning or wiping.
- Disposal of grinding dust, chips and cleaning rags (as normal waste material) as they were generated.

HISTORY OF RADIOLOGICAL WORK ASSOCIATED WITH GENERAL RADIOACTIVE MATERIAL (G-RAM) AT NAVAL BASE (NAVBASE) CHARLESTON

4. Radioactive Solids

Solid G-RAM items used at Naval Base included encapsulated sources containing Ir-192 at the SIMA radiography facility and various radionuclides used at the Naval hospital. Solid G-RAM which was once used at the Fleet and Mine Warfare Training Center included Co-60 and Cs-137. Any waste disposal of these items was performed in accordance with applicable provisions of 10 CFR.

5. Low-Level Solid Radioactive Waste

a. Controlled G-RAM

- The SIMA radiographic sources were always returned to the vendor when the source was no longer of use.
- The sources used by the Fleet and Mine Warfare Training Center were disposed of through an authorized activity to a licensed disposal site.
- Because of the short half-life of the G-RAM waste generated by the Naval hospital, it did not require shipment to a disposal site. After the decay period specified in the NRMP (consistent with Federal regulations), this material was no longer classified as radioactive.

b. Non-Regulated G-RAM

No anecdotal or documented disposal of G-RAM on base property has been identified. However, occasionally a deck marker, compass containing a radioluminescence dial face, clock, or other radioluminescent item has been found on the Naval Base.

SUMMARY OF RADIOLOGICAL CONTROLS WHILE PERFORMING RADIOLOGICAL WORK

A. Controls for the use of G-RAM

Requirements for the control of G-RAM at Naval Base were based on recommendations of the National Committee on Radiation Protection and Measurements (NCRP, founded in 1931, chartered by Congress and renamed in 1964 to the National Council on Radiation Protection and Measurements). The Navy's radiological safety regulations, as revised in 1951, by Bureau of Medicine and Surgery (BUMED), invoked applicable recommendations of the NCRP [published at that time as National Bureau of Standards (NBS) Handbook] for specified radioactive material hazards. Additional requirements were implemented after the passage of the Atomic Energy Act in 1954. The AEC was reorganized in 1974, at which time the licenses were placed under the cognizance of the newly formed U. S. Nuclear Regulatory Commission (NRC). Under the provisions of Title 10 of the Code of Federal Regulations (10 CFR), the NRC has issued a Master Materials License to the Department of the Navy, to control the receipt, acquisition, possession, use, transfer, and disposal of NRC licensed material.

Non-licensed G-RAM had been used at the Naval Base since at least the mid-1940's for various purposes. The earliest documented use of licensed G-RAM at the base was for the training of Navy personnel in the use of radiation detections instruments by the Fleet and Mine Warfare Training Center. A license application for sources to be used in that endeavor was approved and issued by the U.S. Atomic Energy Commission (AEC) in the early 1960's. Two other AEC licenses were obtained by Naval Base tenants. A license for use of medical isotopes was obtained by the Naval Hospital in March 1973, and a license for sealed radiography sources was obtained by the Shore Intermediate Maintenance Activity (SIMA) in September 1979.

Audits for compliance with the regulations were routinely conducted by the Nuclear Regulatory Commission, Naval Nuclear Propulsion, Radiological Affairs Support Program and the Naval Shipyard.

B. Environmental Monitoring

Beginning in 1959, before any nuclear work was performed or a nuclear-powered ship was berthed at the shipyard, a baseline study of the radiological environment on the Cooper River was conducted. Periodic radiological environmental monitoring has continued through December 1995. Results are forwarded to the NNPP headquarters which, since 1967, has published an annual report with distribution to other Federal

Agencies, States, Congress, and the public. Although conducted by the NNPP, this monitoring was additionally indicative of the presence or absence of any G-RAM.

Independent environmental surveys by the U.S. Public Health Service (USPHS) and the U.S. Environmental Protection Agency (USEPA) were also conducted. These independent verifications were consistent with NNPP and shipyard results and conclusions.

SUMMARY OF RADIOLOGICAL SURVEY PLAN

A. Introduction

For the property at Naval Base to be released to the public, surveys of areas having the possibility of containing radioactivity associated with G-RAM operations had to be surveyed to confirm the property met free release criteria. Any areas containing G-RAM above release criteria was to be remediated.

Consequently, extensive surveys with sensitive radiation detection, indicating and computation (RADIAC) instruments were performed over all areas where radioactive material had been handled or stored. In addition, solid material samples were obtained and radioisotopic analysis performed. Detailed work instructions for the surveys required to release an area were based on the radiological history of the property. Areas were classified according to their potential for containing radioactivity.

The USS FRANK CABLE (AS 40) coordinated the unrestricted release surveys for Naval Base Buildings X-10, 641, 646, 646A, Piers R and Z and a portion of Building FBM-61 (Rooms 2-172 and 2-177). The CNSY produced "Radiological Engineering Division, Group 1 Survey Instruction 105.2-SPG-1" was used as the Naval Base decommissioning plan by the AS 40. CNSY provided the G-RAM release surveys for the remainder of Building FBM-61 and Piers K, L, M, N, P, Q, S, T and Y in accordance with the "General Radioactive Material (G-RAM) Survey Plan: Radiological Surveys Conducted to Support Closure of Charleston Naval Base Facilities."

The necessary infrastructure needed by both the AS 40 and CNSY to perform work was resident within the talent of the shipyard and the FRANK CABLE.

B. The Process

1. The basic considerations used in the plans development were:

   - Removal of all known radioactive material prior to the radiological survey of a specific site, area or facility.

   - To divide all areas into classifications based on radiological history. (For the purpose of the plan, radiological history referred to the catalog of facts, written or oral, with respect to the handling or use of radioactive material or radioactivity).

SUMMARY OF RADIOLOGICAL SURVEY PLAN

- After radioactive material removal, the site, area or facility was surveyed and sampled for residual radioactivity. The following techniques were used to verify the removal of radioactivity in excess of the maximum permissible limits specified for G-RAM.

  - Direct scan of surfaces using a sensitive gamma-scintillation detector (IM-253 with a SPA-3 Probe or equivalent).

  - Direct scan of surfaces for beta-gamma radioactivity using a DT-304/PDR Geiger-Mueller frisker probe attached to an IM-247/PD or its equivalent.

  - Determining the existence of loose surface alpha-beta radioactivity through the use of swipes/smears and swabs analyzed through the use of a TENNELEC Corporation, Model 5100 (LB 5100) or an XETEC Corporation, Model 560A, ABACUS Sample Counter.

  - Analyzing potentially contaminated earth (e.g., sand or soil), ground covering (e.g., asphalt or concrete), paint or building material through the use of a gamma-scintillation detector with a multichannel analyzer capable of identifying low levels of radioactivity.

2. The extent of the surveys and sampling were commensurate with the potential for radioactive contamination of the area(s). In addition to the categorization of areas, surfaces within those categorized areas, which had the higher potential to be radioactively contaminated, received more extensive surveys. In all cases, areas known or suspected of having a higher potential for contamination, such as floors, ventilation exhaust registers and surfaces next to previous radioactive work areas received more extensive surveys than other areas in that category.

3. Rooms and areas were classified, using the following categories, in accordance with radioactivity contamination potential:

   - Class A: Those industrial areas where G-RAM, or products containing G-RAM, were used or stored and where radiological history indicates no potential, or a very low potential, existed for contamination levels above the limits identified in Table III-1.

SUMMARY OF RADIOLOGICAL SURVEY PLAN

- Class B: Those industrial areas where G-RAM, or products containing G-RAM, were used or stored and radiological history indicates that potential existed for contamination levels at, or slightly above, the limits identified in Table III-1.

- Class C: Those industrial areas where G-RAM, or products containing G-RAM, were used or stored and radiological history indicates that potential existed for contamination levels significantly above the limits identified in Table III-1.

- Class D: Those areas where age and the availability of documented history or anecdotal information regarding previous use or storage of G-RAM, or products containing G-RAM, was inadequate or incomplete to discount the potential presence of residual contamination levels. A Class D area may, however, have an unknown or incomplete history of use or storage of products with trace quantities of G-RAM which were generally exempt from existing controls and regulations. Due to inadequate evidence to the contrary, prudence dictated that a walk through survey be performed. In a Class D area there was no known history of radioactive spills and no documented evidence of radioactive contamination.

C. Determination of Natural Background Radiation Levels

Two primary sources contribute to natural or background radiation; terrestrial origin and cosmic. Terrestrial is the dominant component of background radiation. Rocks, soils, water, air, plants and animal life contain some natural radioactivity. The most significant terrestrial radioisotopes are potassium-40, uranium-238 and thorium-232 and their decay products which include radium-226, radon-222 and their daughters.

Cosmic radiation originates from the stars in outer space and is a relatively small portion of the "natural" background. This radiation, in the form of high energy particles originates from outer space. These particles interact with the earth's atmosphere and produce charged particles, gamma rays and neutrons.

Background radiation levels vary widely with location (as much as a factor of 10 or more). This is caused by several factors. The geology of the area can cause significant variation in the background levels. For example, areas rich in rock formations such as granite, which generally contain some quantity of uranium and its

SUMMARY OF RADIOLOGICAL SURVEY PLAN

progeny, often exhibit higher natural background radiation levels than an area where no rock formations are present. For the Charleston area, large natural phosphate deposits, which are high in potassium and radium, cause higher background radiation levels than occur in other parts of the state. Consequently terrestrial background is highly dependent on the composition, mix, and type of soil.

Within a relatively small area, background radiation levels vary significantly, particularly in an industrial setting where it may not be distributed uniformly throughout the area and construction materials vary, e.g., multiple pours of concrete or asphalt containing different aggregates from different sources with significantly differing amounts of natural radioactivity.

The fact that natural radioactivity varies so widely is important when taking surveys to determine radioactivity added to the environment as a result of Naval Base activities. When surveying with portable instrumentation, it is necessary to account for the effects of natural background. To accomplish this, a comparison must be made with an area made up of similar material which has not been affected by Naval Base activity or in some cases by careful analysis of the types of radioactivity to determine if the isotope is a daughter of a naturally occurring isotope.

The protocol for background determination called for surveys to be performed in unaffected structures and areas similar in all respects to the structure of area being surveyed. The scope of the background determination surveys in these analogous areas was based on the size and physical configuration of the area. For example, an outdoor area paved with asphalt would be scanned near the perimeter and at several locations in the center and the readings would be averaged to determine the specific background value for the area. In the case of a building with a concrete floor and concrete block walls, it was necessary to take more readings. In the center of the structure, background levels are generally less than near the walls. This is because in the center, the primary contributor to the background levels is the floor while near the walls of the structure, the floor and walls contribute to the levels. In some areas, because of the differences in the levels near the walls as opposed to the interior areas of the building not directly adjacent to the walls, it was necessary to assign different background levels to the grids adjacent to the walls than to those in the interior of the building.

The analogous areas were surveyed with both the IM-247 and the IM-253 (HV-1 PHA and HV-2 Gross) to provide background readings for all the surveys to be done in the affected areas. The characteristics of these instruments are discussed in Section IV of this Volume. In addition, a rapid scan of the affected area was conducted prior to the

SUMMARY OF RADIOLOGICAL SURVEY PLAN

actual survey to ensure that no significant differences or anomalies existed which could invalidate the survey results.

In determining which analogous areas would be used for a specific location, where several analogous areas fit the characteristics of the affected area, the most conservative background levels (lowest levels) were used. This approach led to more areas requiring solid samples, however, this approach offered the best chance of identifying any very low levels of radioactivity added as a result of Naval Base work.

D. G-RAM Criteria for Naval Base Charleston Decommissioning Surveys

1. <u>Surface Contamination Limits:</u> The limits used for unconditional release for unrestricted use of Naval Base facilities are radionuclide-specific. The surface contamination limits are consistent with those established by the Radiological Affairs Support Program (RASP) and the Nuclear Regulatory Commission (NRC). The limits are below the values proposed by the State of South Carolina for NORM. Table III-1 lists the surface contamination limit criteria established for the radiological decommissioning surveys of Naval Base areas addressed above.

SUMMARY OF RADIOLOGICAL SURVEY PLAN

Table III-1
Surface Contamination Limits

Radionuclide[a]	Average[b],[c],[f],[h]	Maximum[b],[d],[f],[h]	Removable[b],[e],[h]
Natural uranium, ^{235}U, ^{238}U, & associated decay products	5,000 dpm α/100 cm^2 (2,250 pCi/100 cm^2)	15,000 dpm α/100 cm^2 (6,750 pCi/100 cm^2)	1,000 dpm α/100 cm^2 (450 pCi/100 cm^2)
Transuranics, ^{226}Ra, ^{228}Ra, ^{230}Th, ^{228}Th, ^{231}Pa, ^{227}Ac, ^{125}I, ^{129}I.	100 dpm/100 cm^2 (45 pCi/100 cm^2)	300 dpm/100 cm^2 (135 pci/100 cm^2)	20 dpm/100 cm^2 (90 pCi/100 cm^2)
Natural thorium, ^{232}Th, ^{90}Sr, ^{223}Ra, ^{224}Ra, ^{232}U, ^{126}I, ^{131}I, ^{133}I.	1,000 dpm/100 cm^2 (450 pCi/100 cm^2)	3,000 dpm/100 cm^2 (1,350 pCi/100 cm^2)	200 dpm/100 cm^2 (90 pCi/100 cm^2)
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except ^{90}Sr and other noted above [g]	5,000 dpm β-γ/100 cm^2 (2,250 pCi/100 cm^2)	15,000 dpm β-γ/100 cm^2 (6,750 pCi/100 cm^2)	1,000 dpm β-γ/100 cm^2 (450 pCi/100 cm^2)

(a)Where surface contamination by both alpha and beta-gamma emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should be applied independently.
(b)As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.
(c)Measurements of average contaminant should not be averaged over more than one square meter. For objects of less surface area, the average should be derived for each object.
(d)The maximum contamination level applies to an area of not more than 100 cm^2.
(e)The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying a moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped. Except for transuranics and ^{226}Ra, ^{228}Ra, ^{227}Ac, ^{228}Th, ^{230}Th and ^{231}Pa alpha emitters, it is not necessary to use wiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual surface contamination levels are within the limits for removable contamination.
(f)The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/hr at one centimeter and 1.0 mrad/hr at one centimeter, respectively, measured through not more than seven milligrams per square centimeter of total absorber.
(g)This category of radionuclides includes mixed fission products, including the ^{90}Sr which is present in them. It does not apply to ^{90}Sr which has been separated from the other fission products or mixtures where the ^{90}Sr has been enriched.
(h)(100 dpm = 45 pCi

2. Radioactivity Concentration Limits: The radioactivity concentration limit was 5 pCi/g above natural background for Ra-226 and Th-232 in building materials. This limit also applied to solid material (sediment) samples obtained from fluid systems and any other media. This limit is consistent with CFR, Title 40, Part 192 for uranium and thorium mill tailings and thorium by-product material. The limit is also consistent with the values proposed by the State of South Carolina for NORM.

SUMMARY OF RADIOLOGICAL SURVEY PLAN

E. Significant Radionuclide Considerations of The Survey Plan

1. Based on the radiological history of Naval Base, the significant contaminants associated with the RASP and G-RAM were technologically enhanced Ra-226 and Th-232. Ra-226 was incorporated into radioluminescent products and Th-232 was incorporated into tungsten welding rods.

2. Preparation of the Naval Base G-RAM survey plan acknowledged the complications to be expected from naturally-occurring radioactivity and addressed that concern. Of particular interest was the effect that radium's physical and nuclear characteristics [media-to-air volatilization (radon emanation) and radioactive decay equilibrium] would have. As such:

   - The sampling process disturbed the equilibrium which exists between long-life Ra-226 and its short-lived progeny. Therefore;

     - Each sample of building material suspected of containing Ra-226 (or associated isotopes) was hermetically sealed and held for a period of no less than 27 days prior to counting in order to reestablish that equilibrium.

     - For samples containing only natural radium (uncontaminated concrete, asphalt, soil, etc.) the difference between initial and final analysis was normally within the error expected for any recount of a sample.

     - For samples where radium was introduced into the building material an increase in radium activity based on the progeny ranged from 20% - 40% above the original activity.

   - The holding time was consistent with the radiological laboratory analysis procedure of South Carolina's Department of Health and Environmental Control (SCDHEC).

SURVEY AND SAMPLING TECHNIQUES AND INSTRUMENTATION

A. Introduction

RADIAC instrumentation was required to perform decommissioning surveys. Both CNSY and the FRANK CABLE used its inventory of standard Navy-supplied instrumentation. However, because the scope of the decommissioning process was so large, supplemental devices such as more efficient sample counting equipment was procured. In addition, more efficient sample gathering techniques were pursued.

B. Radiation Equipment Used for Direct Surveys

1. Gamma-Scintillation Equipment

The IM-253/PD count-rate meter, with a DT-640 scintillation-probe assembly or its equivalent, was used for the gamma-scintillation surveys carried out during the decommissioning process. Instruments considered to be its equivalent and also used during the process were:

- The Eberline Instrument Corporation, Model PRM-5N count-rate meter with a Model SPA-3 scintillation-probe assembly.
- The Nuclear Research Corporation, Model CRM-595 count-rate meter with a GP-595 scintillation-probe assembly.

For the purpose of this report they will all be referred to as the IM-253/PD. As such:

- The gamma-scintillation detector probe consists of a cylindrical housing containing a 2-inch diameter by 2-inch long sodium iodide with thallium [NaI (TI)] crystal. It has a linear scale ranging from 0 to 1,000 counts per minute (cpm). Scale multipliers of X1, X10, X100 and X1,000 are selected according to the radiation levels being measured.
- It was calibrated to respond to an energy range which included the Ra-226 gamma ray of 0.1862 MeV while in the pulse height analyzer (PHA) counting mode.
- Each instrument was re-calibrated no less than every six months while in use.

SURVEY AND SAMPLING TECHNIQUES AND INSTRUMENTATION

- Each instrument was response-checked to a Ra-226 check-source such that any readings taken were accomplished within one day after a satisfactory response-source check.

- Characteristics of the IM-253/PD

-Accuracy	±20%
-Minimum Sensitivity	100 cpm

2. Beta-Gamma Survey Equipment

Direct scan surveys (beta, gamma) were performed using a DT-304/PDR frisker probe or an HP-260/PDR frisker probe. The HP-260 probe is the unshielded version of the DT-304 and was used for performing surveys in low background areas. These probes were used in conjunction with either an Eberline E-140N, a Johnson and Associates, Inc. IM-247/PD, or a RAM-3400 or RM-3C Frisker or equivalent. Since they are all equivalent they will hereafter be referred to as the IM-247/PD and were used to detect both fixed and loose surface radioactive contamination. As such:

- It has three linear scales of 0 to 500, 0 to 5,000 and 0 to 50,000 cpm.

- The DT-304/PDR probe or equivalent consists of a 900 V, 2-inch diameter flat Geiger-Mueller tube having a window thin enough to transmit a high percentage of the low-energy beta particles less than 200 keV.

- Each instrument was re-calibrated no less than every six months while in use.

- Each instrument was response-source checked such that any readings taken were accomplished within one day after a satisfactory response check. The check consisted of verifying that the needle of the meter responds correctly to a known value (Tc-99 check source, mainly 204 and 293 keV beta energies). Since the presence or absence of various naturally-occurring radio-isotopes and the equilibrium state of Radium and Thorium was unknown; IM-247/PD scans were used for detection purposes only.

SURVEY AND SAMPLING TECHNIQUES AND INSTRUMENTATION

- Detection characteristics:

-Accuracy	±20%
-Minimum Sensitivity	100 cpm
-Minimum Detectable Activity	100 cpm=450 pCi for Co-60 (317 keV beta energy), or equivalent, in a background of less than 300 cpm.

3. Gamma-Spectrometry Equipment

Two systems were used to analyze soil and surface material samples, solid material core samples and swipes/smears and swabs for gamma radiation. These were the Canberra Genie PC-counting system and the CANBERRA Series 35 + multi-channel analyzer utilizing two 35% efficient intrinsic Germanium detectors, simultaneously.

- Solid samples, swipes and swabs were analyzed for radioactivity over the gamma-energy range of 100 to 2,100 keV.

- For each isotope of interest in each sample, the specific radioactivity, the minimum detectable activity (MDA) and the 95% confidence interval were reported in units of both pCi/g and pCi/100 cm^2. The G-RAM isotopes that were to be quantified included Bi-214 (609 keV), and Pb-214 (352 keV) for determining Th-232 specific radioactivity; U-235 (144 keV) and K-40 (1,461 keV).

- The system was calibrated for three source geometries: (1) a 2-inch petri dish; (2) a 500 ml Marinelli beaker; and (3) a flush disc.

- For sample analyses:

  - Dense building material (e.g., concrete, asphalt, tile. brick, etc.) samples were placed in a petri dish.

  - Less dense building material (e.g., wood, drywall, etc.) samples were placed in a Marinelli beaker.

- Each swipe/smear was placed in a sample container (typically, a small plastic bag). The cotton head of each swab remained intact when trimmed from its stem (stick) and placed in a suitable sample container for analysis. Each swipe and swab was analyzed under the flush disc geometry.

- All calculations of activity, MDA, and the 95% confidence interval were performed via computerized analysis software.

- As an additional intercomparison, some randomly-selected solid samples were sent to a U.S. Department of Energy laboratory for analysis. The specific intent was to verify CNSY results.

4. Alpha-Beta Counting Systems

The shipyard used two systems for counting swipes/smears and swabs for alpha/beta radiation. Both were analytical and used to determine the gross alpha and beta radiation in low-activity systems. These were:

- The TENNELEC Corporation, Model 5100 (LB 5100)

  - The detector assembly consists of two "pancake-type" gas flow proportional counters stacked on top of each other. The gas is "P-10" (90% Argon and 10% Methane).

  - The system was calibrated through the use of various alpha and beta 1-inch reference sources. The available sources were Am-241, Th-230, C-14, Cl-36, Sr-90, Pm-147, Tc-99, Cs-137 and Co-60. All sources were traceable to National Institute of Standards and Technology (NIST) standards. The system was calibrated with the sources counted in the same geometric configuration as the samples counted.

  - For analysis, each swipe/smear was placed in a sample container (typically, a small plastic bag). The cotton head of each swab remained intact when trimmed from its stem (stick) and placed in a suitable sample container. Each swipe/smear and swab was placed directly in the system inserts or in a planchet for counting.

- All calculations of activity, MDA, and the 95% confidence interval were performed via computerized analysis software.

- The XETEC Corporation, Model 560A, ABACUS Sample Counter

  - The detector is a sealed gas proportional counter utilizing Argon/CO_2 gas. The sample detector is 2-inches in diameter with a 2.0 mg/cm^2 window that is surrounded by two pair of lead blocks.

  - The system was calibrated through the use of various alpha and beta sources (the same as used for the TENNELEC system with the addition of Ra-226). All sources were traceable to the NIST Standard.

5. In addition to the instrumentation addressed above, CNSY did make limited use of the Eberline Model E-600 Radiation Monitor. This instrument has the capability to accept both conventional and "smart" Geiger Mueller, scintillator and proportional detector probes. "Smart" probes permit the changing of detectors at any time to adapt to a different measurement type or to replace a damaged detector without the need for re-calibration.

C. Survey Techniques

1. Scan Surveys

- 100% of the surface of each grid or sub-grid (see Section VI) was monitored. Multiple detectors were mounted on a cart such that the face of the detector was within 1/2 inch of the surface. The cart was maneuvered such that 100% of the surface of the grid was monitored. Areas where the cart could not go were hand monitored.

- A wide-energy band, gamma scan was conducted with the IM-253/PD using an SPA-3 probe (or equivalent) operating in the GROSS mode. A narrow energy band, gamma scan was conducted with the IM-253/PD (or equivalent) operating in the PHA mode. A reading exceeding twice background, in either mode, required an investigation and identification of cause.

SURVEY AND SAMPLING TECHNIQUES AND INSTRUMENTATION

- A beta-gamma survey was conducted using an IM-247/PD. Any level equal to or greater than the respective limit was considered to be unsatisfactory and additional surveys were required to determine if this was a variation in background or evidence of a small amount of contamination.

- Scanning speeds (rate of probe movement) were normally one to two inches per second for gamma-scintillation and beta-gamma surveys. Scan rates were reduced when surveying in areas with high background or fluctuating radiation levels wherein the detection of radioactivity above the limit was more difficult to distinguish.

- The scanning detector was held within one-half inch of the surface for gamma and beta-gamma measurements. (To ensure absolute compliance with the one-half inch distance factor, the probes were mounted on the base of a survey cart which was moved over the surfaces to be monitored). The detector was held (or placed) such that its most sensitive position was parallel to the surface. Scanning practices included using the audible response (speakers or headphones) of the RADIAC for detection and--after stabilization--using the meter response for measurement.

2. Walk-Through Surveys

- Performed with a gamma-scintillation meter (IM-253/PD) operating in the GROSS mode and a beta-gamma survey meter (IM-247/PD). Walk-through surveys were carried out by holding the detector probe approximately three feet above the floor and walking slowly through the specific site--stopping approximately every ten feet or when increases in count rates were observed.

- Scanning practices included using the audible response (speakers or headphones) of the RADIAC for detection and--after stabilization--using the meter response for measurement.

- The speed of the walk-through was no more than one-foot per second.

- Walk-through surveys included traverse routes, tool storage areas, office spaces and work areas. Any detectable increase above background was investigated by a more detailed survey in the suspect area.

- Surveys in low potential areas were supplemented by a detailed scan survey of approximately one-third of the desks, lockers, drawers and their associated contents. (Low potential areas included secretarial areas, private offices, bathrooms, dressing areas and areas where personal items were stored.)

- Surveys in high potential areas were supplemented by a detailed scan survey of all desks, lockers, drawers and their associated contents. (High potential areas included machine shops, shop offices, tool rooms, storage rooms, calibration rooms, traverse routes from radiological areas and other work areas of radiation workers.)

3. Removable Surface Contamination Surveys (Swipes/Smears and Swabs)

- Conducted as deemed necessary to determine if radioactivity above the limit is removable (or loose).

  - Performed by wiping a 100 cm^2 surface (applying moderate pressure) with a dry filter paper (smear/swipe).

  - Wet smears/swipes were permitted for monitoring wet or damp areas and when surface contamination is suspected but was not detected through use of the dry filter paper.

  - Measurements of a contaminant were not averaged over more than one square meter. For objects of lesser surface area, the average was derived for each object.

- Cotton swab-type methods were used to make loose surface contamination surveys of cracks and crevices where potential residual radioactivity could not be detected by any other survey method.

- Swipes and smears were monitored in the field with portable RADIAC's that could detect betta-gamma radiation also (IM-247). They also were analyzed for gamma radiation using the CANBERRA

SERIES 35 + multi-channel analyzer and for alpha and beta radiation using the TENNELEC LB 5100 system.

4. Fixed-Surface Contamination Surveys (Surface Material Sampling)

The purpose of surface material sampling was to relate and quantify the specific radioactivity of solid material samples to surface contamination. This method used solid material sampling as an adjunct to swipe and scan surveys to verify compliance with average surface contamination limits.

5. Supplemental Surveys

Remaining ventilation ducts, electrical boxes, conduit or other interior surfaces of equipment, in affected areas, which could have contained residual contamination, were accessed at random and surveyed by scanning, swiping or swabbing. They also included surfaces which had remained undisturbed over an extended period of time (e.g., top surfaces of suspended light fixtures, structural, overhead girders, etc.).

6. Fluid-System Surveys

Those systems suspected of being exposed to radioactivity were surveyed. They were opened at convenient locations for access and appropriate surface contamination surveys performed. In addition:

- Some system accumulators (e.g., valves, strainers, S- and U-shaped bends, traps, areas of low-fluid flow, etc.), where particulate may have settled or mixed with sediment, were accessed and surveyed for radioactivity.

- Where present, solid sediment samples were obtained and evaluated for the presence of residual radioactivity.

7. Solid (Surface) Material Samples

These refer to samples of surface material (e.g., concrete, asphalt, wood, etc.) retrieved from a specific site for analyses of radioactivity concentration. They also refer to facial materials such as paint, wall paper and floor tile.

- Each sample was analyzed by gamma spectrometry and the radioactive concentration (specific radioactivity) was then mathematically equated to surface contamination and presented in pCi/100 cm^2.

8. Solid-Material Core Sample

Solid core samples of building material were obtained by a mechanical device such that an intact, cylindrical column of material was retrieved.

- Core samples were required to aid in determining the extent and magnitude of an area known to be contaminated.

- Solid material core samples were obtained by drilling with a core drill bit to a depth sufficient to obtain a sample representative of the radioactivity deposited or naturally-occurring in that area.

D. Sample Control

To ensure the integrity of the samples, sample identification, collection, chain-of-custody and retention procedures were established.

1. Samples collected were traceable from the time collected through the analysis phase, during the retention period and until they are disposed of properly. To maintain and document sample possession, chain-of-custody procedures were followed.

- <u>Sample Custody:</u> All samples collected were maintained under secure conditions. In general, as few people as possible were part of the chain-of-custody.

- <u>Transfer of Custody and Shipment:</u> Samples were accompanied by a Chain-of-Custody Sheet. When transferring the possession of samples, the individual relinquishing and the individual receiving signs, dates and notes the time on the record. This record documents the sample-custody transfer.

- <u>Sample Packaging:</u> Samples were collected, placed in bags at the point-of-generation and heat-sealed by trained personnel. These bags were brought to a sample-preparation area, opened and the sample substance placed into either petri dishes or Marinelli beakers.

2. These samples were retained in storage for as long as feasible to support analysis data. Samples, when analyzed, were retained in secure storage 30 days from the completion of the TGI to allow review of the data and then disposed of.

RADIOLOGICAL DECOMMISSIONING STRATEGY

A. Discussion

While the G-RAM decommissioning plan was in compliance with the requirements of the RASP manual, it was patterned after, and followed, the same general outline as employed by the Naval Nuclear Propulsion Program. It included:

- Review of use and work history.
  - Records prior to 1960 were essentially non-existent. Almost all information prior to that time was the result of conversations with former employees who were employed in the 1940's and 1950's. Much of the information obtained was of a general nature because of the difficulty personnel had in remembering details of work performed years ago.
  - Some records for the period between 1960 and 1970 were available with the earliest being radiological surveys conducted by the shipyard's Industrial Hygiene Division (a component of the Medical Department). Information provided by personnel was more detailed and complete.
  - Records and information provided by personnel made for a complete history of the use of all areas from 1971 to closure.
- Identifying specific areas that would require a G-RAM release survey based on a review of the history.
  - Developing a brief history of each area/site such that all available pertinent historical information is presented.
  - Determining the radiological significance of each and the projected survey requirements.
  - Determining the historical "preservation" value and status of each. Investigate the potential impact of solid material sampling.
  - Developing illustrated layouts for the affected buildings, facilities, etc.
  - Preparing work instructions for performing the free-release surveys.

RADIOLOGICAL DECOMMISSIONING STRATEGY

- Transferring all radioactive material to a recipient authorized by an NRMP, NRC License or Agreement State License to receive radioactive material; or dispose of as radioactive waste.

  - Providing a written request to RASO for termination of the NRMP. (The NRMP was considered terminated when a termination amendment was received from the NRSC.)

- Removal and disposal of portable "non-permitted/licensed" radioactive equipment, system or waste.

  - The survey required for closure did not begin until all such material had been removed from the area(s) of interest.

  - Accumulated G-RAM waste was stored at one central location with all necessary radiological controls imposed.

- Gridding areas and survey grids:

  - All Class A, B and C areas were gridded. Because of the age of most facilities, the limited information available on the G-RAM history prior to 1960 and the limited controls that most likely had occurred in the 1930's and 1940's, the approach taken was considered to have been conservative.

- Conducting background radiological surveys (see Section III).

- Conducting the free-release surveys.

  - Performed remedial actions as dictated by the survey results.

  - Corrective actions were in compliance with separate plan-of-action documents and detailed in separate technical work documents.

- Investigating unusual results and resurveying.

  - Unusual results were expected because of instrument sensitivity, the limited knowledge of the base's operations during its earlier years and the nature of natural background radiation. All radioactivity found was removed and the areas resurveyed. Discovery of additional radioactivity required reevaluation, entailing additional surveys for adequate release of the area.

- Preparing final summary and providing detailed records.

  - All areas required before and after photographs, a detailed graphical representation of the result of every survey taken, and a data base of survey results documenting the successful completion of radiological clearance process.

  - This information could be used by the USEPA, state and local agencies to evaluate the Navy's closure effort at Naval Base Charleston.

B. Personnel Training

1. Personnel assigned to perform those decommissioning surveys falling under the cognizance of the FRANK CABLE were:

   - Qualified as Radiological Control Monitors (RCM's) in accordance with NAVSEA 389-0153.

     - Assisted by non-RCM's who were assigned to survey teams as recorders.

     - Routinely monitored by supervisory RCM personnel and IMANPY representatives.

2. Personnel assigned to perform the decommissioning surveys falling under the cognizance of CNSY were qualified as Radiological Control Technicians (RCT's) in accordance with NAVSEA 389-0288.

   - To ensure adequate staffing for the "free-release surveys" addressed by the decommissioning strategy covered by this section, a group of persons with production backgrounds were selected to serve as Radiological Control Surveyors.

     - A prerequisite for selection required that the individual either currently be, or in the past have been, an Article 107 qualified Radiation Worker.

     - Selected individuals were trained and qualified to operate an IM-247/PD and an IM-253/PD as well as performing radiological decommissioning surveys for Class D areas having no known radioactive contamination history. The training program consisted of lectures, demonstrations, as well as written and practical examinations.

- All surveys were conducted under the direction of an Article 108 qualified RCT who reviewed and countersigned all surveys.

CLASSIFICATION AND SURVEY PROCEDURES

A. Area/Facility Classification and Unrestricted Release Procedures

1. Specific sites were categorized into different classifications based on G-RAM contamination potential.

2. With the exception of Class D areas, each specific site was marked and divided in the manner outlined below. Typically, a grid system was labeled such that each grid is uniquely identified with an abscissa-ordinate coordinate as in a two-dimensional Cartesian system. The abscissa was labeled with letters, while the ordinate was labeled with numerals. The result was an alpha-numeric designator, such as A1, B2, AA1, BB22, etc., that is unique to each grid. Sections of grids, referred to as sub-grids or quadrants, were typically labeled with Roman numerals. Subsequently, sub-grids have typical identifiers such as A1-I, B2-II, C3-III, etc.

3. The following provides the survey requirements as summarized in Table VI-I, for each of the survey classifications.

    - Class A areas were those industrial areas where G-RAM, or products containing G-RAM, were used or stored and radiological history indicated that no potential, or a very low potential, existed for contamination levels above the limits identified in Table III-1.

        - Deck/floor surfaces were divided and marked into 20-foot by 20-foot square grids.

        - Each deck/floor grid was sub-divided into 5-foot by 5-foot square sub-grids.

        - Each grid and sub-grid was identified with a unique designation.

        - A narrow gamma-energy range scintillation scan survey (IM-253/PD operating in the PHA mode) was performed over four pre-determined 5-foot by 5-foot sub-grids to represent 25% of the grid surface.

        - A wide gamma-energy range scintillation modified walk-through scan survey (IM-253/PD operating in the GROSS mode) was performed over the specific site. This survey was not governed by the grid system.

CLASSIFICATION AND SURVEY PROCEDURES

- A beta-gamma scan survey (IM-247/PD) was performed over four other pre-determined 5-foot by 5-foot sub-girds to represent an additional 25% of the grid surface.

- A minimum of two swipes/smears were taken in each grid.

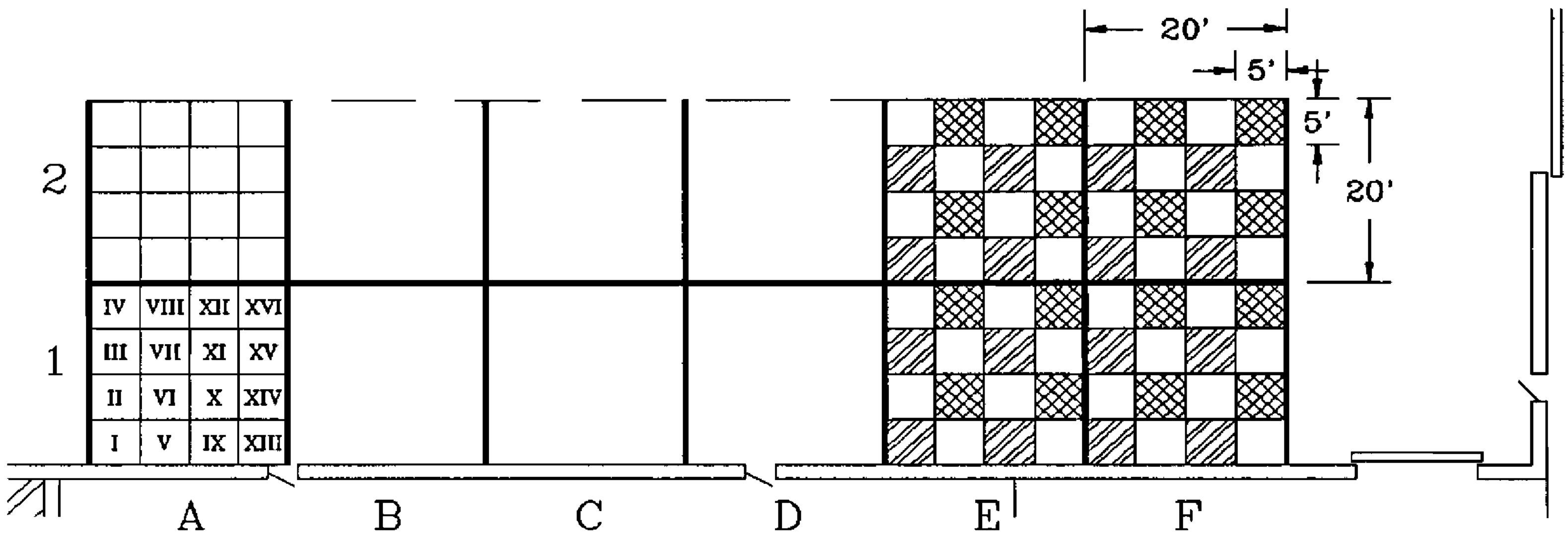
- A minimum of 10% of accessible cracks and crevices in the specific site were surveyed using the swab technique.

- A minimum of one solid-surface material sample was taken from each grid. The location of that sample was based on the results of the radiological surveys described previously. The sample was taken from the area of the grid having the highest potential for radioactivity (i.e., the area having the highest reading). If no area had been identified, the sample was taken from the center of the grid.

- The radioactive concentration (as determined by gamma spectrometry in units of pCi/g) of solid-material sample(s) previously collected in each grid was mathematically equated to surface contamination (in units of dpm/100cm^2 or pCi/100cm^2). Calculations were based on samples collected over an approximate surface of 250cm^2.

- Refer to Figure VI.1 for illustrative clarity.

Figure VI.1 Typical Class A Grid System and Scan Survey Scheme



Legend:

Denotes sub-grids to receive a narrow range gamma scan survey (i.e., IM-253/PD operating in the PHA mode).
This survey scheme represents 25% survey coverage of each grid.

Denotes sub-grids to receive a beta-gamma scan survey (i.e., IM-247/PD).
This survey scheme represents an additional 25% survey coverage of each grid.

Notes:

(1) Wide range gamma scan surveys performed in Class A areas are walk-through surveys performed with the IM-253/PD operating in the GROSS mode.

CLASSIFICATION AND SURVEY PROCEDURES

- Class B areas were those industrial areas where G-RAM, or products containing G-RAM, were used or stored and radiological history indicated that potential existed for contamination levels at or slightly above the limits identified in Table III-1.

  - Deck/floor surfaces were divided and marked into 10-foot by 10-foot square grids. The lower 6-foot surfaces of each wall were horizontally divided into 10-foot grids to effect a pattern of grids 6-feet high and 10-feet wide.

  - Each deck/floor grid was sub-divided into quadrants to effect four 5-foot by 5-foot square sub-grids.

  - Each wall surface was sub-divided into quadrants to effect a pattern of sub-grids 3-feet high and 5-feet wide.

  - Each grid and quadrant/sub-grid was identified with a unique designation.

  - A narrow gamma-energy range scintillation scan survey (IM-253/PD operating in the GROSS mode) was performed over two diagonal quadrants to represent the remaining 50% of the grid surface.

  - A wide gamma-energy range scintillation scan survey (IM-253/PD operating in the GROSS mode) was performed over two diagonal quadrants to represent the remaining 50% of the grid surface.

  - A beta-gamma scan survey (IM-247/PD) was performed over 100% of the grid surface.

  - A minimum of two swipes/smears was taken in each grid.

  - A minimum of 10% of accessible cracks and crevices in the specific site was surveyed using the swab technique.

  - A minimum of two solid-surface material samples was taken from each grid. The location of the samples was based on the results of the radiological surveys described previously.

CLASSIFICATION AND SURVEY PROCEDURES

The samples were taken from the area of the grid having the highest potential for radioactivity (i.e., the area having the highest reading). If no area(s) was identified, the samples were taken near the center of the grid such that the combination of the two samples were representative of the grid surface.

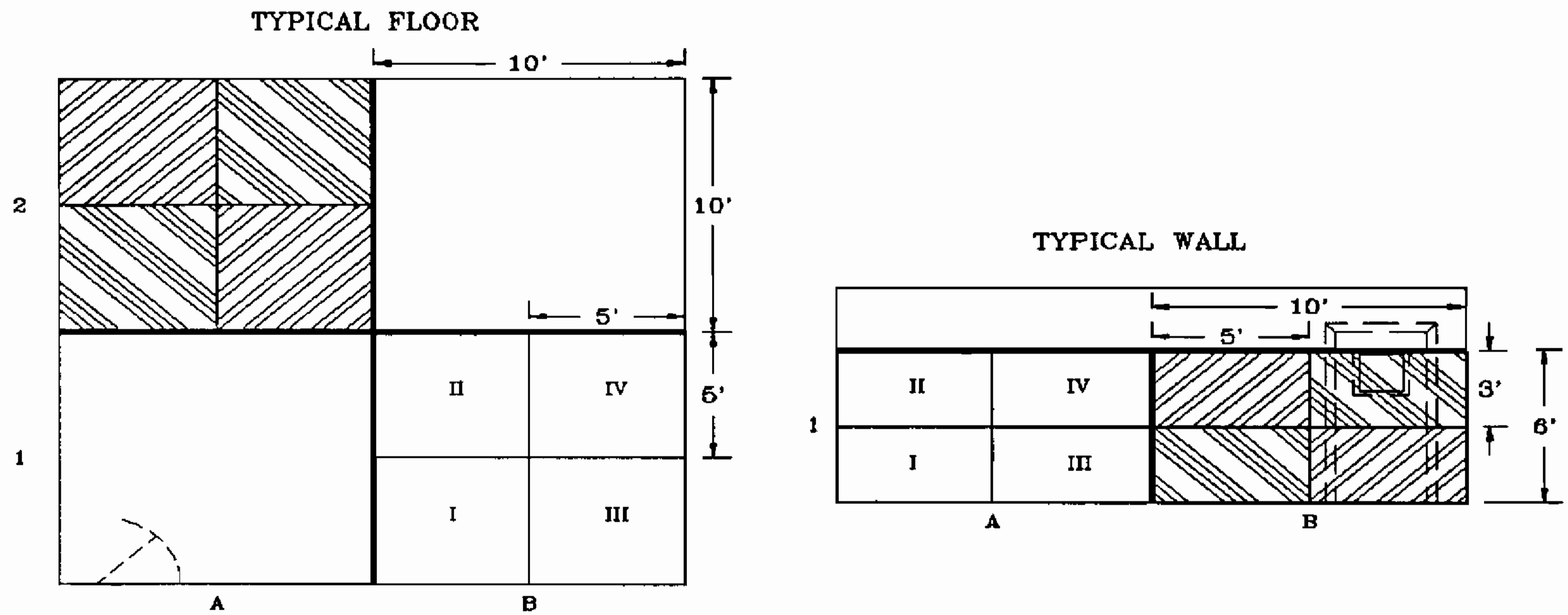
- The radioactive concentration (as determined by gamma spectrometry in units of pCi/g) of solid-material sample(s) previously collected in each grid was mathematically equated to surface contamination (in units of $dpm/100cm^2$ or $pCi/100cm^2$). Calculations were based on samples collected over an approximate surface area of $250cm^2$.

- Remaining ventilation ducts, electrical boxes, conduit or other interior surfaces of equipment and services in affected areas, which may contain residual contamination, were accessed at random and surveyed by scanning, swiping or swabbing. Surveys of undisturbed surfaces were also performed.

- Fluid systems having a potential of being radioactively contaminated were accessed and surveyed for surface contamination. Solid sediment, if available, was evaluated with a multi-channel analyzer.

- Refer to Figure VI.2 for illustrative clarity.

Figure VI.2 Typical Class B Grid System and Scan Survey Scheme



Legend:

Denotes sub-grids to receive a narrow range gamma scan survey (i.e., IM-253/PD operating in the PHA mode). This survey scheme represents 50% survey coverage of each grid.

Denotes sub-grids to receive a wide range gamma scan survey (i.e., IM-253/PD operating in the GROSS mode). This survey scheme represents an additional 50% survey coverage of each grid.

Notes:

(1) 100% of each grid will receive a beta-gamma scan survey (i.e., IM-247/PD).

(2) The lower six feet of walls will be gridded and surveyed.

CLASSIFICATION AND SURVEY PROCEDURES

- Class C areas were those industrial areas where G-RAM, or products containing G-RAM, were used or stored and radiological history indicated that potential existed for contamination levels significantly above the limits identified in Table III-1.

  - Deck/floor surfaces were divided and marked into 5-foot by 5-foot square grids. The lower 6-foot surface of each wall was horizontally divided into 5-foot grids to effect a pattern of grids 6-feet high and 5-feet wide.

  - Each grid was identified with a unique designation.

  - A narrow gamma-energy range scintillation scan survey (IM-253/PD operating in the PHA mode) was performed over 100% of the grid surface.

  - A wide gamma-energy range scintillation scan survey (IM-253/PD operating in the GROSS mode) was performed over 100% of the grid surface.

  - A beta-gamma scan survey (IM-247/PD) was performed over 100% of the grid surface.

  - A minimum of one swipe/smear was taken in each grid.

  - A minimum of 25% of accessible cracks and crevices in the specific site was surveyed using the swab technique.

  - A minimum of one solid-surface material sample was taken from each grid. The location of the sample was based on the results of the radiological surveys described previously. The sample was taken from the area of the grid having the highest potential for radioactivity (i.e., the area having the highest reading). If no area had been identified, the sample was taken from the center of the grid.

  - The radioactive concentration (as determined by gamma spectrometry in units of pCi/g) of solid-material sample(s) previously collected in each grid was mathematically equated to surface contamination (in units of dpm/100cm^2 or pCi/100cm^2).

CLASSIFICATION AND SURVEY PROCEDURES

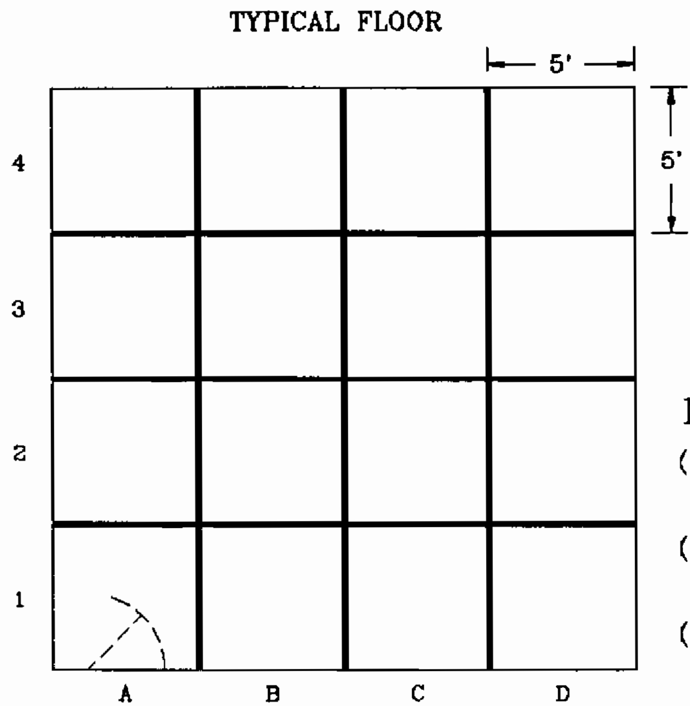
Calculations were based on samples collected over an approximate surface area of 250cm^2.

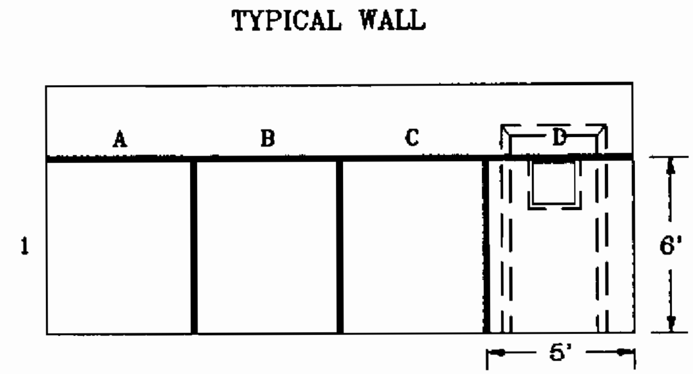
- Remaining ventilation ducts, electrical boxes, conduit or other interior surfaces of equipment and services in affected areas, which may contain residual contamination, were accessed at random and surveyed by scanning, swiping or swabbing. Survey of undisturbed surfaces were also performed.

- Fluid systems having a potential of being radioactively contaminated were accessed and surveyed for surface contamination. Solid sediment, if available, was evaluated with a multi-channel analyzer.

- Refer to Figure VI.3 for illustrative clarity.

Figure VI.3 Typical Class C Grid System and Scan Survey Scheme





Notes:

(1) 100% of each grid will receive a beta-gamma scan survey (i.e., IM-247/PD).

(2) 100% of each grid will receive a narrow range gamma scan survey (i.e., IM-253/PD operating in the PHA mode).

(3) 100% of each grid will receive a wide range gamma scan survey (i.e., IM-253/PD operating in the GROSS mode).

(4) The lower six feet of each wall will be gridded and surveyed.

CLASSIFICATION AND SURVEY PROCEDURES

- <u>Class D</u> areas were those where age and the lack of documented history or anecdotal information regarding previous use or storage of G-RAM was either inadequate or too incomplete to discount the potential presence of residual contamination levels.

  - Surveys were for confirmations only and were not included in the final report. Approval for relinquishing control of these areas was maintained at the local level; however, survey documentation is being maintained for future reference.

  - No gridding was required.

  - A wide gamma-energy range scintillation walk-through (IM-253/PD operating in the GROSS mode) was performed over the specific site. This survey was not governed by the grid system.

  - Surveying was performed along paths approximately 10 feet apart such that representative measurements of potentially deposited surface contamination is obtained.

  - At approximately 5 to 6 foot intervals along the survey path, point (static) measurements were taken using the wide gamma-energy range scintillation meter (IM-253/PD operating in the GROSS mode). The probe was held at waist level or approximately 3 feet above the deck/floor.

  - Point (static) measurements were required when sustained increases in count rates were observed.

  - Where it became necessary to quantify surface contamination, solid (surface) material samples were collected from the suspect location for accurate assessment.

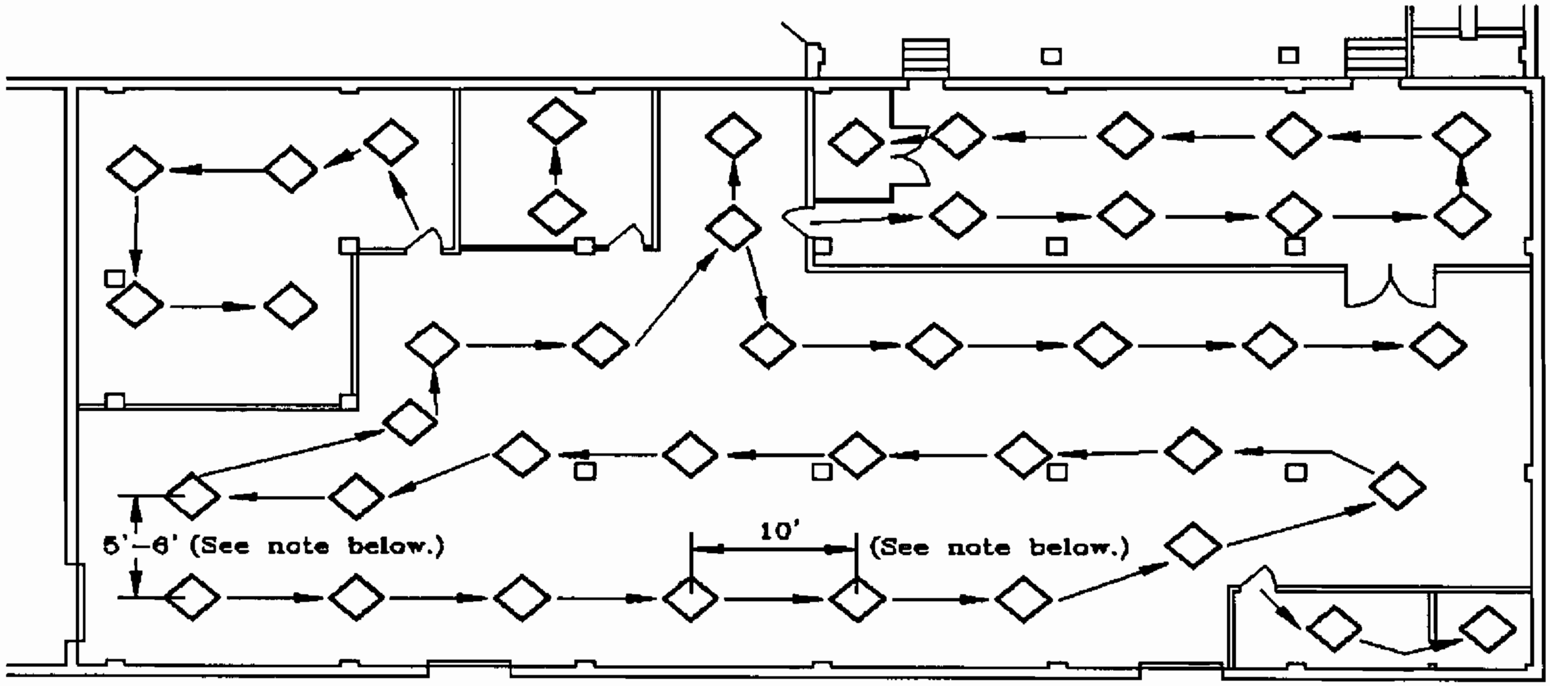
  - Walk-through surveys performed in low potential areas included the walk-through surveys supplemented by a detailed survey of approximately one-third of desks, lockers, drawers and their associated contents. Low areas included secretarial areas, private offices, bathrooms, dressing areas and areas where personal items were stored.

CLASSIFICATION AND SURVEY PROCEDURES

- Walk-through surveys performed in high potential areas included the walk-through surveys supplemented by a detailed scan survey of approximately one-half of desks, lockers, drawers and their associated contents. High potential areas included machine shops, shop offices, tool rooms, storage rooms, calibration rooms, traverse routes from radiological areas and other work areas of radiation workers.

- Refer to Figure VI.4 for illustrative clarity.

Figure VI.4 Typical Class D Survey Scheme



Legend:

→ Denotes typical survey path.

◇ Denotes typical location of point (static) measurements.

Notes:

(1) Survey paths are typically parallel and five to six feet apart.

(2) Point (static) measurements are typically taken at ten foot intervals.

(3) Walk-through surveys are performed with the IM-253/PD, gross mode.

Table VI-1 Surveying and Sampling Requirements According to Class

Requirement	Class A Area	Class B Area	Class C Area	Class D Area
Grid System	20' x 20' square grids, deck/floor	10' x 10' square grids, deck/floor, Lower 6' of walls divided every 10' to effect 10'(w) x 6'(h) grids	5' x 5' square grids, deck/floor. Lower 6' of walls divided every 5' to effect 5'(w) x 6'(h) grids	Not Required
Sub-Grid System	5' x 5' deck/floor sub-grids	5' x 5' deck/floor quadrants 5'(w) x 3'(h) wall quadrants	Not required	Not Required
Narrow Gamma Energy Range Scan Surveys (IM-253/PD: PHA mode)	25% of grid surface	50% of grid surface	100% of grid surface	Not Required
Wide Gamma Energy Range Scan Surveys (IM-253/PD: GROSS mode)	Walk-through survey	Remaining 50% of grid surface	100% of grid surface	Walk-Through Survey
Beta-Gamma Scan Surveys	Additional 25% of grid surface	100% of grid surface	100% of grid surface	Not Required
Swipes (Smears)[1]	2 (minimum)	2 (minimum)	1 (minimum)	Not Required
Swabs[2]	Minimum 10% of accessible cracks and crevices in the specific site.[3]		Minimum 25% of accessible cracks and crevices in the specific site.[3]	Not Required
Solid Material Sampling	1 (minimum)	2 (minimum)	1 (minimum)	Not Required
	Based on results of previous radiological surveys. Samples were taken from the area having the highest potential for radioactivity. If no higher potential area exists, the sample point was taken from the center of the grid.			Not Required
Surface Material Sampling	The specific radioactivity (pCi/g) of solid sample(s) collected in each grid was related to surface contamination (dpm/100 cm^2 or pCi/100 cm^2). Calculations were based on sample surface area of 250 cm^2.			Not Required
Supplemental Surveys	Required only for Class B and C Areas. Remaining ventilation ducts, electrical boxes, conduit or other interior surfaces of equipment and services in affected areas, which may contain residual contamination, were accessed at random and surveyed by scanning, swiping or swabbing. Surveys of undisturbed surfaces were also performed.			
Fluid System Surveys	Required only for Class B and C Areas. Fluid systems having a potential of being radioactively contaminated were accessed and surveyed for surface contamination. Solid sediment, if available, was evaluated with an MCA.			

[1]Swipes were analyzed for alpha/beta radiation with the TENNELEC LB 5100.
[2]Swabs were analyzed for alpha/beta radiation with the TENNELEC LB 5100.
[3]Accessibility, location and numbers were determined via engineering evaluation based on radiological potential.

AREAS AND FACILITIES REQUIRING RADIOLOGICAL SURVEYS

A. Release of Facilities and Equipment Previously Used for Radiological Work

NAVSEA regulations require that activities engaged in NRMP-controlled work compile and maintain lists of facilities, areas and equipment that have been used in support of radiological work. These instructions further require that extensive radiological surveys be conducted when radiological work or storage areas or equipment are being released from radiological controls.

B. Areas and Facilities Requiring Radiological Surveys

1. Site-specific NRMP-controlled radiological work and storage areas identified in Table VII-1. (This table represents the status of these facilities as of the beginning of base closure efforts.) One of these, NH-1, serves as Naval Hospital Charleston. That tenant is not a participant in the decommissioning process.

Table VII-1
NRMP-Controlled Radiological Facilities
(In Use at Beginning of Naval Base Closure)

FACILITY	RADIOLOGICAL USE
NS-26	Radioactive Material Work/Storage
NH-1	Radioactive Material Work/Storage

2. Other Naval Base facilities had a history of operations or activities which involved use or storage of non-NNPP controlled G-RAM. These applications either involved exempt quantities of radionuclides or involved operations which occurred prior to licensing/permitting requirements. These facilities and the potential operation of concern are identified in Table VII-2. (This table represents the status of these facilities as of the beginning of base closure efforts.)

AREAS AND FACILITIES REQUIRING RADIOLOGICAL SURVEYS

Table VII-2
Non-NRMP Controlled Radiological Facilities
(In Use at Beginning of Naval Base Closure)

FACILITY	RADIOLOGICAL USE
Buildings 198, 224, 1172, 1501, 1632, 1639, NSC-66 and NSC-67	Receipt/Storage of G-RAM Commodities
Buildings NS-26, 191, 200, 202, 1197, 1296, FBM-61, NS-46 and X-10	Storage/Use of G-RAM Commodities

Note: Building NS-26 is included in both Tables VII-1 and VII-2. It housed two G-RAM areas of concern, one of which was NRMP-controlled.

DISPOSITION OF RADIOLOGICAL FACILITIES EQUIPMENT

A. General

At the time the closure process began:

- Two Naval Base tenants were in possession of active NRMP's.
    - SIMA was authorized to possess and utilize a multi-curie industrial radiography source.
    - Naval Hospital Charleston was permitted to possess various radio-pharmaceuticals, etc., in order to provide a wide range of medical diagnostic services for military personnel and their dependents.
- The Fleet and Mine Warfare Training Center had several micro-curie size RADIAC response type sources in their custody. These had been a part of a RADIAC training program falling under their cognizance.
- Approximately seven thoriated tungsten welding electrodes containing naturally-occurring Thorium-232 were in the Weld Shop (Room 2-172) of Building FBM-61.

B. Equipment Disposition

1. The material addressed in the preceding paragraph made up the entire inventory of Naval Base tenant-possessed G-RAM equipment.

2. The disposition of Naval Base G-RAM was as listed below:

    - Naval Hospital Charleston is not a participant in the closure process. Therefore, there has been no change in the status of its G-RAM program.
    - The industrial radiograph sources and its associated equipment possessed by SIMA has been returned to the vendor from whom it was obtained. Its site-specific NRMP was terminated in August 1995.

DISPOSITION OF RADIOLOGICAL FACILITIES EQUIPMENT

- The RADIAC response sources held by the Fleet Mine Warfare Training Center were disposed of as low-level radioactive waste via an authorized disposal contractor.

- The thoriated tungsten welding electrodes were disposed of properly.

SOLID RADIOACTIVE WASTE GENERATED DURING RADIOLOGICAL FACILITIES DECOMMISSIONING

With one exception the results of the decommissioning surveys fell within the Navy's established criteria for the unconditional release for unrestricted use of Naval Base facilities. The one exception was an approximate six square foot section of wall in the Building FBM-61 Weld Shop. That small area was remediated, and the waste disposed of as G-RAM.

QUALITY CONTROLS PROGRAM

A. Introduction

1. This section of the report summarizes the quality provisions used in this comprehensive survey project to assure surveys were satisfactory for the release of Naval Base facilities for unrestricted use by the general public. Those surveys were performed by CNSY. The radiological control expertise exercised by the shipyard stemmed from a relationship of over thirty years with the NNPP. The same rigorous attitude as applied to reactor operation and design was applied to radiological and environmental controls. The effectiveness of these controls had been demonstrated through the years and by over-sight environmental surveys from the U.S. Public Health Services (USPHS), the USEPA, USDOE contractors and SCDHEC. The quality provisions included: formal personnel training and qualifications, strong technical supervision, multiple reviews of data, strict equipment calibration/daily checks and independent reviews.

2. Standards for closing radiological facilities are presently being developed by the EPA, NRC and DOE. The available drafts were reviewed, and the quality control/quality assurance provisions used by CNSY met or exceeded the proposed requirements of those documents.

B. Training and Qualification of Personnel

1. Management, engineering, radiological control, quality control and trades personnel involved in the release survey project had previously performed complex overhauls of nuclear-powered submarines. The extent of training and qualification for the project personnel was commensurate with the education, experience and individual proficiency. In most instances, prior qualifications were still valid. Qualification typically included:

- A course of instruction provided by detailed lesson plans.
    - A written final examination.
    - A practical demonstration performing simulated work.
    - Periodic requalification.

For example, Radiological Control Technicians were required to complete a course of six months to one year in length in radiological controls with

QUALITY CONTROLS PROGRAM

numerous written tests--including a final comprehensive written examination. They were also required to demonstrate practical abilities in work operations and emergency drills as well as pass a comprehensive oral examination. Radiological controls supervisors were required to have the same technical knowledge and abilities as the technicians; however, passing scores for examinations provided for supervisors were higher than for technicians. Requalification was required at least every thirty months. Between qualification periods, these persons participated in periodic training and were subject for selection for impromptu written and practical examinations.

2. U.S. Navy Report, "Occupational Radiation Exposure From U.S. Naval Nuclear Plants and Their Support Facilities, Report NT-95-2" provides additional details on radiological training programs.

C. Work Control

1. The same disciplined work control process used for nuclear submarine work was used for this project. Detailed, written engineered procedures were prepared and used. Each procedure was identified by a unique number. Procedures were followed verbatim. If the procedure could not be performed as written, a formal change was made. Such procedure changes were numbered and tracked to ensure all required work was accomplished. A separate work packaging and control group tracked the work procedures and verified that all work had been completed.

2. Trained personnel performed the work and assured the accuracy of the data recorded and performed signature certification. Qualified supervisors provided on-site work direction. These supervisors reviewed data as it was collected and performed spot-check surveys to further assure the validity of survey results. Individuals were held accountable for performing tasks as specified.

3. Signature chain-of-custody was maintained on all samples to ensure that the samples taken from a specific location were counted and recorded for the proper location. Sample containers were used only once to eliminate the possibility for contamination of another sample.

D. Survey Data Review

1. There were multiple reviews of survey data for completeness, validity and accuracy. They included a review by radiological controls supervisors or

laboratory analysis supervisors, the production work-packaging group, radiological engineering and a team of middle managers called the internal quality assurance group. Guidelines for conducting them were established to ensure that consistent, in-depth analyses were performed.

2. Computer programs were used to check data and to provide verification that all data required by the survey plan had been obtained and was within the required specifications.

3. Selected areas were resurveyed and sampled to validate the survey and sampling results.

4. Finally, all survey data contained in this comprehensive report was reviewed by senior technical personnel.

E. Measuring Equipment Calibration and Checks

1. All measuring and test equipment was maintained and calibrated in accordance with the standard Navy calibration program. Additionally, field radiation detection equipment was checked on a daily basis to a known quantity of radioactivity (source) traceable to a National Institute of Standards and Technology standard. This check, performed by qualified radiological controls personnel, ensured proper instrument response to radioactivity.

2. Laboratory equipment used for solid and water-sample analysis was maintained and calibrated in accordance with detailed written instructions. These instructions included a series of daily checks with NIST traceable standards. On a quarterly basis, the sample counting laboratory provided samples to an independent Department of Energy laboratory (Knolls Atomic Power Laboratory) for duplicate counting to confirm the adequacy of the shipyard's results. On a periodic basis the same Department of Energy laboratory provided blind standards to the shipyard to confirm the ability of the sample counting laboratory to detect known values of radioactivity.

F. Audits and Reviews

1. Numerous checks, cross-checks and inspections were included as part of the normal work process. In addition to these checks, a strong independent audit program verified compliance with the requirements of the survey plan. This was not a new concept; an audit program has been in existence since nuclear

QUALITY CONTROLS PROGRAM

submarine work began. This radiological audit group was independent of the radiological controls and production organizations and its findings were reported regularly to senior management. This group performed continued surveillance of the project. In-depth audits of specific aspects, as well as overall assessments, were performed.

2. A representative of the Director of the Naval Nuclear Propulsion Program, had been in place on CNSY since shortly after the inception of nuclear work on the Naval Base complex. That representative and his staff were dedicated to oversight of this project following the cessation of nuclear submarine work.

3. NNPP headquarters technical personnel conducted periodic inspections of the project. They also reviewed all survey data collected prior to its final distribution.

4. The SCDHEC and USEPA reviewed the survey plan, the drafts of this report and performed independent observations, over-check surveys and sampling of facilities and areas. Their results were consistent with Navy results. Both agencies concurred with the Navy conclusion that:

   - There are no significant radiological hazards from residual radioactive material.

   - Activities conducted by the Navy were not in excess of regulatory standards.

   - There are no instances which would be detrimental to the health and safety of the public or the environment.

   - The facility could be released from radiological controls for unrestricted use.

GLOSSARY OF ACRONYMS/ABBREVIATIONS

ABC : Atomic, Biological, and Chemical.

AEC : Atomic Energy Commission (replaced by the NRC).

Am-241 : Americium-241.

AMS : Aerial Measuring Systems.

Bi-214 : Bismuth-214.

BRAC : Base Realignment and Closure Commission.

BUMED : Navy Bureau of Medicine and Surgery. The Navy Command responsible for radiological controls associated with the nuclear medicine operations and Navy medical facilities.

C-14 : Carbon-14.

Cd-109 : Cadmium-109.

10 CFR : Title 10 of the Code of Federal Regulations.

Curie : Abbreviated Ci. A unit of measure of the amount of radioactivity equal to 3.7×10^{10} disintegrations per second of 2.22×10^{12} disintegrations per minute.

Cl-36 : Chlorine-36.

CNSY : Charleston Naval Shipyard.

Co-60 : Cobalt-60.

Cs-137 : Cesium-137.

G-RAM : General Radioactive Material. Radioactive materials that are not associated with the Naval Nuclear Propulsion Program.

IMANPY : Intermediate Maintenance Activity Nuclear Planning Yard.

GLOSSARY OF ACRONYMS/ABBREVIATIONS

Ir-192	:	Iridium-192.
K-40	:	Potassium-40.
MDA	:	Minimum Detectable Activity.
NAVBASE CHAS	:	Naval Base Charleston.
micro	:	Abbreviated μ. A prefix denoting a one-millionth part (10^{-6}).
milli	:	Abbreviated m. A prefix denoting a one-thousandth part (10^{-3}).
NaI	:	Sodium-Iodide.
NAVSEA	:	Naval Sea Systems Command. The Navy command responsible for radiological controls associated with industrial radiography and the radiation detection instrument calibration operations at CNSY.
NBS	:	National Bureau of Standards.
NCRP	:	National Committee on Radiation Protection and Measurements.
NIST	:	National Institute of Standards and Technology.
NNPP	:	Naval Nuclear Propulsion Program. A joint Navy/Department of Energy program to design, build, operate, maintain and oversee operation of Naval nuclear-powered ships and associated support facilities.
NORM	:	Naturally-Occurring Radioactive Material.
NRC	:	Nuclear Regulatory Commission.
NRMP	:	Navy Radioactive Materials Permit. Site-specific or broad scope Navy license for the use of specified radioactive material under specified conditions. These permits are issued by the Navy Radiation Safety Committee under the authority of the Master Materials License granted to the Navy by the NRC.

GLOSSARY OF ACRONYMS/ABBREVIATIONS

NRSC	:	Navy Radiation Safety Committee. The Navy organization providing administrative control of all Nuclear Regulatory Commission--licensable radioactive material used in the Navy and the Marine Corps.
Pb-214	:	Lead-214.
pico	:	Abbreviated p. A prefix denoting a one-trillionth part (10^{-12}).
PHA	:	Pulse Height Analyzer.
Pm-147	:	Promethium-147.
Ra-226	:	Radium-226.
RADIAC	:	Radiation Detection/Indicating and Computation instrument(s).
RASO	:	Radiological Affairs Support Office. RASO provides technical support to the NRSC for radiological controls associated with NRMP-related activities under NAVSEA cognizance.
RASP	:	Radiological Affairs Support Program. NAVSEA uses the RASP to discharge its responsibility for radiological controls for applicable sources of ionizing radiation.
RCM	:	Radiological Control Monitor.
RCT	:	Radiological Control Technician.
RSO	:	Radiation Safety Officer.
SCDHEC	:	South Carolina Department of Health and Environmental Controls.
SIMA	:	Shore Intermediate Maintenance Activity.
Sr-90	:	Strontium-90.
Tc-99	:	Technetium-99.

GLOSSARY OF ACRONYMS/ABBREVIATIONS

TGI	:	Task Group Instruction.
Th-230	:	Thorium-230.
Th-232	:	Thorium-232.
TIG	:	Tungsten Inert Gas.
U-235	:	Uranium-235.
USEPA	:	U.S. Environmental Protection Agency.
USNRC	:	U.S. Nuclear Regulatory Commission (formerly the AEC).
USPHS	:	U.S. Public Health Service.