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HISTORICAL RADIOLOGICAL ASSESSMENT VOLUME 2 GENERAL RADIOACTIVE MATERIAL 1942 TO 1994 CNC CHARLESTON SC

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CNC CHARLESTON

Historical Radiological Assessment

Charleston Naval Shipyard

Volume II

GENERAL RADIOACTIVE MATERIAL

1942 - 1994

Radiological Control Office
Charleston Naval Shipyard
Charleston, South Carolina 29408

February 1996

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1.0 Executive Summary

1.1 Purpose

This Historical Radiological Assessment (HRA) has been prepared by Charleston Naval Shipyard (CNSY) pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the Superfund Amendments and Reauthorization Act of 1986 (SARA). The purpose of this HRA is to catalog and present over 30 years of radiological environmental data within the framework of the CERCLA process and within the pathway scoring protocol of the revised Hazard Ranking System (HRS).

Volume II of this HRA addresses general radioactive material (G-RAM), including all non-Naval Nuclear Propulsion Program (non-NNPP) applications of radioactivity. These include Radiological Affairs Support Program (RASP) material and unregulated consumer products. Site-related medical applications would be included, except none apply at CNSY. Volume I addresses radioactivity associated with the NNPP. Different branches of the Navy are responsible for these categories of radioactivity, and different historical practices have applied.

1.2 Background

Requirements for the control of any G-RAM at CNSY, even before passage of the 1954 Atomic Energy Act, 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 the Bureau of Medicine and Surgery, invoked applicable recommendations of the NCRP (published at that time as National Bureau of Standards Handbooks) for specified radioactive material hazards. Historical G-RAM practices are outlined in Section 4.4.3.

Non-licensed G-RAM has been used at CNSY since at least the mid-1940's for various purposes. The earliest documented use of licensed G-RAM at the shipyard is for industrial radiography. A license application for source radiography was approved and issued to the shipyard by the U.S. Atomic Energy Commission (AEC) in 1960. Two additional AEC licenses were obtained by the shipyard in late 1960 or 1961. The first of these licenses was obtained to allow the Industrial Manager to own sealed sources for a calibration laboratory. The second of these was for the shipyard's calibration laboratory. A license for the use of a tritium source used in an experimental neutron activator facility was obtained in 1969 and a license was issued to the Radiological Control Department in the early 1970's for sealed response check sources. Licensed G-RAM at the shipyard is described in Section 4.4.

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. Radiological environmental monitoring has continued through the present. 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 is additionally indicative of the presence or absence of G-RAM, and pertinent results of this monitoring are included in this volume.

Independent surveys of the harbor by the Public Health Service (PHS) and the Environmental Protection Agency (EPA) have also been conducted. These independent verifications have been consistent with NNPP and shipyard results and conclusions.

1.3 Findings

The controls applied to G-RAM at the shipyard have historically been consistent with federal regulations and with national scientific committee recommendations.

Of all the radiological data collected by the Navy, the Public Health Service, the Environmental Protection Agency, and the state of South Carolina, no radioactivity attributable to G-RAM operations is detectable in the vicinity of the shipyard.

CNSY was designated for closure by the 1993 Base Realignment and Closure Commission. This recommendation was adopted and became law on September 27, 1993. As a result, an extensive radiological survey plan was started in October 1994 to identify any remaining radioactivity associated with operations involving G-RAM. To date only one isolated area has been identified for remediation.

1.4 Conclusions

This HRA concludes that: (a) operations involving G-RAM at CNSY have had no adverse effect on the human population or the environment of the region; and (b) independent reviews by the Public Health Service, the EPA, and the South Carolina Department of Health and Environmental Control are consistent with these conclusions. CNSY concludes that, based on this assessment, no additional characterization and no remedial actions are necessary as a result of G-RAM activities at the shipyard. CNSY notes that ongoing shipyard closure surveys will verify the absence of remaining G-RAM radioactivity prior to release of the shipyard land and facilities for unrestricted use.

2.0 Introduction

2.1 Background

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 established a process whereby past private sector disposal sites were scored for environmental contamination, and remedial action initiated where warranted. Federal facilities were not included within CERCLA; however, under Executive Order 12316 of August 20, 1981, the President directed the Department of Defense (DOD) to conduct similar evaluations of their installations.

By the mid-1980's, most DOD facilities had been evaluated. These Initial Assessment Studies were conducted for Naval shipyards and operating bases where nuclear-powered ships were maintained or berthed. The CNSY Initial Assessment Study, Reference 1, was completed in 1983.

During 1986, DOD realigned its programs to be more consistent with those of the Environmental Protection Agency (EPA) in the private sector. Initial Assessment Studies paralleled the Preliminary Assessments and Site Inspections of CERCLA. Confirmation Studies paralleled the Remedial Investigation and Feasibility Studies of CERCLA.

The Superfund Amendments and Reauthorization Act (SARA) of 1986 required that Federal agencies comply in the same manner and extent as private entities and allowed Federal activities to be placed on the National Priorities List (NPL). Executive Order 12580 of January 23, 1987 gave additional jurisdiction to the EPA for Federal facilities on the NPL.

SARA also directed the EPA to revise its Hazard Ranking System (HRS) used to score sites undergoing the CERCLA process. This was completed and the revised HRS was published in the Federal Register in December 1990.

The EPA has evaluated CNSY using the revised Hazard Ranking System (HRS), a scoring system used to assess the relative threat associated with the release or potential release of hazardous substances from a facility. The HRS score is the primary criterion EPA uses to determine whether a site should be placed on the NPL. The EPA has placed CNSY in the Site Evaluation Accomplished category (United States Environmental Protection Agency Region IV letter 4WD-FFB dated January 8, 1993), which means that CNSY requires no further evaluation and is not included in the NPL at this time.

2.2 Purpose

This Historical Radiological Assessment (HRA) was produced to provide a comprehensive review and assessment of the impact of radiological operations at CNSY. This assessment is organized in a format similar to the standard Preliminary Assessment (PA) protocol used by the EPA within the CERCLA process. This format was chosen as a vehicle that is in common use and is easily understood.

Environmental radiological data collected for CNSY are catalogued and presented in Section 6 within the pathway evaluation protocol of the PA. Additional environmental data collected by the Public Health Service and the EPA and their independent conclusions are included in the relevant sections of this assessment.

Section 8 of this assessment addresses each pathway along with the salient data results contained in previous sections and evaluates estimates of radiological impact to the public and to the environment from CNSY operations associated with G-RAM.

This assessment is historical in that the regulatory and policy changes that have occurred during the evolution of G-RAM work are included as an explanatory supplement to the analytical results.

2.3 Methods

2.3.1 Counting Terminology

"Gross Gamma" spectrometry systems used for counting environmental samples are currently calibrated to respond to gamma energies between 0.1 MeV and 2.1 MeV, and thus detect a combined total of all radionuclides with gamma energies between 0.1 and 2.1 MeV. (The gross gamma energy range for counting systems used from 1964 through 1974 was between 0.6 and 1.6 MeV). Where activity in this range is above 1 pCi/g, detailed radionuclide analysis is generally performed to determine whether all the activity is due to other (natural or fallout-related) radionuclides. For some analyses (e.g. modern environmental monitoring sediment, water, and biota samples), detailed radionuclide analysis is performed regardless of measured gamma levels.

Gross gamma is measured in the gamma energy range of interest (0.1 - 2.1 MeV) using the efficiency value of cobalt-60, since surveys are conducted by the NNPP and cobalt-60 is the limiting radionuclide of concern in that program. Natural background and G-RAM radionuclides generally have only one gamma per disintegration, of lower energy than cobalt-60's two gammas (potassium-40 is an exception). Hence, actual background radioactivity and G-RAM radioactivity are likely higher than measured and reported by this procedure. Nevertheless, this is acceptable since background radioactivity is not of concern, and since gamma-emitting G-RAM radionuclides, if present, will cause a detectable increase in measured levels.

When detailed radionuclide analyses are performed, germanium detectors are used. Specific photopeaks are used to identify and quantify specific radionuclides.

2.3.2 The Investigatory Process

The pathways, targets, and potential release mechanisms described in this HRA were used to guide the process of selecting information to be reviewed in preparing this assessment. During the course of the investigation, they were used to gauge the adequacy of the historical record of radiological work at CNSY.

Information descriptive of CNSY was in large measure taken from Reference 1. Navy and CNSY correspondence and history files were reviewed to ensure all potential source terms of radioactivity were identified. Navy and CNSY historical records were reviewed to ensure that an accurate account is presented of past requirements and practices.

All available records related to release, monitoring, and waste disposal were reviewed to determine: where radiological work was performed; what the environmental impact of radiological operations has been; and the history of radioactive waste disposal. Records were reviewed to determine if any inadvertent releases of radioactivity to the environment were not immediately remediated. Records of areas formerly used for radiological work were reviewed to determine whether all such areas have been appropriately released from radiological controls in accordance with all applicable requirements. A more detailed discussion of the specific types of records reviewed, and the results of that review, are contained in Section 5.

2.3.3 Interviews

Interviews with employees, retirees, local officials, and citizens were conducted during preparation of Reference 1 (1983 IAS). For the 1983 IAS, the contractor invited employees to participate in interviews. The subject of past practices associated with the former (non-radioactive) disposal sites on base was emphasized in these interviews. Radioactivity was not raised as a concern in these interviews.

To confirm that past practices at the shipyard were in keeping with local and headquarters instructions, the Navy considered interviewing people who were assigned to NNPP radiological work at CNSY in the early years of nuclear power operations, since these individuals would also likely be knowledgeable in G-RAM operations. Two individuals who were instrumental in the development of the radiation health program at CNSY were identified and served as an invaluable resource for information on G-RAM operations from 1959 to the present. In addition, these individuals were able to contact many past employees of CNSY who worked in the areas of radiation health, radiological controls and occupational safety and health. Unfortunately, most of these interviews provided little additional information.

The CNSY Human Resources Office has minimal information for past civilian employees of CNSY. These employee records number in the tens of thousands, and do not document employment history below the department level. Thus, the records do not uniquely identify persons who might be knowledgeable about past G-RAM work. Radiation exposure records could be examined to identify which personnel were monitored for exposure at the CNSY in a given year. However, attempting to locate persons today on the basis of old exposure records would be an arduous task with an uncertain outcome, and this effort has not been undertaken for this assessment. The record of work as detailed in Section 5 shows that there is no radioactivity associated with licensed or permitted G-RAM at or near CNSY that requires remediation (one site in which non-licensed G-RAM was used has isolated areas which require remediation based on current criteria.)

2.3.4 **Units**

Units used throughout this report include: pCi/g (picocurie per gram), kcpm (thousand counts per minute), mrem/hr (millirem per hour), mrem/qtr (millirem per quarter year), and μR/hr (microroentgen per hour). A further explanation of a particular unit can be found in the glossary.

3.0 Site Description

3.1 Site Name and Location

Charleston Naval Shipyard
Charleston, SC 29408-6100

CNSY is located on the banks of the Cooper River in Charleston County and lies within the corporate boundaries of the City of North Charleston, approximately 5 miles north of the city of Charleston. The installation consists of two major areas: an undeveloped spoil area on the east bank of the Cooper River on Daniel Island in Berkeley County, and a developed area on the west bank of the Cooper River. The developed portion of CNSY lies on a peninsula, bounded on the west by the Ashley River and the east by the Cooper River. The western boundary of the developed area adjoins the city of North Charleston, and the eastern boundary adjoins the Cooper River between river mile 12 and river mile 13. Facilities adjacent to CNSY include Naval Station Charleston, Fleet and Industrial Supply Center, Naval Hospital Charleston, Fleet and Mine Warfare Training Center, Fleet Ballistic Missile Submarine Training Center, Navy Reserve Center and Chicora Tank Farm, all located within 0.5 mile of the shipyard, and all a part of Naval Base Charleston.

The shipyard is located at 32°51'46" North latitude and 79°58'01" West longitude. Figure 3.1 is a copy of four spliced 7.5 minute quadrangle maps, for the North Charleston, Charleston, Johns Island, and Ladson quadrangles. Circles of ¼, ½, 1, 2, 3 and 4 mile radii are shown with the midpoint of nuclear activities in the center. Figures 3.2(a)-(c) are vicinity maps of the shipyard. Figures 3.3 (a)-(d) are historical photographs of CNSY. Figure 3.4 (see map pocket) is a drawing of the shipyard identifying building numbers, piers and berth designations, etc.

3.2 Site History

3.2.1 Type of Site (Reference 1)

CNSY is a public shipyard dedicated exclusively to the repair, overhaul and modernization of Navy warships and auxiliaries. The shipyard now consists of 121 acres (not including the dredge spoil area), with just over one mile of shoreline, 18 miles of paved roads, 17 miles of railroad track, five drydocks, and more than 280 buildings.

Figure 3.1 - 7.5 Minute Spliced Quadrangle Map
(for greater detail, see map pocket)

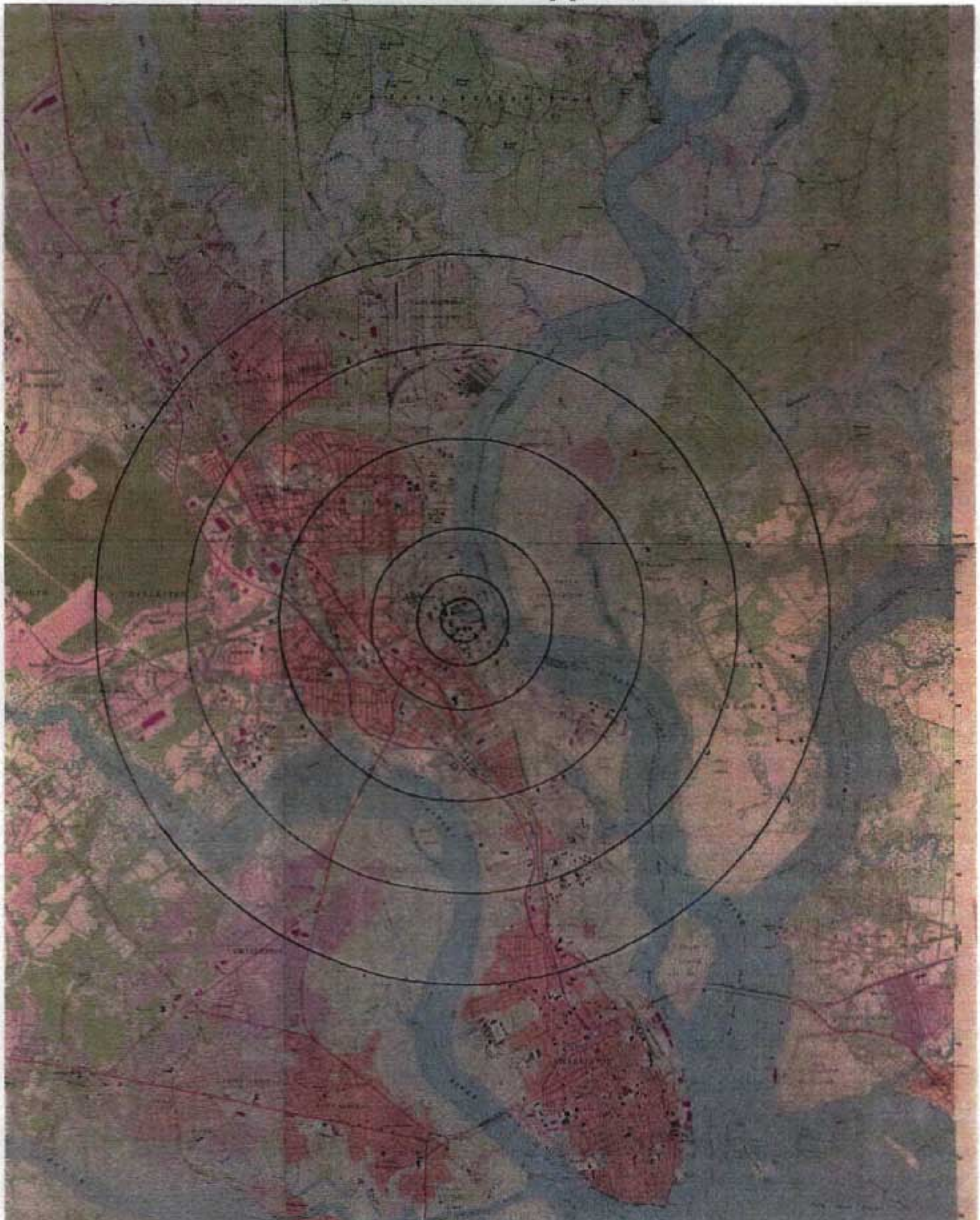
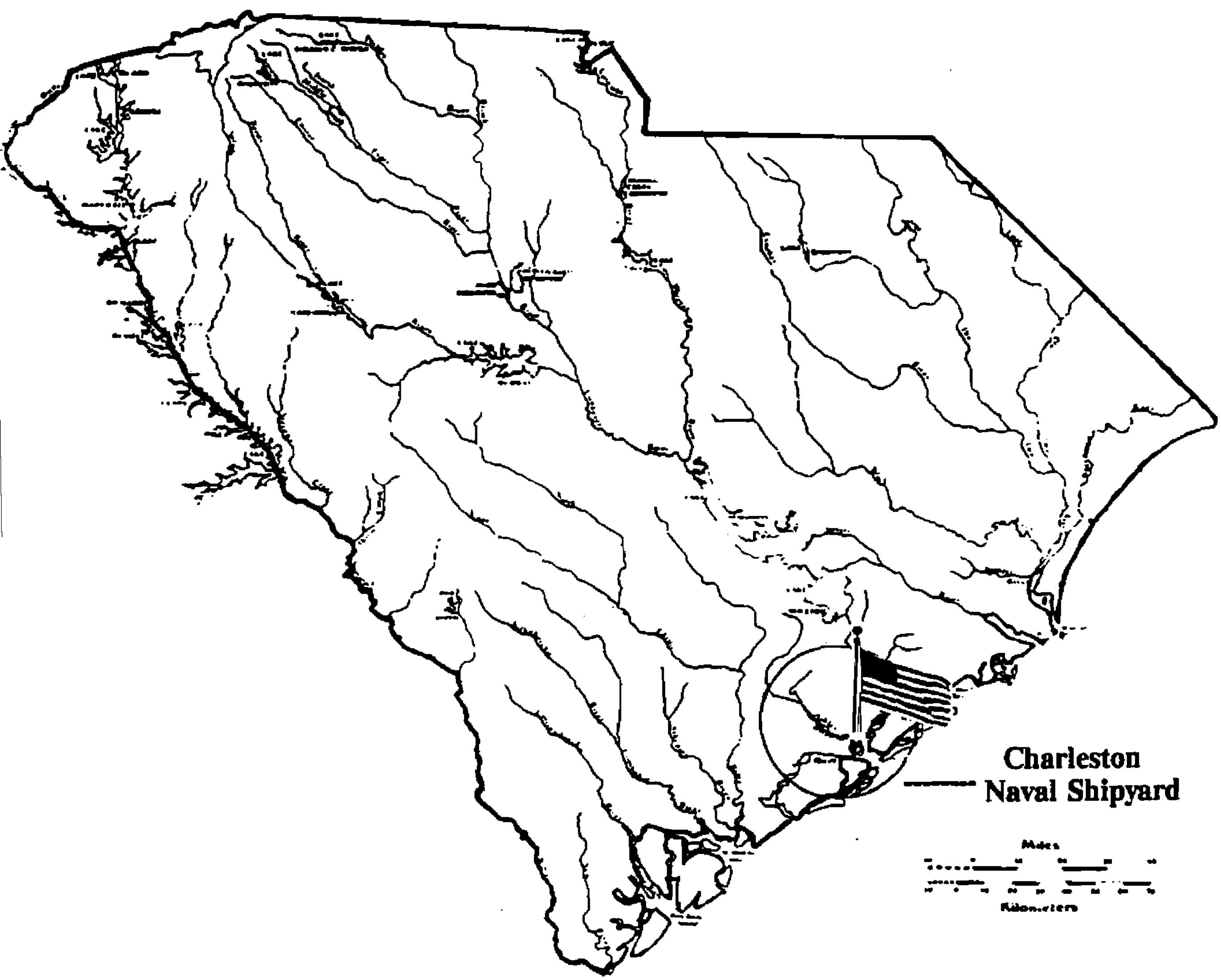


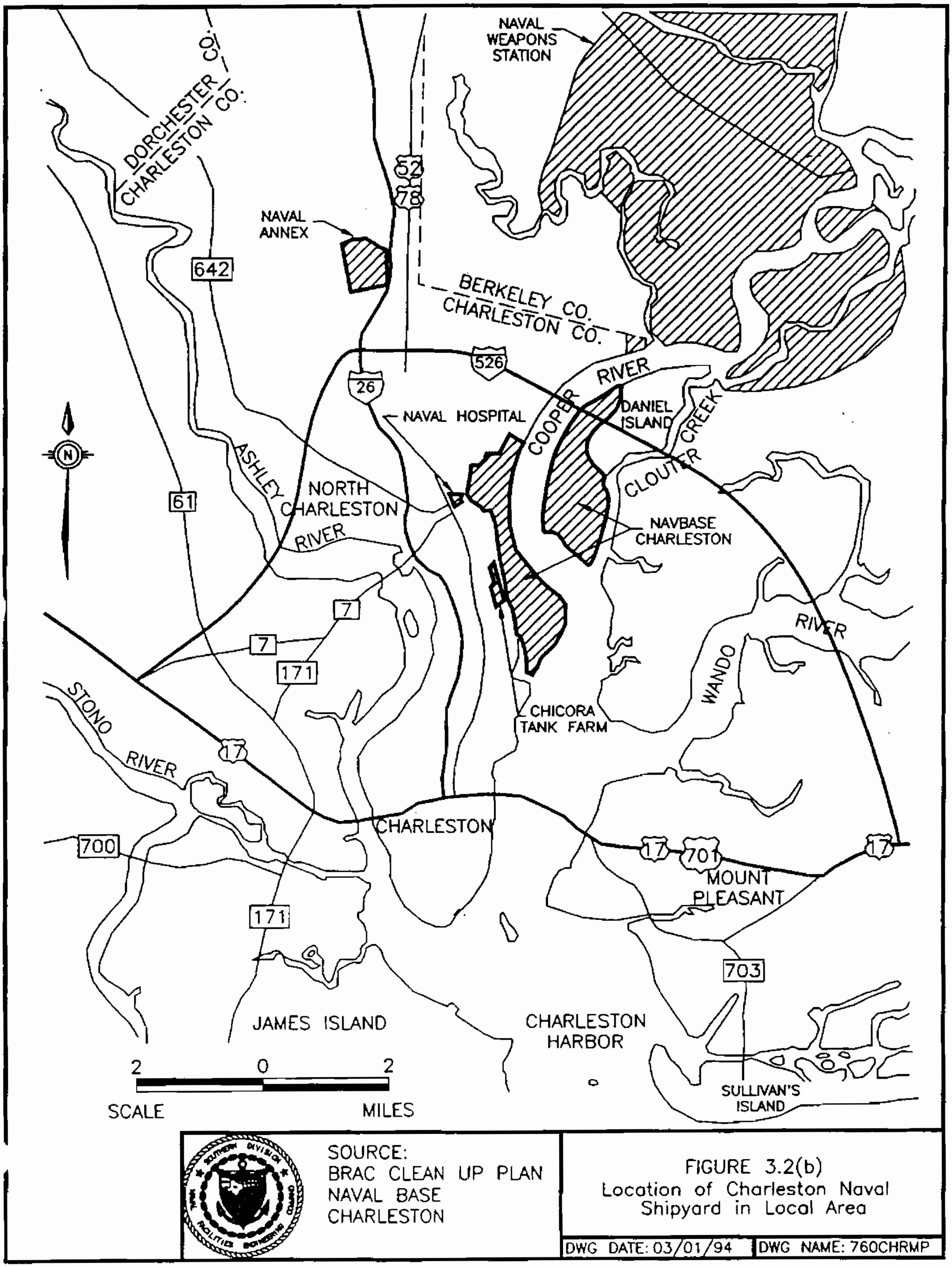
Figure 3.2(a)

State of South Carolina



Location of Charleston Naval Shipyard

in South Carolina


NAVAL WEAPONS STATION
DORCHESTER CO.
CHARLESTON CO.
52
78
NAVAL ANNEX
642
BERKELEY CO.
CHARLESTON CO.
526
26
COOPER RIVER
DANIEL ISLAND
NAVAL HOSPITAL
CLOUTER CREEK
ASHLEY RIVER
NORTH CHARLESTON
61
NAVBASE CHARLESTON
7
7
171
WANDO RIVER
CHICORA TANK FARM
STONO RIVER
17
CHARLESTON
700
17
701
17
MOUNT PLEASANT
171
703
JAMES ISLAND
CHARLESTON HARBOR
SULLIVAN'S ISLAND
2 0 2
SCALE MILES
SOURCE:
BRAC CLEAN UP PLAN
NAVAL BASE
CHARLESTON
FIGURE 3.2(b)
Location of Charleston Naval Shipyard in Local Area
DWG DATE: 03/01/94
DWG NAME: 760CHRMP

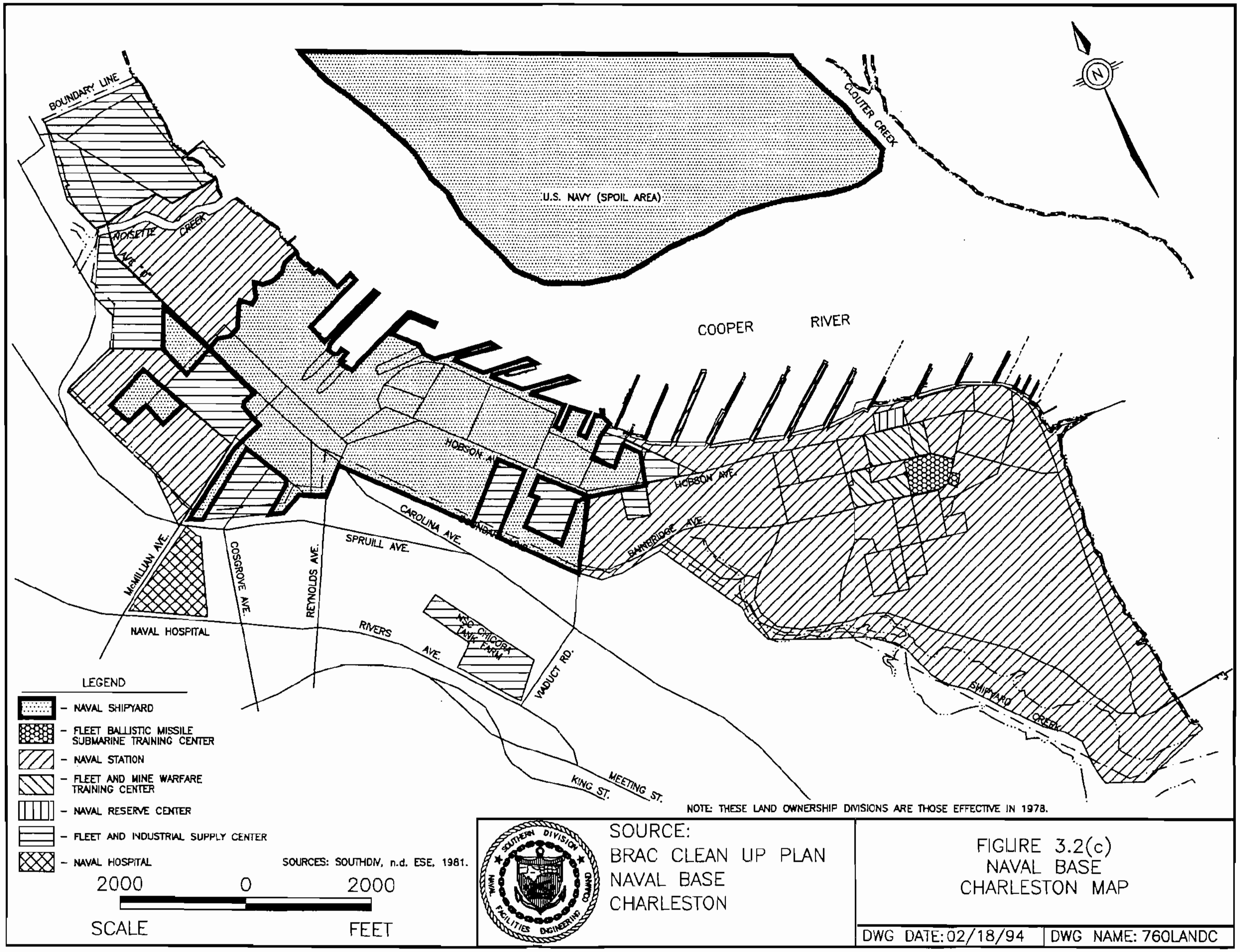


FIGURE 3.2(c)
NAVAL BASE
CHARLESTON MAP

Figure 3.3(a) - Drydocks 3 and 4 to Pier H, circa 1980

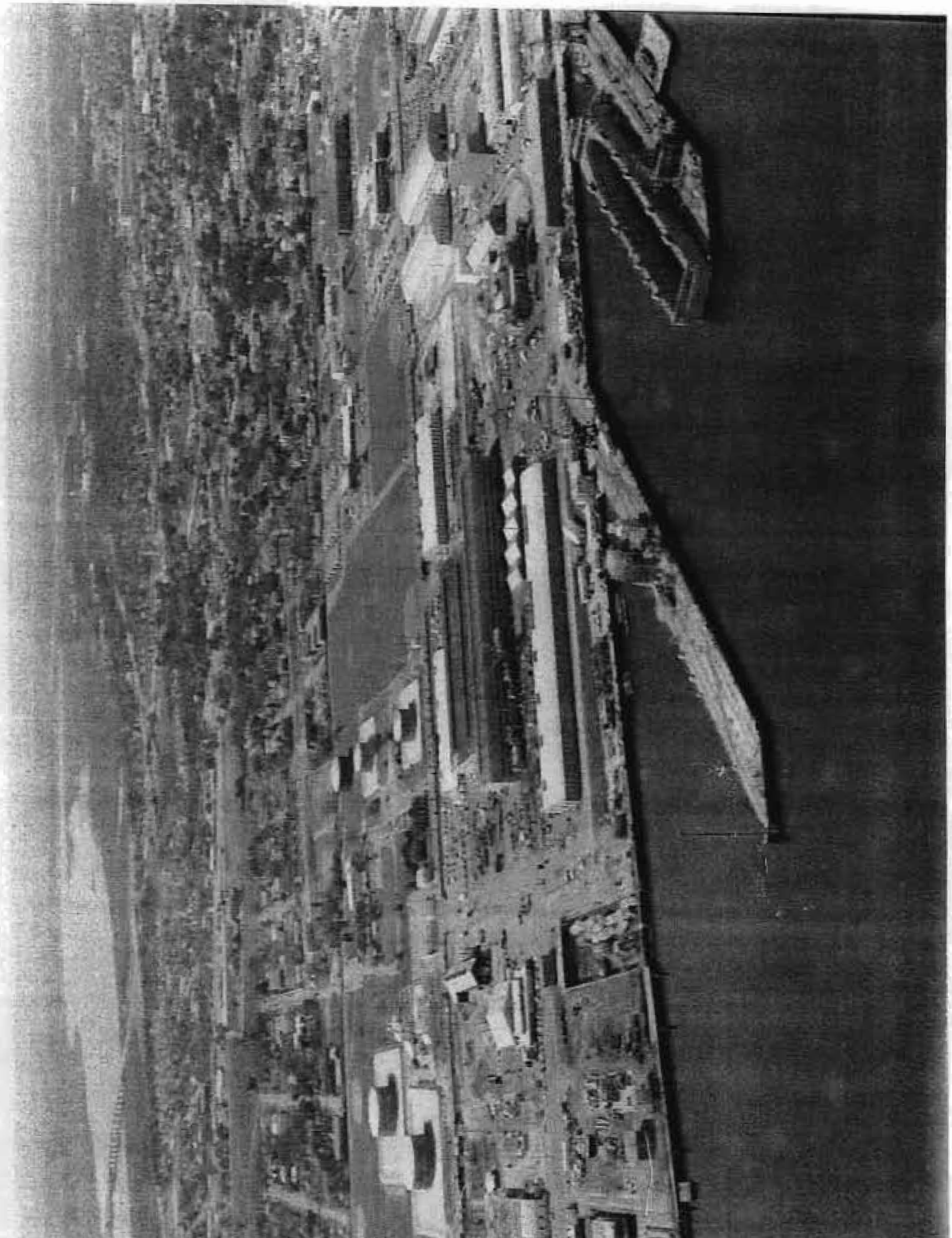


Figure 3.3(b) - Pier J to Pier G, circa 1980

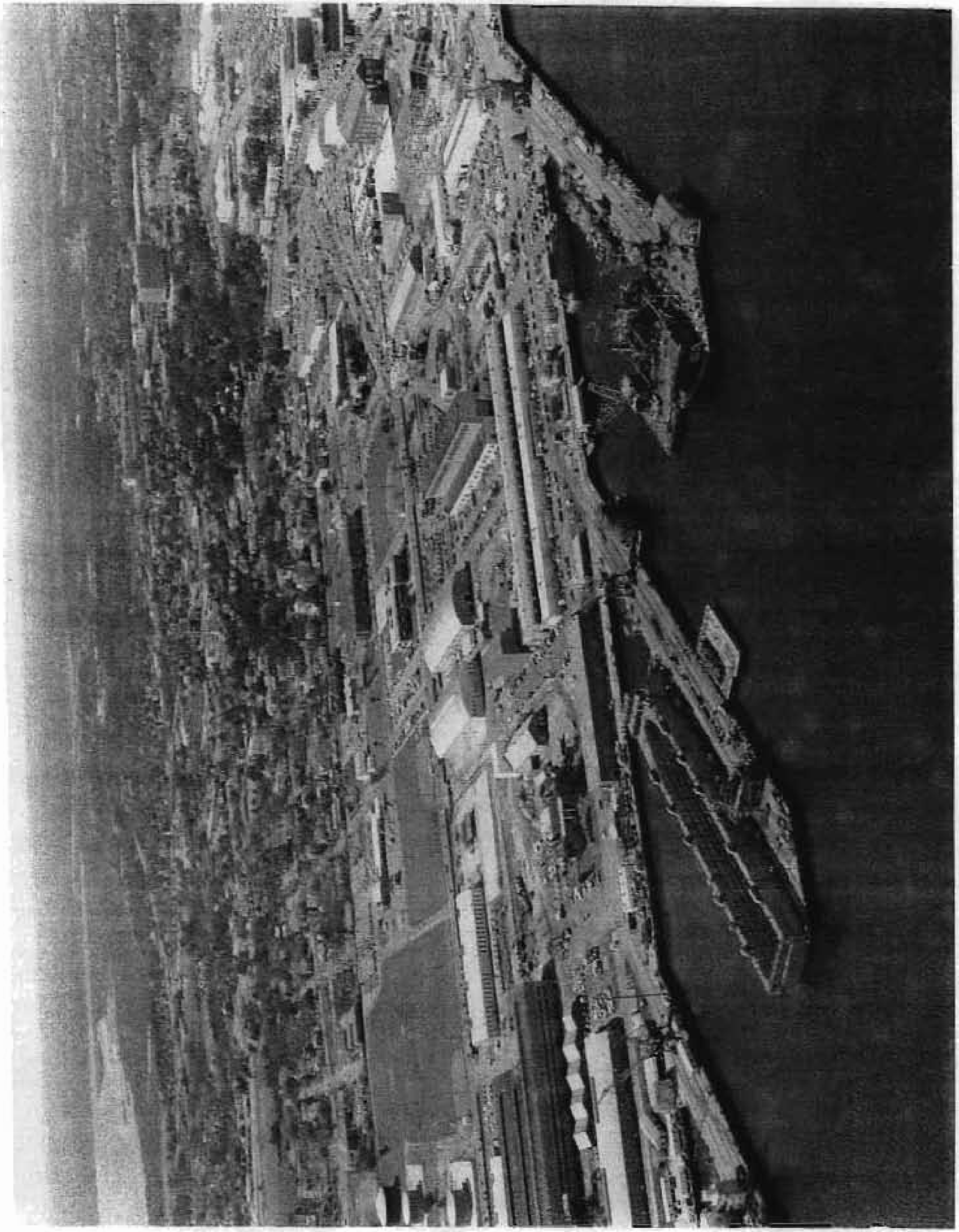


Figure 3.3(c) - Pier G to Drydocks 1 and 2, circa 1980

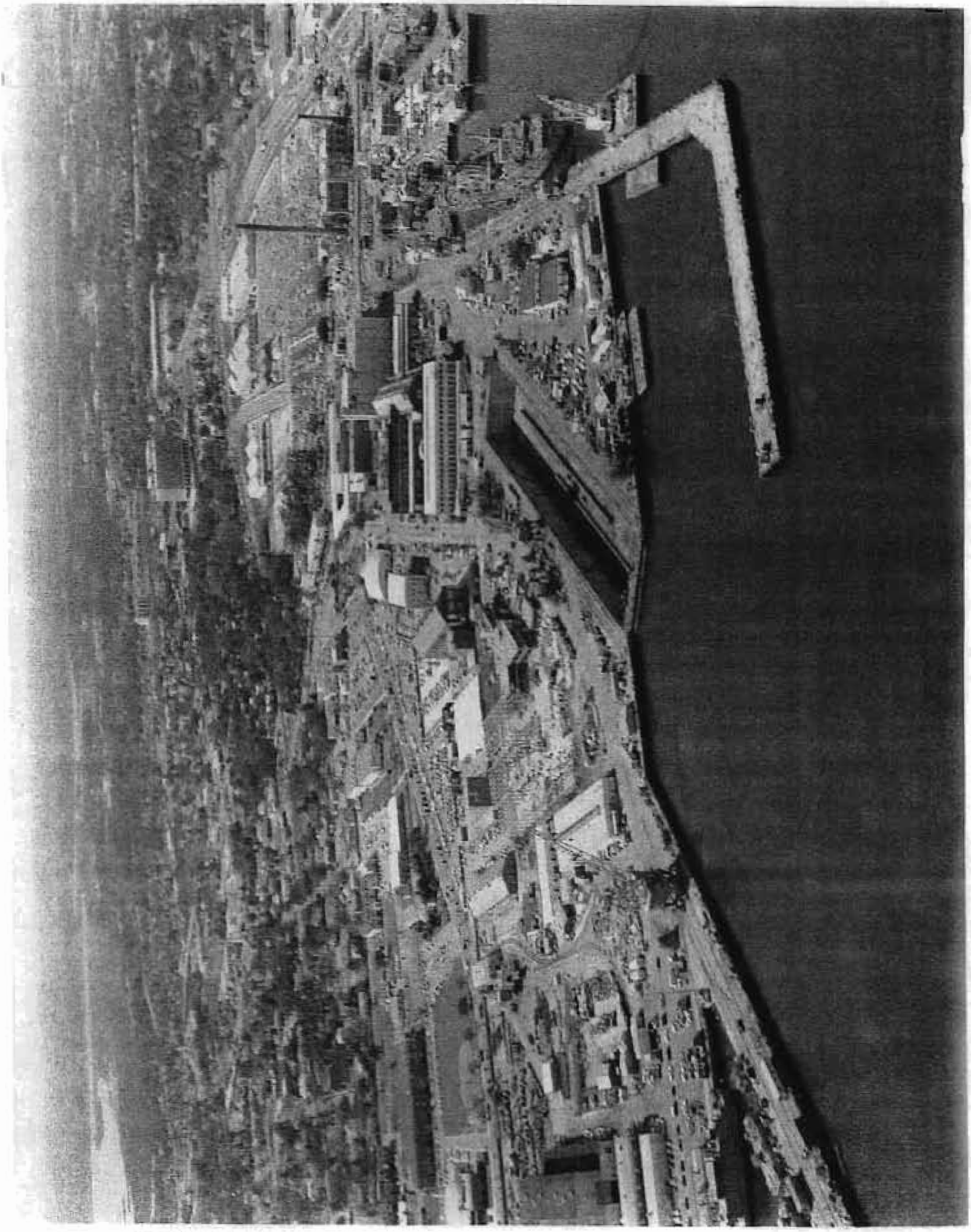


Figure 3.3(d) - Drydock 5 to North of Pier C, circa 1980

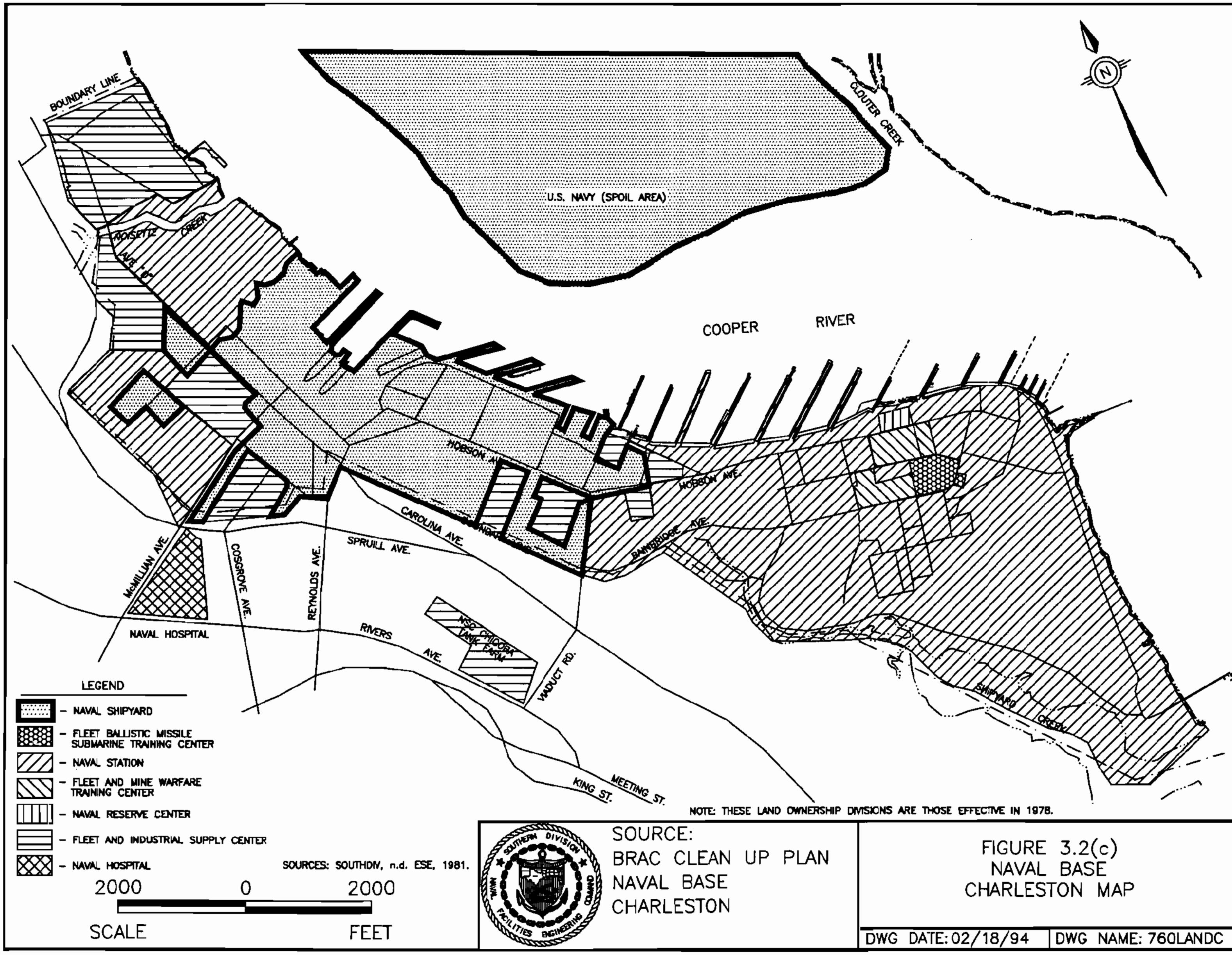


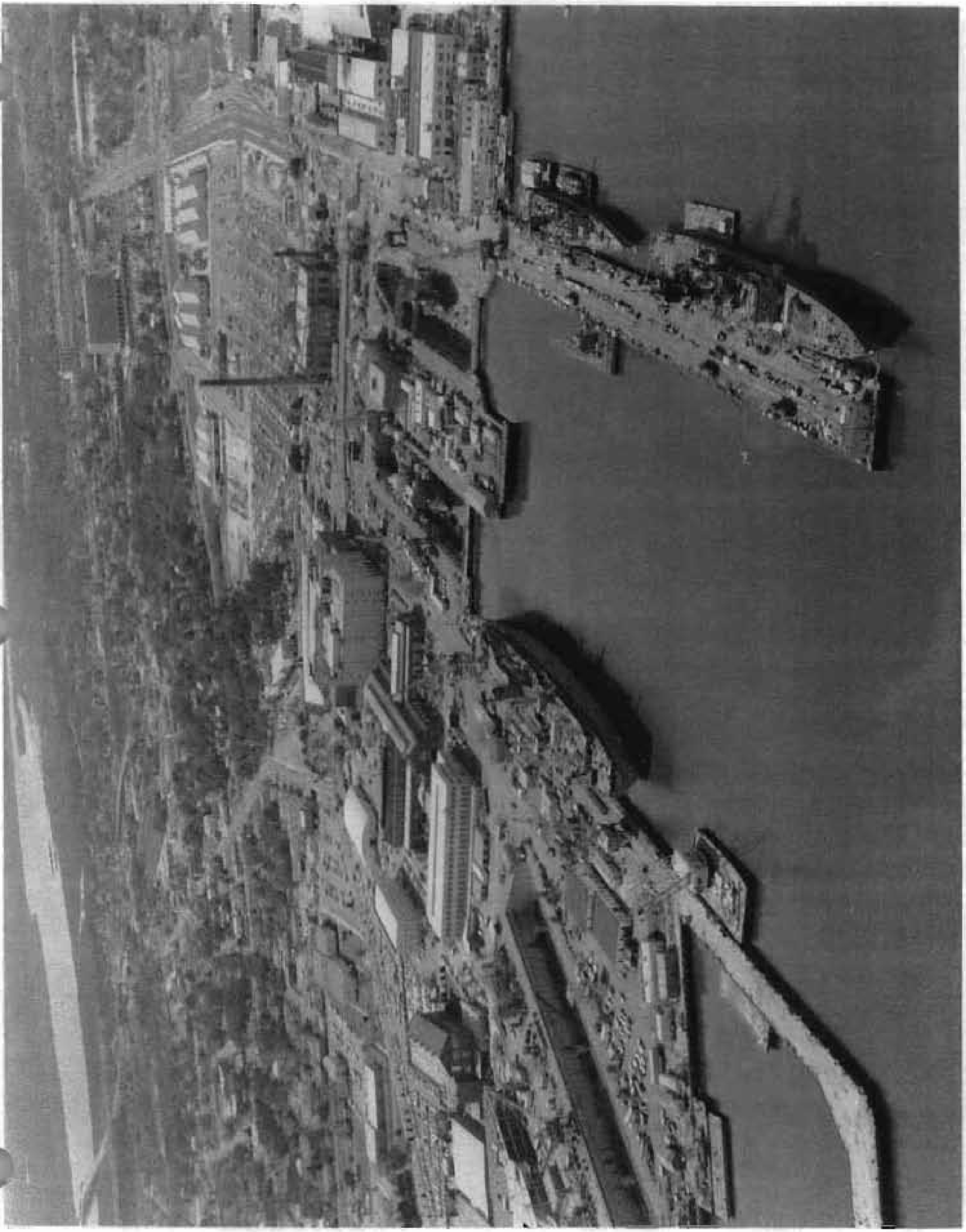
FIGURE 3.2(c)
NAVAL BASE
CHARLESTON MAP

Figure 3.3(a) - Drydocks 3 and 4 to Pier H, circa 1980

Figure 3.3(b) - Pier J to Pier G, circa 1980

Figure 3.3(c) - Pier G to Drydocks 1 and 2, circa 1980

Figure 3.3(d) - Drydock 5 to North of Pier C, circa 1980



3.2.2 Navy Ownership History

Since the early years of English colonial rule, the area around Charleston Harbor has been a center of naval interest. On August 31, 1901, the U. S. Navy took possession of 2,250 acres of hardland and marsh areas and established the U. S. Naval Yard, to make repairs to the smaller vessels of the fleet and supply them with stores.

During the period 1901 - 1915, a number of main shops, the powerhouse, the first drydock (No. 1, completed in 1907), four piers, administrative and storage space, a dispensary, officer quarters, and other miscellaneous facilities were constructed. In 1904 and 1909, marine barracks and officer quarters were constructed to house a contingent of Marines, which arrived October 1, 1903.

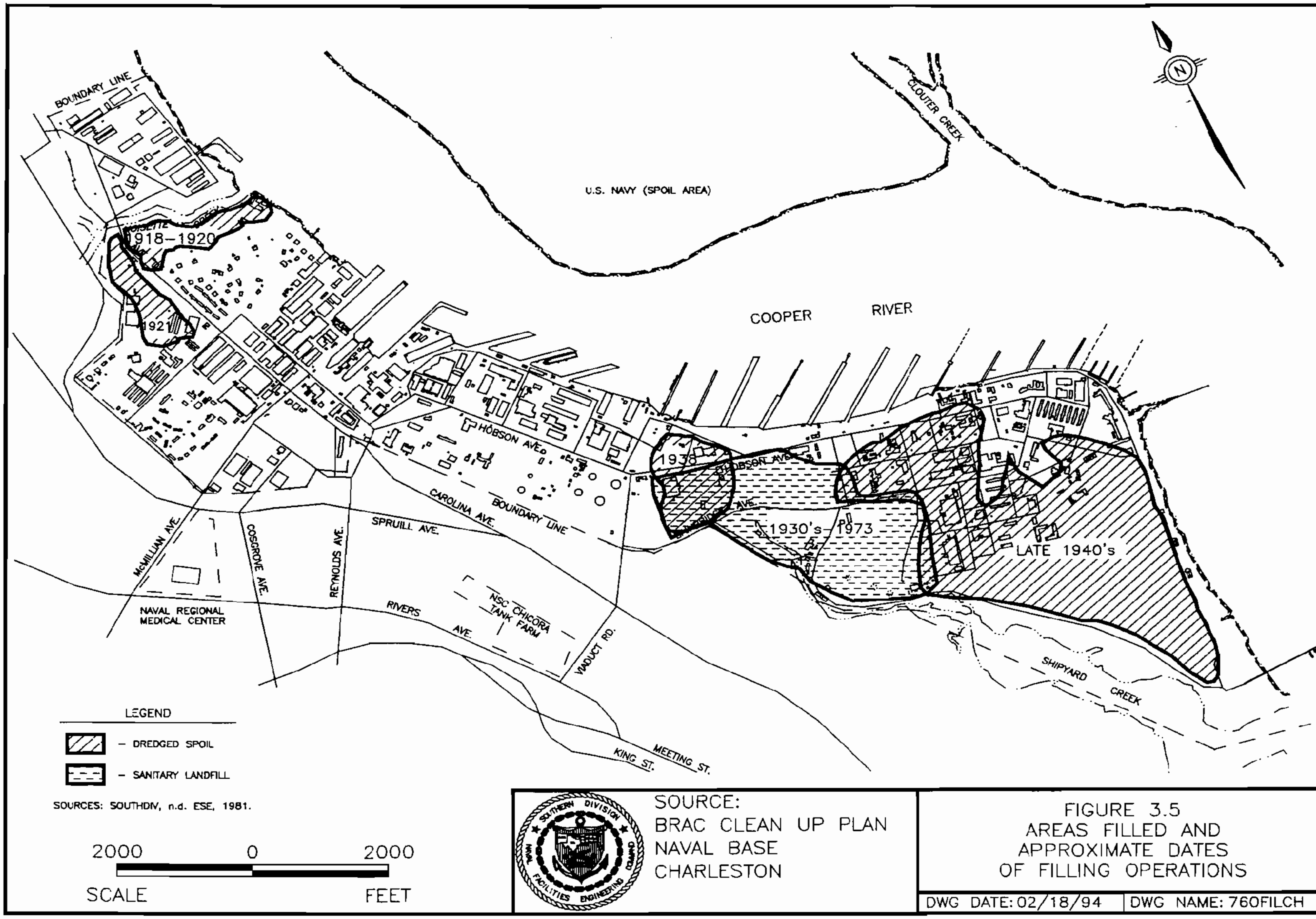
Work conducted at the Navy Yard at this time involved repairing, limited overhauling and supplying stores for smaller vessels, and as of June 30, 1915, involved 1,240 employees. In 1912, a Machinist's Mates School was established at the Navy Yard to provide vocational training.

During World War I, facilities were expanded and the Navy Yard adopted a more diversified mission. Repairs to torpedo craft and other small vessels, major alterations to vessels including destroyers, and construction of smaller fleet vessels including gunboats and destroyers, comprised the majority of industrial activities. In addition, machine parts and clothing were manufactured.

In 1916, under an Act of Congress, the channel between Charleston and the Navy Yard was dredged to a depth of 30 feet (low tide). Over $3 million was expended to improve facilities at the Navy Yard through temporary construction of housing, hospital facilities, storage space, shops, ship-building facilities, and miscellaneous improvements. Employment rose to 3,600 and the workload increased to include alterations and repairs to 160 vessels and construction of 18 new vessels.

During the development of the Navy Yard, many low-lying areas were filled with dredge spoil from the Cooper River. Filling operations began about 1918 near Noisette Creek on the northern end of the Navy Yard and continued through the 1960's, after which time the spoil was deposited on the opposite side of the Cooper River. Figure 3.5 shows the areas filled by dredge spoil and solid waste and the approximate dates of filling. Only the spoil area on Daniel Island on the east side of the Cooper River and portions of the 1921 and 1938 spoil areas at the extreme northern and southern tips, include the current shipyard location.

The post-World War I era (1920-1932) was a period of major reorganization. Up to that time, activities were coordinated by about 14 independent Heads of Department. To increase effective authority, these were consolidated into two major divisions. Industrial activities were placed under one officer named "Manager" and military activities under another officer known as "Captain of the Yard".



SOURCE:
BRAC CLEAN UP PLAN
NAVAL BASE
CHARLESTON

FIGURE 3.5
AREAS FILLED AND
APPROXIMATE DATES
OF FILLING OPERATIONS

DWG DATE: 02/18/94 | DWG NAME: 760FILCH

Since many of the temporary facilities erected during World War I were demolished, many shops were also consolidated. In 1922, the emergency hospital was closed and the dispensary in building 19 was reoccupied and designated as a hospital. Light repair work continued during this period, and six new vessels were constructed. Employment declined by 1932 to 535 employees.

In 1932, the Coast Guard received a piece of land near Pier 317A (quay wall adjacent to Pier J) and a landing field was constructed in the southern part of the Navy Yard.

In 1933, orders for the construction of many new vessels were received, resulting in increased staffing. Buildings were torn down, relocated, expanded or replaced during 1933 - 1938. By the time World War II began, the Charleston Navy Yard had become a major Naval facility. Its mission was primarily to provide logistic support to operating forces in the form of efficient and economical new construction, repairs, overhaul, alterations, conversions, and docking of destroyers and small vessels. Outfitting of ships, related special manufacturing, and necessary replenishment of stores and supplies were made available to nearby ships and shore activities.

The escalation of military activity during World War II caused this to be the period of greatest military ship construction in CNSY history. Three additional drydocks were constructed between 1941 and 1944, a number of new shops were added, and 256 ships were built between 1939 and 1946, compared with 36 between 1913 and 1938. Employment peaked at 25,948 in 1943.

Two significant changes occurred during the World War II era. On September 14, 1945, by general order, the U.S. Naval Base, Charleston, S.C., was formally commissioned, and the Navy Yard was redesignated as the Charleston Naval Shipyard and became a component of the U.S. Naval Base, under military control of the 6th Naval District. Another important development was the purchase of 196 additional acres of land on the northern and eastern boundaries of CNSY for additional storage space. These additional tracts are currently a part of the Naval Base.

Following the end of World War II, the work of constructing new vessels slowed, and the major workload involved disposing of surplus stock and decommissioning ships. This work was particularly heavy in 1946, but by 1948 normal repair, overhaul, and alteration of active Fleet vessels were resumed. In 1948, the shipyard was designated a submarine repair and overhaul yard.

In 1959, the Bureau of Ships directed the shipyard to develop plans for facilities required to repair and overhaul nuclear-powered submarines. Once again, shops were expanded and equipped to support this new mission and a fifth drydock designed specifically to service Fleet Ballistic Missile submarines was completed in 1964.

This submarine overhaul and repair mission continued until 1993, when, as a part of Department of Defense restructuring and downsizing, CNSY was recommended for closure by the Base Realignment and Closure Commission. This recommendation was adopted and became law on September 27, 1993. Closure operations are targeted for completion by April 1, 1996. Ultimate disposition of the land and properties currently associated with CNSY has yet to be determined.

3.2.3 Site Activities

Charleston Naval Shipyard is a large industrial complex capable of providing the full range of industrial, manufacturing, and technological processes required for overhauling and repairing the modern high technology warships of the U.S. Navy.

In the specific case of G-RAM work, which is the focus of Volume II of this HRA, all of the engineering disciplines, trade skills, quality assurance inspectors, and radiological control personnel are available to accomplish work associated with radioactivity. A few of the typical services performed are listed below:

- Industrial radiography
- Calibration of radiation detection instrumentation
- Gas chromatography

Numerous activities support this work such as engineering and planning, supply, electronics, radiological controls, quality assurance, machine shop, and administrative groups required to plan and execute tasks as complex as radiographing a weld within a network of piping in the confined spaces on a submarine.

3.3 Site Description

3.3.1 Site Land Use (Reference 1)

The physical features of the shipyard are discussed above and shown in Figure 3.4. Over 95 percent of the land area within the boundaries of the shipyard is covered by structures or is paved with concrete and asphalt. The shipyard is divided internally into a Controlled Industrial Area and a non-industrial area.

All of the piers, drydocks and work facilities accomplishing industrial radiography, radiation detection instrumentation calibration (RADCAL) work, and gas chromatography are within the Controlled Industrial Area. Radioactive material shipments associated with these functions traverse the non-industrial area but are stored within the Controlled Industrial Area. The radiological facilities for industrial radiography and Radiac Calibration Laboratory are contained within Buildings 13 and 177, respectively. The remaining buildings in the Controlled Industrial Area are shop areas, warehouses, and administrative areas that do not contain radiological material associated with the industrial radiography or Radiac Calibration Laboratory programs. Open paved areas are used for storage of non-radioactive materials and large equipment associated with ship repair functions.

The non-industrial areas associated with CNSY are outside the Controlled Industrial Area, and include Shipyard administrative offices, the Power House, Public Works facilities, and some of the Fleet and Industrial Supply Center functions.

Numerous buildings at CNSY could have historically been used to work on or store G-RAM. Section 5 presents information on identified buildings specifically designated (either currently or in the past) for work on or storage of G-RAM.

Commercial items in common use such as smoke detectors may contain low levels of radioactive material. Current Navy procedures prevent such items from being disposed of on-site, although historical practice cannot be confirmed. The potential use of such items is not considered to have spread "G-RAM usage" throughout the shipyard.

3.3.2 Demography & Adjacent Land Use

CNSY is located in Charleston County and lies within the corporate boundaries of the City of North Charleston on South Carolina's central coast. The areas surrounding the shipyard are heavily developed and characterized by commercial, industrial, residential, and school land use. Commercial areas are located primarily to the west; industrial areas lie to the north and along the west bank of Shipyard Creek. The surrounding land use areas are a mix of urban, suburban, industrial, and rural areas dissected by rivers, creeks, and wetlands.

At the time of the 1990 census, almost 600,000 persons resided within a 50-mile radius from the shipyard. Over 50% of this population resides within 10 miles of the shipyard. Table 3-1 provides the population density and population for principal centers within 50 miles of the shipyard.

Table 3-1
Population and Population Density of Cities Within a 50-Mile Radius of CNSY

City	Population Density (Persons per Square Mile)	Total Population (1990 census)
Charleston	1,861	80,414
North Charleston	1,404	70,218
Mt. Pleasant	1,381	30,108
Goose Creek	789	24,692
Hanahan	1,372	13,176
Summerville	1,620	22,519
Moncks Corner	710	5,607
Ladson	1,556	13,540
Isle of Palms	172	3,608
Walterboro	1,423	5,492

Figures 3.6 and 3.7 are computer generated constructs of 7.5 minute maps with the population by standard zone and sector divisions overlain. A zone is a 22.5 degree arc with Zone "A" centered on geographic north and Zones B, etc. increasing clockwise. A sector is a one-mile, five mile, or ten-mile annular segment. Population data is based on the 1990 census data.

Land use within one mile radius of the shipyard is described by quadrants in the following paragraphs:

> The southeastern quadrant encompasses the greater part of the Naval Base and is an industrial area. The working population for this quadrant is approximately 8,500. This is augmented by ships' crews which varies depending on deployment schedule. Residential population of this quadrant is approximately 1,840.
>
> The northeastern quadrant contains a Naval residential area and the spoil area east of the Cooper River. Occupants of the housing area total approximately 215.
>
> The western quadrants contains the Chicora Tank Farm, Fleet and Industrial Supply Center, Naval Hospital Charleston, business/residential areas, and four schools. The area is used for industrial, business and residential applications. Populations in these quadrants is approximately 5,385.

3.3.3 Physical Characteristics

This section describes the geology, hydrogeology, seismology, and climatology of the region around the shipyard as they relate to infiltration of contaminants into ground waters, mobility and transport via the ground water, and confining features that preclude area-wide distribution of introduced potential contaminants.

The transport and distribution of materials in the local ground water is, in part, a function of the local and regional geological morphology and stratigraphy. The influence of the geological framework on ground water, surface water, and aquifers has been addressed by the South Carolina Department of Natural Resources (References 2 and 3).

Ground and surface water quality is monitored by the South Carolina Department of Health and Environmental Control and reported to congress pursuant to Section 305 (b) of the Federal Water Quality Act (Reference 4).

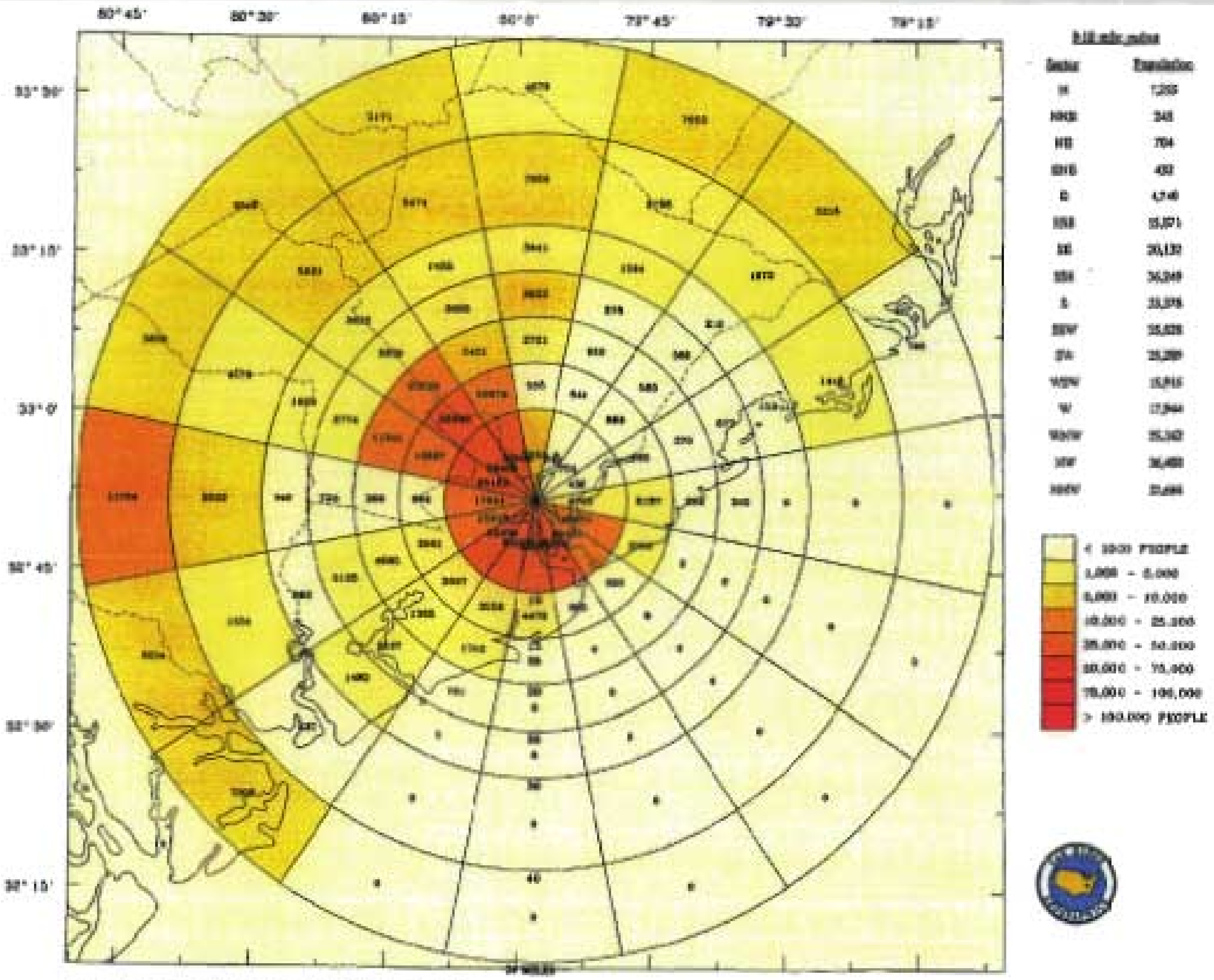
The topography of the area is typical of South Carolina's Lower Coastal Plain, with low relief plains broken only by the meandering courses of many sluggish streams and rivers flowing toward the coast and by an occasional marine terrace escarpment.

Topography at CNSY is essentially flat, with elevations ranging from just over 20 feet in the northwestern part to sea level at the Cooper River.

1990 Regional Population - CHRLTN

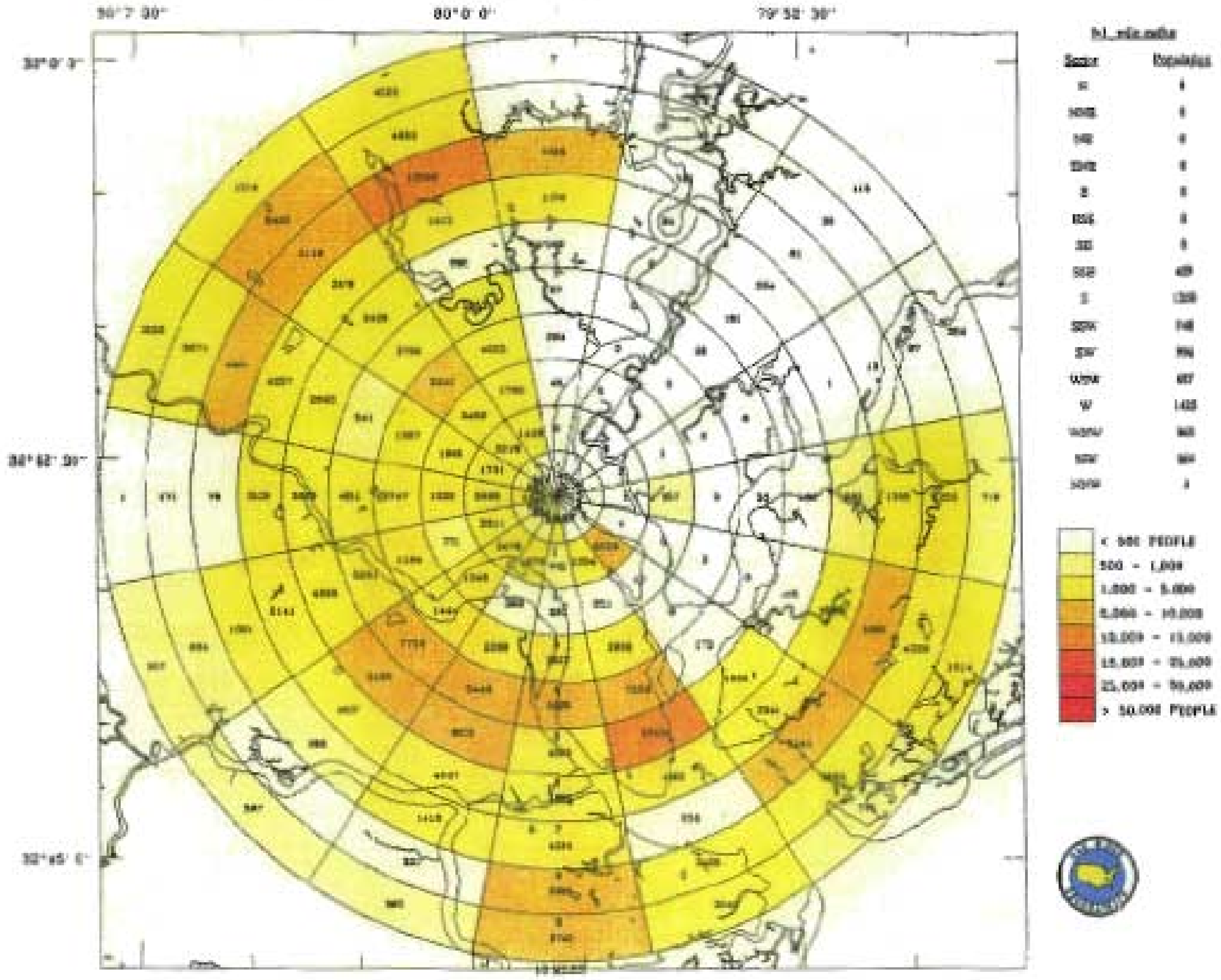
POPULATION COUNT BY SECTORS AND ANNULI - CHARLESTON NAVAL SHIPYARD

1990 Census



Prepared by Geographic Data Systems Group at CAD

1990 Local Population - CHRLTN
POPULATION COUNT BY SECTORS AND ANNULI - CHARLESTON NAVAL SHIPYARD
1990 Census



3.3.3.1 **Geology (References 3 and 5)**

The rock units underlying the Charleston area represent a broad range of lithologies, depositional environments, and ages. The oldest units are of the Late Cretaceous age and were deposited in environments ranging from continental to innershelf marine. Their lithologies are predominately clastic, consisting of sand, silt, and clay. The bulk of the units underlying the Late Cretaceous formations consist of the Tertiary Black Mingo Formation, Santee Limestone, and Cooper Formation (Figure 3.8). The Cooper Formation has been referred to in the literature as the Cooper Marl, but because of its small clay component and large sand component, the U. S. Geological Service has accepted the Cooper Formation name. These units are the result of deposition in marine environments ranging from marginal marine to outer shelf.

The Cooper Formation is significant as a hydrologic unit mainly by virtue of its impermeability. In most localities, its sandy, finely granular limestones act as confining material that causes artesian conditions in the underlying Santee Limestone. Only a few feet of the formation need be present to effectively retard the vertical movement of groundwater. The Charleston (City) Commission of Public Works has taken advantage of this impermeability by boring a 5-foot diameter, 23-mile long unlined tunnel through the Cooper Formation from the Edisto River to their treatment plant in Hanahan.

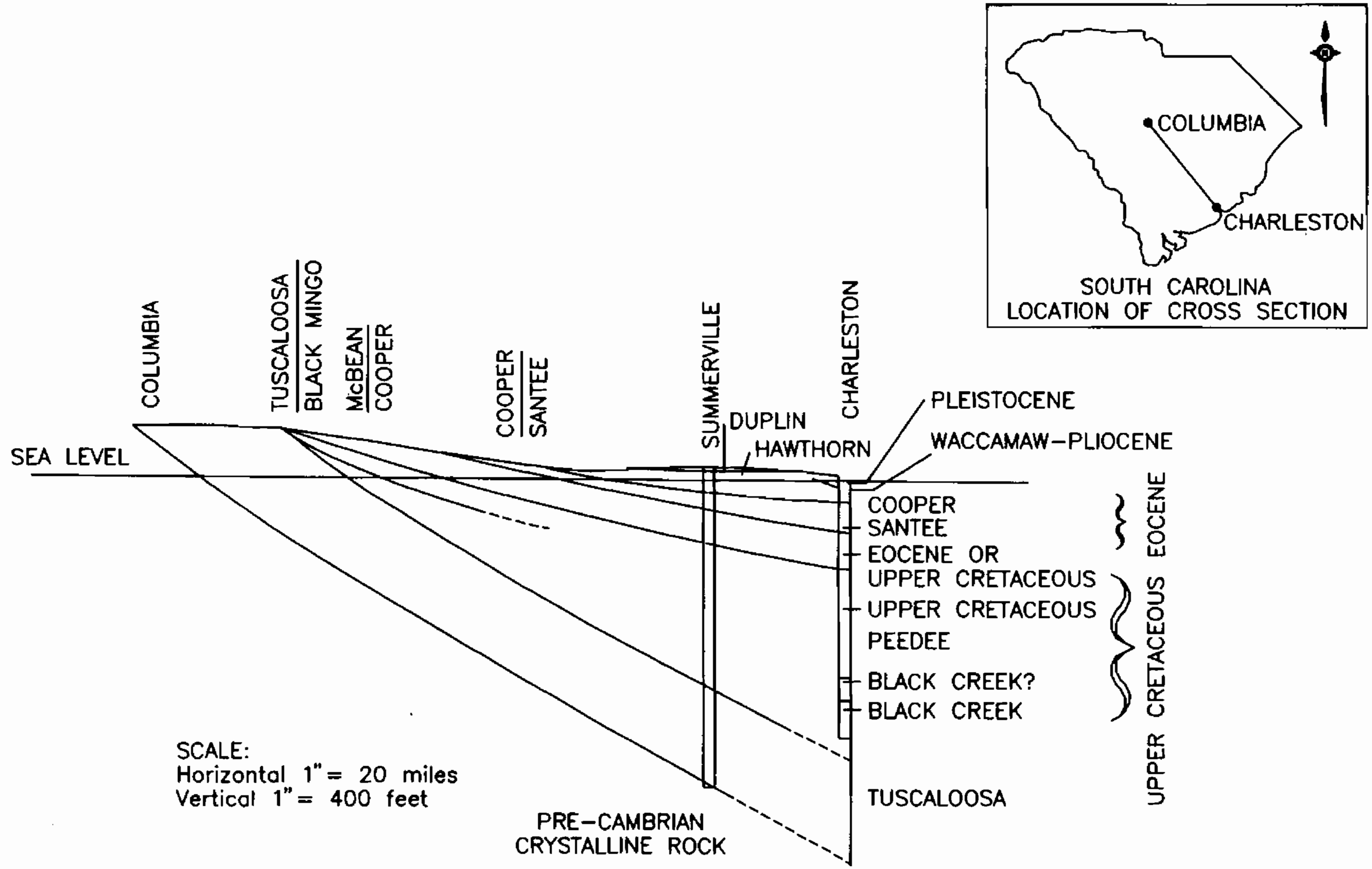
The surface soils have been extensively disturbed by a long history of intensive use. The natural surface soils were probably fine-grained materials typical of tidal marsh environments. No data are available concerning permeability rate and range for the soils; however, the permeability of the surface soils is rather low, as evidenced by the reported history of poor drainage.

3.3.3.2 **Ground Water Sources and Uses**

There are six major aquifer systems which underlie the area and include the Middendorf, Black Creek, Peedee, Black Mingo, Santee Limestone, and Shallow Aquifer Systems. The thickness of the sediment ranges from about 1,700 to 3,200 feet. The principle sources of industrial water supply in the region are the Black Creek, Black Mingo, Santee Limestone, and Shallow Aquifer Systems. The Middendorf system is not generally used as a groundwater source because of its great depth and brackish water. Detailed hydrogeologic information regarding these aquifer systems is contained in Reference 3.

The shallow aquifer underlying CNSY exists under water-table conditions. Recharge is supplied by local rainfall. The water moves by gravity from high elevations to areas of low elevations at a rate characteristic of the water-table and aquifer permeability.

The shallow ground water system is not used for potable supply at or in the vicinity of CNSY.



SOURCE: NAVFAC, 1976 & ESE, 1981.

SOURCE:
BRAC CLEAN UP PLAN
NAVAL BASE
CHARLESTON

FIGURE 3.8
GEOLOGIC CROSS SECTION

DWG DATE: 02/18/94 | DWG NAME: 760EWCRS

Ground Water Flow in the Vicinity of the Shipyard

In the shallow aquifer at CNSY, water flows toward the Cooper River or Shipyard Creek, due to the fine-grained texture of the sediments and the level topography on the Naval Base. The water table is within 3 to 7 feet of the ground surface. All the shallow ground water at CNSY eventually discharges to the Cooper River either directly or via its tributaries. Contaminants present in the shallow ground water system would eventually discharge into the Cooper River if not attenuated by subsurface soils. However, flow rate in the shallow system is expected to be rather slow due to the fine-grained nature of the sediments and the low gradient. Some contaminants, particularly metals, are likely to be attenuated by adsorption to clay minerals. Furthermore, no potable use is made of the shallow ground water downgradient of CNSY, since the Cooper River and Shipyard Creek are the base boundaries and also the downgradient boundaries of the shallow ground water system. It is possible that residential wells in the shallow aquifer exist upgradient. However, these wells are not threatened by contaminant migration from CNSY since they are upgradient and since reversal of the natural gradient by pumpage from any shallow residential wells would be extremely unlikely due to the very small capacity of this type of well.

Ground Water Quality

Ground water quality is monitored by the state and the results are reported to Congress. Reference 4 reports the results for 1992-1993. Radioactivity is included in the analyses performed as a part of the required monitoring. Radioactivity is not designated as a significant contaminant in the ground water of the southern part of the state, because only naturally-occurring radioactivity has been identified.

3.3.3.3 **Surface Water Sources and Uses**

The two major fresh water rivers draining the Naval Base Complex are the Ashley River and the Cooper River. These tidally influenced rivers, along with several saltwater tidal creeks and rivers, discharge into Charleston Harbor.

Prior to the completion of the Santee-Cooper Project by the State of South Carolina in 1942, Charleston Harbor was considered one of the finest natural harbors on the Atlantic Coast, with depths in many areas exceeding 65 feet. Following completion of the project, the average discharge into the Cooper River increased by a factor of greater than 200, from 528 to 124,174 gallons per second. This resulted in shoaling and silt accumulation in the lower reaches of the Cooper River and in Charleston Harbor. As a result, annual maintenance dredging requirements increased from less than 500,000 cubic yards per year to more than 1 million cubic yards per year.

Because of this shoaling problem, the Charleston Harbor estuary has been subject for many years to water quality changes associated with dredging operations. Most of the material creating these shoals is of Piedmont origin, and only a small amount can be attributed to bank erosion. The increased fresh water flow has resulted in the formation of density currents in the harbor which have a predominant upstream bottom flow and, consequently, trap sediment within the harbor.

Surface water from the shipyard flows into the Cooper River, either directly or via the shipyard's storm drain system. The Cooper River empties into Charleston Harbor.

Shipyard Creek is a small tidal tributary about 2 miles in length, which lies south of the shipyard. It extends southeastward along the southwest boundary of Naval Base Charleston to the Cooper River, at a point opposite the southern tip of Daniel Island (river mile 9). Docking facilities are located along the western shore of the lower mile of the Cooper River channel, while the eastern shore is bounded by tidal marshlands along its entire length.

Noisette Creek, which lies north of the shipyard and transects the northern portion of Naval Base Charleston, is a tidal tributary approximately 2.5 miles long. The creek flows almost directly eastward from its headwaters in the city of North Charleston and empties into the Cooper River at river mile 13.

Aquatic ecosystems include the Cooper River, Shipyard Creek, Noisette Creek, Clouter Creek, Wando River, and the upper section of Charleston Harbor. These waters are surrounded by extensive Spartina-Juncus marshes and, as a result, are rich in nutrients and detritus.

Charleston Harbor and lower sections of the Cooper and Wando Rivers are important nursery grounds for finfish and shellfish and contain important populations of game and commercially important species. The Cooper River annually receives large runs of anadromous fish, which ascend the river to spawn. Such species include striped bass, blueback herring, and shad.

Invertebrates and mollusks of commercial importance occurring in Cooper River, Wando River, and Charleston Harbor include shrimp, blue crab, and shellfish. Approximately 30 percent of the 1972 South Carolina shrimp production was captured in the Charleston Harbor area, which has also been identified as containing significant amounts of shellfish.

Reservoirs in the region include Lake Moultrie, which was created with the completion of the Pinopolis Dam in 1941, and Back River and Goose Creek Reservoirs, which were created by impounding the two creeks for storage of fresh water. Lake Moultrie is used for generation of hydroelectric power and recreation. Back River Reservoir receives water primarily from the Cooper River and supplies mainly industrial customers. It is also used as an alternate municipal water supply source for the City of Charleston. Goose Creek Reservoir is also used for recreational purposes and as a backup municipal supply source. These reservoirs are well upstream of the shipyard and water quality in each of these reservoirs has been found to meet South Carolina state standards.

Surface waters sources in the vicinity of the shipyard are not used for public consumption. All of the water used for human consumption in the vicinity of CNSY is normally withdrawn from the Edisto River and is transferred to the area by the Charleston (City) Commission of Public Works; reservoirs are used for backup as noted. Drinking water samples collected by the EPA from the shipyard diving locker room (Building 57) and from the Charleston Municipal drinking water supply were gamma analyzed and no detectable activity was found (reference 6).

3.3.3.4 **Seismology**

Seismic risk maps published by the U.S. Coast and Geodetic Survey place the coastal plain of South Carolina in risk zone 3, indicating an expectancy of major damage due to earthquakes. The Charleston area has a history of seismic activity, dominated by the Great Charleston Earthquake of 1886. Four hundred and two earthquakes were recorded in the Charleston area during the period 1754-1970.

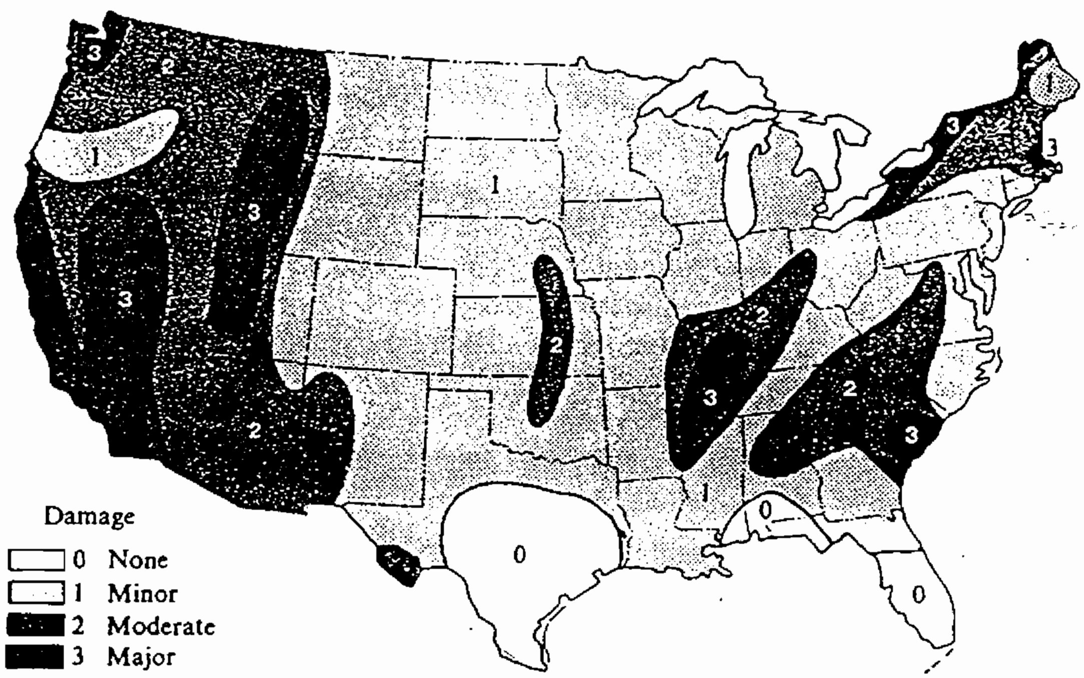


Figure 3.9 Seismic risk map for conterminous U.S. The map divides the U.S. into four zones: Zone 0, areas with no reasonable expectancy of earthquake damage; Zone 1, expected minor damage; Zone 2, expected moderate damage; and Zone 3, where major destructive earthquakes may occur.

Reference: Robert J. Foster, "Physical Geology," Charles E. Merrill Publishing Company, Second Edition, 1975

3.3.4 Climatology

Due to the proximity of the ocean, the climate of Charleston is mild and temperate. Daily weather is controlled largely by the movement of pressure systems across the country and by the diurnal effects of the land-sea breeze. Exchanges of air masses are relatively few in summer, when masses of warm, humid, maritime-tropical air persist for long periods under Bermuda high pressure conditions. Winters are characterized by movements of frontal systems and by replacement of maritime-tropical air with cool, dry, continental-polar air.

Average daily temperatures are recorded during each month by the National Weather Service at the Charleston Municipal Airport. The coldest month is January, when daily temperatures typically range from 37 to 60 degrees Fahrenheit (°F). In July, the warmest month, the average daily temperature extremes vary between 72 and 90°F. The small diurnal temperature variation in summer is due to higher moisture content of the atmosphere on the average day. The record high and low temperatures measured at the airport are 102.9 and 8.0°F, respectively. Normally, during 60 days per year temperatures will be at 90°F or above, while freezing temperatures will predominate during 33 days of the year. The average first occurrence of freezing temperatures is October 10th, while the average last occurrence is February 19th.

The average annual rainfall in Charleston is 49.2 inches, with a summer peak of over 7.5 inches occurring in July. The four summer months (June through September) experience over 50 percent of the annual rainfall. Rain storms during the summer are due to strong convective atmospheric motions, which trigger 72 percent of the average 57 thunderstorms per year. Rainfall during the winter is generally associated with the interface of continental-polar frontal air masses replacing maritime-tropical air. Ordinarily, only traces (less than 0.04 inch) of snow are experienced annually, mostly in January and February. Notable exceptions were snow storms in the winters of 1973 and 1989, which produced snow falls in excess of six inches.

The mean wind speed recorded at the Charleston Airport is 9 miles per hour, with prevailing wind directions of north-northeast during the winter months and south-southwest during the summer months.

Late summer to early fall is the period of maximum threat from hurricanes. Major hurricanes affecting the Charleston area occurred in August of 1885, 1893, 1911, 1940, 1952, 1981, and September of 1928, 1959, 1979, and 1989. A storm tide of 11 feet above mean low water, the highest for which records are available, was recorded during the August 1893 hurricane. Recently, hurricanes David (September 1979) , Dennis (August 1981), and Hugo (September 1989) have affected the Charleston area.

Most of Charleston Naval Shipyard is within the 100-year flood prone zone as indicated in Figure 3.10.

FLOOD HAZARD

100-YEAR FLOOD PLAIN

FLOOD PLAIN ELEVATION -
12.00 FEET N.G.V.D.
14.6 FEET M.L.W.

Plate II-4

MASTER PLAN

Charleston Naval Shipyard

CHARLESTON, SOUTH CAROLINA

4.0 Description of Operations

4.1 Background on Navy Organizational Activities

4.1.1 Naval Facilities Engineering Command (NAVFAC)

NAVFAC is responsible for taking the lead in negotiating Federal Facility Agreements (FFAs) with EPA regional offices and states.

4.1.2 Navy Radiation Safety Committee (NRSC)

The NRSC, acting for the Chief of Naval Operations, manages the Navy's Master Materials License. The Navy has been delegated by the Nuclear Regulatory Commission (NRC), through the issuance of the Master Materials License, regulatory authority for the receipt, possession, distribution, use, transportation, transfer, and disposal of specified radioactive material at Navy and Marine Corps activities. The NRSC has been established to provide administrative control of all radioactive material used in the Navy and Marine Corps except for nuclear propulsion reactors and associated radioactivity, nuclear weapons, and certain components of weapons delivery systems. Navy Radioactive Material Permits (NRMPs, described in Section 4.4.1) are used to maintain this control. RASO and NEHC (see below) are the designated technical support centers for the NRSC.

4.1.3 Naval Sea Systems Command (NAVSEA)

NAVSEA is responsible for the radiological controls associated with the industrial radiography and the radiation detection instrument calibration lab operations at CNSY.

4.1.4 Bureau of Medicine and Surgery (BUMED)

BUMED is responsible for the development and promulgation of protection standards and exposure limits for personnel exposed to sources of G-RAM ionizing radiation. In addition BUMED is responsible for the radiological controls associated with medical applications of ionizing radiation.

4.1.5 Radiological Affairs Support Program (RASP)

The RASP is the vehicle used by NAVSEA to discharge its responsibility for radiological controls for applicable sources of ionizing radiation. The RASP applies to all ionizing radiation sources including NRC-licensed radioactive material, (non-NRC-licensed) naturally-occurring (NORM) and accelerator-produced radioactive material (NARM, which includes NORM), radioactive waste, and machine sources such as x-ray machines, particle accelerators, electron microscopes, laboratory analytical devices, and all other equipment capable of producing ionizing radiation. Excluded are radioactive sources used for medical treatment or diagnosis, radioactivity associated with the NNPP, and radioactivity associated with nuclear weapons.

4.1.6 Radiological Affairs Support Office (RASO)

RASO provides technical support on behalf of NAVSEA to the NRSC, via the RASP, to include radiological assistance, program review, coordination of NRMPs, radiation safety training, and inspection of radiation safety programs.

4.1.7 Navy Environmental Health Center (NEHC)

NEHC provides technical support on behalf of BUMED to the NRSC, to include radiological assistance, program review, coordination of NRMPs, radiation safety training, and inspection of radiation safety programs.

4.2 General Radioactive Material (G-RAM)

The shipyard has had a historical mission to repair, maintain, and construct Naval warships and equipment. Given this long history of industrial activities, general radioactive materials became an integral part of shipyard operations over time, just as G-RAM became an integral part of similar large-scale civilian industrial activities.

General radioactive materials were common in shipboard equipment (e.g., radioluminescent dials) and in equipment used in the shipyard (e.g., thoriated welding rods). The use of radiographic and calibration sources has been essential to the industrial maintenance and repair operations at the shipyard. Although G-RAM consists mainly of sealed or encapsulated sources, radioactivity in other forms are (or have been) used at CNSY.

Examples of G-RAM sources in use at CNSY are:

- Encapsulated iridium-192 radiography sources.
- Sealed radiation detection instrument calibration and reference sources.
- Sealed sources contained in electron tubes.
- Sealed or contained sources in various industrial and consumer products such as self-luminous signs and smoke detectors.
- Sealed sources used in analytical equipment.

An additional potential source of historical significance at CNSY is paint activated with radium. This type of paint was used for over forty years for its self-luminescing characteristic before it was discontinued in the mid-1970's. Various gauges, dials, bridge and deck markers on Naval ships contained this radioactive material. Controls over use of these materials were limited, especially in the early years.

4.3 Type of Activities

The primary activities involving large sources of G-RAM at CNSY are the industrial radiography and radiation instrument calibration operations. All work involving this type of radioactive material is performed by persons specifically trained in accordance with the provisions of the respective Navy Radioactive Materials Permit (NRMP). NRMPs are discussed in detail in Section 4.4.1. Current and historical controls placed on activities involving use of licensed or permitted G-RAM are addressed in Sections 4.4.2 and 4.4.3, respectively.

Activities involving G-RAM not controlled by site-specific NRMP include radioactive commodities procured through open purchase or stocked/distributed by the Fleet and Industrial Supply Center, operating under an NRMP equivalent to an NRC general license for distribution or commodities license for exempt quantities. These commodities are currently controlled under Navy procedures, and include items containing radioactive material such as electron tubes, self luminous devices, smoke detectors, spark initiators, static eliminators, and sealed sources in certain analytical equipment. These may be found in uncontrolled Navy areas.

4.4 Control of Radioactivity

A major objective in performance of work involving any of the G-RAM described in this report is avoiding the potential for releases of low-level radioactivity into the environment. From the beginning of such work at CNSY, radiological work has been controlled to preclude the spread of contamination. This work has always been performed under controls at least as stringent as those imposed on radioactive material licensees by Title 10 of Code of Federal Regulations (10 CFR Parts 19, 20, 21, 30, 31, 34, 35, and 71).

Use of commodities containing radioactive material have not been historically controlled because materials in this category contain quantities of radioactive materials which are below minimum standards set by Federal regulatory bodies (i.e., exempt quantities). Technologically-enhanced naturally-occurring radioactive material has not been regulated. These materials are occasionally identified during a radiological survey.

4.4.1 Licensed Radioactive Material

Under the provisions of 10 CFR, the Nuclear Regulatory Commission (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 radioactive material. The Navy Radiation Safety Committee (NRSC) exercises regulatory authority over individual users, whose former NRC licenses were replaced with Navy Radioactive Materials Permits (NRMPs) in 1987. The NRSC assigns responsibilities to control the use of NRC licensed radioactive material as well as naturally occurring (NORM) and accelerator-produced radioactive material (NARM, which includes NORM). NRC retains oversight for the Navy Radiation Safety Committee management of the master license.

The Navy Master Materials License does not apply to radioactive material transferred from the Department of Energy to the Department of Defense in accordance with Section 91B of the Atomic Energy Act of 1954 (e.g., Pu-Be calibration sources; such items are controlled as G-RAM), and it does not apply to radioactive material associated with the Naval Nuclear Propulsion Program.

There is one active NRMP for sealed sources used in industrial radiography and one active NRMP for sources used in the calibration of radiation detection instruments at CNSY. Both of these NRMPs replaced former NRC licenses. Table 4-1 details the two active NRMPs, a former NRMP and three former site-specific NRC licenses. Table 4-1 does not include NRMPs issued by the NRC for Navy-wide use of certain radioactive material such as liquid and gaseous tritium calibration sources and sealed sources contained within specified analytical equipment; radiation detection instruments and calibrators; and self-luminous gauges and other equipment.

Table 4-1
Current and Former Site-Specific NRMPs and NRC Licenses
Held by Charleston Naval Shipyard

NRMP/ former NRC License	Purpose	Status
39-00191-A1NP/ 39-6126-01	Industrial Radiography	Active
39-00191-C1NP/ 39-6126-03	Radiac Calibration	Active
39-6126-02	Radiac Calibration	Terminated early 1960s (1)
39-6126-04	Neutron Activator Target	Terminated July 1973 (2)
39-6126-05	Instrument Response	Terminated May 1975 (3)
39-00191-P1NP	Density Gauge	Terminated Oct 1993 (4)

Notes: (1) This license was obtained in the early 1960s by CNSY for a radiac calibration function. Radioactive material associated with this license was transferred to a predecessor of NISE-EAST (i.e., NAVELEX).

(2) This license was obtained for a hypothesized sample analysis. The analysis protocol failed and the radioactive material associated with this license was disposed of as radioactive waste.

(3) This license covered radioactive material used for instrument response checks by Radiological Controls Department. The radioactive material was transferred to NAVELEX.

(4) This NRMP was obtained to use a density gauge during dredging operations. The gauge was removed by the manufacturer, the storage site was radiologically surveyed, and the permit was terminated.

4.4.2 **Current G-RAM Controls**

The Navy Radiation Safety Committee exercises headquarters level administrative control over G-RAM held under the provisions of NRMPs. The immediate controls over NRMP sources at CNSY are provided by CNSY for the use/disposal of their own sources and related materials. Technical oversight for the two NRMPs at CNSY is provided by the Naval Sea Systems Command Detachment, Radiological Affairs Support Office (RASO).

All of the shipyard NRMPs require adherence to 10 CFR Parts 19, 20, 21, and 30. Additional requirements are based on the scope of the specific permit: the industrial radiography NRMP requires adherence to 10 CFR Parts 34 and 71. Each command in possession of permitted sources is required to establish a radiological protection program and assign a qualified Radiation Safety Officer (RSO) to establish, implement, and maintain such a program. Each RSO is qualified in accordance with the pertinent 10 CFR requirements and exercises independent authority over G-RAM used within the respective command. Typical NRMP control requirements include: radiological surveys of radioactive material work and storage areas; leak tests of sealed sources; safety inspections; and audits of the radiological protection program.

G-RAM not addressed by site-specific NRMPs is also controlled. Examples of such G-RAM include: thoriated welding rods; specified compasses and depth gauges; check sources attached to or incorporated in certain radiation detection instruments and analytical equipment; radioactive material incorporated in certain ionization and luminescent devices; and radioactive material incorporated in certain electron tubes and electronic devices. Periodic audits of such G-RAM are conducted; these audits continue to verify that appropriate custody, storage, fire protection, marking, transfer, and disposal procedures remain in effect.

4.4.3 **Historical G-RAM Controls**

Requirements for the control of G-RAM have always been consistent with pertinent federal regulations and with recommendations of national scientific committees. Requirements for the control of any G-RAM at CNSY, even before passage of the 1954 Atomic Energy Act, 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 the Bureau of Medicine and Surgery, implemented several recommendations of the NCRP (published at that time as National Bureau of Standards Handbooks) for specified radioactive material hazards including: NCRP Report No. 4, Radium Protection, 1938 (NBS Handbook 23, superseded by a series of NCRP reports); NCRP Report No. 5, Safe Handling of Radioactive Luminous Compounds, 1941 (NBS Handbook 27, out of print); NCRP Report No. 6, Medical X-Ray Protection Up to Two Million Volts, 1949 (NBS Handbook 41, superseded by a series of NCRP reports); and NCRP Report No. 7, Safe Handling of

Radioactive Isotopes, 1949 (NBS Handbook 42, superseded in 1964 by NCRP Report No. 30).

Navy requirements have continued to be updated in accordance with updates to national scientific committee recommendations and federal regulations (e.g., 10 CFR, created pursuant to the 1954 Atomic Energy Act). In 1963, the Navy began a series of programs to remove all non-mission essential equipment containing radioluminescent (e.g., radium) material, and replace such mission essential equipment with equipment containing non-radioluminescent or lower energy radioluminescent substitutes where possible.

Historical documentation is sparse regarding early uses of G-RAM which was not required to be licensed (e. g., radium) or was used before licensing was instituted. The earliest documented use of licensed G-RAM at the shipyard was for industrial radiography. A license application for source radiography was submitted to the U. S. Atomic Energy Commission (AEC) in 1959 and approved in January, 1960. AEC licenses for calibration of radiation detection instruments were obtained in the early 1960s. 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). In 1987, NRC licenses were converted to NRMPs under the Navy's Master Materials License.

4.5 Regulatory Oversight

NRMP radiological controls at the shipyard are overseen by RASO. RASO conducts periodic on-site audits of their respective CNSY NRMPs. RASO audits the radiography NRMP annually, audits the Radiac Calibration Laboratory NRMP every three years, and requires internal audits/inspections on a six month basis or as stated otherwise in the NRMP, the Radiological Affairs Support Program (RASP) regulations, or federal regulations. Radiac Calibration Laboratory operations are additionally audited on an eighteen month basis by NAVSEA.

These audits examine all NRMP-related work practices, including radiological controls, worker training, quality control, and compliance with work procedures and headquarters requirements. Similar on-site audits which include non-regulated G-RAM work practices are conducted at CNSY each year by radiologically-trained personnel.

Regulatory interface regarding mixed (radiological and hazardous) waste is addressed in Section 5.3.

5.0 Policies and Results

5.1 Policies and Records Related to Environmental Release of Radioactivity

The policy of the Navy is to minimize the amount of radioactivity released to the environment. This policy is consistent with applicable recommendations issued by the Federal Radiation Council (incorporated in to the Environmental Protection Agency in 1970), U.S. Nuclear Regulatory Commission, National Council on Radiation Protection and Measurements, International Commission on Radiological Protection, International Atomic Energy Agency, and National Academy of Science-National Research Council. To implement this policy of minimizing releases, BUMED and NAVSEA have issued standard instructions defining radioactive release limits and procedures to be used by Navy Radioactive Material Permit (NRMP) users. NAVSEA has additionally issued standard instructions defining procedures to be used in controlling that G-RAM which is not regulated by specific NRMP. Current and historical G-RAM controls are described in Section 4.4.

5.1.1 Liquids

Liquid G-RAM sources that have been used or are being used at CNSY consist of liquid tritium and chromium-51 standards. The chromium-51 standards were small ampules used by the Chemistry Laboratory in the preparation of calibration check sources. Tritium standards were used by the Chemistry Laboratory and the Radiac Calibration Facility for calibration and response checks of laboratory and RADIAC equipment. Control and disposal of these sources has been in accordance with the applicable provisions of 10 CFR under a broad scope Navy NRMP.

5.1.2 Gases

CNSY performs no work that by regulation in 10 CFR would require filtered and/or monitored exhaust ventilation.

The only gaseous G-RAM items used at CNSY are sources containing tritium for use at the radiation detection instrument calibration facility (RADCAL) during instrument calibration. These gaseous calibration sources are controlled in accordance with applicable provisions of 10 CFR under a general commodities distribution NRMP.

Perhaps the likeliest potential for airborne release of non-NRMP controlled sources involves grinding on thoriated welding rods. Any such work is controlled by Navy procedure to isolate grinding areas, provide exhaust ventilation, use wet belt machines to contain dust, clean grinding areas after use by vacuum cleaning or wiping, and to dispose of grinding dust, chips, and cleaning rags (as normal waste materials) as they are generated. Thorium-232 (a naturally-occurring radionuclide) is contained in various manufactured items such as incandescent gas light mantles, welding rods, lenses, and aircraft engine parts. Manufactured items exempted from licensing requirements in 10 CFR 40.13 (such as thorium in welding rods) or authorized by a general license in 10 CFR 40.22 do not require an NRMP.

5.1.3 Solids

Solid G-RAM items in use at CNSY include encapsulated radiography and radiac calibration sources and various check and/or instrument response sources.

The Non-Destructive Test Laboratory uses multicurie Ir-192 and Co-60 sealed sources in radiography. Also, Cs-137 check sources and gamma-alarm response sources in the microcurie range are currently in use at the facility.

The Radiac Calibration Facility uses a sealed multicurie Cs-137 source, a sealed Pu-Be source, and a sealed Pu-239 source for calibration of radiation detection instruments. This facility also uses a variety of instrument response check sources. Historically, these check sources represented an assortment of radionuclides including (but not limited to) Cs-137, Pu-239, Tc-99, Co-60, Ba-133, Cd-109, Sr/Y-90, Th-232, and Am-241. The current inventory includes sources containing Tc-99, Co-60, Cs-137, Na-22, Ba-133, Cd-109, and Th-232. These sources are all sealed and are typically extremely low activity.

The Radiation Health Division has possessed and used instrument response check sources similar to those used at the Radiac Calibration facility. The present inventory includes Cs-137, Co-60, C-14, Cl-36, Sr-90, Pm-147, Tc-99, Th-230, and Am-241.

The Chemical Laboratory has historically used a number of isotopes as standards similar to those identified above. In addition, Fe-55, Ni-63, Tl-204, Co-57, Ce-139, Hg-203, Sn-113, Sr-85, Y-88, and Mn-54 sources have been used in the past. Again, these were sealed sources of extremely low activity. The current radionuclide inventory in the Chemical Laboratory includes only the Ni-63 sources in the gas chromatograph.

The Power House (Building 32) uses six sealed sources for level detection in the ash hoppers. This detection system contains six mCi quantity Cs-137 sources.

Any use and waste disposal of these sources has always been in accordance with applicable provisions of 10 CFR.

5.1.4 Reports of Inadvertent Releases

An extensive search of available records was conducted for potential releases to the environment. Documents were examined to identify any instances in which G-RAM was inadvertently released. Table 5-1 summarizes data obtained during this review. This table does not include information on non-licensed or permitted materials (i.e., luminous dials and gages) identified while conducting the routine radioactive material search survey described in Section 6.6 unless the item was the source of uncontrolled contamination.

No instance prior to 1956 was identified because of the lack of available records prior to this time. These reviews verified that the affected areas were surveyed and sampled as required by regulations and that the areas were properly released from radiological controls. Release criteria has always been consistent with federal regulations pertinent to the particular material.

That no significant radioactivity was left on the ground as result of past releases, is confirmed by results of aerial monitoring by EG & G and discussed elsewhere in this HRA. That no detectable G-RAM radioactivity has accumulated in river water, river sediment, or edible aquatic species is confirmed by survey results reported elsewhere in this HRA.

Table 5-1
Summary of Reports of Potential Radioactivity
Releases to the Environment

Date	Location	Volume	Activity
11-56	Bldg 177	n/a	Unknown
Summary: Loose surface activity detected on three radium capsule holders and their storage safe. Radon concentrations detected in the safe and source holder cavities.			
Response: Decontamination performed. Sources were returned to the manufacturer for testing and resealing.			

Date	Location	Volume	Activity
7-58	Bldg 177	n/a	Unknown
Summary: Loose surface contamination detected in work area as the result of work with radium dials, etc.			
Response: Decontamination completed.			

Date	Location	Volume	Activity
6-29-60	Bldg 2	n/a	Unknown
Summary: A radioactive deck marker with low level loose surface activity found in an uncontrolled condition.			
Response: The item was packaged, labeled, and disposed of as radioactive material.			

Table 5-1 (continued)

Summary of Reports of Potential Radioactivity
Releases to the Environment

Date	Location	Volume	Activity
1-30-61	Bldg 177	n/a	n/a

Summary: Removable surface activity (14.3 nCi/swipe beta/gamma and 4.4 nCi/swipe alpha) was detected on deck markers and the internal surfaces of the safe in which they were stored.

Response: The sources were packaged and disposed of as radioactive waste. The safe was decontaminated.

Date	Location	Volume	Activity
6-62	Bldg 177	n/a	0.0026 μCi

Summary: Loose surface activity was detected on a sealed instrument response source.

Response: Item packaged and disposed of as radioactive waste. Work area surveyed. No contamination was identified.

Date	Location	Volume	Activity
1-63	Bldg 177	n/a	0.06 μCi

Summary: Removable surface contamination detected on a Sr-90 source.

Response: Work area monitored; no contamination was identified. Disposition was in accordance with instructions from headquarters.

Date	Location	Volume	Activity
2-63	Bldg 177	n/a	0.011 μCi

Summary: Removable surface contamination detected on a Sr-90 source.

Response: Work area monitored; no contamination was found. Disposition of source was in accordance with instructions from headquarters.

Date	Location	Volume	Activity
8-27-63	Bldg 177	n/a	$<$ 0.0068 μCi

Summary: Removable low level activity detected on a Sr-90 response source.

Response: Source packaged and disposed of as radioactive waste.

Table 5-1 (continued)

Summary of Reports of Potential Radioactivity
Releases to the Environment

Date	Location	Volume	Activity
2-12-64	Optical Shop Bldg 177	n/a	Unknown
Summary: Radium contamination in the form of loose surface activity detected on work benches, tools, drawer, etc.			
Response: Radioactive components and furniture were sealed in plastic for controlled disposal. Loose surface contamination was removed. Fixed contamination on work bench covered, sealed and disposed of as radioactive waste.			

Date	Location	Volume	Activity
10-64	Optical Shop Bldg. 177	n/a	Unknown
Summary: Loose surface radioactivity detected on furniture, work benches, tools, etc. Several items contaminated from luminescent materials were in the area.			
Response: All contaminated items were sealed in plastic and disposed of as radioactive waste. The area was surveyed and decontaminated where necessary.			

Date	Location	Volume	Activity
2-24-77	Bldg. 13	n/a	0.0053 μCi
Summary: Loose surface activity (^{192}Ir) detected on the exterior surfaces of the shield containing a radiography source received from a vendor.			
Response: The vendor was notified and the unit was returned to the manufacturer after proper containment measures were taken.			

Date	Location	Volume	Activity
6-20-79	Unknown	n/a	0.07 μCi
Summary: Removable Pm-147 contamination in excess of permissible limits detected on a Teflon thickness gauge.			
Response: Gauge was withdrawn from service and placed in storage pending disposal. No contamination was found in areas where the device was stored or used.			

Note: n/a - data not available

5.2 Low-Level Solid Radioactive Waste Disposal

5.2.1 NRMP-Controlled G-RAM

The radiographic operations do not generate low-level radioactive waste. Radiographic sources have always been returned to the vendor when the source is no longer of use. The RADCAL facility, the Chemistry Laboratory, and the radioanalysis lab generate small quantities of low-level radioactive waste. This waste, as well as radioactive sources which are no longer needed at these facilities will be shipped off-site for ultimate disposal at a licensed disposal site.

5.2.2 Non-Regulated G-RAM

Although the current record is clear that a common commercial item identified as containing general radioactive material (i.e. smoke detector, electron tube, etc.) would not be disposed of in the soil at CNSY, historical documentation proving the prohibition of such disposal in the past has not been identified. No organized or official disposal of G-RAM has occurred and no documentation or interview information relating to the disposal of G-RAM on shipyard property has been identified. However, no definitive statement can be made as to whether such materials were ever inadvertently disposed of on CNSY property.

5.2.3 Conclusion

The policies and practices used for over 50 years in managing radioactive materials and radioactive waste appear to have been successful in preventing discernible effects on the environment. The results of the aerial radiological survey conducted by EG & G and reported in Section 6.7, along with record reviews, provide credible evidence that no solid radioactive waste consisting of NRMP or controlled non-regulated G-RAM has been disposed of on CNSY property. Although unlikely, given what is known about the materials used for fill, small amounts of G-RAM incorporated in consumer products (e.g. radioluminescent exit signs, smoke detectors, etc.) could have been disposed of with other industrial materials in landfill areas.

5.3 Mixed Waste

G-RAM mixed waste (waste which is both hazardous and contaminated with low level radioactivity) has not been generated at Charleston Naval Shipyard. The nature of the work performed at the shipyard makes it unlikely that any G-RAM mixed waste would be produced. Given the lack of national capacity to treat and dispose of mixed waste, it would be necessary to store any such small amounts at the shipyard. It is expected that any such identified material would ultimately be shipped elsewhere for treatment.

5.4 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 regulations further require that extensive radiological surveys be conducted when these radiological work or storage areas or equipment are being released from radiological controls.

Any radioactivity detected by these surveys is removed and the area resurveyed or resampled until levels comparable to background are attained. Release criteria consistent with federal regulations are specified by NAVSEA or BUMED, as appropriate.

Results of surveys are formally documented and archived. A written report describing the area, radiological history, surveys and sampling protocol, tabulated results, and conclusions is forwarded to the appropriate Naval headquarters organizations.

The only site-specific NRMP-controlled facility that has been released for unrestricted use was the dredge Orion, onboard which a density gauge was mounted. The gauge was removed from the dredge by the vendor, a decommissioning survey was conducted, and the dredge was released for unrestricted use.

Portions of several facilities have a history of operations involving non-NRMP-controlled G-RAM. When such operations were discontinued or relocated, radiological surveys were conducted in the affected area prior to reuse. Release of these facilities is addressed in Section 5.5.

5.5 Current Radiological Facilities

Current Navy regulations require the identification and control of buildings, structures, storage areas, or other facilities in which G-RAM is located unless the G-RAM consists of: transient sealed sources; sources with radioactivity levels under the limits specified in 10 CFR 30; sources which are generally licensed by the Nuclear Regulatory Commission or are exempt from licensing under 10 CFR 31 and are not installed in the building; or common commercial items containing G-RAM such as dials, electron tubes, or smoke detectors.

Current site-specific NRMP-controlled radiological work and storage areas are identified in Table 5-2. (This table represents the status of these facilities as of the beginning of shipyard closure efforts.)

Table 5-2
Radiological Facilities
Currently in Use

Facility	Radiological Use
Building 13	Radioactive Material Work/Storage
Building 177	Radioactive Material Work/Storage
Building 32	Radioactive Material Usage

Table 5-2 lists only those facilities controlled by a site-specific NRMP. Other CNSY facilities have a history of operations or activities which involved use or storage of non-NRMP controlled G-RAM. These applications either involve exempt quantities of radionuclides or involve operations which occurred prior to licensing/permitting requirements. These facilities and the potential operation of concern are identified in Table 5-3. (This table represents the status of these facilities as of the beginning of shipyard closure efforts.)

Table 5-3
Radiological Work and Storage Areas Requiring
Unconditional Release from Radiological Controls

Building/Facility	Operation Involving G-RAM
2/2A, 11, 35, 59, 62, 247, 1174, 26-13	Storage, issue and preparation of welding rods
3, 44, 79, 187, 218	Storage and/or maintenance of products containing radium (i.e, gauges, dials, watches, deck markers)
58, 217	Radioanalysis lab operations
10, 57, 190, 1173, 1267	Receipt and temporary storage of radioactive material

There is no record of loss of control of radioactivity in any of these facilities. Affected portions of these facilities have been surveyed in the past and no contamination has been found, and it is concluded that the radioactivity associated with operations conducted in these facilities does not represent a potential environmental hazard. These facilities will, however, receive confirmatory radiological surveys no later than April 1, 1996 in support of base closure and reutilization.

6.0 Environmental Monitoring Program

Radiological environmental monitoring has been conducted at CNSY since the beginning of its involvement with Naval nuclear-powered ships. This monitoring consists of analyzing river sediment, water, and marine life samples for radioactivity, radiation monitoring around the perimeter of support facilities, and related monitoring. Since 1979, a portion of the sediment and water and all of the marine life sample analyses have been performed by a U.S. Department of Energy (DOE) laboratory. The scope and analysis methods of CNSY monitoring are sensitive enough to identify environmental radioactivity from various sources, such as that due to airborne nuclear tests in past years. The DOE laboratory annually analyzes a portion of the environmental samples with equipment and procedures which result in a minimum sensitivity approximating that achieved by the EPA in their 1985 (reported in 1987) survey of the Cooper River, Reference 6.

Although directed toward the NNPP, this monitoring is additionally indicative of the presence or absence of G-RAM, and pertinent results are included in this section.

6.1 Harbor Environmental Records

Harbor environmental data consisting of sediment, water, and marine life sample analysis data are applicable to the surface water pathway.

6.1.1 Sediment Sampling

Initial sediment samples were taken in 1960, as part of a base-line study prior to beginning NNPP work on the Cooper River.

The earliest published report that included sediment sampling data is contained in Reference 7. Table II of Reference 7 shows that in 1966, 368 samples were taken at NNPP facilities on the Cooper River (including the Naval Base). Two samples per quarterly sampling period were sent to the U.S. Public Health Service Southeastern Radiological Health Laboratory for independent analysis. The results of these cross checks were consistent with those of the Navy. As an additional intercomparison, some randomly selected samples were sent to a U.S. Atomic Energy Commission laboratory for analysis.

In 1966, CNSY implemented a uniform Program environmental monitoring protocol. Sediment samples have been collected quarterly through the present.

Beginning in 1967, the NNPP has published an annual report of environmental monitoring and waste disposal throughout the Program. These reports have been made available to federal regulatory agencies, state governments, and the general public. Reference 8 is the latest in this series of reports.

Site-specific sediment sampling data for CNSY are available from 1960 through the present and are included in Table 6-1. The activity in the sediment is primarily the naturally-occurring potassium-40, as shown in Table 6-2. Decay products of the naturally-occurring thorium and uranium series also contribute significantly to the total activity. Small amounts of cesium-137 are occasionally detectable in Cooper River sediment. As reported by the EPA in their latest survey of the Cooper River (Reference 6), this cesium-137 is attributable to past atmospheric nuclear tests. EPA also reports in Reference 6 that the other radionuclides detected in the sediment are naturally-occurring. Trace amounts of other naturally-occurring radionuclides (e.g., cosmogenically-produced beryllium-7) and other radionuclides attributable to past atmospheric nuclear tests are or have been occasionally detected. The gross gamma radioactivity concentration varies from sample to sample due to differences in the concentrations of the various naturally-occurring radionuclides.

At present, 35 samples of river sediment are taken quarterly at CNSY. Sampling locations are shown on Figure 6.1. Sample locations are selected based on berthing locations of nuclear-powered ships and at points upstream and downstream of berths where tidal ebb and flood currents could deposit suspended radioactivity. Although sample locations have been selected based on NNPP operations, it can be seen from Figure 6.1 that samples are collected across the length of the CNSY waterfront. If any gamma-emitting G-RAM attributable to shipyard operations were present in the Cooper River environment, this monitoring program is sufficiently broad to assure detection.

A modified 6 inch square Birge-Ekman dredge is used to obtain a sample of the top 1/2 to 1 inch of the bottom sediment. This was selected since surficial sediments are more mobile and more accessible to marine life.

Prior to 1978, sediment samples were collected in 1-quart cylindrical containers and analyzed using a sodium iodide scintillation detector in conjunction with a 400 channel "Gammascope." In 1978, a 4096 channel analyzer and germanium high resolution spectroscopy system was put into service, and actual activities have been measured since then, in addition to gross gamma. Collected sample material was placed in Marinelli containers to provide consistent counting geometry.

Sample collection and analysis are conducted using a standardized procedure which has been approved by the NNPP. All Program Fleet and shore-based activities conducting environmental monitoring use this method. A portion of CNSY river bottom sediment samples are reanalyzed by a DOE laboratory. This laboratory continues to participate satisfactorily in the quality control programs sponsored by DOE and EPA.

Table 6-1

Average Gross Beta/Gamma Activity Concentration
In Harbor Sediment Samples
Charleston Naval Shipyard/Naval Base/Naval Weapons Station
1960 - 1965

Year	Month or Quarter	Average Gross Beta Radioactivity (pCi/g)				
		Sampling Location				
		Outside of Drydock #1	North of Pier G	South of Pier G	North of Pier A(a)	Naval Base (South End) (a)
1960 (b)	Jul	-	-	3	-	-
	Aug	-	-	3	-	-
	Dec	-	-	8	-	-
1961 (b)	1	-	-	31	-	-
	2	-	-	30	-	-
	3	-	-	25	-	-
	4	-	-	46	-	-
1962 (b)	1	-	-	203	-	-
	2	-	-	131	-	-
	3	-	-	232	-	-
	4	-	-	219	-	-
1963 (b)	1	-	-	331	-	-
	2	-	-	337	-	-
	3	-	-	248	-	-
	4	-	133	152	131	136
1964	1	175	215	224	114	116
	2	172	164	177	100	119
	3	128	117	131	95	101
	4	94	77	92	60	60
1965	1	72	62	66	48	54
	2	69	65	65	50	37
	3	38	56	56	41	23
	4	40	47	46	38	26

Notes: (a) North of Pier A and the south end of the Naval Base (near Pier Y) are the control samples.

(b) 1962 and earlier data were pre-operational.

(c) Gross gamma analysis was performed beginning in 1966. The average gross beta measurements for 1964 and 1965 were 127 pCi/g and 50 pCi/g, respectively. The increase in 1962 is attributed to the atmospheric nuclear weapons testing. The sharp decline in 1965 is due to changes in sample preparation, and counting procedures and the reduction in levels of radioactivity in the environment due to cessation of atmospheric nuclear weapons testing.

Table 6-1 (continued)

Gamma Radioactivity Concentration In Harbor Sediment Samples
Charleston Naval Shipyard/Naval Base/Naval Weapons Station
1966 - 1970

Year	Quarter	Number of Samples	Average Gross Gamma >0.1 MeV (pCi/cm^2)	Range of Gross Gamma >0.1 MeV High/Low (pCi/cm^2)
1966	1	92	10.4	205 - 0
	2	92	0.4	1.6 - 0
	3	92	1.1	4.0 -<1.0
	4	92	1.1	4.7 -<1.0
1967	1	92	8.1	63.0 -<3.4
	2	96	9.5	47.3 - 4.6
	3	96	7.4	20.7 - 3.2
	4	96	6.5	24.6 - 3.2
1968	1	96	1.7	6.0 - 1.0
	2	96	1.5	3.0 -<0.4
	3	96	1.6	8.0 -<0.6
	4	96	1.8	7.0 - 1.0
1969	1	95	1.4	14.0 -<1.0
	2	96	1.6	9.0 -<1.0
	3	94	2.1	8.0 -<1.0
	4	93	1.6	4.0 -<1.0
1970	1	94	1.4	4.0 -<1.0
	2	96	2.1	6.0 -<1.0
	3	96	1.7	6.0 -<1.0
	4	96	1.2	3.0 -<1.0

Note: From 1966 to 1970, the standard reporting requirements were in units of $\mu\mu Ci/cm^2$. The above table has been changed to pCi/cm^2 since $\mu\mu Ci$ and pCi are the same unit. There is no direct conversion from cm^2 to gram without knowing the number of dredge loads needed to obtain a sample. This was corrected in 1971 by reporting pCi/g.

Table 6-1 (continued)

Gamma Radioactivity Concentration In Harbor Sediment Samples
Charleston Naval Shipyard/Naval Base/Naval Weapons Station
1971 - 1994

Year	Quarter	Number of Samples	Average Gross Gamma >0.1 Mev (pCi/g)	Range of Gross Gamma >0.1 Mev High/Low (pCi/g)
1971	1	96	0.48	1.5 -<0.2
	2	96	1.03	1.9 -<0.2
	3	96	0.79	2.0 -<0.2
	4	96	0.47	1.0 -<0.2
1972	1	96	0.50	1.1 -<0.2
	2	96	0.61	4.2 -<0.2
	3	96	0.54	6.9 -<0.2
	4	96	0.36	2.9 -<0.2
1973	1	104	0.6	4.3 -<0.2
	2	104	0.6	3.8 -<0.2
	3	104	1.2	5.4 - 0.5
	4	104	1.1	15.3 - 0.3
1974	1	104	1.2	14.7 - 0.5
	2	104	1.1	4.3 - 0.5
	3	104	1.2	4.4 - 0.6
	4	104	1.2	11.1 - 0.7
1975	1	98	1.2	6.5 -<0.2
	2	51	1.4	5.9 - 0.6
	3	51	1.3	4.1 - 0.6
	4	51	1.0	4.0 - 0.5
1976	1	51	1.2	9.3 - 0.4
	2	55	1.2	6.0 - 0.5
	3	51	1.0	4.2 - 0.5
	4	51	1.4	11.2 - 0.6
1977	1	53	2.4	40.0 - 0.6
	2	50	1.3	5.4 - 0.7
	3	54	1.0	3.5 - 0.7
	4	54	1.2	3.1 - 0.7
1978	1	60	0.90	1.71 - 0.66
	2	60	1.04	4.16 - 0.71
	3	48	1.09	3.84 - 0.62
	4	48	0.84	1.44 - 0.59
1979	1	50	0.86	2.60 - 0.51
	2	52	1.27	12.07 - 0.62
	3	52	1.31	7.23 - 0.57
	4	52	1.50	12.36 - 0.56

Table 6-1 (continued)
Gamma Radioactivity Concentration in Harbor Sediment Samples
Charleston Naval Shipyard/Naval Base/Naval Weapons Station
1971 - 1994

Year	Quarter	Number of Samples	Average Gross Gamma >0.1 Mev (pCi/g)	Range of Gross Gamma >0.1 Mev High/Low (pCi/g)
1980	1	52	0.79	4.30 - 0.52
	2	50	1.08	3.98 - 0.50
	3	57	1.14	5.79 - 0.54
	4	52	1.09	5.32 - 0.51
1981	1	52	1.13	4.59 - 0.63
	2	50	1.39	4.18 - 0.66
	3	52	1.32	5.89 - 0.65
	4	52	0.98	4.51 - 0.61
1982	1	51	1.12	8.92 - 0.59
	2	52	0.96	5.65 - 0.56
	3	52	0.90	2.95 - 0.59
	4	54	0.87	3.09 - 0.54
1983	1	54	0.88	4.20 - 0.57
	2	54	1.08	4.23 - 0.55
	3	54	1.05	5.87 - 0.55
	4	54	0.85	1.84 - 0.51
1984	1	52	0.85	3.48 - 0.54
	2	54	1.08	13.23 - 0.51
	3	56	0.96	3.25 - 0.55
	4	56	0.94	2.46 - 0.47
1985	1	57	1.25	8.20 - 0.55
	2	57	1.10	9.89 - 0.55
	3	59	1.15	4.74 - 0.62
	4	59	0.98	4.88 - 0.55
1986	1	59	1.12	11.50 - 0.61
	2	59	1.11	6.18 - 0.58
	3	65	1.03	4.71 - 0.51
	4	65	1.03	5.90 - 0.63
1987	1	65	1.15	7.95 - 0.59
	2	65	1.03	8.82 - 0.55
	3	70	0.96	2.86 - 0.61
	4	70	1.23	6.55 - 0.59
1988	1	70	1.10	6.47 - 0.58
	2	70	1.18	8.57 - 0.65
	3	70	1.05	3.12 - 0.59
	4	70	1.26	15.25 - 0.71

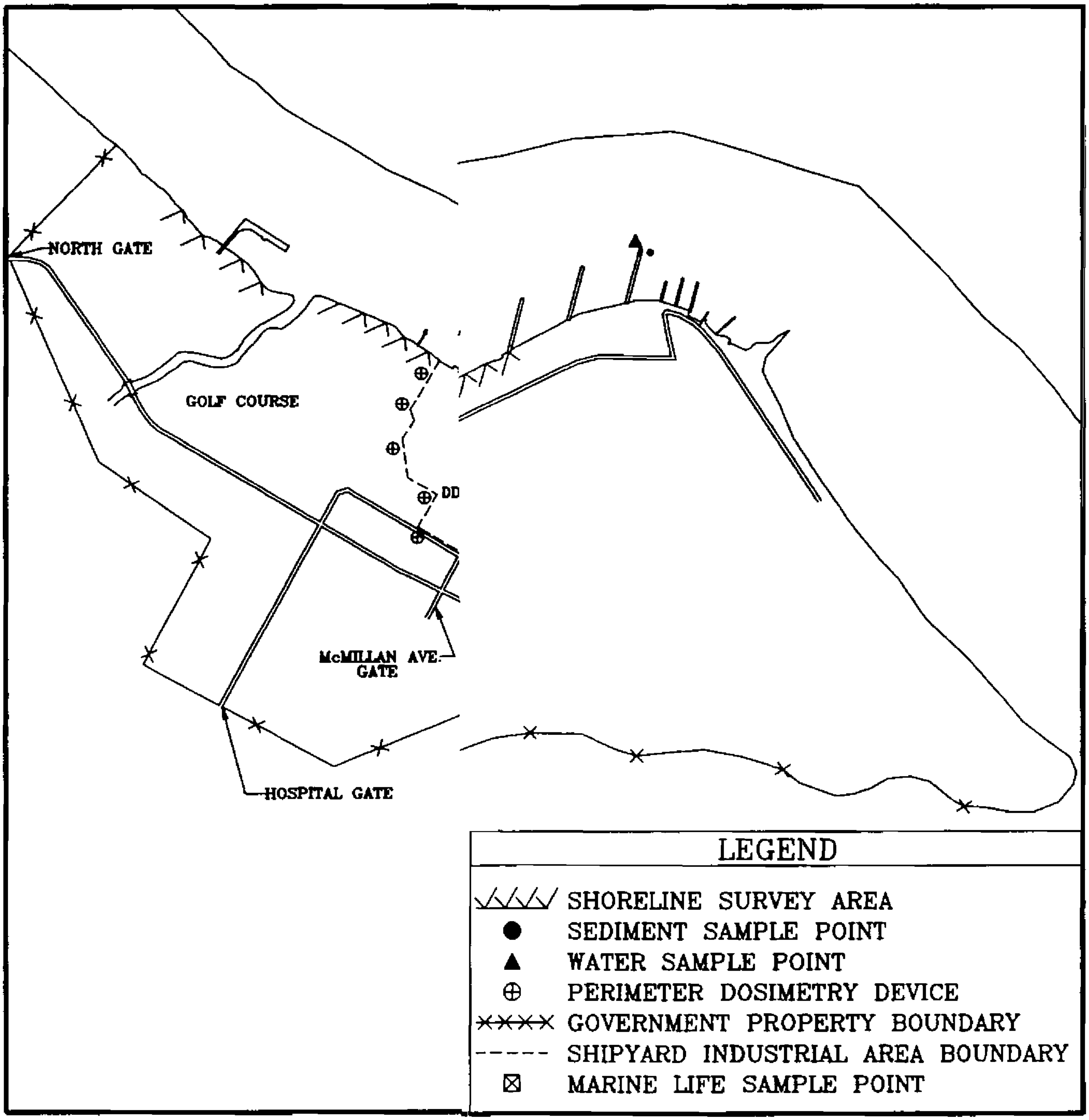
Table 6-1 (continued)

Gamma Radioactivity Concentration in Harbor Sediment Samples
Charleston Naval Shipyard/Naval Base/Naval Weapons Station
1971 - 1994

Year	Quarter	Number of Samples	Average Gross Gamma >0.1 Mev (pCi/g)	Range of Gross Gamma >0.1 Mev High/Low (pCi/g)
1989	1	70	1.21	9.00 - 0.68
	2	70	1.09	7.08 - 0.63
	3	70	1.31	7.44 - 0.66
	4	70	1.28	7.29 - 0.67
1990	1	70	1.15	7.18 - 0.55
	2	70	1.08	6.51 - 0.30
	3	70	1.01	3.68 - 0.62
	4	70	1.10	8.46 - 0.60
1991	1	70	0.98	2.89 - 0.64
	2	70	1.25	9.40 - 0.61
	3	70	1.11	5.76 - 0.52
	4	70	1.13	8.21 - 0.57
1992	1	72	1.22	9.39 - 0.48
	2	72	0.99	3.85 - 0.63
	3	72	0.99	2.64 - 0.62
	4	72	1.21	6.47 - 0.65
1993	1	72	1.05	4.41 - 0.61
	2	75	0.99	5.39 - 0.58
	3	75	1.14	10.12 - 0.58
	4	75	1.14	8.06 - 0.63
1994	1	75	1.18	7.52 - 0.64
	2	70	1.09	6.52 - 0.66
	3	70	1.20	5.35 - 0.64
	4	70	1.17	8.87 - 0.65

Note: The "<" symbol indicates the minimum detectable activity for this analysis.

Figure 6.1
Environmental Monitoring Sampling Points and Survey Locations



A portion of the first quarter samples are re-analyzed by the DOE laboratory. For this analysis, a higher efficiency, larger volume detector and very long counting times are used to provide the capability to detect extremely low concentrations of radionuclides. This analysis achieves a minimum sensitivity on the order of that reported by the EPA in Reference 6. Radionuclide-specific results for the re-analyzed CNSY sediment samples are presented in Table 6-2; gross-gamma activity concentration is not reported for re-analyzed sediment samples. These records are available beginning with 1979 through the present.

Table 6-2
Sediment Enhanced Monitoring Results
Charleston Naval Shipyard
1979 -1994

Year	Radionuclide(s) (a)	Activity Concentration, pCi/g								
		Location Number								
		3	7	13	17	28	35	54	56	68
1979	Uranium Series Thorium Series K-40 Cs-137	(b)	0.209 0.209 2.08 0.080	(b)	(b)	(b)	0.338 0.237 2.34 0.052	0.156 0.199 1.90 0.060	(b)	(b)
1980	Uranium Series Thorium Series K-40 Cs-137	0.152 0.181 1.33 0.043	0.209 0.195 1.58 0.079	0.221 0.236 1.75 0.060	0.613 0.380 4.30 0.042	(b)	(b)	(b)	(b)	(b)
1981	Uranium Series Thorium Series K-40 Cs-137	(b)	0.281 0.333 2.59 0.050	(b)	1.820 0.729 7.46 0.036	0.468 0.446 2.88 0.009	(b)	(b)	(b)	(b)
1982	Uranium Series Thorium Series K-40 Cs-137	(b)	0.622 0.209 1.79 0.050	(b)	0.340 0.224 2.20 0.050	0.523 0.255 1.89 0.040	(b)	0.160 0.162 1.41 0.060	(b)	(b)
1983	Uranium Series Thorium Series K-40 Cs-137	0.222 0.206 1.70 0.056	0.183 0.215 2.30 0.052	(b)	(b)	(b)	0.289 0.234 1.93 0.060	(b)	(b)	(b)
1984	Uranium Series Thorium Series K-40 Cs-137	(b)	(b)	(b)	(b)	0.841 0.268 1.95 0.028	(b)	(b)	0.179 0.151 1.64 0.039	(b)
1985	Uranium Series Thorium Series K-40 Cs-137	(b)	(b)	0.365 0.194 1.82 0.038	1.940 0.230 2.87 0.033	(b)	0.268 0.188 2.52 0.027	(b)	(b)	(b)
1986	Uranium Series Thorium Series K-40 Cs-137	(b)	(b)	(b)	(b)	(b)	(b)	0.411 0.183 2.16 0.032	(b)	(b)

Table 6-2 (continued)

Sediment Enhanced Monitoring Results
Charleston Naval Shipyard
1979-1994

Year	Radionuclide(s) (a)	Activity Concentration, pCi/g								
		Location Number								
		3	7	13	17	28	35	54	56	68
1987	Uranium Series	0.264	0.414	(b)	(b)	(b)	0.349	(b)	(b)	(b)
	Thorium Series	0.184	0.155				0.207			
	K-40	2.43	2.94				2.29			
	Cs-137	0.048	0.033				0.035			
1988	Uranium Series	(b)	(b)	(b)	(b)	0.267	(b)	(b)	0.168	1.23
	Thorium Series					0.232			0.156	0.349
	K-40					2.16			1.77	2.49
	Cs-137					0.046			0.033	0.029
1989	Uranium Series	(b)	(b)	0.564	0.375	(b)	(b)	(b)	(b)	(b)
	Thorium Series			0.240	0.249					
	K-40			2.53	2.52					
	Cs-137			0.034	0.035					
1990	Uranium Series	(b)	(b)	(b)	(b)	(b)	(b)	(b)	0.206	0.988
	Thorium Series								0.194	0.137
	K-40								1.81	1.47
	Cs-137								0.043	0.013
1991	Uranium Series	0.337	0.842	(b)	(b)	(b)	0.453	(b)	(b)	(b)
	Thorium Series	0.193	0.188				0.193			
	K-40	2.62	2.44				2.60			
	Cs-137	0.041	0.026				0.039			
1992	Uranium Series	(b)	(b)	(b)	(b)	0.828	(b)	0.245	(b)	(b)
	Thorium Series					0.249		0.190		
	K-40					2.87		2.37		
	Cs-137					0.020		0.035		
1993	Uranium Series	(b)	(b)	0.503	0.273	(b)	0.387	(b)	(b)	(b)
	Thorium Series			0.216	0.234		0.264			
	K-40			2.35	2.64		2.95			
	Cs-137			0.030	0.038		0.045			
1994	Uranium Series	(b)	(b)	(b)	(b)	(b)	(b)	(b)	0.214	0.127
	Thorium Series								0.182	0.113
	K-40								1.95	1.28
	Cs-137								0.030	0.022
Averages	Uranium Series	0.244	0.394	0.643	0.894	0.585	0.347	0.243	0.192	0.781
	Thorium Series	0.191	0.214	0.239	0.341	0.290	0.221	0.184	0.171	0.199
	K-40	2.02	2.25	1.850	3.67	2.35	2.44	1.96	1.79	1.75
	Cs-137	0.047	0.046	0.035	0.039	0.029	0.043	0.047	0.036	0.021

Notes: (a) Reported activity concentrations for the uranium and thorium series are average concentrations.
(b) A sample from this point was not re-analyzed by the DOE laboratory.

The absence of any radionuclides other than those attributable to past atmospheric nuclear tests or those which are naturally occurring (at background levels) is indicative of no gamma-emitting G-RAM attributable to CNSY having been introduced into the sediment.

No trend, either by location or over time, is apparent from examining these data. The expected ranges of activity concentrations for background levels of these naturally-occurring radionuclides is observed, and these ranges are consistent with those reported by the EPA in Reference 6.

The uranium series overall annual averages range from 0.19 pCi/g to 0.89 pCi/g, over all years tabulated in Table 6.2. Within a given year, the difference between the highest and lowest value has ranged from about 0.09 pCi/g to 1.67 pCi/g. Examination of individual sample location data also shows no trend: location-specific uranium series averages range from 0.13 pCi/g to 1.94 pCi/g; the overall average for the two locations away from the base waterfront (Nos. 35 and 68) is 0.56 pCi/g; the overall average for the remaining Table 6-2 locations (all near the waterfront) is 0.45 pCi/g. The difference between the highest and lowest historical values for a given location ranges from about 0.19 pCi/g to 1.10 pCi/g for Nos. 35 and 68. For the waterfront locations, these differences range from about 0.05 pCi/g to 1.67 pCi/g. Within the Table 6-2 data set, there is also no trend upon examining extremes of the ranges, whether by year or by location. Most of the locations have recorded both high end and low end values for a given year. The historical high end and low end values for a given location also show no trend.

The thorium series overall annual averages range from about 0.17 pCi/g to 0.34 pCi/g, over all years tabulated in Table 6-2. Within a given year, the difference between the highest and lowest value has ranged from about 0.01 pCi/g to 0.40 pCi/g. Examination of individual sample location data also shows no trend: location-specific thorium series averages range from about 0.11 pCi/g to 0.73 pCi/g; the overall average for the two locations away from the waterfront (Nos. 35 and 68) is about 0.21 pCi/g; the overall average for the waterfront locations is about 0.23 pCi/g. The difference between highest and lowest historical values for Nos. 35 and 68 ranges from about 0.08 pCi/g to 0.24 pCi/g. For the waterfront locations, these differences range from 0.03 pCi/g to 0.51 pCi/g. As with the uranium series data, there is no trend discernible upon examining extremes of these ranges, whether by year or by location.

A PHS survey of 1966 (Reference 9) reported an average total radium concentration of 0.55 pCi/g dry silts with a range from 0.37 pCi/g to 0.72 pCi/g in sediment samples collected from the vicinity of CNSY. The EPA study of CNSY vicinity gave no specific nuclide levels, but stated, "Only naturally occurring radionuclides and trace amounts of Cs-137 (typically fallout from previous worldwide nuclear testing) were found in these sediment samples."

The data in Table 6-2 is not directly comparable to the Reference 6 data. These tables report the weighted average activity concentration for readily-detectable radionuclides within the given naturally-occurring series, for wet samples collected from the top one-half to one inch of sediment; the EPA reported radionuclide-specific data in Reference 6 for dried samples collected from the top 10 cm (3.9 inches) of sediment. The labor-intensive steps necessary to assure equilibrium between Ra-226 or Th-232 and all their subsequent decay products in sediment samples are not performed in the course of generating the Table 6-2 data.

The data in Table 6-2 is indicative of the area background activity concentrations (wet weight) of these naturally-occurring radionuclide series averages, with the expected wide range of values comparable to the range reported by the EPA in Reference 6. The data are not indicative of any buildup of uranium series or thorium series radionuclides above background levels in the vicinity of CNSY.

In 1966 the U.S. Public Health Service (PHS) conducted a radiological survey of the Cooper River and its environs in the vicinity of all NNPP sites. This survey was repeated in 1985 by the EPA. The results of these surveys were published in References 9 and 6 respectively, in 1966 and 1987.

The focus of these surveys was to assess any impact of NNPP operations on the Cooper River and surrounding areas. In these surveys, however, analytical techniques capable of detecting the full range of gamma-emitting radionuclides were employed, as evidenced by PHS/EPA noting the presence of various radionuclides attributable to past atmospheric nuclear tests and/or naturally-occurring radionuclides among the collected samples. In these surveys, no occurrences of such radionuclides above background levels were observed.

For example, the 1987 EPA survey report concluded:

> "All samples collected during this survey contained only low levels of natural radioactivity and cesium-137 from fallout. There was no detectable radioactivity in any of the samples due to nuclear operations at the shipyard or weapons station.
>
> "Drinking water from the shipyard and from the Charleston municipal water supply did not contain any detectable radioactivity.
>
> "In the overland survey of the base and shipyard and the weapons station, no elevated readings from nuclear powered warship operations at these facilities were detected.
>
> "Navy practices to restrict the release of radioactive material to the minimum practical into the harbor have been effective."

The 1966 and 1987 PHS/EPA survey reports all note that the only radioactivity attributable to Navy operations in the Cooper River environs is trace amounts of Co-60, found primarily in river bottom sediment and discussed in Volume I of this HRA. Both surveys report the presence of the naturally-occurring K-40, uranium series, and thorium series radionuclides in environmental survey samples. The 1985 survey reports the presence of Cs-137 in various samples, and attributes this to past atmospheric nuclear tests.

South Carolina has performed independent radiological monitoring of river water and bottom sediment since the beginning of NNPP activities along the Cooper River. The most recent state data available to CNSY are consistent with CNSY and EPA results.

The data collected by the shipyard, the State of South Carolina, the Public Health Service, and the Environmental Protection Agency over the period 1960 through 1994 clearly support the conclusion that G-RAM activities at CNSY: a) have contributed no detectable increase to background radioactivity levels; and b) based on sediment data, pose no hazard to the public, either directly or via the food chain, and pose no hazard to the ecological systems of the region.

6.1.2 River Water Sampling

Beginning with the baseline data obtained in 1959, and continuing through the present, samples of water from the Cooper River have been collected and analyzed. Weekly sampling was required in 1964. Quarterly sampling began in 1966. Current sampling locations are shown on Figure 6.1.

Sample locations are selected based on areas where radioactive liquids could have been discharged and at upstream and downstream locations.

From 1959 through 1965, samples were evaporated and counted for gross beta activity. Beginning in 1966, a sodium iodide scintillation detector was used to count one-liter samples in polyethylene bottles. A state-of-the-art 400 multichannel analyzer was used for this analysis. The sodium iodide detector was used to measure gross gamma activity. Since 1978, a 4096-channel multichannel analyzer and germanium high resolution spectroscopy system has been used, and actual radionuclide activities have been measured, in addition to gross gamma. Like sediment samples, a Marinelli container is used for water sample analysis.

Water samples were taken of CNSY vicinity river water and area drinking water supplies by the Public Health Service in 1966 and by the Environmental Protection Agency in 1985. References 6 and 9 report that no radioactivity associated with Navy operations was detected by gamma analysis in any water sample taken during these surveys. No radioactivity attributable to Navy operations has been detected in any water sample taken by CNSY since the inception of the monitoring program. The only radionuclides that have occasionally been detected in these water samples are the naturally-occurring K-40, and series radionuclides of uranium and thorium. A review of both CNSY gamma counting results and the series of environmental monitoring reports published annually by the Naval Nuclear Propulsion Program reveals that no above-background levels of any radionuclides have ever been detected in river water samples. Quarterly data for each year is reported annually by CNSY. The water sample data are not tabulated in this report since they reflect 34 years of less than minimum detectable activity concentration values for radioactivity attributable to Navy operations.

The conclusions reached by the Navy in its annual reports are confirmed by References 6 and 9. The results of water sample analysis conducted by the State of South Carolina since 1960 are consistent with these conclusions.

6.1.3 Marine Life Sampling

As part of the 1975 environmental assessment, Reference 10, marine life samples were collected near shipyard piers and analyzed to determine if they may be concentrating the very low levels of radioactivity in the harbor environment. Species collected and analyzed included oysters, crabs, eels, and catfish (bottom feeding fish). Samples were analyzed for gross gamma radioactivity and radionuclide content with a gamma scintillation spectrometer. No radioactivity except for naturally occurring radionuclides has been detected.

Beginning in 1978, shipyards conducting NNPP environmental monitoring were required to obtain marine life samples during July of each year. Samples include available species of marine plants, mollusks, and crustaceans from locations in the vicinity of CNSY piers where nuclear-powered ships berth. The collected samples are sealed in plastic containers with formaldehyde preservative. The samples are shipped to a DOE laboratory for high resolution radionuclide analysis by gamma spectroscopy. Qualitative analysis data of marine life samples taken since 1978 are shown in Table 6-3. In addition, samples of algae were collected in July 1983 and have been collected quarterly since 1984. No radioactivity attributable to Navy operations has been assimilated into marine life in the Cooper River environs. The activity concentrations of naturally-occurring radionuclides in marine life determined by this analysis have been consistent with that reported by the EPA in Reference 6.

During the 1985 Environmental Protection Agency survey aquatic life samples (fish and shellfish) were collected. Reference 6, page 11, reports that "all radioactivity detected in these samples is of natural origin with no contributions based on shipyard or weapons station operations."

On the basis of the data shown in Table 6-3 and the findings of the Environmental Protection Agency survey reported in Reference 6, there has been no accumulation of G-RAM in marine organisms as a result of operation of nuclear-powered ships or work on those ships by Charleston Naval Shipyard.

Table 6-3
Marine Life Monitoring Results
Charleston Naval Shipyard/Naval Base/Naval Weapons Station
1978-1994

Year	Sample Type (a),(b)	Average Gross Gamma(pCi/g) (c)	Year	Sample Type (a),(b)	Average Gross Gamma (pCi/g) (c)
1978	Crustaceans Mollusks	0.14 0.12	1987	Crustaceans Mollusks Algae	0.22 0.06 0.24
1979	Crustaceans Mollusks	0.12 <0.08	1988	Crustaceans Mollusks Algae	0.23 0.11 0.25
1980	Crustaceans Mollusks	<0.09 <0.07	1989	Crustaceans Mollusks Algae	0.23 0.12 0.33
1981	Crustaceans Mollusks	0.20 0.09	1990	Crustaceans Mollusks Algae	0.16 0.15 0.30
1982	Crustaceans Mollusks	0.32 0.10	1991	Crustaceans Mollusks Algae	0.31 0.05 0.27
1983	Crustaceans Mollusks Algae	0.32 0.11 0.27	1992	Crustaceans Mollusks Algae	0.29 <0.07 0.29
1984 (c)	Crustaceans Mollusks Algae	0.24 0.07 0.30	1993	Crustaceans Mollusks Algae	0.32 0.09 0.24
1985	Crustaceans Mollusks Algae	0.22 0.12 0.29	1994	Crustaceans Mollusks Algae	0.19 0.07 0.21
1986	Crustaceans Mollusks Algae	0.20 0.09 0.19			

Notes: (a) Marine plants have been and continue to be unavailable due to the speed of the currents and the excessive silt in the Cooper River.

(b) Algae samples have been obtained quarterly since April 1984.

(c) 1978-1994 samples analyzed with a high resolution germanium detector and 4096-channel analyzer.

6.1.4 Core Sampling

Core samples were taken as part of the environmental assessment done by the shipyard in 1975 (sampling conducted in 1974), Reference 10, and by the Environmental Protection Agency during their 1985 survey, Reference 6. These samples were taken to determine whether radioactivity may have accumulated below the top layer of sediment, which is sampled on a routine basis. CNSY took a core sample in 1974 adjacent to a pier where nuclear-powered ships berth. No man-made radioactivity was detected in this sample. During the Environmental Protection Agency survey reported in Reference 6, seven core samples were taken at CNSY. EPA cores were obtained with a 3.8 centimeter diameter by 61 centimeter plastic tube pushed into the sediment by a diver. Cores were frozen, cut in sections, freeze dried, and counted on an intrinsic germanium detector. None of these cores contained other than naturally occurring radionuclides and trace amounts of CS-137.

Beginning in 1977, regulations required that core samples be taken in areas where sediment samples exceeded 3 pCi/g. No sediment samples have exceeded this trigger level since 1977 and therefore no additional core samples have been taken.

6.2 Dredging Records

Maintenance dredging is periodically conducted at CNSY to maintain the prescribed depth in slips, at various berths and at the entrances to drydocks. The dredging is performed by both the U.S. Army Corps of Engineers and the shipyard.

All of the dredged material is deposited at the Clouter Creek spoils area. Dredging operations at CNSY are shown in Table 6-4. Records detailing the volume of spoil material deposited at the Clouter Creek spoils area prior to 1969 are not available.

Maintenance dredging removes the layer of silt down to the hardpan. Prior to dredging, quarterly sediment samples are easily obtainable with the modified Birge-Ekman dredge and consists of loose silt and ooze. After dredging, some locations require multiple attempts to collect a 500 gram sample. This helps confirm that with routine maintenance dredging, the old consolidated bottom is not disturbed.

Radiation surveys using the PRM-5N gamma survey meter were performed in the spoils area from 1972 through 1986. Results of these surveys were consistent with background radiation levels. In addition to these instrument surveys, samples of water and spoil material have periodically been obtained and analyzed. These samples have all contained only trace levels of naturally-occurring radioactivity. The last samples collected from the spoils areas was in June 1986. Considering the sediment sampling data shown in Table 6-1, this result for spoil material is as expected.

Table 6-4
Dredging Conducted at Shipyard and Naval Base
Piers and Berthings Combined
1969-1994

Year	Volume (cubic yards)	Year	Volume (cubic yards)
1969	4,340,600	1982	3,916,570
1970	3,928,350	1983	4,314,269
1971	3,181,950	1984	3,636,806
1972	3,937,600	1985	1,748,871
1973	2,459,900	1986	2,836,145
1974	3,807,600	1987	1,861,850
1975	3,709,700	1988	1,470,765
1976	4,114,400	1989	1,877,715
1977	3,987,500	1990	1,455,069
1978	3,492,300	1991	2,824,896
1979	2,407,282	1992	1,220,707
1980	2,673,330	1993	1,329,547
1981	2,863,400	1994	1,225,214

The amount of naturally occurring radioactivity removed as a result of dredging operations and deposited in the spoil area, primarily potassium-40 in organic detritus, would far exceed the total upper limit gross gamma radioactivity found in CNSY sediment even if all the sediment removed from the shipyard since 1963 had been deposited in one location.

6.3 Perimeter Radiation Records

Beginning in 1966, beta-gamma film badges were posted outside of controlled radiation areas to ensure that unmonitored personnel within the shipyard and the general public were not exposed to radiation levels above that due to natural background.

In March 1969, the regulations were revised to include a group of film badges close to or at the perimeter of the shipyard. This second group of film badges provided additional data that no member of the general public living or working outside the shipyard exceeded the radiation exposure they would receive due to natural background, even if they lived or worked immediately adjacent to the shipyard perimeter 24 hours per day.

For the second and third quarters of 1974, both film badge and thermoluminescent dosimeters (TLDs) were posted in the same locations. For the fourth quarter of 1974 and all subsequent quarters, TLDs only have been posted at the shipyard perimeter.

Figure 6.1 shows the locations of currently posted TLDs. Reference 10 provides an extensive discussion of the TLD perimeter radiation monitoring program.

During 1974, as reported in Reference 10, a special survey of the entire shipyard perimeter was performed using a gamma scintillation portable survey instrument (PRM-5N/SPA-3). The instrument was calibrated for gamma energies of greater than 0.1 MeV. Measurements made along the land perimeter ranged from 5.8 thousand counts per minute (kcpm) to 13.0 kcpm with a mean value of 8.4 kcpm. Readings significantly above the average were obtained over land fill areas having a high percentile content of crushed granite which has above average concentrations of natural radionuclides (e.g., uranium ore and thorium). As a comparison, a survey was also performed at off-shipyard locations in the Charleston area. Readings obtained during that survey ranged from 4.0 to 27.5 kcpm with a mean value of 10.2 kcpm. Harbor property line measurements range from 0.5 to 1.0 kcpm with a mean of 0.7 kcpm. Variances of this magnitude are typical for background radiation, as shown in the aerial survey in Section 6.7.

Beginning in 1978, a cluster of five TLDs were posted at background locations, replacing the single TLD posted previously. Examples of background locations include: on a brick structure over a grass surface 5.5 miles northwest of CNSY in a residential area of North Charleston, on a wooden fence over a grass surface 7 miles west of the shipyard in a residential area of Charleston, and on a utility pole over a sandy surface 13 miles southeast of CNSY in the residential area of Isle of Palms. This method provided a better statistical basis for background determination and improved reliability.

Results of perimeter radiation monitoring are reported quarterly to the Naval Nuclear Propulsion Program. Since 1967, over 3000 data points have been obtained. Table 6-5 lists the quarterly results of the CNSY perimeter monitoring program since the second quarter of 1974, when the use of TLDs was initiated. The results of the monitoring verify that radiation exposure to the general public in occupied areas surrounding the shipyard is indistinguishable from natural background.

Table 6-5
Perimeter Radiation Monitoring
Charleston Naval Shipyard
1974 - 1994

Year	Quarter	Exposure Rate Range (mrem/qtr)		Average Exposure Rate (mrem/qtr)	
		Background	Perimeter	Background	Perimeter
1974	2	21.9 - 33.5	17.8 - 31.1	27.6	22.9
	3	20.4 - 33.0	18.4 - 33.6	26.0	23.7
	4	15.5 - 35.2	19.9 - 36.6	23.7	26.9
1975	1	11.0 - 31.0	17.5 - 31.4	18.9	22.6
	2	14.5 - 15.8	17.7 - 29.5	15.3	24.3
	3	18.7 - 27.0	16.1 - 28.5	21.0	21.6
	4	21.1 - 29.1	17.6 - 32.3	24.8	24.8
1976	1	19.5 - 25.5	14.2 - 27.3	22.5	20.8
	2	21.7 - 28.1	14.9 - 33.5	24.9	24.2
	3	16.5 - 24.3	15.3 - 28.8	20.4	22.1
	4	23.8 - 30.0	17.5 - 30.7	27.4	24.1
1977	1	27.7 - 27.8	13.6 - 25.2	20.0	19.4
	2	15.0 - 32.4	17.5 - 30.5	23.8	24.0
	3	12.8 - 35.6	18.0 - 31.1	24.2	24.6
	4	14.3 - 32.7	15.3 - 30.7	23.5	23.0
1978	1	13.5 - 27.3	16.7 - 28.7	19.2	21.8
	2	16.8 - 29.9	15.8 - 32.4	25.8	23.8
	3	14.7 - 27.2	17.2 - 29.3	20.6	22.4
	4	17.9 - 28.6	18.4 - 30.3	23.3	22.6
1979	1	15.6 - 25.4	14.8 - 27.4	19.7	21.0
	2	16.1 - 27.2	17.3 - 29.3	22.4	21.7
	3	15.0 - 27.0	14.9 - 29.3	20.9	20.5
	4	19.4 - 30.2	17.1 - 32.2	24.8	23.3
1980	1	20.1 - 29.9	16.3 - 29.0	23.5	20.7
	2	19.2 - 29.4	17.9 - 33.3	22.8	23.6
	3	19.1 - 28.1	15.9 - 30.7	22.3	21.8
	4	18.6 - 27.7	16.3 - 33.6	22.4	23.1
1981	1	20.1 - 28.9	17.6 - 32.3	23.8	24.0
	2	18.5 - 27.5	16.7 - 30.7	22.5	22.9
	3	19.4 - 28.8	17.2 - 33.2	23.7	24.1
	4	19.5 - 27.4	16.1 - 30.7	22.4	22.8
1982	1	17.8 - 28.8	17.3 - 32.1	22.4	23.6
	2	17.6 - 27.5	15.8 - 19.9	21.7	22.3
	3	17.7 - 28.2	17.5 - 31.2	21.3	23.9
	4	18.0 - 27.5	16.4 - 31.1	21.7	22.9

Table 6-5 (continued)
Perimeter Radiation Monitoring
Charleston Naval Shipyard
1974 - 1994

Year	Quarter	Exposure Rate Range (mrem/qtr)		Average Exposure Rate (mrem/qtr)	
		Background	Perimeter	Background	Perimeter
1983	1	17.9 - 27.4	18.2 - 34.9	21.9	24.4
	2	19.2 - 27.6	15.7 - 31.1	22.1	23.6
	3	19.0 - 28.0	16.5 - 30.6	22.0	23.4
	4	20.2 - 28.3	18.5 - 31.0	23.2	23.5
1984	1	17.6 - 27.0	18.0 - 30.3	21.3	23.6
	2	19.0 - 30.1	18.9 - 26.3	22.8	23.2
	3	19.3 - 29.4	18.0 - 27.0	22.9	22.7
	4	19.5 - 29.0	18.1 - 27.5	25.3	23.6
1985	1	19.4 - 27.6	17.8 - 26.4	23.4	23.0
	2	21.0 - 27.7	18.2 - 28.9	23.4	23.0
	3	22.0 - 29.0	17.6 - 28.0	24.6	22.2
	4	17.4 - 27.0	17.7 - 28.3	22.1	22.2
1986	1	18.8 - 28.1	16.9 - 29.3	22.5	22.8
	2	17.7 - 28.3	17.9 - 28.2	22.9	22.5
	3	17.7 - 27.7	18.0 - 29.1	22.2	22.7
	4	17.8 - 27.9	18.1 - 28.4	22.1	22.5
1987	1	18.8 - 28.4	17.4 - 28.6	23.0	22.4
	2	17.7 - 27.3	17.8 - 28.8	22.6	22.8
	3	17.3 - 28.1	18.3 - 29.0	22.9	22.8
	4	18.6 - 29.9	18.8 - 29.4	24.3	23.1
	1	17.9 - 28.1	17.8 - 29.4	23.1	22.9
1988	2	18.1 - 28.1	18.5 - 29.5	18.4	23.4
	3	18.8 - 30.0	18.5 - 29.0	19.7	22.9
	4	18.8 - 27.8	16.6 - 28.4	23.2	22.7
1989	1	19.0 - 28.1	18.2 - 29.0	23.2	22.6
	2	18.6 - 27.6	17.6 - 28.3	23.1	22.6
	3	18.0 - 28.8	18.4 - 30.6	23.3	23.2
	4	21.9 - 28.0	17.9 - 27.6	22.5	22.1
1990	1	18.3 - 27.4	11.2 - 27.7	22.5	20.8
	2	18.9 - 27.4	11.0 - 28.5	23.2	21.2
	3	18.5 - 27.7	11.2 - 27.6	22.7	21.2
	4	19.2 - 27.8	11.2 - 27.3	23.4	21.2
1991	1	17.4 - 28.7	11.2 - 29.0	23.3	21.5
	2	18.2 - 27.2	10.6 - 28.3	23.0	21.4
	3	19.3 - 29.1	11.7 - 28.7	23.7	22.0
	4	18.4 - 28.7	12.2 - 29.0	23.3	21.7

Table 6-5 (continued)
Perimeter Radiation Monitoring
Charleston Naval Shipyard
1974 - 1994

Year	Quarter	Exposure Rate Range (mrem/qtr)		Average Exposure Rate (mrem/qtr)	
		Background	Perimeter	Background	Perimeter
1992	1	18.3 - 28.2	11.5 - 30.6	22.8	21.8
	2	17.6 - 28.3	11.5 - 29.3	23.7	21.8
	3	17.5 - 26.4	12.0 - 29.3	22.5	21.2
	4	17.5 - 27.9	11.0 - 29.0	23.0	21.4
1993	1	17.3 - 28.9	11.5 - 28.1	22.4	21.2
	2	17.6 - 27.5	11.6 - 28.5	22.1	21.7
	3	18.4 - 28.2	11.7 - 29.0	23.1	22.0
	4	19.7 - 28.8	11.3 - 29.3	23.4	22.0
1994	1	18.8 - 28.5	11.3 - 28.8	23.1	22.1
	2	18.2 - 28.9	11.2 - 29.5	23.6	21.8
	3	19.2 - 29.0	11.5 - 27.6	24.0	21.6
	4	17.5 - 28.3	11.2 - 28.7	22.9	21.6

Table A-1 of Reference 11 lists the annual total body dose due to natural sources in the vicinity of CNSY as approximately 63.7 mrem (7.3 μR): 22.8 mrem is due to terrestrial sources of natural radioactivity and 40.9 mrem is due to cosmic radiation. Reference 11 is cited exclusively by the National Council on Radiation Protection and Measurements (NCRP) as a continuing source of data for natural background radiation exposure estimates. This reference estimate for natural background radiation exposure rate in the vicinity of CNSY is consistent with data in Table 6-6, which is a tabulation of values reported in References 6, 10, 12 and 13 along with the randomly selected CNSY fourth quarter data for 1993. The results of one of the initial quarters of monitoring using TLDs are reported in Table 4-2 of Reference 10. Reference 6 reports the results of the Environmental Protection Agency survey. Reference 13 reports the results of the aerial radiological survey of CNSY).

EPA concluded in Reference 6 that "In the overland survey of the base and shipyard and the Weapons Station, no elevated readings from nuclear powered warship operations at these facilities were detected." This conclusion is consistent with the Navy findings reported annually for the past 28 years in Reference 7 and successive reports through Reference 8.

Table 6-6
Perimeter Radiation Monitoring Comparison

Year	Survey	Ref	Exposure Rate Range (μR/hr)	Average Perimeter Exposure Rate (μR/hr)
1975	CNSY Assessment of Environmental Radioactivity	10		
	Perimeter		5.0 - 42.0	13.0
	Off-Yard (a)		7.0 - 43.0	18.0
1983	EG & G Aerial Radiological Survey	13	7.0 - 60.0	7.0 - 12.0
1983	CNSY Assessment of Environmental Radioactivity - Shoreline	12	N/A (b)	10.0
1987	US EPA Radiological Survey	6	6.0 - 46.0	8.0 - 15.0
1993 4th Qtr (c)	CNSY Quarterly Monitoring	N/A		
	Background Land		9.0 - 13.2	10.7
	Background Shoreline		7.6 - 28.9	10.7
	Perimeter Land		5.2 - 13.4	10.1
	Perimeter Shoreline		5.4 - 15.1	9.8

Notes: (a) Exposure rate range and average exposure rate apply to off-shipyard (non-perimeter) locations.
(b) N/A - Not Available
(c) Land monitoring data from posted TLDs; shoreline data from PRM-5 reading.

6.4 Shoreline Monitoring Records

CNSY has conducted gamma radiation survey of selected shore areas uncovered at low tide since 1966. The purpose of this monitoring is to determine if any radioactivity has washed ashore. These surveys are conducted during the second and fourth quarters of the year. Areas are selected based on the likelihood of suspended radioactivity being deposited by tidal currents upstream and downstream of industrial work and berthing areas. Two or more background readings are taken at least thirty feet from the high water line at each survey location.

Table 6-7 summarizes the results of these surveys taken since 1966. From 1966 through 1970, these surveys were obtained using a Geiger-Muller gamma survey instrument (AN/PDR-27). Beginning in 1971 and continuing through the present, a PRM-5N/SPA-3 gamma scintillation survey meter has been used. This instrument is calibrated to permit distinguishing between naturally and non-naturally occurring radioactivity; it is not calibrated for direct conversion of count rate data to natural background radiation dose rates. The AN/PDR-27 count rate data and PRM-5 count rate data are not comparable.

The location of shoreline area surveyed for 1994 are shown on Figure 6.1. These areas are located on Federal property and are thus readily accessible for monitoring. The data of Table 6-7 shows that since 1966 there has been no increase in radioactivity along monitored shorelines.

In 1985, the EPA conducted surveys along shorelines within the shipyard and along public shorelines. The results are listed in Figure 4 of Reference 6. On the basis of this survey, EPA concluded that "...the occasional slightly elevated radiation levels detected in the overland survey are not associated with any nuclear operations at the facilities but result from sandblasting sand, asphalt, stone and concrete, which are slightly higher in natural radioactivity content than the silt and soil along the shoreline."

Table 6-7
Shoreline Radiation Monitoring
1966 - 1970

Year	Range of Dose Rates (mrem/hr) (a)	Average Dose Rate (mrem/hr)	Average Background Dose Rate (mrem/hr)
1966	0.01 - 0.03	0.025	0.02
1967	0.01 - 0.03	0.025	0.02
1968	0.01 - 0.04	0.02	0.02
1969	0.01 - 0.03	0.02	0.02
1970	0.009 - 0.019	0.013	0.015

Note: (a) Gamma survey meter was the AN/PDR-27 connected to a counter register. Radiation levels were recorded by count rate, then converted to mrem/hour.

Table 6-7 (continued)
Shoreline Radiation Monitoring
1971 - 1994

Year	Average Background Count Rate (kcpm)	Average Shoreline Count Rate (kcpm)	Shoreline Count Rate Range (kcpm) (a)
1971	5.9	6.5	4.1 - 8.8
1972	11.8	11.8	5.9 - 23.5
1973	8.6	7.4	1.8 - 20.0
1974	6.6	6.1	2.5 - 20.0
1975	7.6	7.0	4.5 - 12.0
1976	7.8	7.2	2.0 - 30.0

Table 6-7 (continued)
Shoreline Radiation Monitoring
1971 - 1994

Year	Average Background Count Rate (kcpm)	Average Shoreline Count Rate (kcpm)	Shoreline Count Rate Range (kcpm) (a)
1977	7.9	7.1	2.0 - 25.0
1978	6.2	5.7	2.0 - 20.0
1979	6.2	5.8	1.5 - 22.0
1980	6.9	6.9	1.4 - 26.0
1981	6.3	6.3	2.0 - 25.0
1982	7.1	7.5	4.0 - 22.0
1983	7.1	6.1	2.2 - 25.0
1984	7.8	6.3	2.8 - 26.0
1985	6.4	5.2	2.1 - 11.0
1986	7.9	6.5	2.8 - 11.0
1987	7.2	5.6	3.0 - 13.0
1988	6.6	5.5	2.5 - 14.0
1989	6.6	5.3	2.0 - 9.0
1990	7.4	5.9	2.0 - 15.0
1991	6.8	5.5	2.4 - 12.0
1992	6.5	5.4	2.2 - 10.0
1993	6.8	5.8	3.2 - 9.0
1994	6.8	5.4	3.2 - 9.2

Notes: (a) Gamma survey meter used was the PRM-5N.
(b) In all instances where a reading exceeded twice the average background, a soil sample confirmed the presence of only natural uranium and thorium activity.

6.5 Storm Drain and Drydock Sampling Records

6.5.1 Storm Drain Sampling

Prior to 1971, the shipyard's sanitary and storm drainage systems shared common outfalls into the Cooper River. In 1971 they were separated with the tie-in of the sanitary sewerage into the North Charleston Sewer District. In December 1973, special sediment samples were taken from the Cooper River near storm drain outfalls. Storm drain areas are likely to accumulate radioactivity in the event of an inadvertent radioactive discharge. Storm drains can also accumulate radioactivity from the run-off of precipitation, if inadvertent releases of radioactivity were not cleaned up properly or had occurred without proper reporting of the release. Table 6-8 provides the results of this initial analysis.

Table 6-8
Initial Storm Drain Sampling
1973

Sample Location	Gross Gamma (0.1 - 2.1 MeV) Activity (pCi/g)
Vicinity Building 55 (Radar Tower)	0.85
Head of Pier D and Drydock #1	0.78
Head of Pier E and Drydock #1	0.76
Head of Pier G	0.78
Between Drydocks #3 & #4	0.89

Between 1974 and 1976, sediment samples were collected from accessible storm drain catch basins around areas where Navy nuclear work is performed.

In 1977, NNPP regulations were revised to include these samples in an annual sampling routine.

There are 200 possible storm drain locations. A random selection of drains is made and sampling is done each year. Locations of storm drains sampled include near areas such as:

a. Radiological Work Facilities
b. Radioactive Material Storage Areas
c. Radioactive Liquid Waste Tank Storage Locations
d. Drydock Perimeters
e. Piers

Figure 6.2 shows the storm drain sampling locations around Drydocks 1 and 2 and is typical of the other storm drain configurations around work areas.

A sodium iodide (NaI(Tl)) detector was used for sample analysis until the fourth quarter of 1978. Since then, the shipyard has used a 4096 channel analyzer equipped with a high resolution germanium (Ge(Li)) detector.

The results of storm drain sampling are listed in Table 6-9. The presence of Cs-137 has been noted on numerous occasions during the shipyard's storm drain survey process. This is the result of fallout from atmospheric nuclear weapons testing and the Chernobyl nuclear reactor accident.

Figure 6.2
Typical Storm Drain Sample Location
Charleston Naval Shipyard
Drydocks 1 and 2

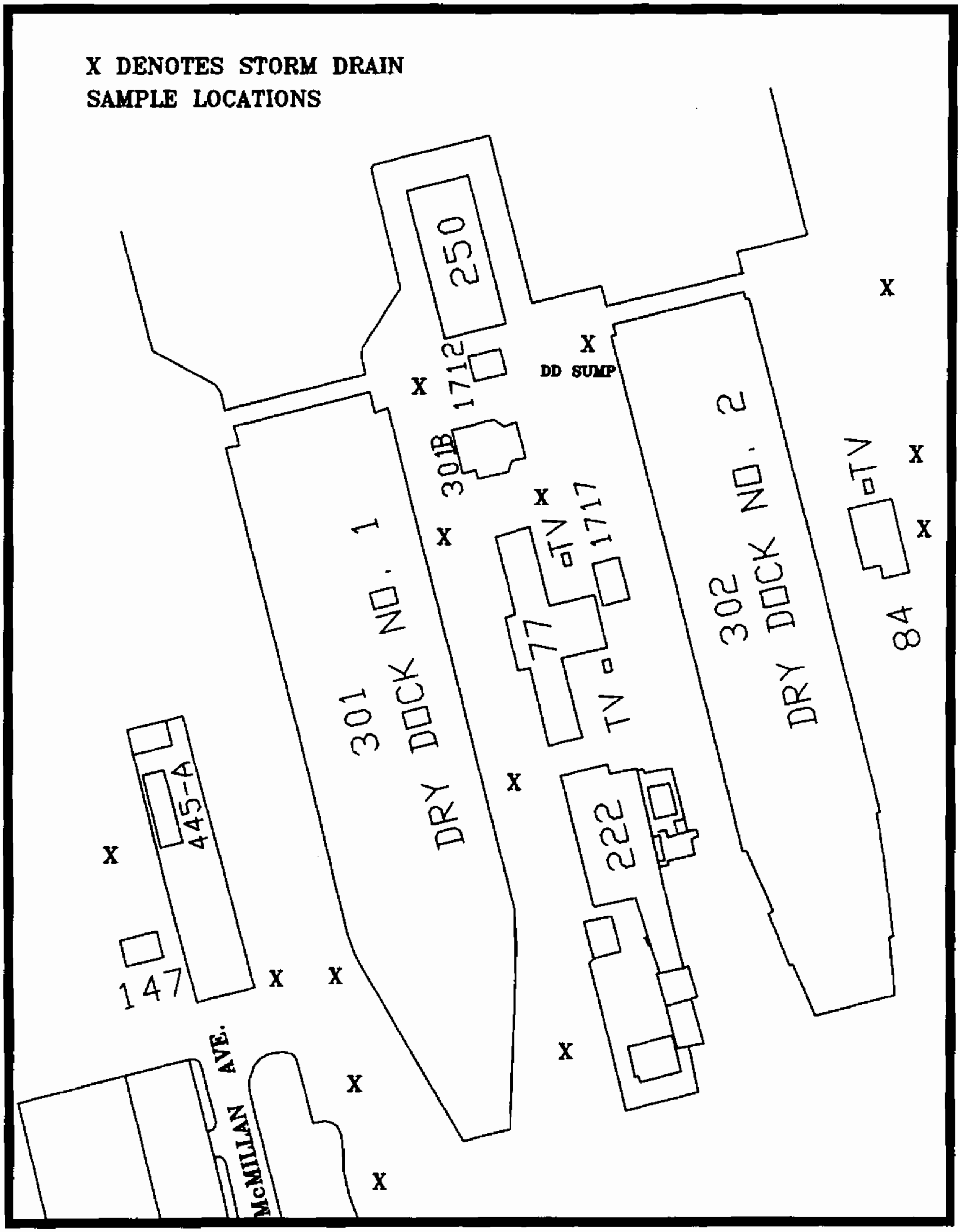


Table 6-9
Storm Drain Sediment and Water Sample Results
1976 - 1994

Year	Sediment (pCi/g)		Water (μCi/ml)	
	Number of Samples	Gross Gamma (0.1-2.1 MeV)	Number of Samples	Gross Gamma (0.1-2.1 MeV)
1976	16	2.93	36	$<3.8 \times 10^{-7}$
1977	13	3.78	17	$<2.0 \times 10^{-7}$
1978	23	3.19	25	$<1.8 \times 10^{-7}$
1979	26	2.47	44	$<6.1 \times 10^{-8}$
1980	29	2.26	41	$<5.1 \times 10^{-8}$
1981	25	3.11	35	$<5.0 \times 10^{-8}$
1982	24	2.52	41	$<4.8 \times 10^{-8}$
1983	29	2.98	46	$<4.8 \times 10^{-8}$
1984	28	2.46	44	$<4.6 \times 10^{-8}$
1985	27	5.67	47	$<4.9 \times 10^{-8}$
1986	31	2.40	49	$<3.8 \times 10^{-8}$
1987	34	2.64	46	$<4.2 \times 10^{-8}$
1988	36	2.42	31	$<3.6 \times 10^{-8}$
1989	31	2.77	55	$<3.6 \times 10^{-8}$
1990	54	3.40	45	$<3.5 \times 10^{-8}$
1991	17	2.00	68	$<3.4 \times 10^{-8}$
1992	14	2.05	70	$<3.3 \times 10^{-8}$
1993	10	2.25	62	$<3.4 \times 10^{-8}$
1994	11	1.88	53	$<3.5 \times 10^{-8}$

6.5.2 **Drydock Sampling**

Drydocks routinely used for nuclear-powered ships are surveyed annually due to the potential for the release of radioactivity into the drainage and pumping systems.

Radiation surveys are performed using a gamma scintillation meter (PRM-5N/SPA-3) and/or a survey meter with a Geiger-Mueller detector. Measurements are taken one-half inch from the drydock floor surface at intervals of approximately 20 feet, depending on the expected likelihood of the presence of contamination (e.g., smaller intervals are surveyed if the area was used for placement of radioactive tanks or if radioactive liquid discharges were performed.) The floating drydock, ARDM-3, is scanned at intervals of approximately 12 feet.

Table 6-10 lists the results of shipyard drydock floor surveys since 1992, when a consistent annual monitoring program was instituted. Before 1991, drydocks were surveyed before and after drydocking of nuclear vessels.

The average general area radiation levels in 1991 ranged from 4.2 to 26.9 kcpm in the shore drydocks and from 1.9 to 2.2 kcpm in the floating drydock. In comparison, shoreline measurements reported in Section 6.4 for 1991 ranged from 2.4 to 12.0 kcpm. Higher readings in the shore drydocks are attributed to enhanced naturally-occurring radioactivity in the concrete and granite structural materials in these drydocks. The lower readings in the floating drydock are attributed to lower naturally-occurring radioactivity over water.

Starting in 1992, survey procedures were standardized and the PRM-5N was operated in a mode designed to detect radiations within a narrow energy range which is characteristic of NNPP-related radioactivity. As such, a comparison of these survey data with the shoreline monitoring data reported in Section 6.4 is meaningless.

Table 6-10

General Gamma Radiation Levels
Drydock Surface Areas
Charleston Naval Shipyard
1992-1994

Year	Location	General Area		Adjacent to the Wall	
		Average (kcpm)	Maximum (kcpm)	Average (kcpm)	Maximum (kcpm)
1992	Drydock 1	0.38	1.05	0.32	0.50
	Drydock 2	0.68	0.93	0.81	0.95
	Drydock 4	N/A	N/A	N/A	N/A
	Drydock 5	0.32	0.67	0.41	0.78
	ARDM-3	0.12	0.23	0.10	0.15
1993	Drydock 1	0.31	0.90	0.22	0.28
	Drydock 2	0.61	0.75	0.51	0.67
	Drydock 4	0.17	1.4	0.25	0.61
	Drydock 5	0.26	0.6	0.32	0.58
	ARDM-3	0.14	0.18	0.12	0.14
1994	Drydock 1	(b)	(b)	(b)	(b)
	Drydock 2	N/A	0.63	N/A	0.64
	Drydock 4	N/A	N/A	N/A	N/A
	Drydock 5	0.31	0.80	0.37	0.74
	ARDM-3	0.14	0.18	0.12	0.12

Notes: "N/A" indicates that these data are not available

(a) Drydock 3 was cleared from radiological use in 1970. Drydock 4 data is limited due to serving as long-term storage for a barge with a long history of nuclear work. All survey data for this drydock applies only to the seaward end of the drydock.

(b) Survey could not be conducted due to near continuous use of the drydock during 1994.

Available representative sample material from shipyard drydock floors is analyzed for gross gamma activity, and by examination of the entire gamma spectrum. The average gross gamma activity results are included in Table 6-11. Specific radionuclides encountered in the analysis of the drydock samples since 1991 were naturally-occurring, except for 4 samples in 1991 and 7 samples in 1993 which contained trace quantities of cobalt-60. The source of this activity is addressed in Volume 1 of this HRA.

The pumping stations/caverns are located adjacent to and underneath the Drydocks 2, 4, and 5. The pumping station at Drydock 2 controls all the drainage for Drydock 1 and 2. Drydock 3 and 4 are directed by the pumping station at Drydock 4, and the pumping station at Drydock 5 is separate and pumps only drydock 5. Composite samples of the accumulated sediment and water from these pumping stations are analyzed for gross gamma (0.1-2.1 MeV) activity and by detailed radionuclide analysis. The average gross gamma results are included in Table 6-11. Radionuclide analysis of all samples was performed. All of the radionuclides encountered in the analysis of the sump samples were naturally occurring.

Table 6-11

Drydock Sediment and Liquid Samples
Charleston Naval Shipyard
1991-1994

Year	Type of Sample	Number of Samples	Average Gross Gamma Activity
1991	Sediment-floor	19	4.83 pCi/g
	Sediment-sump	5	2.70 pCi/g
	Liquid-sump	6	all $<3.5 \times 10^{-8}$ μCi/ml
1992	Sediment-floor	20	4.18 pCi/g
	Sediment-sump	4	1.19 pCi/g
	Liquid-sump	4	all $<3.4 \times 10^{-8}$ μCi/ml
1993	Sediment-floor	37	3.33 pCi/g
	Sediment-sump	1	4.26 pCi/g
	Liquid-sump	5	all $<3.5 \times 10^{-8}$ μCi/ml
1994	Sediment-floor	13	3.64 pCi/g
	Sediment-sump	1	2.67 pCi/g
	Liquid-sump	3	all $<5.6 \times 10^{-8}$ μCi/ml

6.5.3 Conclusions

These results demonstrate that no significant amount of radioactivity associated with Navy operations has been discharged into the Cooper River via storm drains or drydocks.

6.6 Routine Radiological Surveys

To ensure proper posting of radiation areas, gamma surveys are performed weekly in occupied radiological areas, including on piers and in drydocks where nuclear ships have been. Monthly surveys are performed on any potentially contaminated ducts, piping, or hoses in use. Surveys are performed quarterly in locked, unoccupied areas.

To ensure no environmental release of contamination, surveys for loose surface contamination are conducted either each shift, daily, or weekly, depending on the work site and potential for release.

Searches are also conducted each month to identify any radioactive material (RAM) outside radiologically controlled areas. Building searches using a beta-gamma frisker and a gamma scintillation survey instrument are performed in areas and buildings where no radioactive work is performed or radioactive material is stored. These searches are conducted on a revolving basis such that all parts of the Controlled Industrial Area are surveyed every three years. These surveys frequently find radioluminescent dials from old watches and naturally occurring radioactivity in building materials. There is no record that any G-RAM requiring controls has been found since this survey program started in 1977.

This routine survey program is conducted in support of the Naval Nuclear Propulsion Program. The surveys are, however, sufficient in scope and sensitivity to detect sources of G-RAM.

6.7 Aerial Radiological Surveys

The Aerial Measuring Systems (AMS) program is managed by the Remote Sensing Laboratory in Las Vegas, Nevada, operated for the Department of Energy by E G & G. Since 1958, hundreds of baseline radiation surveys have been performed as part of the AMS program. EG & G aerial surveys of Department of Energy sites and radioactive waste disposal sites have demonstrated that the AMS can readily detect areas with surface contamination due to liquid or airborne releases and areas with buried radioactive waste.

In 1981, an aerial monitoring survey was performed over the Charleston, SC area. The 10 mile by 12 mile area encompassed most of the cities of North Charleston and Charleston, SC. The helicopter used for the survey flew at an altitude of 400 feet and all readings were extrapolated into data results at 1 meter above ground level. The results of the survey are shown in Figure 6.3, and are reported as radiation exposure rates in microroentgen per hour (μR/hr). The radiation exposure rates reported include terrestrial gamma radiation measured throughout the survey area and an estimated 3.7 μR/hr cosmic ray contribution to the radiation exposure rate.

Figure 6.3
Aerial Radiological Survey Results

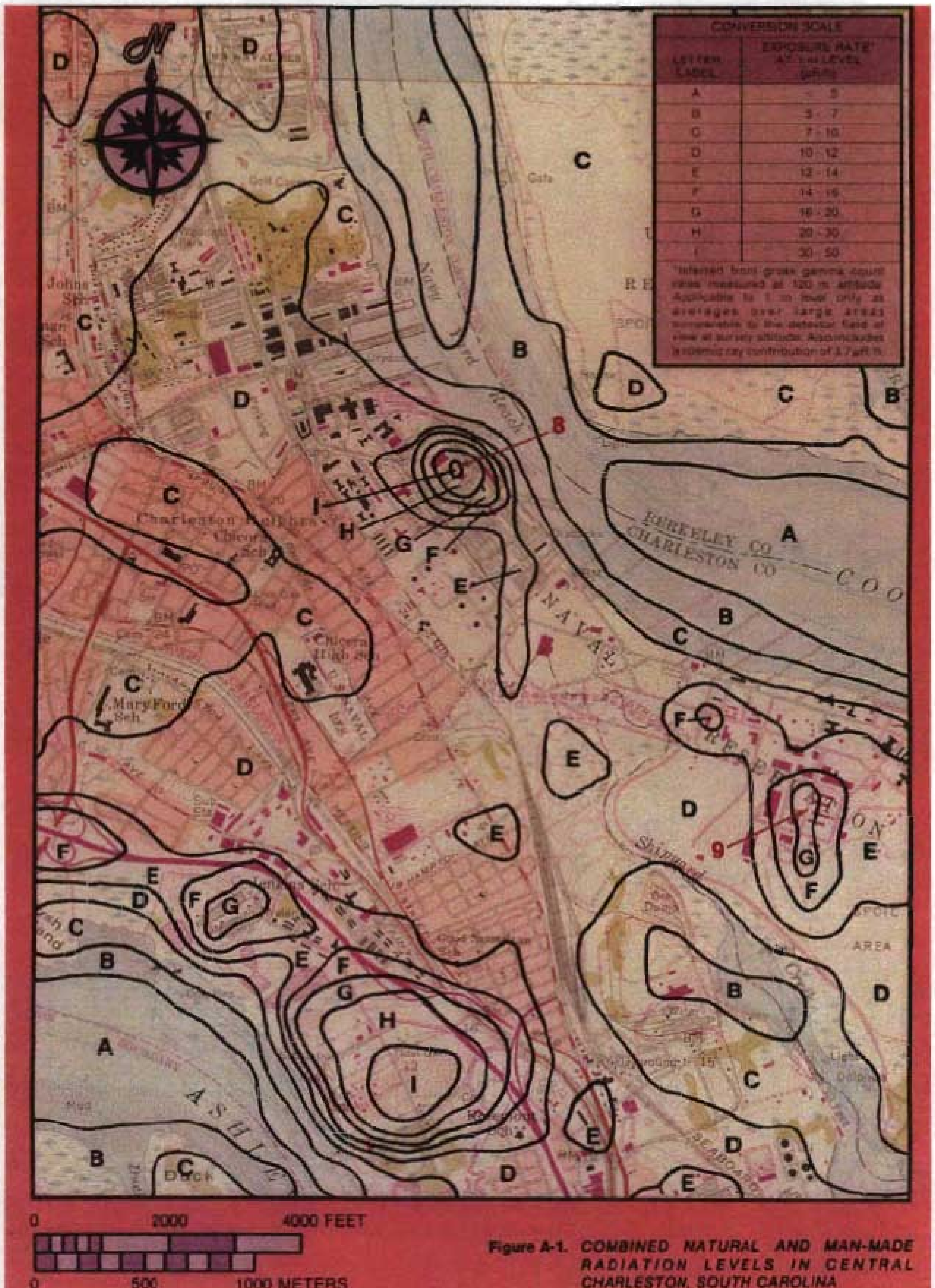


Figure A-1. *COMBINED NATURAL AND MAN-MADE RADIATION LEVELS IN CENTRAL CHARLESTON, SOUTH CAROLINA*

Higher terrestrial background levels correspond to high concentrations of building or paving materials (e.g., location "9" on Figure 6.3). In addition, elevated radiation levels in the Charleston area are attributed to surface phosphate mines (e.g., south area "I" on Figure 6.3), and mill tailings used for land fill. Radionuclide analysis of samples from these areas showed that the elevated radiation levels were caused by Bi-214, an isotope in the radioactive decay chain of natural uranium.

One "peak" shipyard area (labeled "8" in Figure 6.3) corresponds directly with a radiological work and storage location in service. As the survey report, Reference 13, noted, the concentric circles "indicate highly localized sources located in buildings." No man-made sources of radioactivity in the environment were identified.

After the aerial phase survey was completed, ground-based (one meter height) radiation measurements were taken at selected locations to corroborate the aerial measurements. Twelve locations were chosen in the Charleston area (Figure 6.4); site descriptions are given in Table 6-12. Soil samples were also taken at these locations, and radiation levels were projected from radionuclide analysis. These ground-based and soil measurements, and a comparison with the aerial data, are given in Table 6-13. These data confirm the aerial survey results.

With the exception of known radiological work & storage locations, the radiation levels of CNSY property are no different than those found in the survey areas remote from any shipyard activities. This survey is credible independent evidence that there are no locations within the shipyard, other than active facilities, where radioactivity is present.

Figure 6.4
Aerial Survey Soil Sample Locations

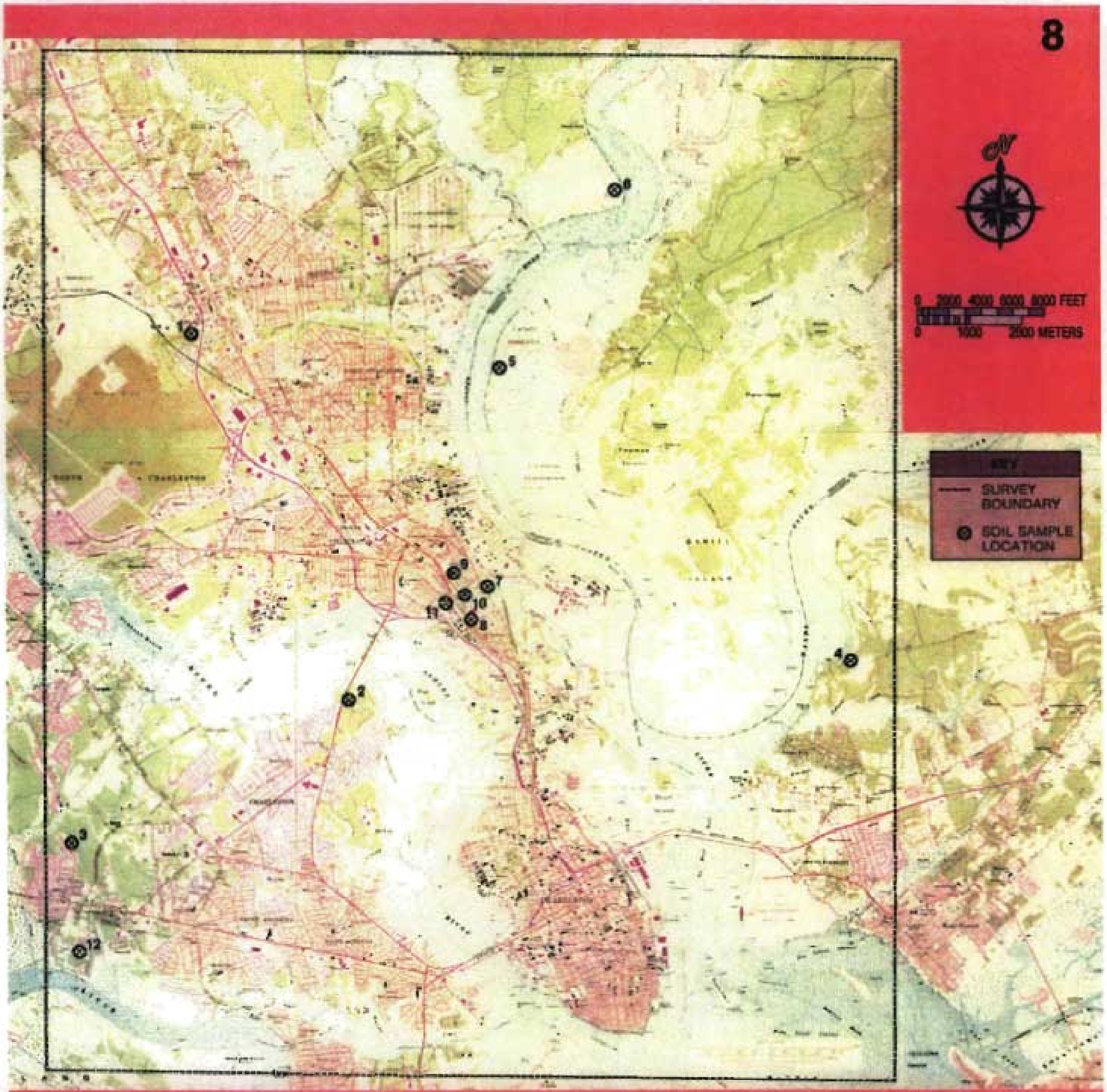


Figure 3. Map of the Charleston Area Showing Aerial Survey Boundary and Soil Sample Locations

Table 6-12
Site Descriptions for Ground-Based Measurements

Sample No.	Area Description
1	South side of Charleston airport. One inch in depth, free of vegetation, although field has some grass and weeds 2 to 3 inches in height. Minimal moisture in soil.
2	Southwestern side of Memorial Bridge area (known as Northbridge). Soil mostly filled with organic debris (pine needles, etc.). Some grass over site, very little vegetation on ground. Fair amount of decayed organic debris in soil sample.
3	Shaftsbury area, off Savannah Highway. Dry dirt, typical of area, some organic debris, but minimal. Fairly sandy composition. Near intersection of Canary Drive and Brighton Circle.
4	North of Hobcaw Creek, area under development. Sample came from wooded area not yet disturbed by earth movers. Some vegetation, mostly grass, removed. One inch depth sample. Minimal moisture.
5 & 6	Samples taken by helicopter (no road access). Samples somewhat moist. Sample 5 contains a number of egg-sized rocks and demonstrates activity. (No μR meter readings at site of sampling.)
7	Sample taken immediately east of Spruill Avenue and Jacksonville Road, 100 yds from road. Minimal moisture.
8	Sample taken immediately southwest of Sample 7, approximately ⅛ mile. Sample has minimal moisture.
9	Sample taken at most northerly tip of diamond-shaped area, approximately ⅛ mile from center of survey site. Sample taken 100 feet from corner of English Street and Spruill Avenue. Minimal moisture.
10	Sample taken near corner of Chicora Avenue and Clement Avenue. Minimal moisture in soil. Essentially no vegetation. Center of survey area.
11	Sample taken from most westerly corner of diamond. Some grass cover (removed). Minimal moisture in soil.
12	Sample taken from southwesterly portion of survey area within 100 feet of road in a fairly dry creek bed. Creek bed was 15 to 20 feet in width. μR meter readings on either bank of creek bed were 18 to 20 μR/h. In middle of creek bed and extending to its banks, the readings were consistent at 65 μR/h at 1 meter in height. Organic debris, leaves, etc., were removed and 1 inch of top soil was removed. The sample itself, when separated from the area, gave a reading of 12 μR/h.

Table 6-13
Comparison of Aerial and Ground-based Results

Ground Survey Results			Aerial Measured Gamma Rates (μR/hr) (b)
Soil Sample Site	Gamma Exposure Rate (μR/hr)		
	Scintillation Survey Meter (a)	Soil Sample Analysis (b)	
1	10	9	7 - 12
2	9	9	7 - 12
3	8 - 13	11	7 - 12
4	5 - 7	7	7 - 12
5	(c)	(d)	16 - 30
6	(c)	33	16 - 30
7	10 - 12	13	7 - 12
8	10 - 13	8	7 - 12
9	8 - 12	9	7 - 12
10	8 - 10	9	7 - 12
11	9 - 10	9	7 - 12
12	18 - 65	62	30 - 60

Notes: (a) Thirty-foot walk-around in area of sample.

(b)Includes an estimated cosmic ray contribution of 3.7 μR/hr; assumes uniform radioisotope concentration both vertically and horizontally.

(c) Sites 5 & 6 inaccessible for survey meter measurement (i.e., salt water marsh).

(d) Site 5 sample too small for meaningful analysis.

7.0 Residual Radioactivity

Based on the environmental radioactivity data collected, analyzed, and reported by CNSY and the state of South Carolina since 1959, by the U.S. Public Health Service (PHS) in 1966, and by the U.S. Environmental Protection Agency (EPA) in 1987, there is no indication of residual G-RAM radioactivity remaining in the environment.

NRMP-controlled G-RAM has not been disposed of at CNSY. Although it cannot be concluded whether any non-regulated G-RAM has ever been disposed of at the shipyard, the most likely indicator of such disposal would be radium-226 (Ra-226).

Radioluminescent dials and gauges were historically in common use in the Navy as well as in civilian industrial applications. Ra-226 has a long half-life, is a relatively high-energy-emitting radionuclide, and has historically not been regulated. It was typically the radioactive component in radioluminescent material generally available many years ago. However, all site surveys conducted by the Navy, PHS, and the EPA have detected no increase in naturally-occurring radionuclides (including the uranium series, of which Ra-226 is a component), nor increases in natural background radiation levels.

Surveys and sampling conducted in support of closure operations have identified limited quantities of residual Ra-226 radioactivity in a facility known to have housed an activity which used radioluminescent paint in the 1940's and 1950's. This residual radioactivity is primarily in the subflooring below one or more layers of floor covering such as tile. All such residual activity will be characterized and remediated to below established levels prior to release of this facility for unrestricted use.

Due to the wide-spread use of consumer products with radioactive sources, nearly every facility, structure, and operational area in Charleston Naval Shipyard is likely to have contained minor exempt quantities of radioactive materials. Most such devices, such as smoke detectors and watches, contain either highly purified naturally-occurring radioactivity or very small amounts of radioactive material of low energy and/or short half-life. Such consumer products are not considered to be a source of G-RAM concern, and do not of themselves cause facilities (e.g., housing) to be classified as G-RAM areas in need of eventual release surveys in the event they are to be decommissioned.

8.0 Assessment of Environmental Impact

Reference 14, "Guidance for Performing Preliminary Assessments under CERCLA", lists four pathways of possible environmental transport, each evaluated by three elements. These pathways include ground water, surface water, soil exposure, and air. The elements are the likelihood of release (including the likelihood of a substance migrating through a specific pathway), the waste characteristics, and the targets.

The following sections evaluate the data and information presented in this report within the framework of Reference 14.

8.1 Ground Water Pathway

The ground water pathway considers potential exposure threats to drinking water supplies via migration to and within aquifers.

As discussed in Section 3, the shipyard Controlled Industrial Area is mostly (>95%) covered with paving or structures that isolate the soil zone from any potential release mechanisms discussed below. Without access to the soil, percolation into the shallow aquifer cannot occur. That no radioactivity to infiltrate the aquifer exists above background levels is established in evaluating the soil exposure pathway in Section 8.3.

The water contained in the shallow aquifer underlying the shipyard discharges to Noisette Creek, Shipyard Creek, and the Cooper River. Wells to the north, east, and south are across these streams and are thus isolated from the potential for contamination from the shipyard. Wells to the west are upgradient and are not used for potable water.

8.1.1 Release Mechanisms Affecting Ground Water

Radioactivity being released to ground water is the least likely mechanism. This could conceivably occur as a result of a release to the soil, atmosphere, or surface water. The radioactivity would have to infiltrate through the soil to the ground water. As discussed above and in Section 3, no drinking water wells would be affected.

8.1.2 Ground Water Targets

Primary targets are defined as populations served by drinking water wells that are suspected to have been exposed to a hazardous substance. There has been no suspected G-RAM release from the site to ground water; thus, no primary targets are identified.

Secondary targets include populations served by all drinking water wells within four miles of the site that are not suspected to have been exposed to a hazardous substance. There are twenty-nine (29) wells within four miles of CNSY. Five (5) are used for domestic applications, nine (9) are for industrial use, two (2) are used for irrigation, two (2) are used for observation, and eleven (11) are abandoned or are unused (including the two wells on the shipyard). These wells are identified in Figure 8.1. There are no public supply wells within four miles of the site. The nearest well in use in the target distance limit is located 1.7 miles north of the center of the shipyard's radiological activities, across Noisette Creek. The nearest domestic well is located 2.7 miles east of the center of the shipyard's radiological activities, across the Cooper River.

There are no Wellhead Protection Areas within the region. Since ground water within the four mile zone has uses other than drinking water, it would be considered a resource.

8.1.3 Ground Water Pathway Assessment

There has been no identifiable release of radioactivity which could threaten the ground water in the vicinity of the shipyard and no mechanism by which a potential contaminant could be transported to target receptors.

8.2 Surface Water Pathway

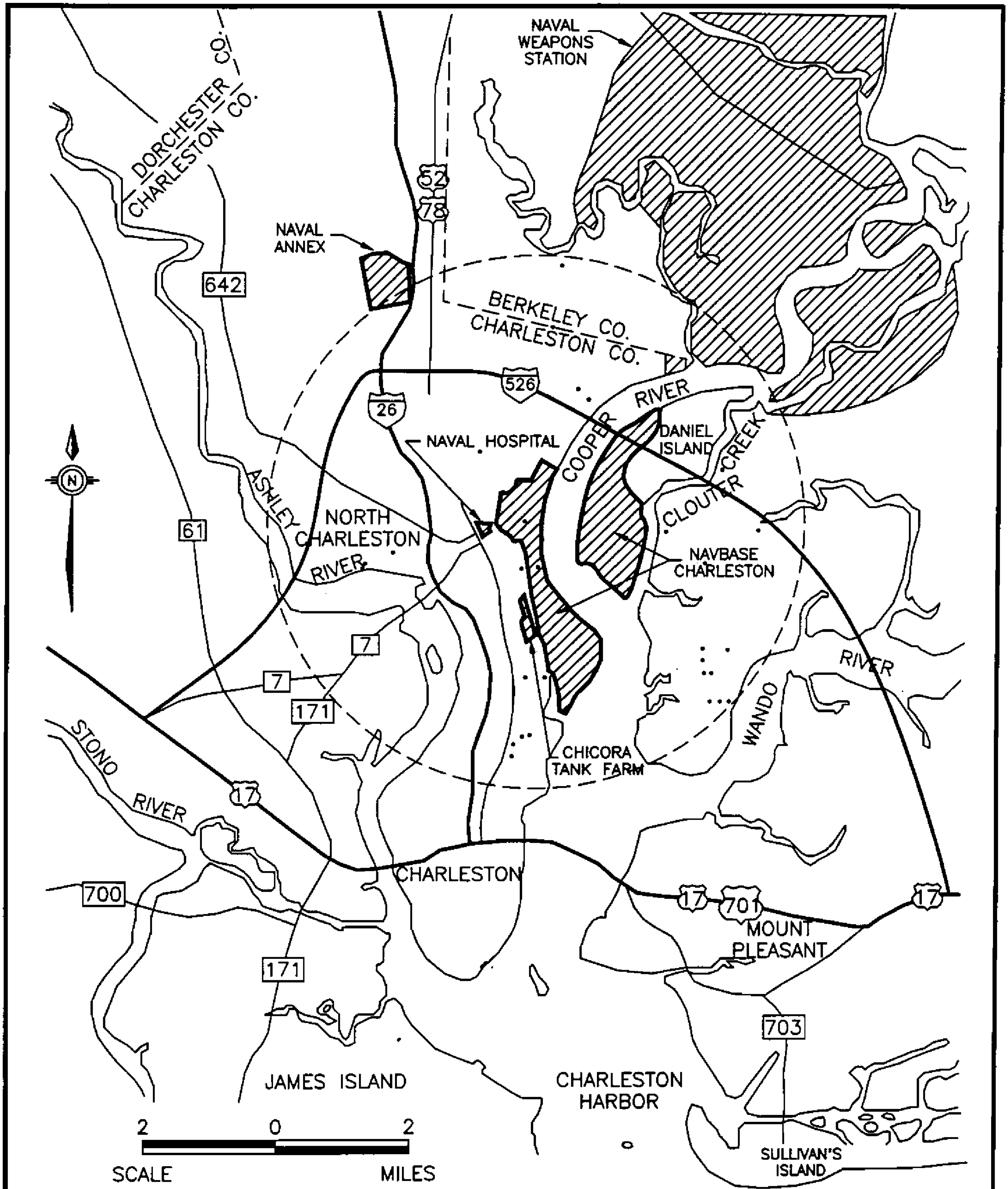
The surface water pathway considers potential exposure threats to drinking water supplies, to human food chain organisms, and to sensitive environments.

Surface water bodies in the immediate vicinity of CNSY are identified in Section 3.3.3.3 of this report. None of these serve as a source of drinking water. Surface drainage is via natural runoff and a storm water drain system. Both pathways drain to the Cooper River (either directly or into one of the two creeks which drain CNSY), which empties into the Charleston Harbor.

Analytical data collected by the shipyard consisting of harbor water, biota and sediment samples, along with data reported in 1967 and 1987 by the Public Health Service and Environmental Protection Agency have not detected any non-naturally-occurring radioactive material in any water or edible marine biota since sampling was begun. Naturally-occurring radioactivity (including the uranium series of which Ra-226 is a component) is within the range of expected background levels.

As discussed in Section 3, any contaminant introduced in the waters near the shipyard will not be transported away from the point of entry but will remain in the area of introduction to be consolidated in bottom sediments.

Primary sensitive environments within the 15-mile tidal influence zones of concern include Heritage Trust Preserves (Capers Island, Snee Farm, Bird Key), State Parks (Charlestowne Landing, Old Dorchester) and Coastal Barrier Resource Act Units (Capers Island, Dewees Island, Morris Island, Bird Key). Secondary sensitive environments consists of wetlands along the shorelines. Wetlands frontage exceeds 20 miles.



Key

Well •

SOURCE:
BRAC CLEAN UP PLAN
NAVAL BASE
CHARLESTON

FIGURE 8-1
WELLS WITHIN A FOUR MILE
RADIUS OF CNSY

DWG DATE: 03/01/94 | DWG NAME: 760CHRMP

8.2.1 Release Mechanisms Affecting Surface Waters

Air release mechanisms can disperse radioactivity to local surface waters but the potential effect of low level discharges via the air pathway is very small. Of greater potential concern would be direct liquid and solid material discharges to surface water. Leaks or ruptures from G-RAM sources being used pier side could spill their contents into the river. Additionally, spillage of radioactive liquids to the shipyard storm drain system could ultimately reach the river.

Spills of G-RAM inside a Naval craft would generally be contained within the craft, but could reach the surface water if a hull penetration below the water line were created by some unforseen event. Spills in a drydock would generally be contained, but could enter the drainage system and thence the river. Also, in the event of a fire in a barge or drydock, the large volumes of water needed to control the fire could result in the transport of radioactive materials in the surface water.

Generally speaking, however, potential sources of G-RAM are small and isolated, and spills would be readily contained.

8.2.2 Surface Water Targets

Surface water targets are sub-divided into drinking water, human food chains, and environmental. All of the fresh water for public supply is withdrawn from the Edisto River. The intake for this supply is approximately 23 miles northwest of the shipyard. The Back River Reservoir, located about eight miles to the north, supplies mainly industrial customers, although it is also used as an alternate source for municipal supply. The intake for this supply source is on Foster Creek, approximately 15 miles to the northeast. Goose Creek Reservoir, located approximately six miles to the northwest, is used for recreational purposes and as a backup municipal supply source.

There are no intakes within the target distance limit as defined in Reference 14. As a drinking water supply, there is no resource within the target distance limit.

Sport and commercial fishing occur within the 15 mile target distance limit. Because the Cooper River is an estuary and the streams are tidal, no gauging stations are located within the first 28.5 miles. The river and its tributaries would be classed as coastal tidal water in accordance with 40 CFR 300, Table 4-13. The river exhibits generally good water quality in the upper portion but conditions in the lower part (below Back River Reservoir) are not suitable to allow the harvesting of shellfish.

Table 8-1 lists major surface bodies within the 15 mile tidal influence zone.

Table 8-1
Water Bodies Within the 15 Mile
Tidal Influence Zone (a)
Charleston Naval Shipyard

Cooper River	**Wando River**
Grove Creek	Mill Creek
Flag Creek	Johnfield Creek
Yellow Horse Creek	Horlbeck Creek
Clouter Creek	Foster Creek
Goose Creek	Beresford Creek
Filbin Creek	Ralston Creek
Noisette Creek	Rathall Creek
Shipyard Creek	Bermuda Creek
Newmarket Creek	Hobcaw Creek
Town Creek	Molasses Creek
Charleston Harbor	**Ashley River**
Shem Creek	Orangegrove Creek
Parrot Point Creek	Old Town Creek
Schooner Point Creek	Elliott Cut/Wappoo Creek
Conch Creek	Dill Creek
Inlet Creek	James Island Creek
Swinton Creek	**Stono River**
Hamlin Creek	Pennys Creek

Note: (a) The major waterways are listed in bold print. Their individual tributaries are listed immediately underneath.

(b) In addition to those waterways listed in this table, the target zone is characterized by numerous streams, creeks, and tidally influenced tributaries which flow towards the coast.

The largest surface-water use in the region is by thermoelectric power plants, followed by industrial and agricultural applications. Many of these water bodies also serve as a source of recreation activities such as swimming, boating, and water skiing. These activities are restricted in the vicinity of Naval operations and therefore any direct exposure would be reduced by large dilution factors.

There are no critical habitats as defined in 50 CFR 424.02 within the tidal influence zone.

Table 8-2 lists state and federally designated threatened or endangered species identified as existing in the region. None of these species have been identified as having habitat on or in the vicinity of the shipyard. However, the Least Tern was a confirmed resident of Naval Base Charleston as late as 1994. The Southeastern Myotis and the Rafinesque's Big-Eared Bat are known to occur in the Charleston Harbor estuary and could possibly occur on the shipyard or Naval Base. Other birds, mammals and reptiles may be occasional visitors but are not confirmed residents.

Table 8-2

State/Federal Designated Rare, Threatened (T), and Endangered (E)
Species in the Vicinity of Charleston Naval Shipyard

Animals/Birds			
Short Nose Sturgeon	E	Bachman's Warbler	E
Bachman's Sparrow	T	Least Tern	T
Flatwoods Salamander	T	Peregrine Falcon	T
Kemp's Ridley Sea Turtle	E	Brown Pelican	E
Loggerhead Turtle	T	American Alligator	E
Rafinesque Big-Eared Bat	T	West Indian Manatee	E
Bald Eagle	E	Eastern Tiger Salamander	T
Wood Stork	E	Broad Striped Siren	T
Southeastern Myotis	T	Osprey	T
Island Glass Lizard	T	American Shallow Tailed Kite	E
Red-Cockaded Woodpecker	E	Piping Plover	T
Crawfish Frog	T		
Plants			
Incised Groovebur	T	Crested Fringe Orchid	T
Seabeach Pigweed	T	Chafseed	E
Venus' Fly-Trap	T	Canby's Dropwort	E
Pondspice	T	Pondberry	E
Boykin's Lobelia	T	Sea Purslane	T

Other sensitive environments as defined in Reference 14 in the target areas are:

- Portions of the Ashley River, which have been declared eligible for inclusion in the South Carolina State Scenic Rivers Program.
- Bird Key Stono, which is the largest rookery island in South Carolina for the endangered brown pelican.
- Capers Island, which is an undeveloped barrier island which has been classified as a unique natural area by the South Carolina Wildlife and Marine Resources Department.
- Francis Marion National Forest, which is a wildlife management area.
- Fort Sumter National Monument
- Fort Moultrie Historical Site

Charleston Harbor and lower sections of the Cooper River and Wando Rivers are important nursery grounds for finfish and shellfish and contain important populations of game and commercially important species. The Cooper River annually receives large runs of anadramous fish, which ascend the river to spawn. Species include striped bass, blueback herring, and shad. Invertebrates and mollusks of commercial importance in the Cooper River, Wando River, and Charleston Harbor include shrimp, blue crab, and shellfish.

As defined by the EPA, all of the undeveloped areas within the tidal influence zone are classified as wetlands. This translates to a cumulative wetland frontage length in excess of 20 miles.

A detailed description of regional ecology and terrestrial, wetland, and aquatic ecosystems in the vicinity of CNSY can be found in Appendix A of Reference 1 as well as reference 15.

8.2.3 Surface Water Pathway Assessment

Previous sections of this report have established that no drinking water intakes from surface water are utilized or could be affected by any potential release via discharge, precipitation run-off, or percolation.

Because of the close proximity of extensive wetlands to the shipyard and due to the strong currents of the Cooper River, the possibility exists for particulate G-RAM to be transported to and deposited on these wetlands. However, the dynamics of transport of particulate G-RAM, if any were present, are such that it is unlikely for any significant amount of radioactivity to reach wetland areas. As discussed in Section 6, shoreline radiation levels have consistently been at naturally-occurring radiation levels.

CNSY concludes that radioactivity in surface waters will not damage sensitive environments as described by Reference 14. No water or marine biota samples have shown levels of non-naturally-occurring radioactivity nor have any shorelines within the littoral zone accumulated any radioactivity above natural background levels.

This evidence supports the conclusion that there has been no environmentally detrimental release of radioactivity to surface waters surrounding the shipyard.

8.3 Soil Exposure Pathway

This soil exposure pathway considers potential exposure threats to people on or near the site who may come into contact with a hazardous substance via dermal exposure, soil ingestion, or plant uptake into the human food chain.

The shipyard is actively engaged in G-RAM work. As such, there are radiological facilities containing radioactivity associated with this work. These facilities and the radiological controls applied to prevent contamination of workers and the environment are discussed in other sections of this report.

For areas and facilities other than those discussed above, this report concludes that there is no likelihood for exposure to humans or to the environment. This conclusion is based on the following:

- Perimeter radiation levels have consistently been comparable to background radiation levels measured by the shipyard, the Environmental Protection Agency and EG & G.
- Shoreline surveys conducted by the shipyard and the Environmental Protection Agency found no radionuclides along the shore attributable to shipyard activities, and no radiation levels above the range attributable to normal concentrations of naturally-occurring radioactivity expected to be found in the vicinity of the shipyard.
- There have been no reported releases of G-RAM onto soil at CNSY.
- There have been no reported airborne releases of G-RAM at CNSY which could have transported measurable radioactivity onto soil.
- An aerial radiological survey conducted by EG & G identified controlled radiological work & storage areas, but did not find other areas within or adjacent to the shipyard with radiation levels higher than background.
- There has been no known disposal of solid radioactive waste on or near shipyard property, as documented by regulatory prohibition, review of historical disposal records, and review of measured radiation.

Since the above evidence would result in a "no likelihood of exposure" finding, the other elements of the soil exposure pathway do not need to be evaluated.

8.3.1 Release Mechanisms Affecting Soil

The release mechanisms discussed in the air pathway section could deposit radioactivity in the soil of affected areas. Radioactive liquid spills to the soil would be much more localized and concentrated than soil contamination resulting from low level airborne radioactivity releases. Liquid spills with the highest potential for reaching the soil are related to activities performed outside of radiological work areas such as the movement of small liquid containers such as plastic bottles. Spills of radioactive liquids inside work facilities would generally be contained within that facility, but could reach the soil through cracks in building materials or by leaching through porous building materials such as concrete. Also, in the event of a fire in a work facility, the large volumes of water needed to control the fire could result in the transport of radioactive materials into the soil.

8.3.2 Soil Exposure Targets

No one physically resides within the Controlled Industrial Area of CNSY; however, there are residences for military families outside the Controlled Industrial Area. There are no residences, schools, and daycare facilities within 200 feet of any potential source.

There are about 4,500 employees working on the shipyard, including within the industrial area. This number is continually decreasing due to base closure.

There are no terrestrial sensitive environments that have been identified within a four-mile radius of the shipyard.

There is no land resource use for commercial agriculture, commercial silviculture, or commercial livestock production or grazing within a four-mile radius of the shipyard.

8.3.3 Soil Exposure Pathway Assessment

The results of environmental monitoring, as discussed in Section 6, and the factors described in this section support the conclusion that there has been no adverse impact on human health or the environment due to the soil exposure pathway.

8.4 Air Pathway

The air pathway considers potential exposure threats to people and to sensitive environments via migration through the air.

As discussed in Section 5.1.2, no G-RAM work requiring monitored and/or filtered exhaust ventilation is performed at CNSY. Other potential sources of airborne radioactivity, such as from contaminated soils or spills of contaminated liquids, were discussed in other sections of this report. Based on the lack of detectable soil contamination, and the immediate containment and recovery actions taken for spills, CNSY considers these potential sources of airborne radioactivity to be negligible.

The operation involving unsealed solid or liquid non-NRMP-controlled G-RAM having the greatest potential for airborne release is grinding on thoriated welding rods. As discussed in Section 5.1.2, all such work is performed under controlled conditions (e.g., wet belt machine, clean up of dust and chips as they are generated) which minimize the potential for airborne release of this material. The material is exempt from licensing requirements per 10 CFR 40.

8.4.1 Release Mechanisms Affecting the Air

Consideration of atmospheric releases is necessary since such releases would potentially allow radioactivity to contact the soil and surface water. Some mechanisms that could cause an atmospheric release of G-RAM include: fire in an area where G-RAM is used or stored; or loss of containment for items being stored or handled, including tears in packaging material, leaks from liquid storage containers, and breaches of sealed sources. Since most of the current and historical operations which involved G-RAM used sealed materials (i.e., industrial radiography, RADIAC calibration) which are routinely leak-tested, the possibility for an airborne release from a storage area is considered negligible.

8.4.2 **Air Targets**

Target populations under the air pathway consist of people who reside, work, or go to school within the 4-mile target distance limit around the site. Preliminary Assessment air pathway targets also include sensitive environments and resources.

Targets are evaluated on the basis of their distance from the site. Those persons closest to the site are most likely to be affected and are evaluated as primary targets. The nearest individual would be an on-site worker.

Like the other migration pathways, a release must be suspected in order to score primary targets for the air pathway. Releases to the air pathway, however, are fundamentally different from releases to the other migration pathways. Depending on the wind, air releases may disperse in any direction. Therefore, when a release is suspected, all populations and sensitive environments out to and including the ¼ mile distance category are evaluated and scored as primary targets. Because air releases are quickly diluted in the atmosphere, targets beyond the ¼ mile distance are evaluated as secondary targets.

As with other migration pathways when a release is not suspected, the residential, student, and worker population within the entire 4-mile target distance limit is evaluated as the secondary target population. The population distribution for the secondary target population is provided in Section 3.

Sensitive environments are defined as terrestrial or aquatic resources, fragile natural settings, or other areas with unique or highly-valued environmental or cultural features.

Typically, areas that fall within the definition of "sensitive environment" are established and/or protected by State or Federal law. Examples include National Parks, National Monuments, habitats of threatened or endangered species, wildlife refuges, and wetlands.

The only sensitive environments within ½ mile of the shipyard are the wetlands.

The resources factor accounts for land uses around the site that may be impacted by release to the air:

- Commercial agriculture
- Commercial silviculture (e.g., tree farming, timber production, logging)
- Major or designated recreation area (e.g., municipal swimming pool, campgrounds, etc.)

The only land resources within ½ mile of the shipyard are designated recreation areas on the Naval Base for use by military personnel and their dependents.

8.4.3 Air Pathway Assessment

Searches of historical records have revealed no occurrences or practices which could have released significant quantities of G-RAM into the air. The record of environmental monitoring, as discussed in Section 6, does not indicate the presence of any airborne radioactivity other than that which is naturally-occurring (and which is within normal background ranges).

Although radioactivity from the use of exempt quantity commodities or from welding operations in which thoriated welding rods are used could likely reach the atmosphere, there is no evidence to either support or eliminate the possibility. The range of dispersal of radioactivity associated with this mechanism would be extremely limited, and environmental monitoring, routine radiological surveys, and radiological surveys conducted in support of closure have not identified any radioactivity which would be characteristic of an unmonitored air release.

These factors support the conclusion that the potential exposure threat to targets via migration of G-RAM through the air at CNSY is insignificant.

9.0 Conclusions

Evaluation of the information and analytical data presented in this HRA leads to the conclusion that past and current activities at CNSY associated with G-RAM work have had no adverse impact on the human population or ecosystem of the region.

There is a limited quantity of residual G-RAM radioactivity in a facility which was used for radioluminiscent paint application in the past which is undergoing remediation. No landfills are located on CNSY property. The potential for low levels of G-RAM in dredged spoil areas is low, and does not warrant action.

CNSY will continue to follow Navy radiological control practices and perform environmental monitoring as discussed in this HRA until operational closure. Because the shipyard is in the process of operational closure, an intensive search and survey of buildings and facilities are in process to release the shipyard for unconditional use. Within the framework of the CERCLA process, no further action is warranted regarding general radioactive material at CNSY.

GLOSSARY

Aquifer: A saturated subsurface zone from which drinking water is drawn.

BUMED: Navy Bureau of Medicine and Surgery. The Navy command responsible for the development and promulgation of protection standards and exposure limits for personnel exposed to G-RAM sources of ionizing radiation. In addition BUMED is responsible for the radiological controls associated with medical applications of ionizing radiation.

CERCLA: Comprehensive Environmental Response, Compensation, and Liability Act of 1980. Legislation that established the Federal Superfund for response to uncontrolled releases of hazardous substances to the environment.

CERCLIS: CERCLA Information System. EPA's computerized inventory and tracking system for potential hazardous waste sites.

CNSY: Charleston Naval Shipyard

Coastal Tidal Waters: Surface waterbody type that includes embayments, harbors, sounds, estuaries, back bays, etc. Such water bodies are in the interval seaward from the mouths of rivers and landward from the 12-mile baseline marking the transition to the ocean water body type.

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

EPA: U.S. Environmental Protection Agency. The federal agency responsible for action under CERCLA.

Factor: The basic element of site assessment requiring data collection and evaluation for scoring purposes.

FFA: Federal Facility Agreement. An agreement among the EPA, state, and site detailing the extent and schedule for remedial actions.

Fishery: An area of a surface water body from which food chain organisms are taken or could be taken for human consumption on a subsistence, sporting, or commercial basis. Food chain organisms include fish, shellfish, crustaceans, amphibians, and amphibious reptiles.

G-RAM: General Radioactive Material. Radioactive materials that are not associated with the NNPP.

GLOSSARY (continued)

HRA: Historical Radiological Assessment. A compilation of site historical radiological data derived from the site environmental monitoring program and other records. This document is intended to be an integral part of a FFA.

HRS: Hazard Ranking System. EPA's principal mechanism for placing sites on the NPL.

IAS: Initial Assessment Study. A study done under the Navy's Installation Restoration program. This study parallels the PA.

kcpm: Thousand counts per minute.

micro: Abbreviated μ. A prefix denoting a one-millionth part (10^{-6}).

milli: Abbreviated m. A prefix denoting a one-thousandth part(10^{-3}).

NAVSEA: Naval Sea Systems Command. The Navy command responsible for radiological controls associated with industrial radiography and the radiation detection instrument calibration operations of CNSY.

NEHC: Navy Environmental Health Center. NEHC provides technical support to the NRSC for radiological controls associated with NRMP-related activities under BUMED cognizance.

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.

NPL: National Priorities List. Under the Superfund program, the list of sites of releases and potential releases of hazardous substances, pollutants, and contaminants that appear to pose the greatest threat to public health, welfare, and the environment.

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 Nuclear Regulatory Commission.

NRSC: Navy Radiation Safety Committee. Navy organization providing administrative control of all Nuclear Regulatory Commission-licensable radioactive material used in the Navy and the Marine Corps.

GLOSSARY (continued)

No Suspected Release: A professional judgement based on site and pathway conditions indicating that a hazardous substance is not likely to have been released to the environment.

PA: Preliminary Assessment. Initial stage of site assessment under CERCLA; designed to distinguish between sites that pose little or no threat to human health and the environment and sites that require further investigation.

PHS: U. S. Public Health Service. The formal federal agency that performed initial independent radiological environmental surveys in the vicinity of NNPP sites.

pico: Abbreviated p. A prefix denoting a one-trillionth part (10^{-12}).

R: Roentgen. A unit of exposure. For cobalt-60 radiation, a roentgen and a rem are considered to be equivalent.

RADCAL: Radiation Detection Instrument Calibration Laboratory.

RASO: Radiological Affairs Support Office. RASO provides technical support to the NRSC for radiological controls associated with NRMP-related activities under NAVSEA cognizance.

rem: Roentgen Equivalent Man. A measure of radiation dose.

SARA: Superfund Amendments and Reauthorization Act of 1986. Legislation which extended the Federal Superfund Program and mandated revision to the HRS.

Surface Water: A naturally-occurring, perennial water body; also, some artificially-made and/or intermittently-flowing water bodies.

Suspected Release: A professional judgement based on site and pathway conditions indicating that a hazardous substance is likely to have been released to the environment.

Target: A physical or environmental receptor that is within the target distance limit for a particular pathway. Targets may include wells and surface water intakes supplying drinking water, fisheries, sensitive environments, and resources.

GLOSSARY (continued)

Target Distance Limit: The maximum distance over which targets are evaluated. The target distance limit varies by pathway; ground water and air pathways -- a 4-mile radius around the site; surface water pathway -- 15 miles downstream from the probable point of entry to surface water; soil exposure pathway -- 200 feet (for the resident population threat) and 1 mile (for the nearby population threat) from areas of known or suspected contamination.

Target population: The human population associated with the site and/or its targets. Target populations consist of those people who use target wells or surface water intakes supplying drinking water, consume food chain species taken from target fisheries, or are regularly present on the site or within target distance limits.

Terrestrial Sensitive Environment: A terrestrial resource, fragile natural setting, or other area with unique or highly-valued environmental or cultural features.

Wetland: A type of sensitive environment characterized as an area that is sufficiently inundated or saturated by surface or ground water to support vegetation adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

Worker: Under the soil exposure pathway, a person who is employed on a full- or part-time basis on the property on which the site is located. Under all other pathways, a person whose place of full- or part-time employment is within the target distance limit.

< : Less than.

> : Greater than.

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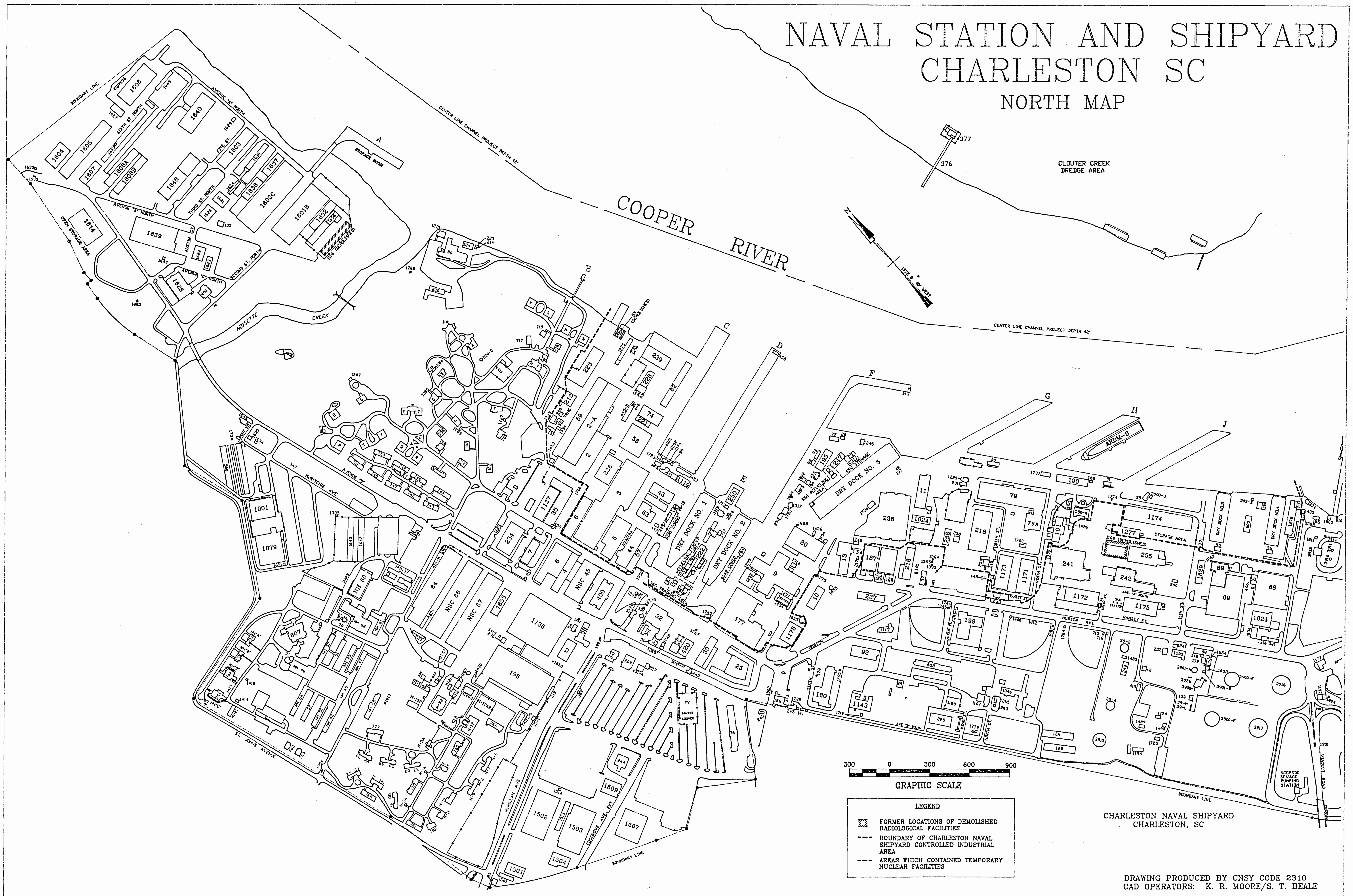
NORTH CHARLESTON
CHARLESTON AIR FORCE BASE
U S NAVAL RESERVATION
COOPER RIVER
ASHLEY RIVER
WANDO RIVER
Daniel Island
Thomas Island
Drum Island
CHARLESTON
SAINT ANDREWS
MOUNT PLEASANT
USS YORKTOWN STATE PARK
Folly Island Channel
Rebellion Reach
Castle Pinckney
Battery
Produced by the United States Geological Survey
Control by USGS, USC&GS, USCE, and South Carolina Geodetic Survey
Culture and drainage in part compiled from aerial photographs taken 1957. Topography by planetable surveys 1958
Hydrography compiled from USC&GS chart 470 (1958)
Polyconic projection. 1927 North American datum
10,000-foot grid based on South Carolina coordinate system, south zone
1000-meter Universal Transverse Mercator grid ticks, zone 17, shown in blue
The difference between 1927 North American Datum and North American Datum of 1983 (NAD 83) for 7.5-minute intersections is given in USGS Bulletin 1875. The NAD 83 is shown by dashed corner ticks
There may be private inholdings within the boundaries of the National or State reservations shown on this map
UTM GRID AND 1979 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
Map photoinspected 1983
No major culture or drainage changes observed
Red tint indicates areas in which only landmark buildings are shown
SCALE 1:24 000
CONTOUR INTERVAL 5 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS MEAN LOW WATER
THE RELATIONSHIP BETWEEN THE TWO DATUMS IS VARIABLE
SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
THE AVERAGE RANGE OF TIDE IS APPROXIMATELY 5.2 FEET
THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY
DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST
QUADRANGLE LOCATION
Revisions shown in purple compiled from aerial photographs taken 1977 and other source data. This information not field checked. Map edited 1979
Boundary lines shown in purple compiled from latest information available from the controlling authority
Purple tint indicates extension of urban areas
ROAD CLASSIFICATION
Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
U. S. Route
State Route
Interstate Route
CHARLESTON, S. C.
32079-G8-TF-024
PHOTOINSPECTED 1983
1958
PHOTOREVISED 1979
DMA 5049 IV SW—SERIES V846
INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1992


NAVAL STATION AND SHIPYARD
CHARLESTON SC
NORTH MAP
COOPER RIVER
CLOUTER CREEK
DREDGE AREA
CENTER LINE CHANNEL PROJECT DEPTH 42'
NOISETTE CREEK
BOUNDARY LINE
DRY DOCK NO. 1
DRY DOCK NO. 2
DRY DOCK NO. 5
ST. JOHNS AVENUE
HOBSON AVE
300 0 300 600 900
GRAPHIC SCALE
LEGEND
FORMER LOCATIONS OF DEMOLISHED RADIOLOGICAL FACILITIES
BOUNDARY OF CHARLESTON NAVAL SHIPYARD CONTROLLED INDUSTRIAL AREA
AREAS WHICH CONTAINED TEMPORARY NUCLEAR FACILITIES
CHARLESTON NAVAL SHIPYARD
CHARLESTON, SC
DRAWING PRODUCED BY CNSY CODE 2310
CAD OPERATORS: K. R. MOORE/S. T. BEALE