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CIVIL DEFENSE UTILIZATION OF SHIPS AND BOATS

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OCD REVIEW NOTICE

This report has been reviewed in the Office of Civil Defense and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Office of Civil Defense.

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ABSTRACT

Various ways in which ships and boats might supplement the overall civil defense program were investigated. Both merchant and reserve ("mothball") fleet ships were considered for the part they might play in a lifesaving, life-sustaining civil defense capacity. Data for two port cities were analyzed to obtain information on population distribution and shipping activity. Engineering feasibility studies were made of the use of ships as personnel shelters and the availability of ships' utilities for use by shore installations. The protection offered from nuclear fallout radiation was calculated for two classes of ships. It was concluded that ships and boats could provide evacuation or fallout-shelter facilities, or both, before or during a nuclear attack. For the postattack situation, ships could serve as headquarters, hospitals, living quarters, storehouses, and prime producers of electrical power and potable water. It is recommended that further studies be made of selected port cities to determine how ships and boats could best be used to supplement present civil defense capabilities of these cities.

SUMMARY PAGE

The Problem

A serious shortage of suitable fallout shelter spaces exists in many areas of the country. Further, shortages of food, fuel supplies, electrical power, and potable water might occur following a nuclear attack. Might ships and boats be used to help alleviate these shortages? This study was undertaken to assess the use of merchant ships, boats, and ships of the reserve ("mothball") fleets in the present civil defense program.

Findings

With sufficient warning of a nuclear attack, merchant ships and boats could evacuate up to 12,500,000 persons from target areas. In addition, Naval reserve fleets with only minor modifications could be used to house another 500,000 persons. Further, at a cost of about $90 per occupant, 800 of the Liberty ships (currently being scrapped at the rate 50 per year) in the Maritime Administration's reserve fleets could be converted into ship shelters that would accommodate an additional 8,000,000 persons.

In the immediate postattack phase, passenger ships, converted Liberty ships, and surplus battleships could be used for civil defense headquarters, hospitals, communication centers, etc. Tankers in the reserve fleets could be used, at modest cost, to store some 8,000,000 barrels of fuel which would be a substantial adjunct to the 50,000,000 barrels of fuel that might be salvaged from merchant tankers surviving the attack. An alternate use of the 800 Liberty ships in the reserve fleets would be to store sufficient wheat at widely scattered locations to feed 60,000,000 people for 6 months. Merchant ships could supply the minimum water requirements of large segments of the population. Ships in the reserve fleets could be activated to provide 400,000 kw of electrical power to shore installations.

Successful utilization of ships and boats for civil defense functions can be achieved if (1) the intended uses are well defined and documented, (2) all cognizant government agencies agree to participate in such utilization, and (3) ships intended for such use are promptly diverted from the scrap program.

Recommendations

One or two port cities should be selected for a detailed study to determine how ships and boats might be integrated most effectively and efficiently in existing civil defense plans.

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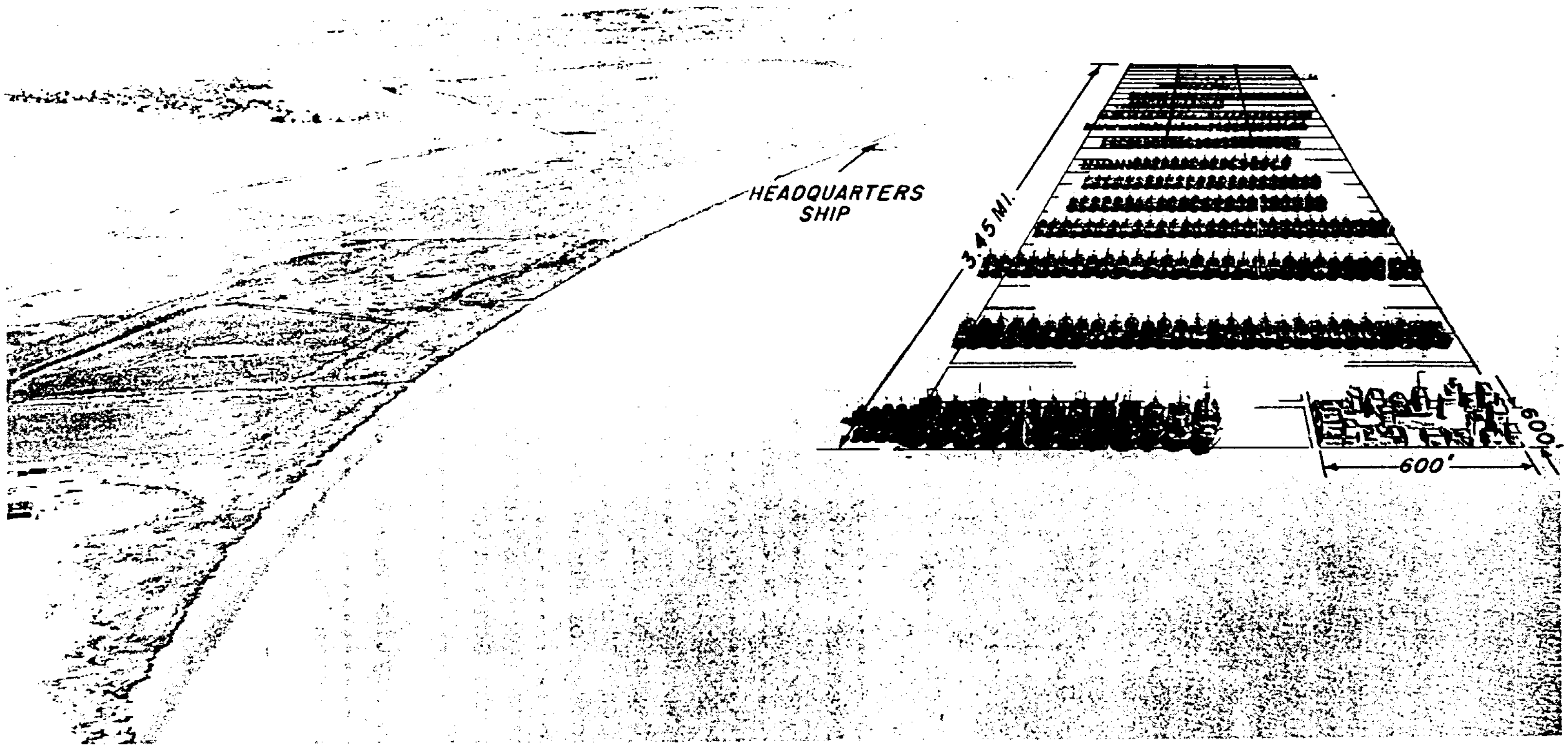

Aerial View of the National Defense Reserve Fleet: Suisun Bay, California
This fleet covers an area of 84 city blocks.

(Photo courtesy Maritime Administration)

SECTION 1

INTRODUCTION

1.1 PROBLEM AND BACKGROUND

As a part of its overall study of suitable shelters throughout the nation, the Office of Civil Defense (OCD) is interested in determining possible shelter spaces that might be available through unconventional sources, including ships and boats. Ships and boats were also to be considered for other possible civil defense uses, including food and supply storage, electricity generation, water purification, and civil defense headquarters. The purpose of this study then is a broad one, intending to delineate the possible civil defense applications of ships and boats, and to evaluate the ultimate usefulness of these vessels in the national civil defense effort.

Callahan et al.[1] investigated the possibility of using ships and boats as fallout shelters. The vessels would be anchored in the middle of large bodies of water to reduce the radiation contribution from the fallout-contaminated shore while reducing that from fallout deposited in the water because of the shielding characteristics of the water. They found that a reduction factor* of 0.01 could be obtained by various combinations of river width, off-shore distance, and depth. For example, for an average depth of 50 ft, the vessel would have to be anchored near the middle of an 1800-ft-wide river to obtain a reduction factor of 0.01. The river must be at least 17 ft deep (with an associated width of 3000 ft or more) in order to attain a reduction factor of 0.01.

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* The reduction factor is defined as:

$$\frac{\text{dose rate at the sheltered location, 3 ft above the deck}}{\text{dose rate at 3 ft above an infinitely contaminated land surface}}$$

Callahan et al. did not consider concomitant radiation either from fallout deposited on the deck of the vessel or from transit radiation from the radioactive cloud passing overhead.

In broad terms, Callahan et al. showed that evacuation of persons by ships and boats would provide an estimated 2,000,000 to 5,000,000 shelter spaces, for the entire nation. Of particular interest was the distribution of these potential ship and boat shelter spaces in areas where conventional basement shelters were often totally inadequate due, in many cases, to the presence of high water tables.

Rubenstein[2] investigated in some depth the possible use of the National Defense Reserve Fleet (NDRF), which is under the jurisdiction of the Maritime Administration (MARAD), for civil defense purposes. That report, based on an ad hoc study by representatives from Department of Agriculture, Department of Health, Education, and Welfare, MARAD, and OCD, recommended that scrapping of surplus ships in the NDRF be discontinued until the desirability of the following proposals could be fully evaluated:

(1) The Department of Agriculture would distribute surplus food strategically among all the states, using NDRF vessels where feasible.

(2) The Public Health Service would consider the use of NDRF vessels for emergency hospitals and for warehousing medical supplies.

(3) The National Association of State Civil Defense Directors would undertake a pilot study to determine the feasibility of using NDRF ships for emergency operations at the state and local level for civil defense training centers, as auxiliary electric-power installations, etc.

The Public Health Service recently completed a study[3] in which they concluded that the conversion of surplus EC-2-S-C1 (Liberty) ships for the accommodation of mobile medical-care facilities was not desirable; land storage of medical supplies seemed more advantageous. A preliminary study by the Public Health Service in 1957 had reached similar conclusions, but also suggested the possibility of using commercial passenger ships for emergency hospital centers. The objections to using surplus Liberty ships include the cost of conversion, cost of maintenance, and the possible difficulty in moving the ships into population centers after attack.

The Naval Civil Engineering Laboratory has studied the feasibility of using obsolete SS-212 (GATO) class submarine hulks as protective shelters.[4] They estimated that, for $60,000, a suitably modified submarine hulk could be moved into a dredged slip in a beach area and covered with sand. The resultant shelter, equipped with a new entrance, an electrical system, and a ventilation layout, would provide 138 bunk spaces, protection against airblast overpressures of 130 psi, and radiation protection equivalent to 8 ft of sand cover. Although deemed economically feasible, no subsequent action has been taken because the total number of surplus hulks is quite small--less than 50.

1.2 OBJECTIVES

This study was conducted to evaluate all ways in which every available ship and boat might be used to support the civil defense effort. More specifically, investigations were to be made of (1) the feasibility of using ships and boats as fallout shelters or, alternatively, for evacuation; (2) the use of reserve fleets, either <u>in situ</u> or as otherwise deemed practical; (3) the use of ships for storage of food, fuel, and other strategic supplies; (4) the capabilities of ships to provide utilities to shore installations; and (5) the use of ships as civil defense headquarters, hospitals, or communication centers.

To attain these objectives, it was necessary to consider the type of fallout situation that might be encountered, the availability of ships and boats, the shielding characteristics of ships and boats, the evacuation of person to loading points, the costs involved in the various proposed uses, and the probable nationwide potential.

It is not the intent of this report to suggest ways in which ships can compete with shore-based shelters, warehouses, utilities, etc. Rather, the emphasis is on how ships can supplement existing shore installations as necessary or furnish the desired service when shore facilities are totally inadequate. In brief, this report discusses how the unique characteristics of ships and boats can best be utilized in the civil defense effort.

1.3 CIVIL DEFENSE REQUIREMENTS AS A FUNCTION OF TIME

Depending on the attack time continuum civil defense activity will vary greatly, being essentially nil before an attack, reaching a maximum during and just after an attack, and gradually tapering off in the recovery period. Figure 1 illustrates, for ships and boats, the interrelationship of these factors. In the preattack period, ships and boats should be available for normal usage or, in the case of

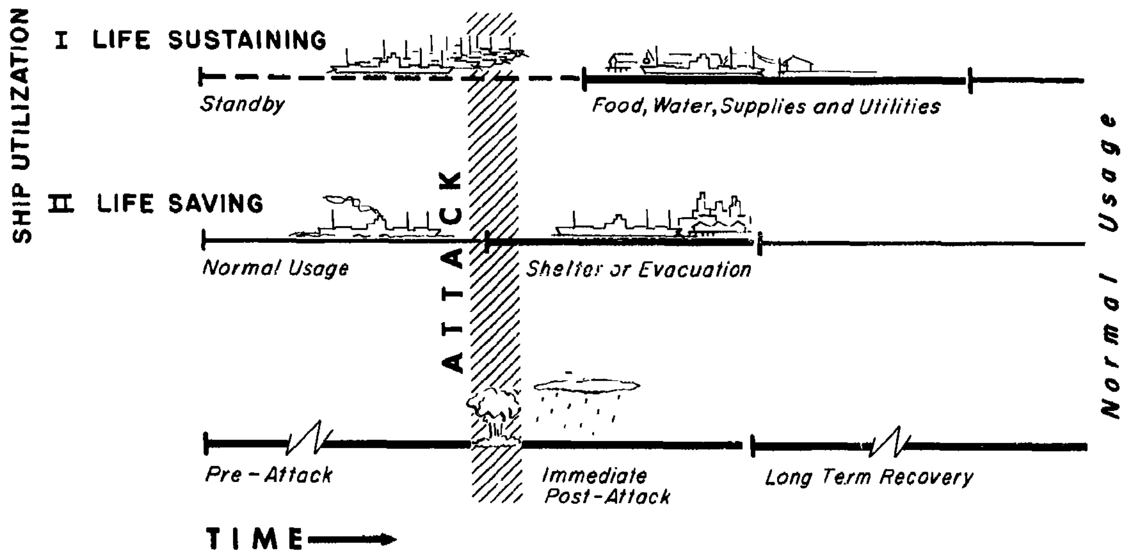

Fig. 1 Ship Utilization as a Function of an Attack Time Continuum

reserve fleets, available within a designated period for their normal duty. Prior to, during, and just after an attack, ships and boats, if they are to have value for civil defense, should serve a life-saving function, that is, save the lives of people from the effects of the attack itself. This function can conceivably be effected by removing people from the attack situation (evacuation) and/or protecting them from the effects of the attack (shelter). After this initial period, ships may then assist in life-sustaining operations, serving as hospitals, monitoring centers, etc. or in providing essential services, such as water, food, fuel, and electricity. Ultimately, the ships and boats should again become available for normal service. This report discusses the applicability of ships and boats for these two broad life-saving and life-sustaining functions, and points up the problems created by these functions with respect to normal usage.

The introduction of the concept of evacuation as a means of saving lives is not intended to imply an endorsement of this concept; rather it is a necessary assumption if ships and boats are to be considered for any major life-saving role.* In addition, current doctrine calls for the evacuation of ships to sea, which may be compatible with the concept of personnel evacuation as discussed in this study.

A generalization that is used throughout the report for convenience is the term, 2-wk shelter staytime. The reader should realize that "2 wk" is not a magic number that speaks for any given fallout situation. The time that persons may be required to spend in a shelter could vary from a few hours in some instances to several months in rare cases. Another simplification that is used in this report is that of reporting doses over a 1-yr period. Obviously no individual will remain aboard a ship in a particular location for 1 yr. However, the error introduced by the 1-yr dose value is less than 10% for shelter staytimes of 2 wk or longer; that is, an individual receives approximately 90% of the first year's dose in the first 2 wk after fallout occurs. Those readers who might be interested in more information on staytimes and dose calculations are referred to the manual, Radiological Recovery of Fixed Military Installations.[6]

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* However, a recent report[5] suggests that, in a variety of strategic situations evacuation of civilian populaces over a period of hours or days would appear to be an acceptable practice.

SECTION 2

BASIC CRITERIA AND DATA

This section discusses fallout radiation dose, radiological countermeasures, airblast, and thermal radiation; presents statistical data on commercial shipping and population distribution in the United States and selected data on certain major ports; and discusses ship movement in the Port of New York.

2.1 WEAPON EFFECTS

2.1.1 Fallout Radiation Dose*

The free-field fallout radiation dose at a point offshore from a land surface nuclear burst can come from 4 sources, 3 of which are interrelated. The transit dose is that received from the radioactive cloud as it passes overhead; this dose is independent of other doses and of the surface over which the cloud travels. As the radioactive cloud passes it deposits radioactive particles. If these particles settle on the deck of a ship it is defined as the deck deposit dose; if the particles settle on an adjacent land surface it is defined as the land deposit dose. Finally, if the particles settle on the water surrounding the ship it constitutes the waterborne dose. This waterborne dose can be further subdivided into a water settling dose, which is a short-term dose received only during the time that the particles are falling from the surface of the water to the bottom of the water medium, and a water solution dose, a long-term dose, which results from dissolution of a portion of the radioactivity as the particles fall through the water. (See Appendix A for further details.)

To determine the relative importance of land deposit, deck deposit, and waterborne dose, a contribution factor, which is dependent on the placement of the ship in relation to the land and water areas, must be calculated for each source. Finally, in order to determine the dose to a person on a vessel, we must consider the structural shielding of

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* The data of this section are based on Appendix A which also includes studies for 1 and 20 MT bursts.

the vessel itself as well as the time over which the particular radiation contributes to the total dose. Transit radiation will penetrate the ship from all sides, but only while the cloud is passing near the vessel. Deck-deposit radiation will penetrate from the weather surfaces of the ship from the moment of contaminant deposition until the contaminant is removed by washdown or decontamination. Land-deposit radiation will penetrate the ship or boat from the moment of deposition until the land surface is decontaminated. Waterborne radiation will penetrate primarily through the hull, the water-settling component contributing only during the period of actual fallout, the water-solution component remaining as a contributor for an indefinite time or until dispersed by tidal action and dilution.

Figure 2 depicts the various components of the free-field radiation dose received up to 1 yr after burst time as a function of downwind distance along the hotline for a 5-MT land-surface burst. A 100% fission yield and a 15-knot effective wind are assumed. Smaller fission yields would result in proportionately smaller doses. A 5-MT nuclear burst is discussed here and elsewhere in the text as a representative case, whereas 1-MT and 20-MT nuclear bursts are discussed in Appendix A. These three weapon yields bracket the range of yields most frequently anticipated for a nuclear attack. Comparison of the 1-MT and 20-MT radiation-dose components in Appendix A with those of Fig. 2 reveal that the component curves are essentially the same shape. In addition, for a given component of the total dose, there is usually no more than a 50% increase in the total free-field radiation dose received at a given downwind distance along the hotline even when the total weapon yield increases from 1 MT to 20 MT. However, the fallout contour pattern for a 20-MT burst would be significantly larger than that for a 1-MT burst. Thus, a 20-fold increase in weapon yield would result in moderately higher component doses (and dose rates) spread out over a much larger area.

Shielding and Washdown

Figure 3 shows the 1-yr radiation doses to occupants of (1) a boat with a washdown system, (2) the SS INDEPENDENCE with a washdown system, and (3) a converted Liberty ship* with a washdown system, along with

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* This refers to a Liberty ship that has been modified to serve as a fallout shelter for 10,000 persons for a period of at least 2 wk. Figures 10 and 11 illustrate the proposed modifications. A converted Liberty ship shelter most probably would be beached on a shore, as shown in Fig. 12b, near a shelter-deficient population center.

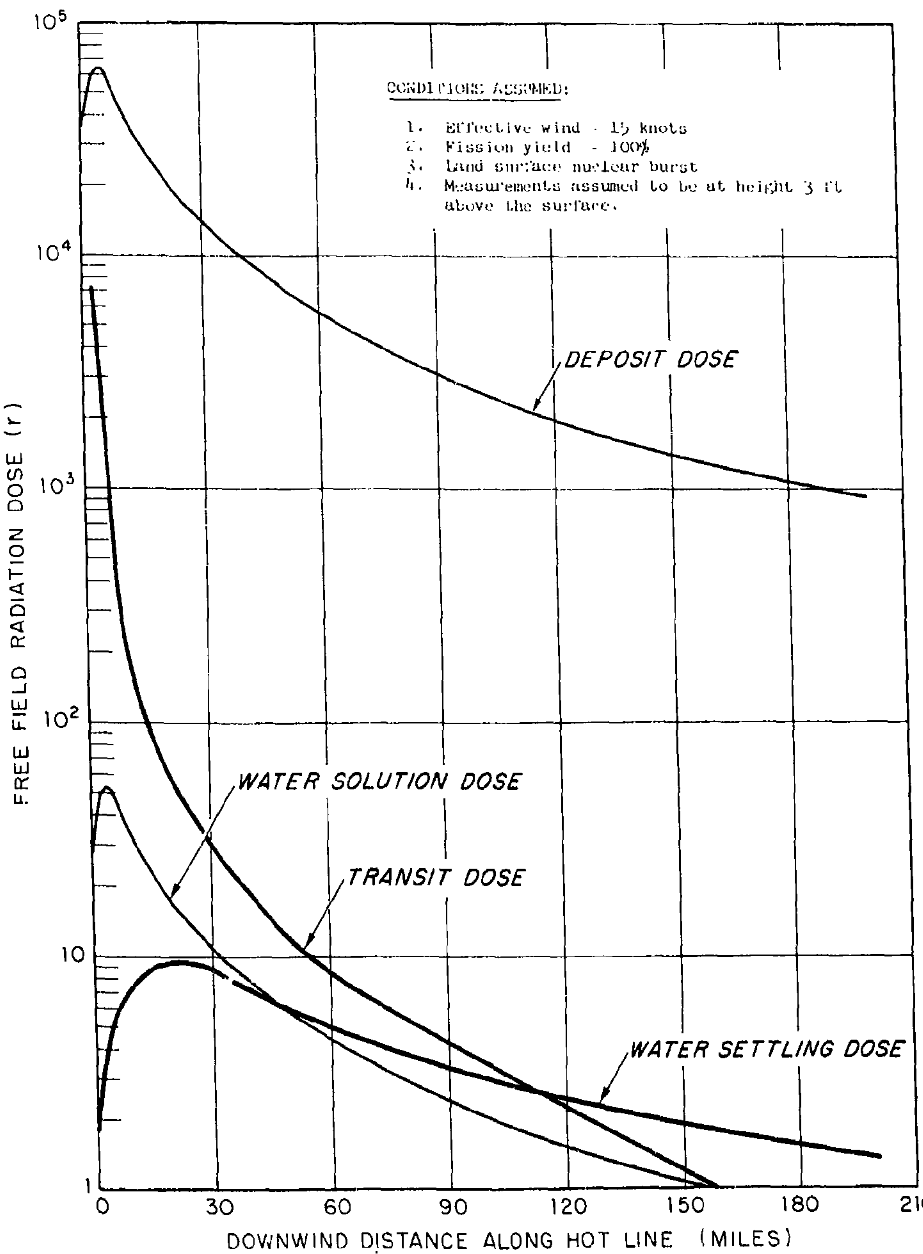

Fig. 2 Radiation Dose Studies - 5 MT Weapon Yield

Various Components of the Free Field Radiation Dose Received up to One Year After Burst vs Downwind Distance Along the Hot Line

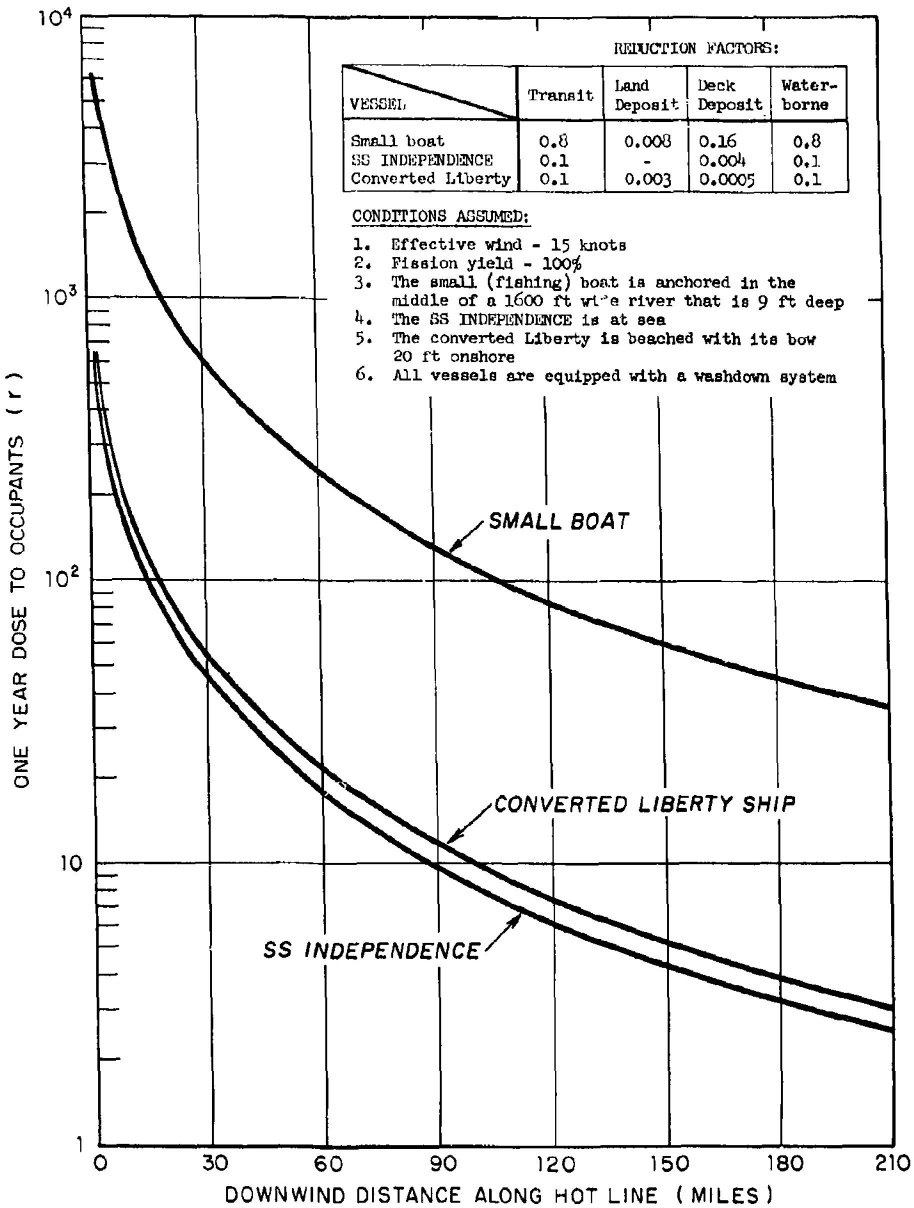

Fig. 3 One Year Doses to Occupants of Various Type Vessels Downwind from a 5-MT Burst

the assumed conditions and shielding factors for these three cases. Actual doses would be proportionately less than those shown if the fission yield is less than 100%. Further, an actual fallout model must be consulted to determine the total radiation dose for points downwind but not on the hotline.

Appendix A describes in detail the computations and assumptions used to obtain the values of Fig. 3 and also Figs. A.4 and A.5 for 1-MT and 20-MT land-surface bursts. In essence, the 3-ft free-field radiation dose is modified to account for the shielding afforded by the given vessel, for the effectivness of the washdown system, and for each component of the free-field radiation dose. By continually flushing deposited fallout overboard, a washdown system will reduce the dose by as much as 90%.

Figure 3 indicates that a converted Liberty ship beached on shore and the SS INDEPENDENCE at sea provide about an equivalent degree of protection against radioactive fallout. People aboard either ship would not receive excessive fallout radiation doses (no more than 300 r in 1 yr) at 6 miles downwind from a 5-MT land-surface burst. A small boat would provide the same degree of protection (a 300-r 1-yr dose*) only at 50 miles downwind distance. However, the small boat does provide definite protection, since the 1-yr free-field dose at this location (Fig. 2) would be over 7000 r. In perspective then, a converted Liberty ship would be best utilized close to a target area; a large passenger liner (with washdown) could safely evacuate personnel to sea even if high fallout-radiation levels were encountered; larger boats (with washdown) could be used to protect people beyond the blast- and fire-damaged areas but still within the high fallout-radiation areas.

2.1.2 Blast and Thermal Effects

The blast and thermal effects resulting from a nuclear burst would significantly affect the civil defense use of ships. A given blast overpressure may cause structural damage and loss of a vessel

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* The permissible dose limit suggested by the sponsor is 150 r for any period between 1 mo and 1 yr. This value is arbitrarily doubled when considering a case, such as Fig. 3, where a fission yield of 100% is assumed.

that was to have functioned as a floating warehouse. Thermal radiation may render the washdown system on a ship inoperable, thereby permitting lethal deposit-radiation doses below decks. Decisions on ship locations, the uses to which ships might be put in a given location, the extent of ship preparation or modification for civil defense purposes, and many other factors depend greatly on the maximum permissible weapon effects considered tolerable in a given situation as well as on the type of vessel involved and the attack situation anticipated.

For the specific case of a beached converted Liberty ship equipped with a washdown system capable of removing 90% of the deposited fallout, Table 1 presents, the closest distances from ground zero that this ship might be positioned for each of three weapon yields. The maximum allowable conditions for blast, thermal, and fallout-radiation effects determine the closest distance at which a ship would protect its occupants. In the case cited in Table 1, fallout radiation determines the closest distances for all three yields.

Similar tables drawn up for a wide variety of attack conditions, vessel types, vessel uses, etc. might be used as aids in determining the optimum use of ships for civil defense purposes. For example, if other permissible radiation doses are decided on, the data presented here, in 2.1.1, and in Appendix A could be used to calculate either the closest distance of approach for a given variety of shielding conditions, or the shielding protection required for personnel at a given shelter location.

2.2 STATISTICAL DATA

2.2.1 Commercial Shipping

Table 2 summarizes the 1960 commercial shipping in the United States in terms of the volume of usable ship space available on various classes of vessels. This summary of ship potential by volume of usable ship space is significant, since waterborne-commerce summaries are frequently in terms of weight of cargo handled. The available volume is used here because it is considered more significant for civil defense purposes.

Four items in this table are especially noteworthy. Nearly 23% of the volume of usable ship space for the contiguous United States is concentrated in self-propelled passenger and dry-cargo ships on the Atlantic Coast, and all self-propelled passenger and dry-cargo vessels accounted for nearly 50% of the total volume of ship space in this country. Further, all usable volume of non-self-propelled vessels

Table 1

Permissible Distances From Land-Surface Bursts for a Beached Converted Liberty Ship With a Washdown System

Yield (MT)	BLAST[a]		THERMAL[a]		FALLOUT RADIATION	
	Maximum Allowable Dynamic Pressure (psi)	Distance (Mi)	Maximum Allowable Thermal Radiation (cal/sq cm)	Distance (Mi)	Maximum Allowable 1-Yr Dose[b] (r)	Distance[c] (Mi)
1	5	1.7	> 500	< 1.7	300	2
5	5	3.0	> 500	< 3.0	300	6
20	5	4.7	> 500	< 4.7	300	9

[a]Glasstone, S., ed. The Effects of Nuclear Weapons, April 1962, pp. 175, 135, and 365. Dynamic pressures of 5 psi will cause moderate damage to a ship, while thermal radiation in excess of 500 cal/sq cm will only cause blistering of painted surfaces. However, if plastic pipe and linen firehose are components of the washdown system, failure of these components would undoubtedly occur at high thermal levels.

[b]For a 100% fission yield.

[c]Values for hotline obtained from Figs. 3, A.1, and A.2.

Table 2

1960 Annual National Summary of Inbound Waterborne Commerce in Units of Millions of Net Tons (NT)[a]
(One NT Equals 100 Cubic Feet of Usable Ship Space)

LOCATION	SELF-PROPELLED VESSELS			NON-SELF-PROPELLED VESSELS[c]		TOTALS[b]
	Passenger and Dry Cargo	Tanker	Towboat or Tugboat	Dry Cargo	Tanker	
ATLANTIC COAST	440.5	159.2	23.7	115.4	53.6	797.9
GULF COAST AND THE MISSISSIPPI RIVER SYSTEM	118.0	146.3	12.3	103.0	77.8	518.9
GREAT LAKES	321.8	12.5	2.2	23.6	7.3	370.6
PACIFIC COAST	146.9	55.4	8.7	24.3	24.0	259.9
TOTAL (National Summary)	1027.2	373.4	46.9	266.3	162.7	1947.3

[a] Waterborne Commerce of the United States, Calendar Year 1960, Corps of Engineers, Department of the Army.

[b] This column does not necessarily represent the sum of the figures given for self-propelled and non-self-propelled vessels since various miscellaneous vessels are included in this total.

[c] Non-self-propelled vessels, which are normally moved by tugboats or towboats, include barges and lighters.

accounted for only 22% of the national usable ship volume. Tankers, self-propelled and non-self-propelled, accounted for 28% of the usable ship volume.

Figure 4 indicates the completed and projected channel depths in the principal waterways of the United States. These depths give some indication of the type of ship traffic that might be handled in a waterway or port as well as the limitations or difficulties that might be encountered when moving vessels from one location to another for civil defense purposes. Also shown are the locations of the various Maritime Administration and Naval Reserve Fleets.

2.2.2 United States Population Distribution: 1960

Figure 5 shows the 1960 population distribution for the United States; outstanding is the non-uniformity of the population distribution. There is an extremely heavy population concentration in the northeast United States and a much greater concentration of people in the eastern half of the United States than in the western half except for a heavily populated strip of land along the Pacific Coast. By superimposing Fig. 5 on Fig. 4, one can see that there is an extremely good chance of finding large harbors or navigable waterways in just those locations where the population is most heavily concentrated. This distribution is quite reasonable, since it is those places with good water transportation facilities that one might expect to grow into centers of commerce and industry and to acquire large populations.

Table 3 lists the 25 most populous Standard Metropolitan Statistical Areas (SMSA's) in the United States, along with their ranks, resident populations, short tons of commerce handled in 1960, and the number of fallout shelter spaces (reduction factor ≤ 0.01) available in each. The resident populations of these SMSA's represented approximately one-third of the United States' resident population for 1960. The resident population listed for an SMSA may or may not represent an actual daytime or nighttime population (see Table 4).

Table 3 indicates that (1) there is a positive correlation between the number of short tons of commerce handled in a given SMSA and the SMSA's resident population, (2) there is a shortage of shelter spaces having reduction factors equal to or less than 0.01 in most SMSA's and (3) 23 of the 25 most populous SMSA's are port cities located on the Atlantic, Gulf, or Pacific Coast or on an inland waterway.

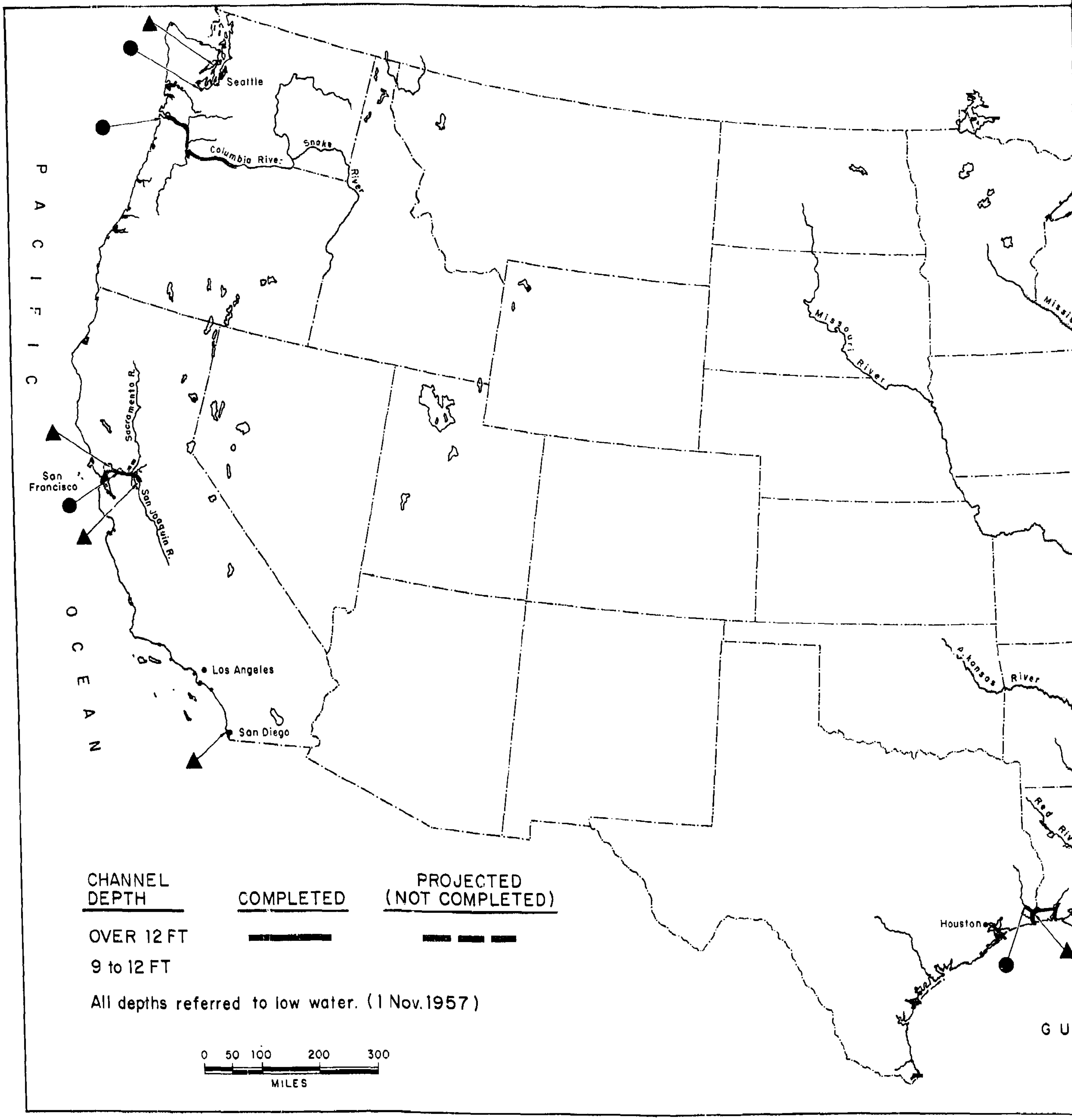
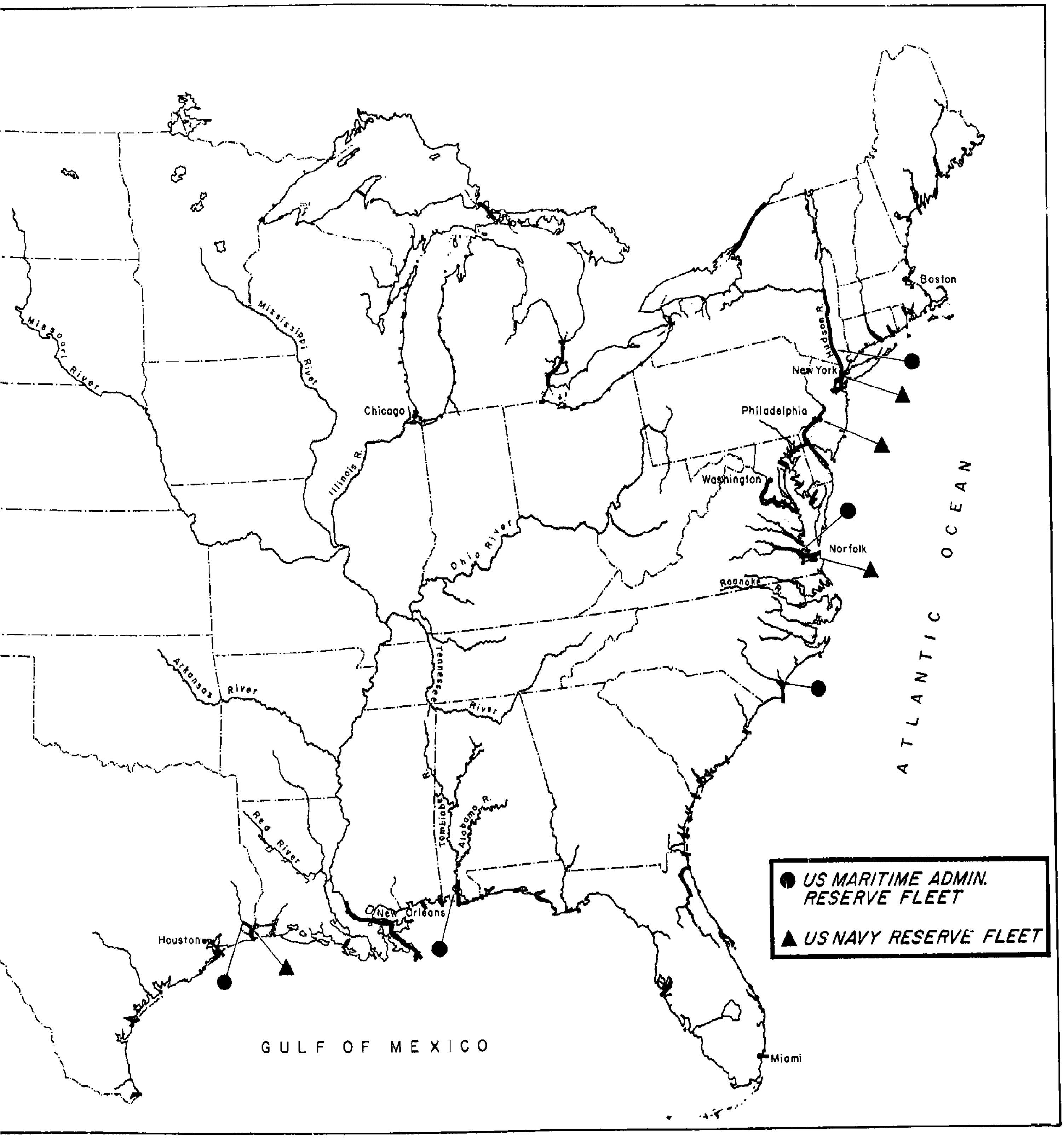


Fig. 4 Principal Waterways of the United States and Locations o



nited States and Locations of the MARAD and Navy Reserve Fleets

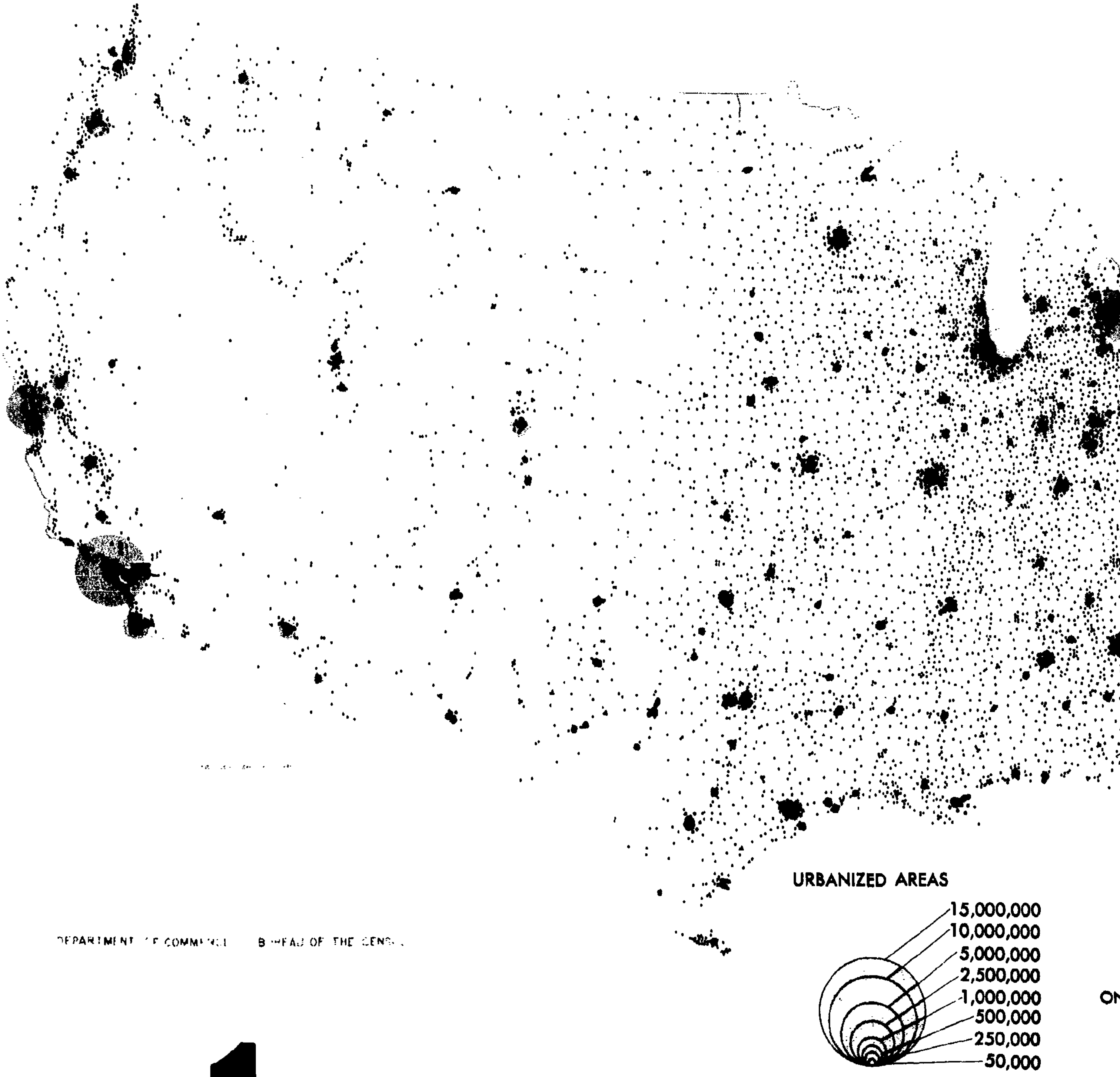


Fig. 5 United States Population Distribution: 1960

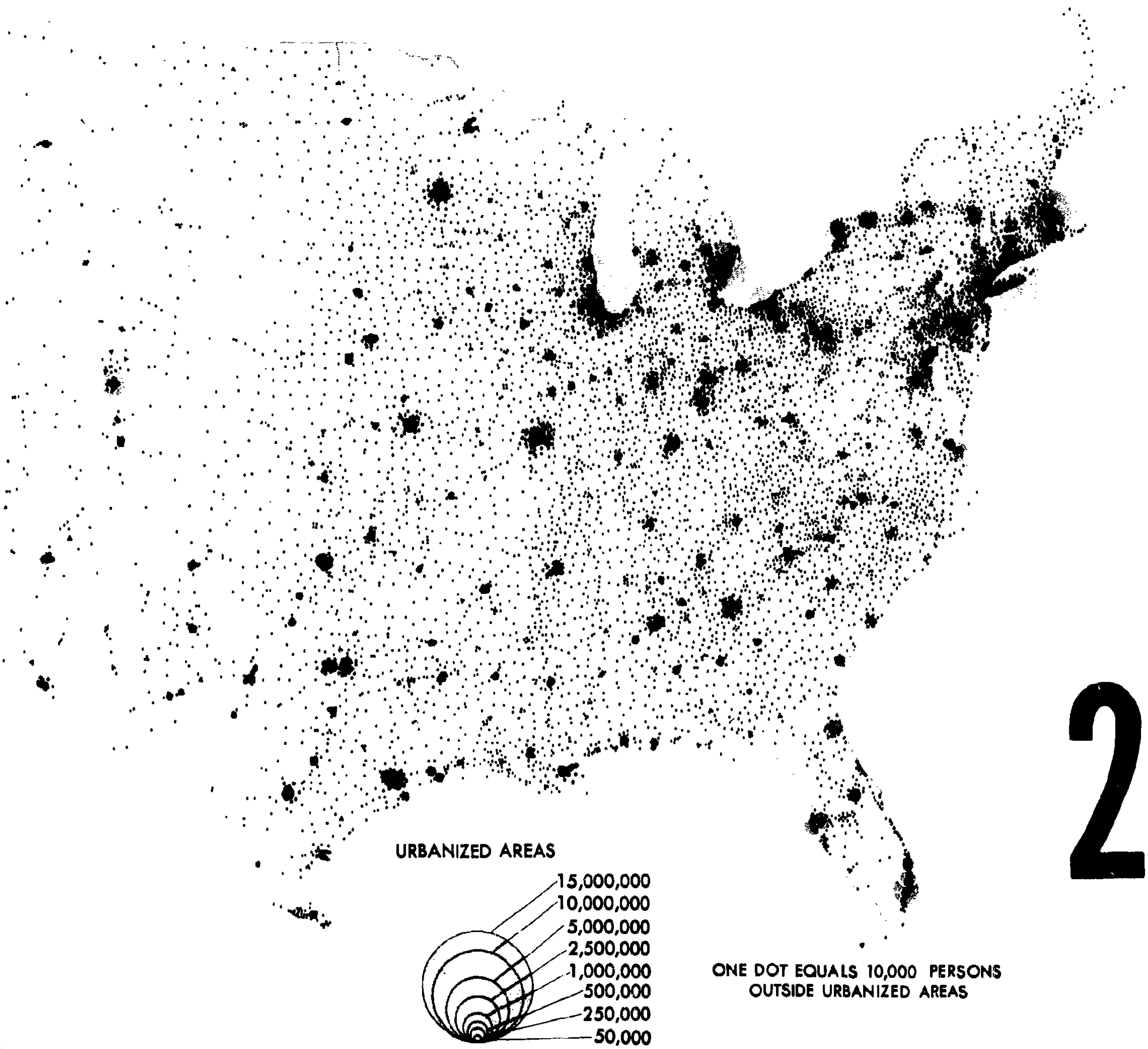


Fig. 5 United States Population Distribution: 1960

Table 3

Resident Population, Waterborne Commerce, and Fallout Shelter Spaces Available in the 25 Largest United States Standard Metropolitan Statistical Areas (SMSA)[a]

SMSA	SMSA Rank[b] (By population)	SMSA Resident Population[b]	Tons (2000 lb) of Waterborne Commerce Handled in 1960[c]	Fallout Shelter Spaces (Reduction Factor ≤ 0.01)[d]
New York, N.Y.	1	10,695,000	153,199,000[e]	16,031,000[f]
Los Angeles-Long Beach, Calif.	2	6,743,000	31,892,000	1,644,000
Chicago, Ill.	3	6,221,000	39,055,000	6,496,000
Philadelphia, Pa. - N.J.	4	4,343,000	49,634,000	2,260,000
Detroit, Mich.	5	3,762,000	27,478,000	1,136,000
San Francisco-Oakland, Calif.	6	2,783,000	29,116,000	952,000
Boston, Mass.	7	2,589,000	19,020,000	1,471,000
Pittsburgh, Pa.	8	2,405,000	6,581,000	1,131,000
St. Louis, Mo.- Ill.	9	2,060,000	9,092,000	792,000
Washington, D.C.- Md. - Va.	10	2,002,000	2,686,000	2,214,000[g]
Cleveland, Ohio	11	1,797,000	17,801,000	824,000
Baltimore, Md.	12	1,727,000	43,420,000	574,000
Newark, N.J.	13	1,689,000	see note e	523,000

Table 3 continues

Table 3 (cont.)

Resident Population, Waterborne Commerce, and Fallout Shelter Spaces Available in the 25 Largest United States Standard Metropolitan Statistical Areas (SMSA)[a]

SMSA	SMSA Rank[b] (By population)	SMSA Resident Population[b]	Tons (2000 lb) of Waterborne Commerce Handled in 1960[c]	Fallout Shelter Spaces (Reduction Factor ≤ 0.01)[d]
Minneapolis-St. Paul, Minn.	14	1,482,000	4,597,000	811,000
Buffalo, N.Y.	15	1,307,000	17,704,000	327,000
Houston, Texas	16	1,243,000	57,133,000	230,000
Milwaukee, Wis.	17	1,194,000	8,519,000	382,000
Paterson-Clifton-Passaic, N.J.	18	1,187,000	see note e	130,000
Seattle, Wash.	19	1,107,000	16,614,000	302,000
Dallas, Texas	20	1,084,000	not a port	280,000
Cincinnati, Ohio-Ky.	21	1,072,000	7,430,000	616,000
Kansas City, Mo.-Kans.	22	1,039,000	1,374,000	668,000
San Diego, Calif.	23	1,033,000	2,136,000	83,000
Atlanta, Ga.	24	1,017,000	not a port	287,000
Miami, Fla.	25	935,000	1,612,000	169,000

Table 3 continues

Footnotes for Table 3

[a]An SMSA is composed of the entire population living in the area in and around a relatively large central city, and may also refer to the area itself. The activities of this population form an integrated social and economic system. For the Bureau of the Budget's established definition, see pp. XXIV and XXV of the United States Census of Population: 1960 (see footnote b).

[b]U.S. Bureau of the Census. U.S. Census of Population: 1960. Number of Inhabitants, United States Summary. Final Report PC(1)-1A, U.S. Government Printing Office, Washington, D.C., 1961 (pp. 1-117, Table 36).

[c]Waterborne Commerce of the United States, Calendar Year 1960. Corps of Engineers, Dept. of the Army.

[d]National Shelter Survey: Phase I. Department of Defense, Office of Civil Defense, Washington 25, D.C.

[e]The tonnages for the Newark, N.J. SMSA and the Patterson-Clifton-Passaic, N.J. SMSA are included in the New York, N.Y. SMSA.

[f]Approximately 85% of these shelter spaces are in the Borough of Manhattan.

[g]Approximately 90% of these shelter spaces are in Washington, D.C.

2.2.3 Selected Data for Port Cities

Table 4 lists and helps to correlate a mass of data about certain selected ports. This table is meant to suggest possibilities for future analysis of the civil defense use of ships. The type of data presented here might be gathered for any location in the country and for any specific city, region, or SMSA.

Table 4 shows that the resident, daytime, and nighttime populations are distinctly different. A "satisfactory" number of fallout shelters at any SMSA would depend on which one of these populations one was interested in sheltering, as well as the distribution of these shelters within the SMSA. For example, the New York, N.Y. SMSA has more shelter spaces (Table 3) than residents (Table 4), but this situation does not mean that all these residents could be sheltered. Brooklyn has a large deficit of shelter spaces, whereas Manhattan has such a huge surplus of spaces that there is an overall surplus of shelter spaces. This situation is also true in the Washington, D.C.-Md.-Va. SMSA, because most of the shelter spaces are located in the large government buildings in downtown Washington, D.C. (Manhattan and Washington, D.C., each contain approximately 85% of the shelter spaces in their respective SMSA's.)

Civil defense use of ships would be complicated at ports, such as Minneapolis-St. Paul, Minn. and Buffalo, N.Y., that are closed during the coldest winter months. All of the other ports listed in Table 4 normally have a year-round navigation season.

The columns in Table 4 listing net tons (100 cu ft) of waterborne commerce and the principal cargo handled in each port together give an idea of the type and volume of waterborne commerce at selected locations throughout the United States. This and similar information should be useful in helping to select and evaluate those locations in the United States where the civil defense use of ships might be a significant and valuable adjunct to any other civil defense activity.

2.3 SHIP MOVEMENT WITHIN THE PORT OF NEW YORK

Intensive studies were made of the Ports of New York and San Francisco and are reported in Appendices C and D. These studies were made to obtain pertinent information bearing on the civil-defense use of ships at certain specific ports. Highlights of the Port of New York study are presented here both to indicate the types of information that might be of interest at any given port and to present such information for one highly significant port.

Table 4

Detailed Population, Waterborne-Commerce, and Fallout-Shelter Data for Certain United States Ports

PORT	SMSA RANK[a] (By population)	POPULATION DATA FOR GIVEN SMSA OR COMPONENT AREA			FALLOUT SHELTER SPACES (Reduction factor ≤ 0.01)[c]
		Resident[b]	Daytime[c]	Nighttime[c]	
Brooklyn, New York (part of NY,NY SMSA)	see note[d]	2,627,000	3,343,000	2,803,000	1,051,000
Manhattan, New York (part of NY,NY SMSA)	see note[d]	1,698,000	4,507,000	2,359,000	13,528,000
Los Angeles-Long Beach, Calif.	2	6,743,000	8,476,000	7,148,000	1,644,000
Chicago, Ill.	3	6,221,000	--	--	6,496,000
San Francisco-Oakland, Calif.	6	2,783,000	4,124,000	3,365,000	952,000
Boston, Mass.	7	2,589,000	3,417,000	3,107,000	1,471,000
Pittsburgh, Pa.	8	2,405,000	2,545,000	2,480,000	1,131,000
St. Louis, Mo.-Ill.	9	2,060,000	--	--	792,000
Washington, D.C.-Md. - Va.	10	2,002,000	2,625,000	2,528,000	2,214,000
Minneapolis-St. Paul, Minn.	14	1,482,000	--	--	811,000
Buffalo, N.Y.	15	1,307,000	1,235,000	1,380,000	327,000
Houston, Texas	16	1,243,000	--	--	230,000

Table 4 continues

Table 4 (cont.)

Detailed Population, Waterborne-Commerce, and Fallout-Shelter Data for Certain United States Ports

PORT	SMSA RANK[a] (By population)	POPULATION DATA FOR GIVEN SMSA OR COMPONENT AREA			FALLOUT SHELTER SPACES (Reduction factor ≤ 0.01)[c]
		Resident[b]	Daytime[c]	Nighttime[c]	
Seattle, Wash.	19	1,107,000	--	--	302,000
New Orleans, La.	27	868,000	--	--	327,000
Norfolk-Portsmouth, Va.	44	579,000	526,000	573,000	165,000
Jacksonville, Fla.	58	455,000	--	--	135,000

Table 4 continues

Table 4 (cont.)

PORT	INBOUND WATERBORNE COMMERCE IN UNITS OF NET TONS (NT)[e] (one NT equals 100 cu ft of usable ship space)				
	SELF-PROPELLED VESSELS		NON-SELF-PROPELLED VESSELS		TOTAL OF ALL INBOUND VESSELS[g]
	Passenger and Dry Cargo Vessels	Tankers	Passenger and Dry Cargo Vessels	Tankers	
Brooklyn, New York (part of NY,NY SMSA)	83,992,000	3,709,000	21,373,000	4,481,000	124,628,000
Manhattan, New York (part of NY,NY SMSA)	32,173,000	1,075,000	21,423,000	1,670,000	59,823,000
Los Angeles-Long Beach, Calif.	16,229,000	9,752,000	325,000	1,271,000	27,655,000
Chicago, Ill.	10,023,000	748,000	8,012,000	3,214,000	22,488,000
San Francisco-Oakland, Calif.	21,850,000	6,586,000	858,000	3,460,000	34,179,000
Boston, Mass.	8,405,000	6,525,000	298,000	1,116,000	16,559,000
Pittsburgh, Pa.	9,000	None	4,940,000	665,000	6,610,000
St. Louis, Mo.-Ill.	25,000	None	2,250,000	1,750,000	4,430,000
Washington, D.C.-Md. - Va.	188,000	464,000	1,085,000	369,000	2,181,000
Minneapolis-St. Paul, Minn.	13,000	None	1,140,000	888,000	2,240,000

Table 4 continues

Table 4 (cont.)

PORT	INBOUND WATERBORNE COMMERCE IN UNITS OF NET TONS (NT)[e] (one NT equals 100 cu ft of usable ship space)				
	SELF-PROPELLED VESSELS		NON-SELF-PROPELLED VESSELS		TOTAL OF ALL INBOUND VESSELS[g]
	Passenger and Dry Cargo Vessels	Tankers	Passenger and Dry Cargo Vessels	Tankers	
Buffalo, N.Y.	9,019,000	382,000	105,000	217,000	9,750,000
Houston, Texas	10,716,000	13,172,000	5,613,000	4,953,000	34,852,000
Seattle, Wash.	28,672,000	2,787,000	3,621,000	1,505,000	37,842,000
New Orleans, La.	17,230,000	7,954,000	6,619,000	9,204,000	42,108,000
Norfolk-Portsmouth, Va.	24,344,000	5,450,000	1,497,000	2,182,000	33,765,000
Jacksonville, Fla.	2,426,000	3,011,000	621,000	549,000	6,692,000

Table 4 continues

Table 4 (cont.)

PORT	NAVIGATION SEASON[e,f]	PRINCIPAL CARGO HANDLED IN PORT[e] (Percent by weight of total port cargo)			
		3% - 10%	10% - 20%	20% - 40%	> 40%
Brooklyn, New York (part of NY,NY SMSA)	all year	misc. comm., sand, coal, iron + steel	--	--	petroleum and related products
Manhattan, New York (part of NY,NY SMSA)	all year	--	misc. commodities, pet. prod.	coal and lignite	--
Los Angeles-Long Beach, Calif.	all year	iron + steel, industrial chemicals	--	--	petroleum and related products
Chicago, Ill.	all year	corn, limestone	pet. and related prod., sand, rock	coal, iron ore + concentrates	--
San Francisco-Oakland, Calif.	all year	shells	--	--	petroleum and related products
Boston, Mass.	all year	coal	--	--	petroleum and related products
Pittsburgh, Pa.	all year	sand, gravel	pet. + related items, iron + prod.	--	coal and lignite
St. Louis, Mo.-Ill.	all year	steel + related products, cement	pet., coal, grain, sand, rock	--	--

Table 4 continues

Table 4 (cont.)

PORT	NAVIGATION SEASON[e,f]	PRINCIPAL CARGO HANDLED IN PORT[e] (Percent by weight of total port cargo)			
		3% - 10%	10% - 20%	20% - 40%	> 40%
Washington, D.C.- Md. - Va.	all year	sand, rock, gravel	--	--	petroleum and related products
Minneapolis-St. Paul, Minn.	4 Apr - 2 Dec	--	grains	pet. + rel. items, sand, rock, coal	--
Buffalo, N.Y.	23 Apr - 17 Dec	petroleum and related products	limestone, paper, grains	--	iron ore and related products
Houston, Texas	all year	grains	shells	--	petroleum and related products
Seattle, Wash.	all year	grains	sand, rock	pet. + products, wood + wd. prods.	--
New Orleans, La.	all year	grain, food, sulphur, chem., shells	--	--	petroleum and related products
Norfolk - Portsmouth, Va.	all year	grains	petroleum and related products	--	coal
Jacksonville, Fla.	all year	wood + prods., gypsum foods	--	--	petroleum and related products

Table 4 continues

Footnotes to Table 4

[a]U.S. Bureau of the Census. U.S. Census of Population: 1960. Number of Inhabitants, United States Summary. Final Report PC-(1)-1A. U.S. Government Printing Office, Washington 25, D.C., 1961 (pp. 1-117, Table 36).

[b]Reference in a, above, pp. 1-100, Table 31.

[c]National Shelter Survey: Phase I. Department of Defense, Office of Civil Defense, Washington 25, D.C. Among other data available from this Survey are the total number of buildings, the number of buildings rejected, the shelter spaces in various other categories, etc.

[d]This port is only a component area of the New York, N.Y. Standard Metropolitan Statistical Area (SMSA).

[e]Waterborne Commerce of the United States, Calendar Year 1960, Corps of Engineers, Dept. of the Army. Certain data from this source were recompiled, estimated, or averaged to obtain other statistics.

[f]Ports of the World, 16th Ed., Shipping World Limited, London, England (1962). For the purposes of this tabulation, the navigation season is defined as that part of the year when there is at least one outlet (via river, ocean, lake, etc.) from the given port. If only the port is navigable for intraport traffic and all port outlets are closed, the port is listed as closed for that period of time.

[g]This column does not necessarily represent the sum of the figures given for self-propelled and non-self-propelled vessels, since tug-boats, towboats, and some miscellaneous vessels are included in this total.

Figure 6 gives a comprehensive picture of the most significant of the 28 harbors that comprise the Port of New York. The most important feature to be noted is the heavy concentration of port activity in a relatively few harbors. This situation is even more extreme than that indicated, since, at any given harbor (for example, Brooklyn), some piers or groups of piers are much busier than others. If port activity is measured in terms of the number of ships docking, then Brooklyn accounts for 46% of the shipping activity in the entire Port of New York, and Manhattan accounts for another 17%. Thus, these two harbors alone account for nearly two-thirds of all the shipping activity in the Port of New York.

Figure 7 shows extremely wide fluctuations in the daily ship total from one part of the week to the next. The numbers of ships in port exhibit a midweek maximum and a weekend minimum; these within-week fluctuations are far greater than any week-to-week fluctuations.

For the year 1961, the Port of New York Authority reports that, of the commercial deep-sea ships entering the Port of New York, 50% are general-cargo common carriers, 27% are tankers, 18% are specialized or industrial carriers, and 5% are passenger vessels. The total number of ships in port at any given time ranges from a low of 90 ± 20% over weekends to a maximum of 180 ± 20% during the middle of the week.

One-half of the ships entering the Port of New York stay less than 2 to 3 days, and very few ships stay longer than 8 to 10 days. This "staytime" or "turn-around time" is a function of the type of vessel and varies from a low of 1 to 2 days for tankers to 2.5 to 3.5 days for passenger vessels to 3.5 to 4.5 days for general-cargo common carriers. Specialized vessels vary widely from 1.5 days for container ships to 8 days for vessels carrying scrap metal.

In conclusion, on any given day, one can expect in the Port of New York 45 to 90 general-cargo common carriers, 24 to 48 tankers, 16 to 32 specialized carriers, and 5 to 10 passenger vessels. The sum total of all these vessels represents a definite civil defense potential that might be utilized in a wide variety of ways.

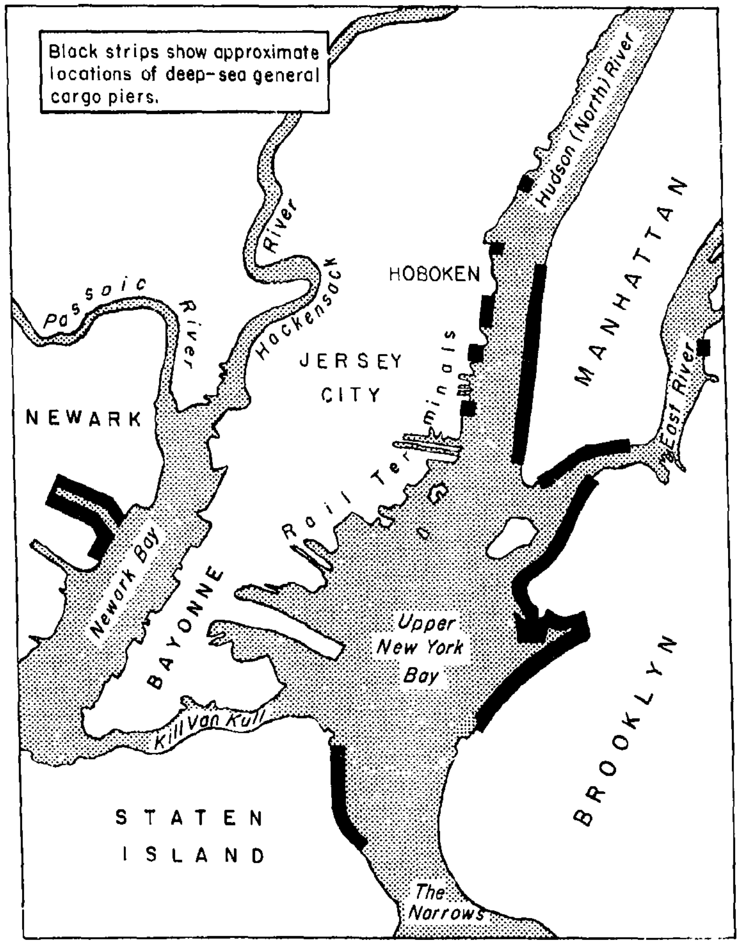


Fig. 6 The Port of New York Showing General Cargo Waterfronts

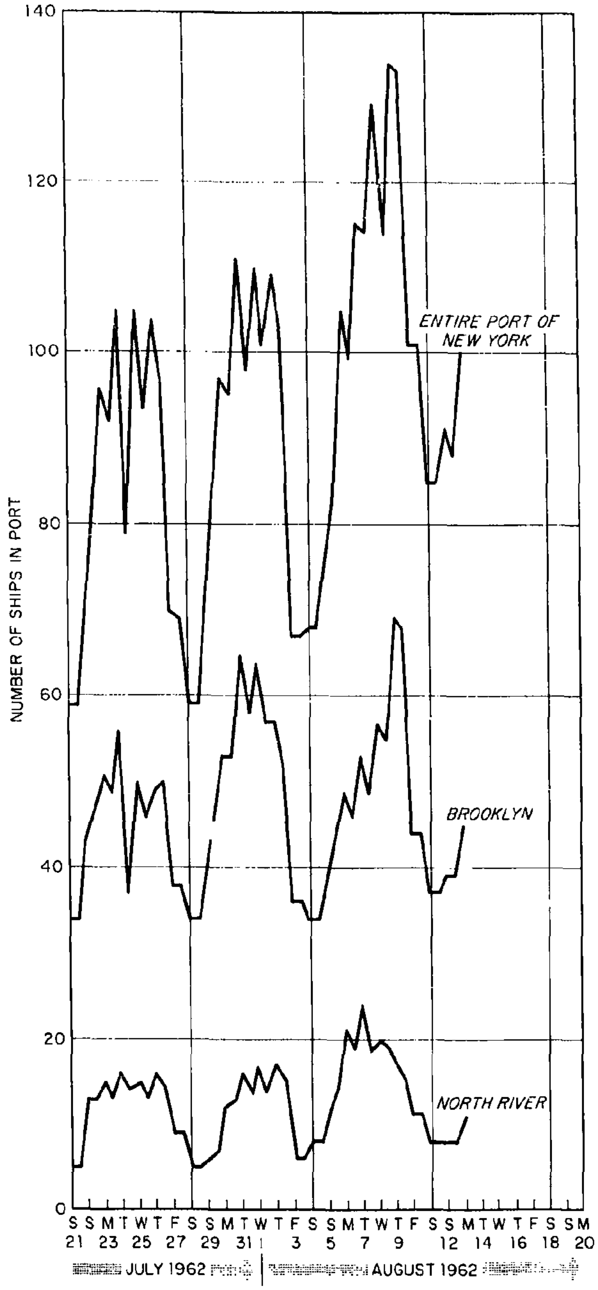


Fig. 7 Daily Totals of All Ships (Except Tankers) in the Port of New York Based on Data Obtained from The Journal of Commerce and Commercial

SECTION 3

CIVIL DEFENSE USE OF SHIPS AND BOATS BY VESSEL TYPES

3.1 GENERAL

Ships can be broadly classed as either active, meaning that they are in service and carrying cargo from port to port, or inactive, meaning that the ships are inoperable and decommissioned in a reserve or "mothball" fleet. Both active and inactive ships can, in turn, be categorized by vessel types--passenger or troop ships, general cargo ships, tankers, small boats, and naval ships. In this section, the civil defense potential of each specific type of vessel is discussed separately within the two broad categories: active and inactive.

Civil defense use of ships and boats can be broadly classified according to the following six life-saving and life-sustaining functions: (1) "as is" shelters--used as fallout shelters without any modification, but providing additional stocks of food and water; (2) evacuation--used to transport people from a target area to a less hazardous location; (3) converted shelters--modified prior to attack to improve their shelter potential; (4) civil defense headquarters or hospitals--making limited prior provisions for such use; (5) floating warehouses--used to store food, equipment, water, fuel, etc., prior to attack without subverting the basic mission of the vessel; and (6) floating utilities--used to provide electrical power and potable water to shore installations with either the existing shipboard equipment or added equipment.

The remainder of this section discusses evaluations of the potential civil defense uses for each ship type. Table 5 summarizes the several combinations possible and indicates the probable usefulness of each combination. Starting with 3.2.2, Table 5 should be used as a guide by the reader.

3.2 ACTIVE SHIPS

3.2.1 Port Operation, Emergency Evacuation, and Ship Availability

This section of the study is concerned with ships in port that

Table 5 Civil Defense Utilization of Maritime and Naval Ships

POTENTIAL USE	ACTIVE VESSELS				INACTIVE VESSELS					
					NATIONAL DEFENSE RESERVE FLEET					NAVAL RESERVE FLEET
					SURPLUS					
	PASSENGER	GENERAL CARGO	TANKER	SMALL BOATS	LIBERTY	S-4	GENERAL CARGO	TROOP and HOSPITAL	TANKER	
"AS IS" SHELTER and/or EVACUATION	○	▲	●	▲	●	▲	●	▲	●	○
CONVERTED SHELTER	●	●	●	○	★	▲	●	▲	●	●
CD HEADQUARTERS CD HOSPITAL	○	▲	●	●	★	▲	●	▲	●	▲
STORAGE (FOOD, EQUIPMENT, WATER, FUEL, etc.)	▲	▲	○	●	○	●	▲	●	○	▲
FLOATING UTILITY (WATER PURIFICATION, POWER GENERATION)	○	▲	○	●	★	○	●	▲	○	▲

Legend: Ship potential for various CD uses.

○ *PROMISING*
▲ *POSSIBLE*
● *HIGHLY IMPROBABLE*
★ *PROMISING AFTER MAJOR SHIP MODIFICATION*

might be used for civil defense purposes. Since the majority of such ships would normally be under foreign flags, there is some doubt of their availability in time of crisis. However, we have made the simplifying assumption that all ships and boats in port would be available for emergency use. Ships and boats are generally classified according to net tonnage, an ambiguous term since 1 net ton is actually defined as 100 cu ft of cargo-carrying capacity; however, for our analysis, this definition of capacity was used. We have no good information on the distribution of ships according to capacity, but the data in Table 6, derived from Ref. 1, are considered good approximations. The relatively few ocean-going ships account for most of the capacity. Boats, although numerous, have limited total capacity.

Table 6

CATEGORY	SIZE RANGE	PERCENT BY NUMBER	PERCENT BY CAPACITY
Ocean-going	1000-80,000 tons	1	84
Inland	5-1000 tons	7	15
Boats	16-28 ft	92	1
	TOTAL	512,000	19,000,000 tons of 100 cu ft

Quantitative analysis has been devoted primarily to ocean-going vessels because of their overwhelming importance on a capacity basis and their more desirable characteristics for civil defense use.

Port Operation

Ports, which in a metropolitan area may include many separate facilities (see Fig. 6 for example), are extremely complex operations. The piers likewise, and supporting functions, such as tugs, barges, and elevators, may be publicly or privately owned and operated. Ships using the port are under private ownership and may be under almost any flag. Yet superimposed upon this complex situation is the Captain of the Port, a Coast Guard official, who in peacetime holds almost complete control of ship movement into and out of the port. The Coast Guard is concerned also with ship safety, security of the port (a function of interest also to the Maritime Administration), welfare of seamen, etc. A quasi-official organization, the American Bureau of

Shipping (ABS), representing the shipping industry and insurance brokers, determines the seaworthiness of a ship and its crew. The Coast Guard and the ABS controls on passenger traffic are very rigid and preclude the use of ships in any other than a prescribed manner. However, in the event of hostilities the U.S. merchant fleet, including vessels under foreign flags of convenience, would come under the control of the Maritime Administration, which would become responsible for their utilization.

Emergency Evacuation of Active Ships From a Port

Each U.S. port has a port dispersal plan, prepared by the Coast Guard, that delineates what action is to be taken in the event of a yellow alert or other suitable warning. All known incoming ships would be alerted to remain at sea, and all ships in port that could readily be moved would be dispersed out to sea as rapidly as possible. These dispersal plans are designed to save the ships; any effort to superimpose a lifesaving mission on these plans would require a complete evaluation of the relative importance of ship saving and lifesaving. These aims are not necessarily incompatible, but difficulties can be foreseen. For example, if a ship could be ready to put to sea within 2 hr after an alert, but people were still loading, which mission would have priority: ship saving or life saving? In this report, we can only point out that these difficulties do exist; we have assumed for our analysis that the civil defense function of lifesaving has the higher priority.

Ships, after reaching the comparative safety of the open seas, would be directed, probably by the Navy, to rendezvous at some designated location or at a "safe harbor" (a port or location that had been deemed to be far enough removed from probable targets to be safe from direct or indirect weapon effects). At this time, the Office of Emergency Transportation of the Department of Commerce would serve as a utilization czar, using the framework of the MARAD, for all American ships, including those flying foreign flags of convenience.[7] Claimant agencies, which include the OCD, would make their requirements known to MARAD and, if approved, would receive a use order for the necessary vessel(s). The Navy would then become responsible for the movement of the vessels to their assigned stations. Presumably, civil defense requirements would receive high priority; however, if probable requirements could be agreed upon before an emergency arises, better and more expeditious utilization for civil defense functions might result.

Ships in port for loading or unloading always maintain a standby crew that provides security and mans the engineroom to provide the necessary power for ship operations. Theoretically the standby crew could, if necessary, man the ship and take it to sea; actually they would almost always be assisted by off-duty crewmen on board or by crew members who returned to the ship upon suitable notification.

Motorships powered by diesel engines are widely used by many foreign lines, and can become operational almost at the flick of a switch; motorships might be able to be seabound in less than an hour after a warning. Steamships are widely used by American lines and on all larger ships. In port, only one boiler is normally fired; this boiler could provide sufficient power to "limp" out of port, but additional boilers would have to be activated for normal steaming operations. Most steamships could be underway within 2 hours, although at reduced speed, but some might require considerably longer times. If a ship were loading cargo or fuel, additional time might be required.

Since the number of tugs in a port is small in relation to the number of ships, it might be necessary for many ships to move out under their own power; this could be done, with some risk, by most smaller ships. Pilots, too, could be in short supply, but again most captains are competent to pilot their vessels, particularly if they are following other ships. Normally, no unsurmountable traffic problems would be anticipated in the dispersal of many ships to sea; however, movement at nighttime or in foul weather would increase the probability of collision between ships, or of a ship going aground.

A ship suddenly ordered to sea might be in any state of readiness. It may have just refueled and taken on supplies so that it might be well prepared for a prolonged trip or, it might have just arrived from a long voyage and have little fuel and few supplies left. In the latter case, however, it would undoubtedly have enough fuel left to carry it out to sea where, if necessary, it could sit "dead" until it was refueled. Food and water for the crew would probably never be completely depleted by the end of a voyage. Thus, under most circumstances, ships could be dispersed to sea within a few hours after notification to move.

<u>Availability and Accessibility of Active Ships</u>

Subsection 2.3 and Appendix D discuss in some detail the availability of ships in the ports of New York and San Francisco. Generalizing from these data it becomes apparent that ships do not represent firm shelter spaces* because the number and types of ships in a given port will vary greatly from day to day making prediction of available space unreliable. Further, the pattern of the location of ships within

*Firm shelter spaces are those that can be counted upon in all circumstances.

the port can vary considerably. These variations suggest that ships should be considered for use only as shelters for persons working on or about the ship or for those in the immediate vicinity. Because waterfronts are generally in industrialized areas of low population density, it is unlikely that the indigenous population would overwhelm the available space on ships. However, if people from the nearby residential or business districts descended on the ships, the capacity of ships in port would be totally inadequate. In Appendix C, an analysis was made of the time required for all segments of the population of San Francisco to reach a waterfront "loading area" by foot. It was found that 1 hour after warning, 86% of the daytime or 63% of the San Francisco nighttime population would have reached a loading area. If we limit the evacuees only to those who work in the section of the city adjacent to the active piers, we still find that with a 1-hr warning, 47% (430,000 persons) of the daytime population or 17% (130,000 persons) of the nighttime population would reach the 10 to 20 ships that might be in port. The large difference between the daytime and nighttime figures is due to an assumed slower response time at night and to the redistribution of the population in nonworking hours.

The situation might not be much different in most other port cities, since industrial waterfronts are often flanked by high-density residential areas. We cannot make categorical statements, however, because we have not studied such cities as New Orleans where there is a long, accessible waterfront and a population small in comparison to the average shipping capacity in the port.

If ships were to be used for sheltering persons in numbers much in excess of their normal crew complement, provisions would have to be made for supplemental food and water stores. Such supplies would logically be stored on or near frequently used piers where, in the event of need, the evacuees could carry individual rations aboard whichever ship was in port at the time of the alert.

3.2.2 Passenger Ships

Passenger ships range from the passenger-cargo type which may carry as few as 13 passengers, to the giant liners, such as the UNITED STATES, which carry a complement of 3100 passengers and crew (see Table 7). Ships which carry fewer than 100 passengers will be considered under general cargo ships. The giant liners, although of large capacity individually, are few in number and the ports at which they call are restricted to one or two in the nation. The medium-size liners in the 15,000 to 25,000 gross-ton range are of most interest for civil defense applications because they call in many U.S. ports and are more numerous.

Table 7

Some Characteristics of Several Types of Merchant Ships

Type	Name	Dimensions			Tonnage (100 cu ft)		Complement	
		Length (Ft)	Breadth (Ft)	Depth (Ft)	Gross	Net	Passengers	Crew
Passenger	QUEEN ELIZABETH	987	119	68	83,000 (est.)	50,000 (est.)	2300	1200
Passenger	UNITED STATES	917	102	39	53,300	28,600	2000	1100
Passenger	INDEPENDENCE	638	89	38	23,800	11,200	1000	575
Passenger	PRESIDENT WILSON	573	76	29	15,500	7,780	760	340
Passenger-Cargo	SANTA BARBARA	441	63	37	8,360	4,920	52	83
Cargo	Liberty	418	57	37	7,200	4,380	--	40
Cargo	Victory	436	62	38	7,600	4,550	--	48
Cargo	Mariner	530	76	31	12,600	7,500	12	57

The total number of ocean-going passenger ships of U.S. flag in service is about 20. This number, of course, does not represent the total number of passenger vessels of all flags that might be in all the ports of the nation at a given time; however, it is probable that the number would be of this order, that is, 10 to 30. Let us consider now what the possible usefulness of passenger vessels is in various civil defense applications (cf. Table 5).

"As Is" Shelters and Evacuation. Since passenger vessels are designed to house people for extended periods, the basic question is not "How?" but "How many?". The QUEEN ELIZABETH, which carries a total complement of 3500 in normal service, was converted during World War II to transport 20,000 troops; however, this increase in capacity by a factor of 6 was accomplished only with considerable modification of her interior. Callahan[1] et al, using data based on evacuation of refugees, estimated that a ship can carry 1 person per net ton of capacity for periods of up to 2 wk; at this rate the QUEEN ELIZABETH could carry about 50,000 occupants. In a well-documented case in the evacuation of Pusan, Korea, during the Korean conflict, a Victory ship carried 14,000 Koreans, landing them 24 hr later at a safe harbor. Feeding was not attempted, conditions were primitive, and sanitation was indecorous. It is said that even today this ship can be recognized by the lingering odor. An apocryphal story also adds that, shortly after this incident, the captain retired from the sea to enter a monastery.

It would be safe to assume that for evacuation purposes a passenger liner could carry up to 6 times its normal complement if food and water supplies were adequate. The only way to ensure adequate food supplies for such overcapacity would be to stock civil defense type dry rations near the boarding area and have each evacuee carry his own rations aboard. This arrangement would present no hardship since a 2-wk supply of survival biscuits for one person could be containerized in a volume of less than 1 cu ft, and would weigh about 20 lb. Water should present no problem, since modern passenger vessels maintain appreciable stored water supplies using their own distillation equipment (Table 8 gives some actual capacities). By reducing the water consumption to 0.5 gal/day/person, the stored supplies would be ample.

If 6 times the normal complement were aboard a ship, bunking space would be inadequate even using 3 sleeping shifts per 24 hr (so-called "hot bunking"). The deficiency could be met either by bedding people down in the public rooms on furniture, the floor, or on previously stocked emergency bedding. A 2-wk stay under such conditions would not be pleasant but it would be survival.

Table 8

Storage and Utility Data for Three Types of Passenger Vessels[a]

	PRESIDENT WILSON	PRESIDENT ROOSEVELT	INDEPENDENCE
Full load draft, ft.	31	25	30
Total fuel oil capacity, gal.	1,200,000	850,000	2,260,000
Potable water capacity, (normal) gal.	100,000	78,000	200,000
Total potential water capacity, gal.	390,000	160,000	285,000
Total water distillation capacity, gal/day.	182,000	121,500	240,000
Fuel consumption gal/day.[c]	4,500	6,400	12,600
Maximum excess electric power available for shore use, kw.	15,000[b]	1,700 (dc)	4,000
Fuel consumption gal/day.[c]	41,500	8,800	17,600
Number of vessels of type in service	2	1	2

[a]From Appendix G.

[b]Primarily from turboelectric propulsion generators.

[c]Assumes main propulsion generator is in partial or full service.

Complications arise when a fallout situation is superimposed on the evacuation scheme. It is improbable that the loaded ship would remain in a port anticipating attack, but the ship might be caught in fallout on its way to sea or even at some distance at sea. If this occurred, much of the space allocated to housing persons, particularly in the superstructure, would be unsafe for personnel until after the fallout had ceased and decontamination had been accomplished. Figure 8 shows the shielding factors at three locations along the midline of the SS INDEPENDENCE. Using as a conservative value a reduction factor of 0.02, Figure 3 shows the distances downwind from a 5-MT land-surface burst at which occupants would receive a given radiation dose. As an example, for the idealized wind structure and 100% fission yield assumed, the occupants of the ship would theoretically receive 200 r by the end of 1 year at a downwind distance of 40 mi. Actually, the dose received would not be this high, since the real wind structures would tend to disperse the fallout more widely, lowering the peak intensities. Account must also be taken of the fact that the fission yield of the weapon employed would probably be less than 100%. Thus, if the weapon were assumed to have only a 50% fission yield, the doses would be reduced by a factor of 2.

In an impending attack situation it would be difficult to predict the time of fallout occurrence and the amount of fallout likely to be encountered but if such a situation seemed probable, the following precautions should be taken:

1. All evacuees should be crowded into the better protected spaces on the ship for the few hours fallout might be anticipated.

2. The washdown system, if the ship is so equipped, should be readied; the ventilation system should be prepared for shutdown.

3. The watch on the bridge should be prepared to "lay to" on very short notice, descend to protected spaces below if fallout occurs, and remain there until such time as it is safe to resume steaming operations from the bridge.

Once the ship has reached the safety of the open sea, it will come under the control of a cognizant agency that will either direct it to a safe harbor or otherwise see to the disposition of the ship and its occupants.

No census was attempted of the number of inland or intracoastal passenger steamers that are normally used for pleasure and entertainment purposes. Such vessels are widely distributed and undoubtedly represent an appreciable passenger capacity. In addition, they are

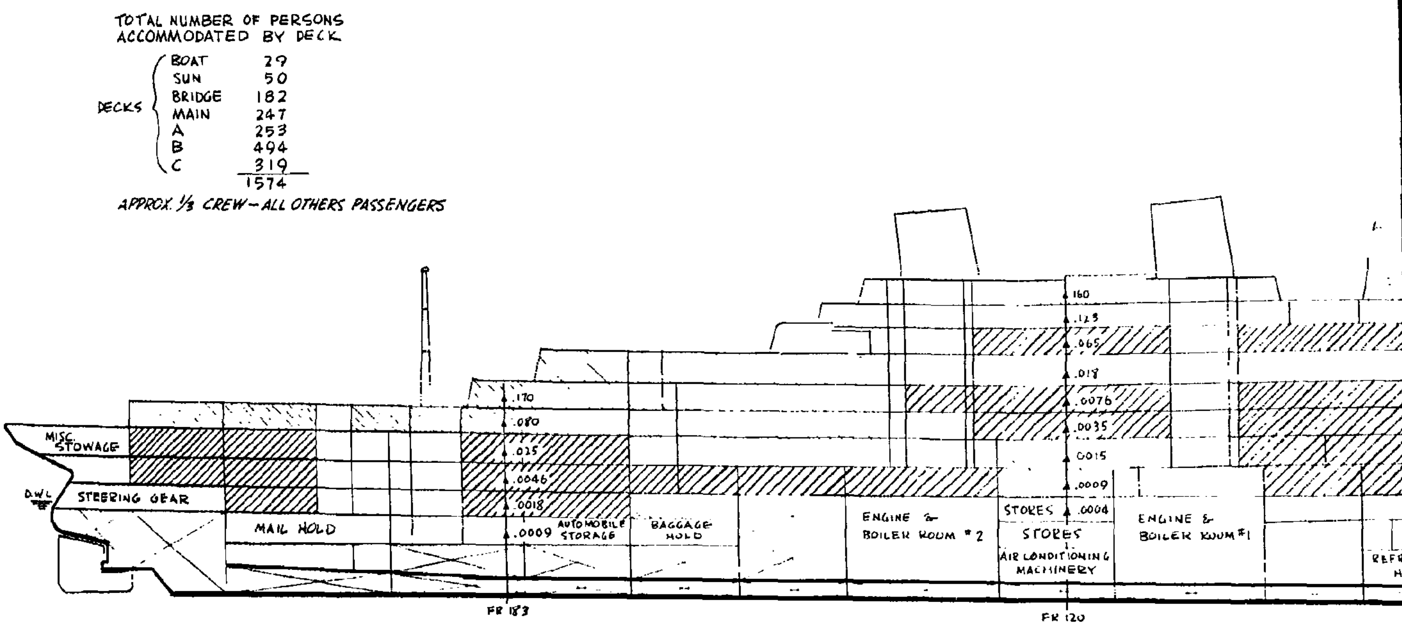
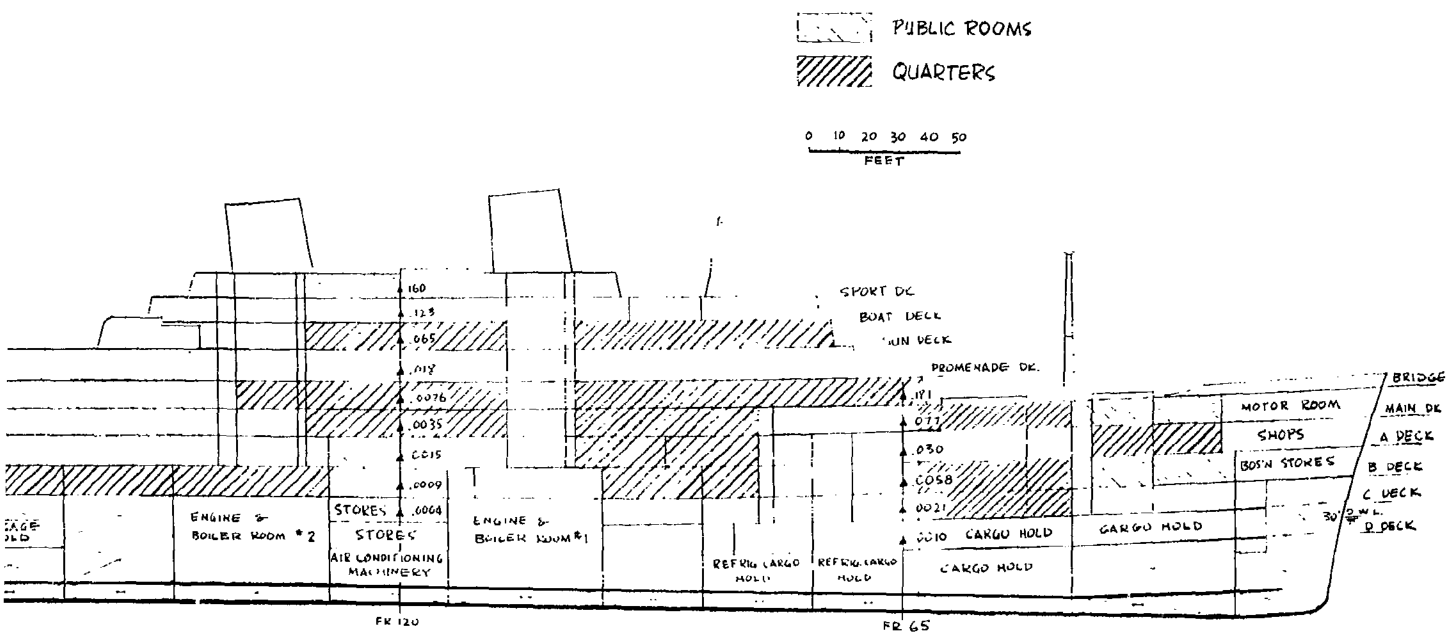


Fig. 8 Perspective View of the SS INDEPENDENCE Showing Depo
Reduction Factors at Various Points

(Reduction factors were obtained by the method described



spective View of the SS INDEPENDENCE Showing Deposit Radiation
actors at Various Points

ion factors were obtained by the method described in App. B)

2

normally stationed in port for as long as the port is open, at least 7 or 8 months out of the year. They do have decided shortcomings, however, including:

1. They generally have no overnight accommodations and are not equipped to handle a crowd for more than a few hours.

2. They are of light construction and would offer essentially no protection against fallout.

3. They are limited in the amount of maneuvering they could undertake to evade fallout.

In summary, such pleasure steamers could be used to evacuate persons from probable target areas, but only with considerable risk to the evacuees from subsequent fallout; and, the evacuees might be stranded and starved on the ill-prepared steamers.

Converted Shelters. Since passenger ships do not represent firm shelter spaces, no consideration should be given to spending additional effort and money in converting them into shelters. At best they are expedient shelters.

Civil Defense Headquarters or Hospitals. Passenger ships that survived the attack phase of a nuclear attack could serve as mobile platforms from which a variety of life-sustaining civil defense functions could be performed. A ship, preferably one not loaded with evacuees, could be moved to the very edge of population centers to serve a variety of needs. It is unlikely that ship movement would be impeded for any length of time by debris in the channel. For example, if the Golden Gate Bridge in San Francisco were to collapse, it would fall into 200 ft of water; any structural members extending into the channel could probably be disposed of in short order by demolition experts.

Because piers are hard targets, it is likely that ships could be moved in and moored at the edge of areas of heavy blast damage, coincidentally probable centers of high need. The ships could take advantage of the inherent shielding of the water, although decontamination of piers and adjacent land areas would be necessary. Once tied up at a dock, or even moored offshore but accessible by small craft, ships could function as headquarters for recovery operations, clearing houses for displaced persons, etc.

Ships tied up at a dock could use their own limited hospital facilities for handling the injured, but unless additional hospital supplies were available, the scale of operation would have to be very limited. If Public Health Service civil defense hospital units were available, they might be adaptable to shipboard erection, using the many large public rooms.

The ship, if supplied with fuel, could furnish most or all of the requirements a field hospital would demand. No attempt has been made to quantify the compatibility of a civil defense field hospital and a ship, since this effort falls under the purview of the Department of Health, Education and Welfare[3]; but it does appear that plans for passenger ship utilization for hospital purposes might well be further evaluated.

Floating Storage. Passenger ships do not represent any excess storage capability, since they are designed to be self-sufficient little cities. However, those stores they normally carry for their own consumption could, in time of emergency, be rationed to provide for many more persons than originally intended. The stored water on a liner such as the SS INDEPENDENCE could, for example, be rationed at the rate of 0.5 gal/day/person, serving 30,000 people for 14 days. Here again, though, passenger vessels should not be considered as firm sources of supplies, since, even if present in a port, they might be low on stores. The fuel that a ship carries is generally adequate only for its own continued activity; furthermore, such fuel is of a quality generally unusable in shoreside power plants. Table 8 and Table I, Appendix G, give further details of passenger vessel storage capacity.

Floating Utilities. In an emergency, passenger vessels would be excellent sources of potable water and might be good sources of electric power. All three of the liners shown in Table 8 can produce large amounts of potable water each day in their evaporators with the expenditure of relatively small amounts of fuel. The potential of a ship, such as the SS INDEPENDENCE, for supplying the potable water needs of a refugee population is indeed significant. At the minimum ration of 0.5 gal/day per person, approximately one-half million people could be sustained. The use of shallow-draft tankers or barges for distribution would, in addition, appreciably increase the potential area of coverage.

The excess electrical power available for shore use varies from the virtually useless direct current (1700 kw) of the PRESIDENT ROOSEVELT to the entire alternating current output of the PRESIDENT WILSON (15,000 kw). The SS INDEPENDENCE, a more typical case, could supply 4000 kw, ac. Although this amount may sound quite impressive, it must be brought into perspective. Consolidated Edison Company, which serves New York City, has generating capacity of roughly

5,000,000 kw. If, in an emergency, it were possible to cut the demand back to only 1% of this value and somehow distribute it where needed, 50,000 kw would still be required. This amount is far in excess of the power available from a ship. Further, complications arise when considering the distribution of power from a ship; the ship generates power at 450 v. which must be increased through suitable transformers to match the line voltage of the system, usually 12,000 v. However, it is true that communities have depended from time to time on ship-generated power using temporary connections, and it might be feasible to so serve critical functions in a widespread disaster area. It would appear more practicable though, to limit the distribution of the power from a ship to some small nearby sector so that elaborate transformers and connections would not be required.

The problem of transferring the power from the ship to shore is slight if the ship is docked at a modern pier that has provisions for the interchange of power. In other situations, particularly if the ship is moored more than 200 feet from shore, the hookup will be considerably complicated. For these longer distances, underwater cable would be the only possible hookup. The installation of such cable would not be a simple task even if a special boat were available.

The fuel requirements for power generation are relatively low and represent quite efficient utilization of available fuel. A shoreside steam plant produces, on the average, 500 kwhr per barrel of fuel oil;[8] the rates for the WILSON and INDEPENDENCE are 375 and 250, respectively.

3.2.3 General Cargo Ships

General cargo ships, commonly called freighters, constitute the major portion of the traffic in most ports. Freighters may have five or more separate holds, some of which may be refrigerated space ("reefers"); they are generally adaptable to carrying a variety of cargos. The net tonnage (a measure of volume) of such ships may vary from 1000 tons for some of the very small foreign ships up to 7500 tons for the Mariner, the newest class cargo vessel in the American fleet. Freighters can legally carry up to 12 passengers, and many do so. Specialized ships may also be found in most ports and predominate in some ports. Such ships are built to carry only one type of cargo (iron ore, coal, bananas, automobiles, etc.). The bulk material carriers, because of their design and utilization, appear to have little or no civil defense usefulness; the others will be grouped and discussed with general cargo ships. Pertinent data on several classes of cargo ships are given in Table 9.

The number of general cargo freighters in a port will fluctuate

Table 9

Selected Data for Several Classes of General Cargo Vessels[a]

Item	Victory	C3 (old)	C3 (1960)	Mariner (1960)	Mariner (1960)
Length, ft.	455	492	492	563	563
Breadth, ft.	62	67.5	73	76	76
Depth, ft.	38	42.5	42	44.5	44.5
Full load draft, ft.	28.5	28.5	28	30	31.5
Cargo capacity, tons (2240 lb)	7436	9690	10,700	13,000	12,000
Total fuel oil capacity, gal.	800,000	450,000	750,000	850,000	770,000
Potable water capacity (normal), gal.	31,500	23,000	20,000	67,000	15,000
Total potential water capacity, gal.	117,000	675,000	490,000	320,000	775,000
Total water distillation capacity, gal/day	10,800	11,100	14,000	24,000	13,000
Fuel consumption, gal/day	1200	1230	730	1260	680

Table 9 continues

Table 9 (cont.)

Selected Data for Several Classes of General Cargo Vessels[a]

Item	Victory	C3 (old)	C3 (1960)	Mariner (1960)	Mariner (1960)
Maximum excess electric power available for shore use, kw.	300 (dc)	400 (dc)	800	800	800-2100
Fuel consumption, gal/day	2400	3000	4850	4850	4850-10,000
Number of vessels of class in service.	--	--	40	32	30

[a]From Appendix G.

considerably, as shown in Appendix D, Fig. D.3. Further, the type and amount of cargo on a ship might be a limiting factor for civil defense usage. Thus, freighters cannot be predicated for any firm civil defense usage; however a previously formulated plan could ensure that such potential as they do possess would be utilized.

"As Is" Shelters and Evacuation. A freighter has accommodations for about 50 crew members and, often, for 12 passengers. Even utilizing hot bunking and available space in the few public rooms, a typical freighter would be unable to house more than 300 or 400 evacuees, and that with considerable discomfort. Moreover, all living spaces are either in the superstructure or just below the main deck and offer practically no shielding from fallout. For these reasons, it would appear logical to limit the lifesaving utilization of freighters to crew members and to any laborers working on the ship at the time of the alert.

In certain circumstances and locations, the use of freighters for local evacuation might be considered. In this case, evacuees might fill to capacity the main deck and 'tween-decks spaces that are cargo-free. A ship of the C3 class might be able to transport 10,000 persons short distances. In a port such as New Orleans, a ship loaded to capacity could steam upstream or downstream some 50 or 100 miles and land the evacuees in some safer area. Hopefully, the evacuation route would evade any fallout, since the ship itself would provide little shielding (see Fig. 9). After discharging the evacuees, the ship could continue to a designated safe harbor for assignment.

If the ship is about to be, or is caught in, fallout, the crew can drop anchor, secure the main engines, cut out the unnecessary boilers, button up the weather envelope, and go below to the engine room and shaft alley for the duration of fallout.

Converted Shelters. Any effort to modify cargo ships for passenger carrying service would subvert their basic assignment. Such a conversion is deemed unacceptable.

Civil-Defense Headquarters or Hospitals. The large spaces in the 'tween decks of freighters might have usefulness in some civil defense applications. For example, with suitable lighting and improvised access ladders, such spaces could be turned into large offices, monitoring headquarters, etc. However freighters, especially older ones, have limited electrical generating capacity so that the number of activities that could be headquartered on a ship might be limited. Improvised sanitary facilities would also have to be provided.

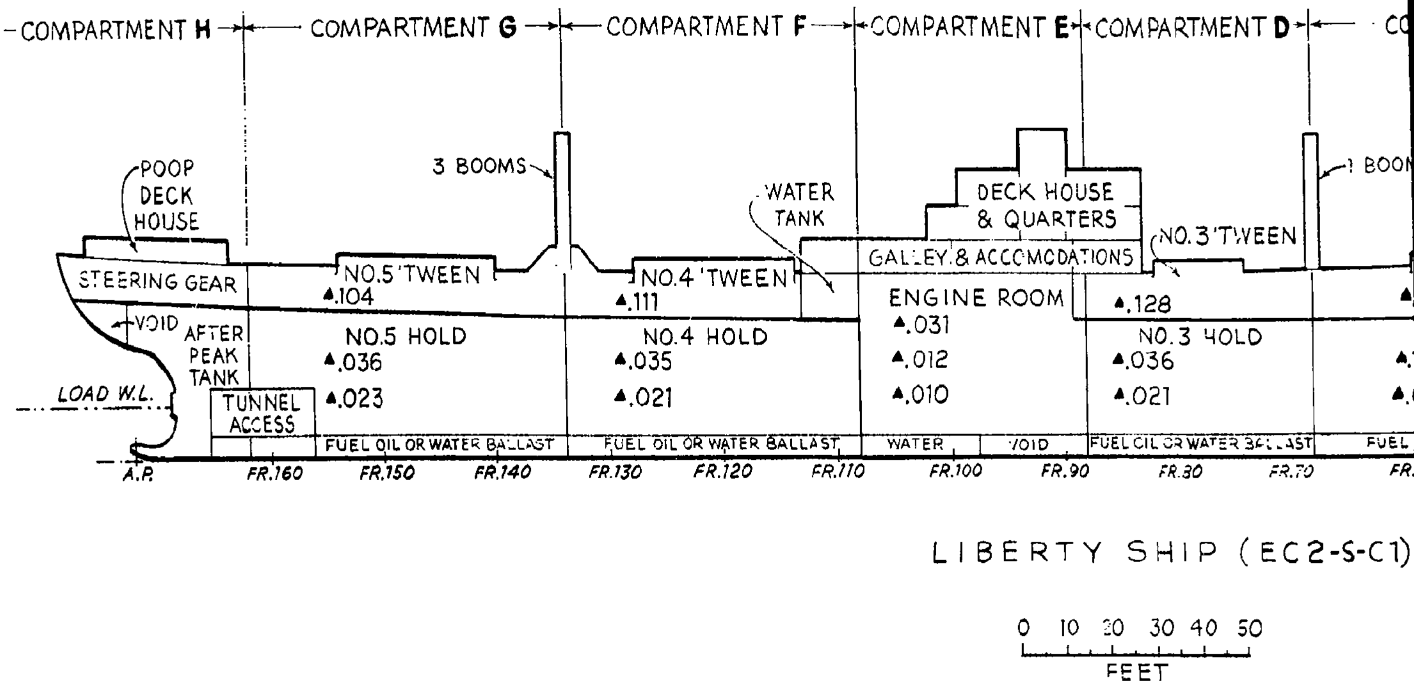


Fig. 9 Inboard Profile of an Unmodified Liberty Ship Show
Reduction Factors for Deposit Radiation at Various Points

(Reduction factors were obtained by the method describ

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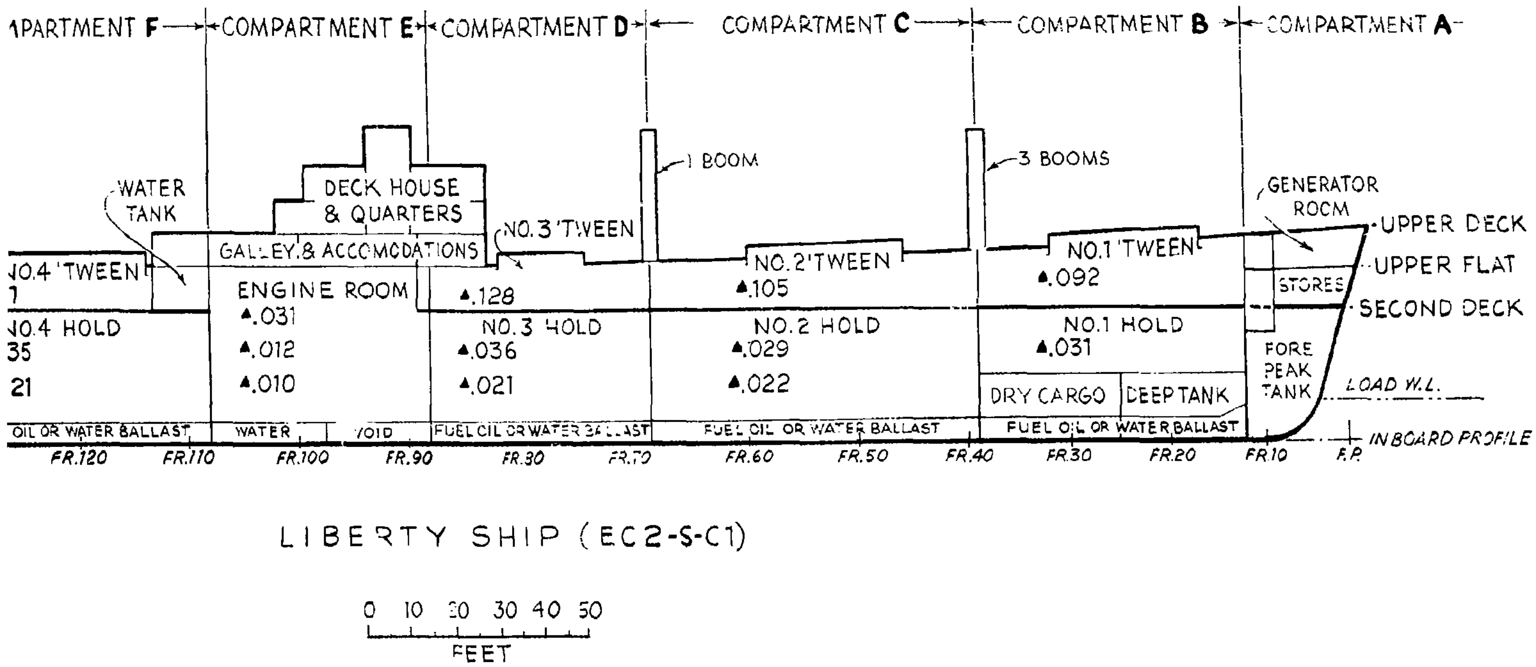


Inboard Profile of an Unmodified Liberty Ship Showing Radiation
on Factors for Deposit Radiation at Various Points

luction factors were obtained by the method described in App. B)

2

If no suitable buildings survived the airblast and fire, a civil defense field hospital might be installed in the large open spaces available in the 'tween decks spaces. Most freighters would have the necessary utilities for the functioning of such a hospital.

Floating Storage. The cargo a freighter carried at the time of attack might represent a real asset to national survival in the post-attack period. Consequently, the cargo of each vessel should be documented as soon as it arrives at a safe harbor and the resulting tabulation used to employ any useful materials in the best interest of the nation. Such disposition would involve agreement between MARAD, the military, OCD, and, if feasible, the owners of the cargo. In toto, such cargo could represent a significant lifesaving capability, and preplanning should be instigated to ensure that this potential is not overlooked in the event of attack.

Freighters do not carry quantities of fuel and water much in excess of their own requirements and are not deemed sources of these commodities. However, stores could be rationed to serve a much larger population than that of a ship's crew. Certain classes of ships have appreciable tank capacity--normally used for transporting edible oils, etc.--that could be converted for storage or transportation of water. However, the converted tankers would probably be useful in civil defense only in a secondary role.

Floating Utilities. It can be seen from Table 9 that the newer cargo ships have a definite capability to provide both water and electric power to shore points. However, the quantities are insufficient to suggest this capability as a primary use for cargo ships. Moreover, if these ships were used for hospitals, headquarters, etc., available utilities would be fully used. The older cargo ships and most foreign ships, produce either dc power, which is unusable at most shore installations, or else insufficient power. The relatively small evaporator capacity coupled with the large storage capacity suggests that tanks might be filled while the ship cruised at sea, and the potable water transferred to shore installations upon arriving in port.

3.2.4 Tankers

Tankers range in size from the supertankers capable of carrying some 800,000 barrels of oil, down to the now obsolescent T2's of World War II, with a capacity of about 150,000 barrels. In many ports, tankers represent about a quarter of the total traffic. These ocean-going tankers are supplemented by a number of shallow-draft smaller vessels for intracoastal or inland use, many of which are non-self-propelled, for instance, barges, which must be towed. Most tankers carry only crude or refined petroleum products, although specialized tankers, which can carry ammonia, molasses, edible oil, wine, etc., are in service. Tankers, because of their excessive draft (some have a 50-ft draft), often anchor in midchannel and unload through pipelines or by lighters to shore. A tanker can unload its three or four major products simultaneously and in a matter of a few hours.

"As Is" Shelters and Evacuation. Tankers carry 40 to 50 crew members, and some have space for up to the legal limit of 12 passengers. Aside from these spaces, however, there is hardly even "standing room" aboard for possible evacuees. Tankers are designed to ride low in the water; consequently, the deck is often awash on a fully loaded tanker in moderately gentle seas. An open raised catwalk allows crewmen to get from one end of the ship to the other when necessary. Such a design obviously precludes using tankers for even the most elementary evacuation purposes. At best, a tanker could accommodate its crew plus the various workers who might be employed at the terminal. The lowest level in the engineroom would be the only possible shelter space in the ship; however, because of the placement of the engines in the stern of the ship, the degree of shielding obtainable there might be mediocre.

Converted Shelters; Civil Defense Headquarters. Tankers have little or no civil defense potential as converted shelters, headquarters, etc.

Floating Storage. Petroleum and petroleum products constitute about 40% of the total tonnage of waterborne commerce (Table 4). This tonnage also represents a stored reserve that would be available after the attack, except for those tankers damaged or destroyed by the direct weapon effects. Prompt evacuation of tankers from ports and diversion of those at sea to safe harbors would act to save these important ships and their equally important cargo. However, about one-third of this potential reserve (Table 10) would be on smaller domestic-internal vessels or barges, and unless preplanning is thorough, many of these vessels might be caught in areas of heavy physical damage.

Definite problems may arise in selecting the best utilization of petroleum reserves that have survived the attack. Refined products (gasoline, diesel, etc.) would have only to be allocated and dispersed for use. The residual fuels (Bunker C, etc.) are generally usable only in large stationary or marine engines so that allocation and distribution would be the only concern. Crude oil, which accounts for about one-third of the potential shipborne reserve, could be delivered to a refinery for processing. What is to be done, however, if the refinery is damaged by the attack? The crude oil could either be stored

Table 10

Waterborne Movement of Petroleum Products for Calendar Year 1960

(Net traffic in 1000's of tons of 2,000 pounds)

Movement \ Type	Crude Oil[b]	Refined Products[c]	Residuals[d]	Total
Foreign[a]	68,363	11,028	42,345	289,452
Domestic-Coastwise	39,175	106,488	22,053	
Domestic-Internal	34,962	83,645	31,106	149,713
Total	142,500	201,161	95,504	

[a]Predominately imports.

[b]Commodity code 511.

[c]Commodity codes 507,510,512,513,518,519,520, and 522.

[d]Commodity codes 514 and 516; most could be used to fire stationary or marine engines.

Source: Table 2 of Ref. 16.

in available space, transported to another refinery that could utilize the particular grade of crude,* or used unrefined to fuel large stationary or marine engines. For life-sustaining operations, this latter use might be very valuable, since crude oil could be burned directly to provide steam, electricity, and water during the early recovery phase. Decisions for such use would depend on the immediate situation, but guidelines should be developed and promulgated.

The use of general-purpose tankers for the movement of water supplies into destitute areas does not hold much merit. First, the ships have an important mission in hauling petroleum products and second, the tanks, even if carefully cleaned, would probably contaminate any water subsequently carried. Only if special coatings were applied to the walls of the tanks could the potability of the delivered water be assured. However, certain tankers now in commercial service would seem to be nearly ideal for water carrying service. The ANGELO PETRI, for example, is a modified T-2 tanker fitted with stainless steel cargo tanks throughout, with a total capacity of 2,500,000 gallons. This ship, which normally carries wine and other edible products, could transport sufficient water to maintain a substantial population.

Floating Utilities. Tankers have limited usefulness as sources of potable water both because their evaporator units are quite small and because these units are of the relatively inefficient single-pass type. However, this capacity might be used as an adjunct to the primary mission. For example, a tanker while crossing the Pacific with a load of petroleum products could be using its excess evaporator capacity to fill 2 or 3 (of its 40) tanks that had been converted for water storage. Also, a tanker used primarily for power generation in port could simultaneously produce potable water.

The auxiliary generating capacity of the larger, modern tankers, could produce appreciable power for use on shore. However, the T2 tankers of World War II vintage are driven by turbo-electric propulsion, which is so designed that the entire electrical output can be used shoreside. In the past, several T2's have had the misfortune to split in two; on occasion the stern containing the engines has been salvaged and beached, there to serve the electric needs of nearby communities for extended periods. No unusual problems, aside from the customary ship-to-shore hookup were encountered with such use of a T2. As can be seen from Table 11, a T2 fully loaded with fuel that could be used in its boilers (practically any petroleum product but gasoline) could run

*A crude oil is not necessarily usable in a nearby refinery, since refineries are designed around one type of crude.

Table 11

SELECTED DATA FOR SEVERAL CLASSES OF COMMERCIAL TANKERS[a]

Item	T-2	Post WW II Tankers		
		30 DWT[c]	45 DWT	60 DWT
Length, ft	533	661	725	825
Breadth, ft	68	90	100	110
Depth, ft	39	45	50	60
Full load draft, ft	30	34	36-38	42-46
Cargo capacity, tons (of 2240 lb)	15,640	32,000	45,000-50,000	60,000-80,000
Total fuel oil capacity (for ship operation), gal	620,000	850,000	1,670,000	1,670,000
Cargo capacity, fuel oil, gal (maximum)[b]	4,350,000	9,750,000	14,000,000	22,300,000
Potable water capacity (normal), gal	36,400	35,500	~ 30,000	~30,000
Total water distillation capacity, gal/day	7800	12,000	18,000	18,000
Fuel consumption, gal/day	870	1350	2000	2000
Maximum excess electric power available for shore use, kw	5400	600	1000	1000
Fuel consumption, gal/day	16,700	4000	5600	5600
No. of vessels of class in service	50	450	150	150

Table 11 continues

Table 11 (cont.)

[a]From Appendix G.

[g]Capacity would be very slightly less for water.

[c]Dead weight tons.

for almost 10 months as an isolated generating plant. Simultaneous use of the evaporator plant would have little effect on this time. This combination of power production and built-in fuel supply suggests that T2 tankers be allotted a high priority for postattack power generation and that the larger tankers be reserved for continued operation as fuel transports.

3.2.5 Small Vessels and Boats

Small vessels--those in the 5-ton to 1000-ton class--number perhaps 35,000 and are widely scattered throughout the nation. Most are used in inland or coastal commercial service although a few, including fishing boats and yachts, are routinely in service, at sea. Most of the vessels in inland or coastal commercial service, including barges, lighters, tugs, etc., do not appear to have significant civil defense usage except in their very necessary support functions. Ocean-going fishing boats and yachts, which represent only a small fraction of the class, are considered in connection with pleasure boats.

Pleasure boats--less than 5 tons--are estimated to number 4,500,000 for the country.[9] However, only about 12% (estimated 550,000) of these are designed to house four or more people for overnight or longer. Most of these boats are the inboard-engine type, and all are at least 16 ft in length.[10] Few of these larger boats are intended for, or ever given, service at sea. They are primarily for use in inland areas or sheltered coastal regions; civil defense utilization should recognize this limitation. Within these limits, though, these larger boats could well serve as supplemental, or even firm, shelter spaces for a widely scattered, but highly selective population.

What little shielding protection boats offer from fallout can be effectively increased by the installation of a simple washdown system. After the cessation of fallout, boats can take advantage of the shielding offered by anchoring off shore in the middle of a deep body of water. Figure 3 shows the radiation dose that might be received aboard a small boat at various downwind distances from a 5-MT land-surface burst. Even with a washdown system, it seems likely that occupants of a boat could receive a fatal radiation dose even 20 miles downwind from the point of burst. For this reason the mobility of the craft is of great importance. Prior evaluation of probable target areas could locate probable safe harbors for boats at reasonable distances from normal berths. Thus, in the face of an attack, boat owners could load their families and friends in their boat and head for the nearest safe harbor, laying to there for as long as necessary. Such a course of action would require prior preparation and might well include the installation of a washdown system to provide better protection from fallout. With sufficient provisions, a family group could live on a larger boat for 2 wk.

Certain negative factors may vitiate much of the value of larger boats as shelters; these include:

1. Inaccessibility of the boat to the owner at the time of alert or attack. Many people do not live close to the place at which their boat is docked.

2. Environmental conditions that prevent the use of the boat. Foul weather, frozen waters, or even the darkness of night may make movement of the boat impractical or impossible.

3. Excessive deposition of fallout on the boat even with the best planning and navigation.

4. Occurrence of piracy or other acts of lawlessness.

5. Damage of the boat by the attack.

The multitudinous smaller boats scattered throughout the nation could conceivably be used to ferry people from population centers to good shelters (perhaps caves) along adjacent waterways. However, the problems mentioned for the larger boats become compounded, and it appears probable that such a mass evacuation attempt might serve only to expose people needlessly.

Larger sea-going craft, which should also be equipped with a wash-down system, appear relatively promising as supplementary shelters. Fishing craft, for example, could sustain a number of people in addition to the crew and would be less subject to the negative factors outlined above. Such craft could also simultaneously fulfill their normal role of food suppliers.

Boats offer no usable capacity for headquarters, storage, or utility generation.

3.3 INACTIVE SHIPS

3.3.1 National Defense Reserve Fleets (NDRF)

Large numbers of U.S. ships, merchant and naval, are not currently in active service for several reasons. Some ships are always in shipyards undergoing major repair or modification, and would be unavailable in an emergency. Some merchant ships may be laid up in a dead state for extended periods because of economic and business factors; these ships could be made available with 1 or 2 day's notification providing operating crews were available. Most inactive ships, however, are to be found in two major reserve fleets: the National Defense Reserve Fleet (NDRF) under MARAD and the Naval Reserve Fleet under Bureau of Ships, U.S. Navy, Department of Defense. The former fleet is composed primarily of commercial-type vessels; the latter of naval ships. These two fleets will be discussed in detail in the next subsection.

The MARAD maintains 8 reserve fleets at those locations shown on Fig. 4. One of the largest fleets--and typical of many of the fleets--is the one located at Suisun Bay, about 40 miles northeast of San Francisco. An aerial view of this fleet is shown in the frontispiece. Table 12 indicates the diversity of the vessels found in the Suisun fleet. A considerable number of these ships belong to the Navy, which rents space from MARAD. This arrangement has been made because these particular Navy ships, mostly support types (personnel or cargo transports), do not require the relatively expensive mothball preservation the Navy uses on its fighting ships.

Let us consider now the modus operandi of a reserve fleet, such as the one at Suisun Bay. The site selected must be out of active shipping channels, yet accessible via them. The location must not intrude on commercial fishing waters. Sufficient depth must be available to float the ships. The bottom material must be suitable for anchoring, and tidal action cannot be too strong. The water cannot be too saline, or preservation becomes very difficult and expensive. Because of such requirements the reserve fleets usually are located in rather remote areas, which is normally satisfactory since only a small crew of maintenance personnel have occasion to regularly commute. The land approach to the Suisun fleet, for example, is a narrow, twisting two lane road that stretches over salt flats, ending at the headquarter ship. From there, the fleet is accessible by one of the four or five patrol boats or tugs that the custodial and maintenance personnel use. The roving patrols, which operate 24 hr a day to keep off sightseers, thieves, etc., and to check for any signs of ship leakage, make a round trip of the fleet in a little over an hour. An individual ship can be boarded only from the ends of the rank, using the small floating dock and steel ladder way provided there. All ships in between must be crossed, through unlit passageways, to reach the desired ship; thus, it may require 15 min to reach a more remote ship in a rank of 30 ships.

The preservation technique used on vessels in the NDRF varies, depending on the priority assigned, that is, how available the vessel must be for reactivation. (There are six priority classifications as well as a nonpriority, or "ready for scrapping," classification.)

Table 12
Summary of Vessels in the United States
National Defense Reserve Fleet[a]

RESERVE FLEET NAME AND LOCATION[b]									
VESSEL TYPE	TOTAL	ATLANTIC COAST			GULF COAST		PACIFIC COAST		
		Hudson River	James River	Wilmington	Beaumont	Mobile	Astoria	Olympia	Suisun Bay
GENERAL CARGO		Jones Point, N.Y.	Lee Hall, Virginia	Wilmington North Carolina	Beaumont, Texas	Bay Minette, Alabama	Astoria, Oregon	Olympia, Wash.	Benicia, Calif.
Liberty	949	91	143	144	128	191	114	33	105
Victory	181	34	27	-	13	25	23	23	36
S4-SE2-BE1	25	2	2	8	2	3	1	4	3
Others	262	38	37	15	32	39	152	34	53
TOTALS	1417	165	209	167	175	258	152	94	197
PASSENGER & TROOPERS									
Victory	123	4	65	8	1	5	2	8	30
Liberty	18	-	-	-	-	-	-	-	18
S4-SE2-BD1	15	-	1	3	-	-	-	4	7
Others	105	12	36	-	5	-	6	16	30
TOTALS	261	16	102	11	6	5	8	28	85
TANKERS									
T2	47	-	12	-	15	1	-	9	10
Others	30	-	2	-	6	3	3	2	14
TOTALS	77	-	14	-	21	4	3	11	24
HOSPITAL SHIPS									
Liberty	6	-	3	-	-	-	2	-	1
Others	1	-	-	-	-	-	-	-	1
TOTALS	7	-	3	-	-	-	2	-	2
DISTILLING SHIPS									
Liberty	2	-	1	-	-	-	1	-	-
T2	2	-	1	-	-	-	-	1	-
TOTALS	4	-	2	-	-	-	1	1	-
NAVY OWNED VESSELS IN TEMPORARY FLEET CUSTODY[c]	96	4	23	-	12	2	-	23	32
GRAND TOTAL	1766	181	330	178	202	267	166	134	308

[a]United States Department of Commerce, Maritime Administration, Division of Ship Custody, 30 June 1962.

[b]See Fig. 4, Map of Principal Waterways of the United States, for the location of each of these fleets.

[c]These vessels are *not* included in the grand totals.

Priority ships, although completely dead, are under a continuous maintenance program to protect exterior and interior surfaces as well as the engineroom components. Such ships, if supplied with utilities (light, heat, water, and sanitation), sleeping accommodations (most ships have bunks but no mattresses) and rations, would be habitable without further cleanup. Nonpriority ships, which may have received no maintenance for 5 or more years, present a less palatable picture and some preliminary work would be required to meet minimum habitation standards.

Ships in the NDRF are given periodic engine maintenance. They carry sufficient fuel and water supplies aboard to permit them, after an in situ recommissioning by assigned crews (requiring 48 to 72 hours), to steam to a shipyard where the vessel could be completely reactivated for sea duty. Although this concept seems workable, it is definitely limited by the number of crews that could be recruited, by the quantity of spare parts aboard the ship itself, and the capacity of available shipyards. Realistically, after an enemy attack, most of the ships in a reserve fleet could be expected to remain in place (unless moved by tugs to another storage area) and would be available as short term shelters.

3.3.2 Liberty Ships

Liberty ships, some 2000 of which were built in World War II, comprise the majority of ships in the NRDF. Of the total of approximately 900 now in the fleet (see Table 12) 250 are priority ships, 400 have recently been placed under the Emergency Ship Program for limited maintenance, and the rest just sit, unattended, awaiting scrapping. Currently, about fifty Liberties a year are scrapped at an average sale price of $40,000 each; the original cost was $2,400,000. When the Liberties are gone, the next lowest priority ships, probably the C1's, will be scrapped.

"As Is" Shelters. Liberty ships possess little or no "as is" shelter potential both because of their inherent structural characteristics and their locations in MARAD reserve fleets. Reiterating, the deficiencies of an NRDF for emergency housing of an evacuee populace are:

1. The fleet is usually not readily accessible by a land route from population centers.

2. Movement of evacuees to the ship is possible only with small boats.

3. Boarding a rank of ships and reaching the desired position in a given ship represents a possible major bottleneck. Even if thousands of small boats brought evacuees to the ships, access is only through one or two points of entry for all ships in a rank.

4. The ships are dead and have no facilities for housing or feeding people.

Liberty ships, in addition to the corporate shortcomings of reserve fleets, were designed as cargo carriers and the only housing space is in the deck house where there is little protection from fallout radiation. To think of funneling evacuees into a dark dead ship and having them climb down the oil-covered rungs of a steel ladder into the bowels of a mammoth hold is ludicrous. Of course, the holds have no sanitation, lights or ventilation. Even if, somehow, it appeared to be the best choice of shelter available, an inspection of Fig. 9 shows that the shielding afforded by a Liberty ship, with the possible exception of the engine room area (which is also the most accessible, but could hold very few people), may be no better than that of a well-built office building. In summary, Liberty ships hold no merit as "as is" shelters.

Converted Shelters. A Liberty ship, because of the open construction of its cargo holds, could be modified for shelter purposes. Furthermore, since these ships are surplus, unusual concepts can be considered. Figure 10 shows a proposed accommodation plan of the second deck of a Liberty ship converted to provide accommodations for approximately 5100 persons and to afford an average protection factor against fallout of 0.005 (0.0005 with washdown). The shielding factors for deck-deposit radiation at various points within the ship are shown in Fig. 11. Appendix E lists in some detail the modifications and costs for the indicated conversion. Basically, a 4 inch concrete shield* has been placed on the main deck of the vessel and two additional decks have been laid throughout the ship, including the engine room whose components have been removed to provide additional shelter space. The layout of the living areas is oriented to survival standards; there are no frills. The design capacity of 5066, based on an average of about 12 sq. ft. per person, could be doubled using hot bunking without affecting the stability of the ship. The modified

*A 4 inch layer of concrete was used in order to provide a minimum reduction factor of 0.015 on the second deck of the ship shelter. Coupled with a 90% efficient washdown system, the overall reduction factor on the second deck would be 0.0015. It is conceivable that the need for the concrete deck could be eliminated by crowding everyone onto the lower decks while the radiation was most intense, but since the cost of the concrete deck is only 6% of the entire conversion cost (App. E), this expedient does not seem warranted.

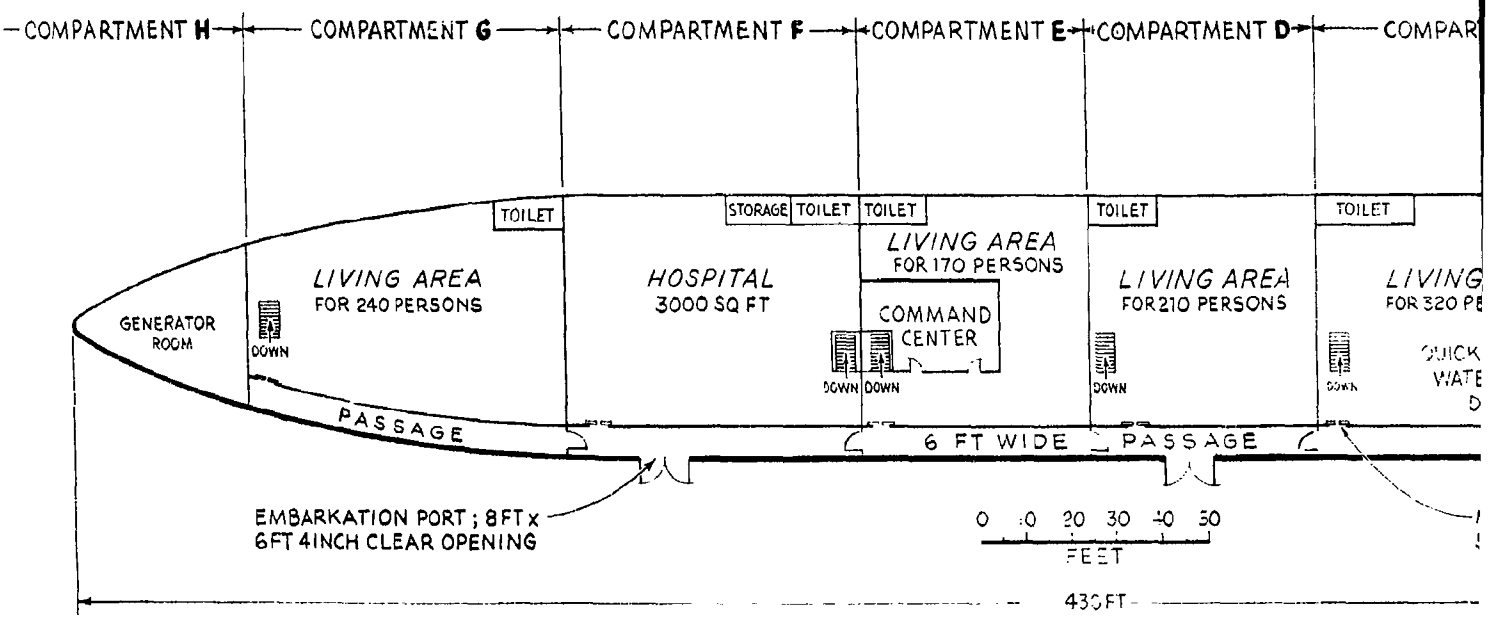
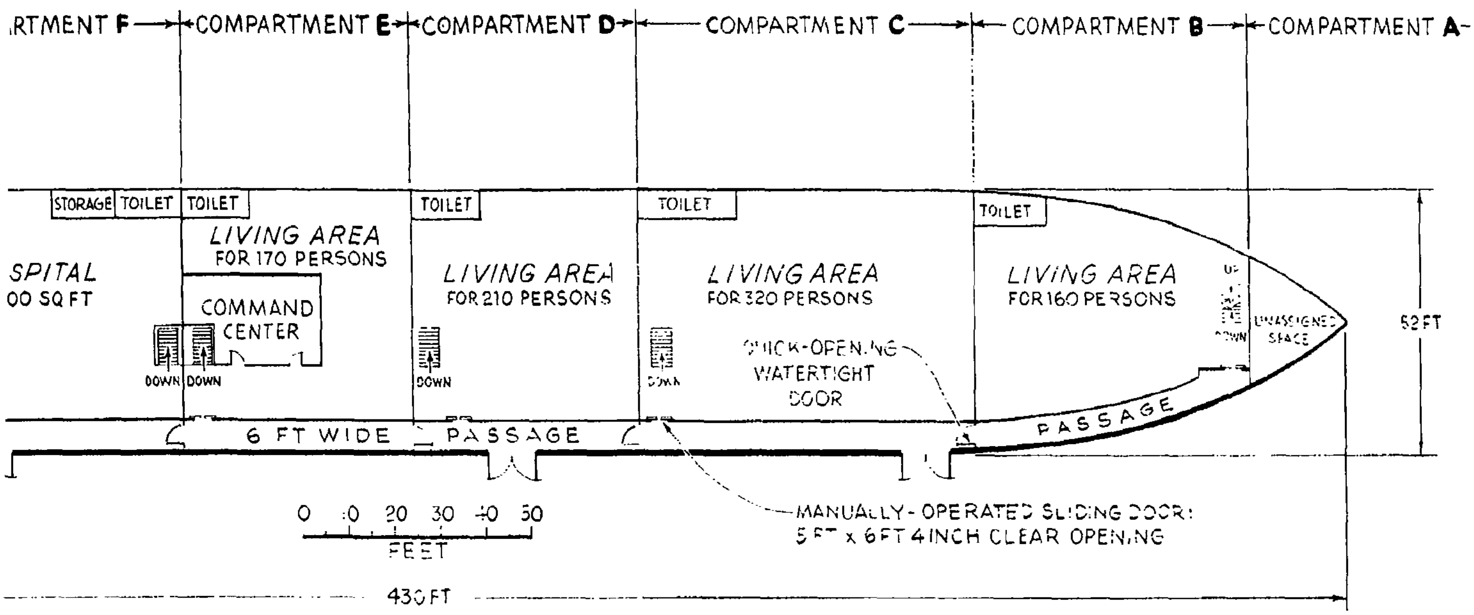


Fig. 10 Accommodation Plan of the Second Deck of a Lib
Converted for Shelter Use

1



;. 10 Accommodation Plan of the Second Deck of a Liberty Ship
ıverted for Shelter Use

2

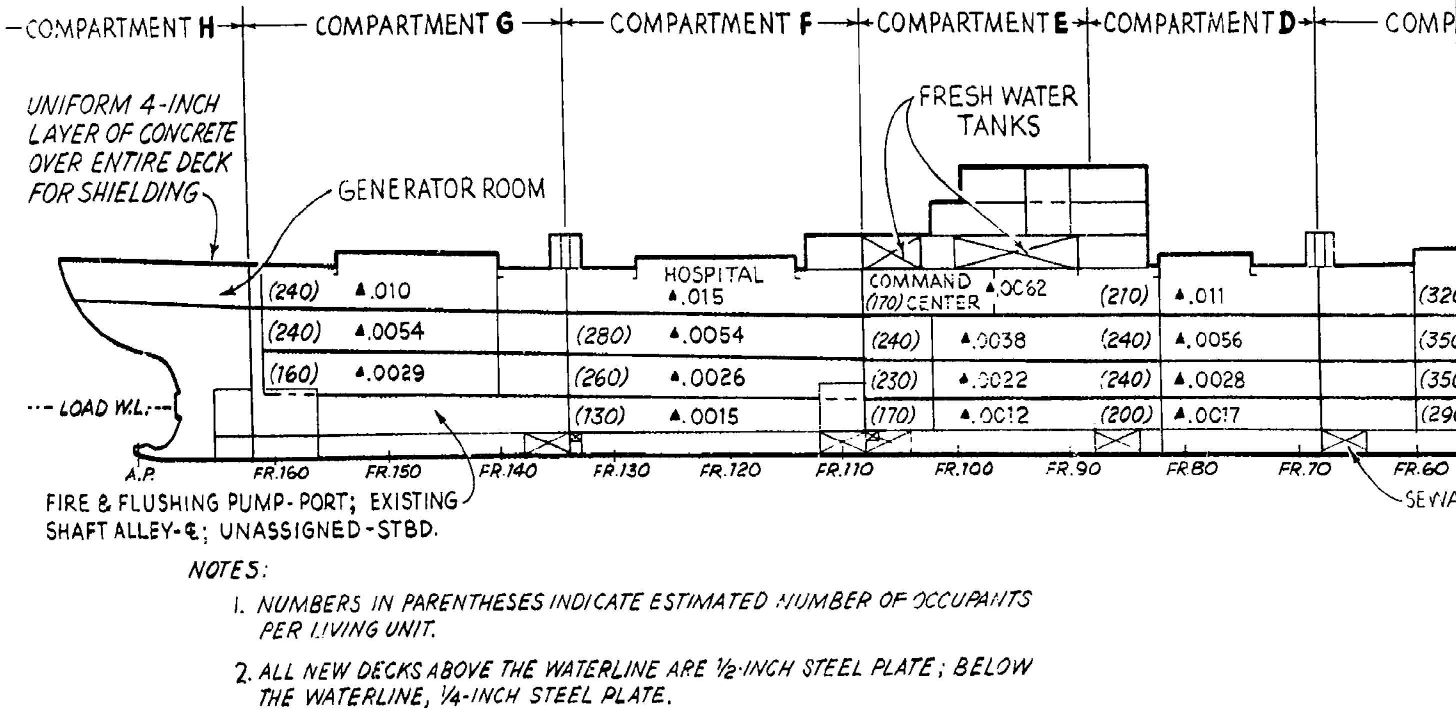


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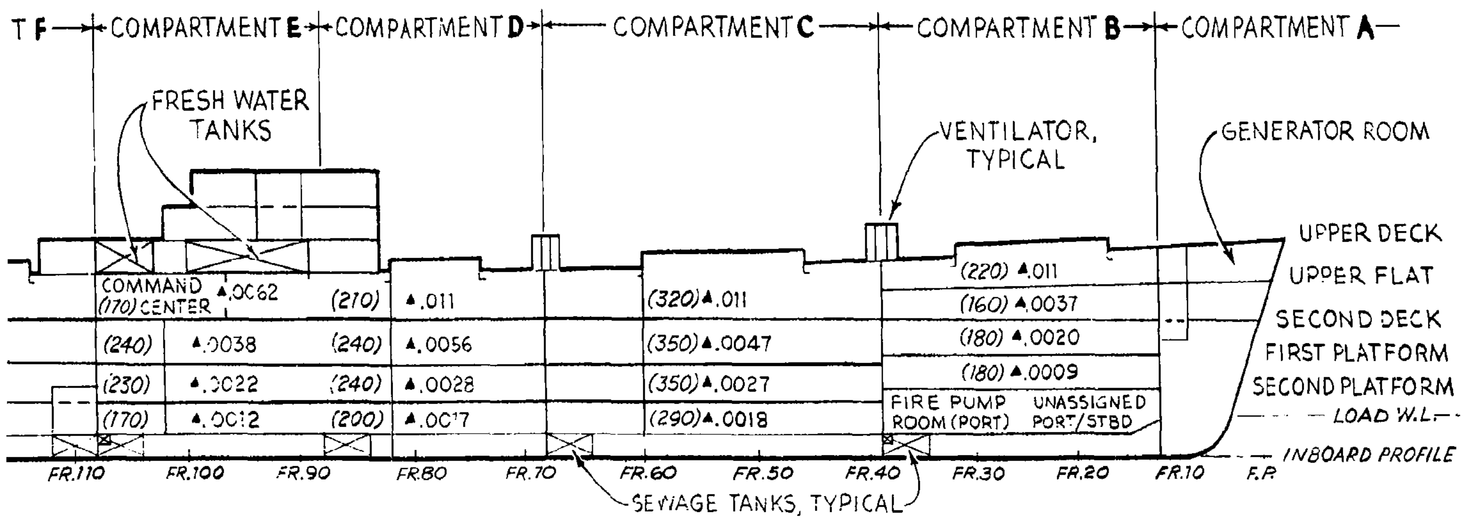
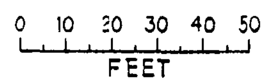
Fig. 11 Inboard Profile of a Converted Liberty Ship Sh
Radiation Reduction Factors at Various Points

(Reduction factors were obtained by the method describe



NUMBER OF OCCUPANTS

CH STEEL PLATE ; BELOW



Inboard Profile of a Converted Liberty Ship Showing Deposit Reduction Factors at Various Points

n factors were obtained by the method described in App. B)

2

vessel would be entirely self-contained and could house its occupants for 2 wk or more. Power for the washdown system (which can be run intermittently after fallout ceases to reduce the heat load from the occupants), the lighting and ventilation systems, and the sanitation and firefighting systems (which use sea water) is provided by two 100-kw diesel generators. Fuel and water supplies, far in excess of anticipated needs, can be readily stored on the vessel. The design ventilation rate is 10 cfm per person which would be cut to 4 cfm per person while the washdown system was operating. No analysis was made of the total heat load, but it is probable that in warmer climates additional ventilation or air conditioning would be required. No provisions have been made for cooking in this shelter; the use of dry rations has been assumed. Areas have been set aside for a hospital, a headquarters, and segregation. The sleeping spaces in the ship are subdivided into units, each accommodating up to 350 persons (700 persons with hot bunking). No attempts have been made to promote the inter-accessibility of various parts of the ship; rather, it is visualized that persons would generally remain in the section to which they were originally assigned. However, as the radiation hazard abated, evacuees could move into the deck house, and perhaps even onto the main deck, thus alleviating overcrowding below decks.

The conversion of the Liberty ship involves removal of the masts, king-posts, and other unnecessary protuberances from the main deck, but does not involve the deck house where the living quarters are normally located. It is contemplated that this area would be made available to the community in which the ship shelter is to be located. A fairly minor expenditure of funds could convert the existing facilities into civil defense offices, police headquarters, etc. or, at somewhat more expense, into a community recreation center. A swimming pool, tennis courts, etc., could be placed on the main deck without subverting the use of the space below while adding to the usefulness and acceptability of the ship to the community. Such dual service would also provide security for the ship, which is a most necessary item.

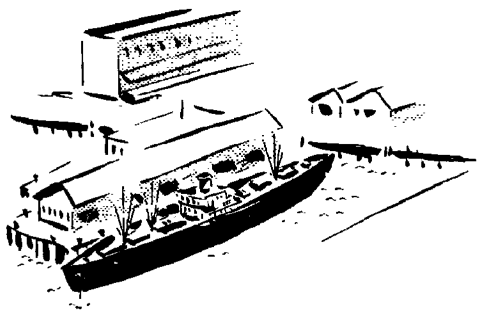
The interior of the ship (the shelter spaces), would normally be closed to the public but maintained in a state of readiness. This condition could be most easily maintained by dehumidifying the shelter space so that corrosion would be practically eliminated. Routine maintenance, which could be done by city personnel, would involve periodic checks on the condition of the food and water supplies (the latter might have to be changed every 3 to 6 months), the operation of the dehumidifying system and the functioning of the two diesel generators. Automatic sensing devices would be employed for fire and leak detection. The built-in fire protection system should be capable of handling any fires that might occur although such fires are rare occurrences in dead ships.

A converted Liberty ship could be used in a number of different situations and locations, particularly since its 9-ft draft (empty) would allow it access to most of the larger cities of the U.S. (Fig. 4). However, since it would have to be moved by tug, the distance it would be desirable to move it would be limited.

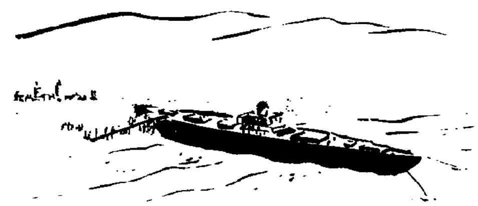
This complete dependence of a ship shelter on outside motive power strongly suggests that postattack plans envisage the loaded ship remaining in situ despite the fact that better shielding could be obtained by movement to midchannel. (Even under good conditions, it would take several tugs several hours to move a moored or beached dead ship into a new position.) Nor is it practical to speak in terms of permanently mooring a ship in midchannel because then the personnel loading problem would be insurmountable. Further, the possible use of the main deck and superstructure of the ship to the community is lost unless the ship is permanently moored or beached for ready access. Since a beached ship would not provide so much shielding protection as a ship moored in midchannel, the shielding must be increased; hence the suggested 4-in concrete deck cover.

Several placement methods appear possible, the choice depending primarily on the location selected. The simplest placement would be at an existing pier which would most probably be near an area of high population density (business or residential, or both). Unfortunately, however, suitable piers (of fireproof concrete construction) are at a premium, and rent for tens or hundreds of thousands of dollars a year. Nevertheless, in some locations and especially where civic interest is aroused, the use of a pier might be possible. The advantages, in addition to accessibility and loading ease, are: ready sources of water and electricity, immediate availability, and the ultimate release of the pier for cargo handling. Figure 12-a and drawing No. 1, Appendix F, illustrate a ship shelter at a pier.

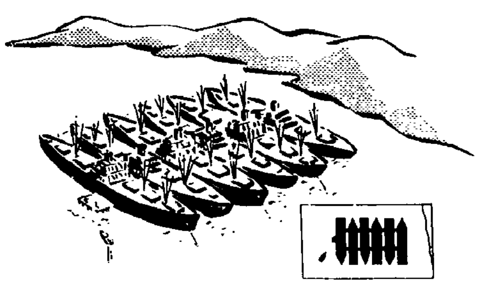
The emplacement method which would be applicable in most locations is beaching one or more ship shelters (as shown in Fig. 12-b) near a population center. The manner in which a ship shelter is beached would depend on the selected site; the simplest case is one in which the converted Liberty is pushed by tugs onto a sandy shore, there to rise and fall with the tide. In the more complicated case illustrated in Drawing No. 2, Appendix F, a slipway would be dredged permitting the ship shelter to be beached with its bow about 100 ft inshore of the high water mark. Once the ship was in location, backfill would be placed against the bow to promote stabilization against abnormal tidal action and/or blast effects.



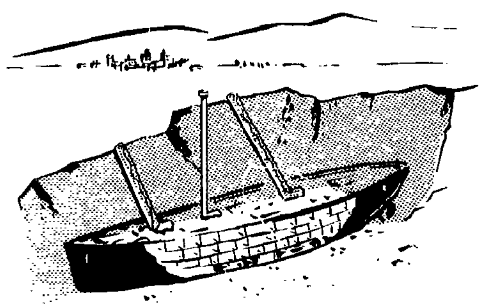
a. Floating Fallout Shelter (converted Liberty) Moored at Pier



b. Evacuees Board Beached Fallout Shelter (converted Liberty)



c. Moored Nest of Six Liberty Ships used for Material Storage



d. Blast and Radiation Shelter Used as Command Center (buried Battleship)

Fig. 12 Potential Ship Emplacement Conditions

A paved access road and a parking area, which would serve for both civic activities and a disaster event, would be constructed. Electrical power would be brought in either from existing utility lines or provided by an adjacent generator set. Fresh water would preferably come from a drilled well, which could also serve as an auxiliary supply to the ship during an emergency. Three or more ships could be beached adjacent to each other and interconnected to form a shelter complex, permitting the interchange of utilities. Drawing No. 3 of Appendix F shows such an arrangement for three ships.

In some locations, a ship shelter might be landlocked by first floating the ship into a dredged slip longer than the length of the ship and then backfilling on all sides. Such an arrangement might be used where harbor space is at a premium or where beaching is not feasible because of soil considerations. However, the higher cost of such an operation overbalances the advantages of this usage. Drawing No. 4, Appendix F, shows a landlocked ship.

It is noteworthy that two battleships have been successfully landlocked in recent years, and serve as state monuments; these have attracted much public attention. The Battleship TEXAS, emplaced almost 15 yr ago adjacent to the Houston Ship Channel, has survived the full force of several hurricanes. The most recent, Carla, in September of 1961, brought tides of an estimated 15 feet that lifted the TEXAS 5 or 6 ft out of her bed but redeposited her, undamaged, as the wind and tides subsided. The NORTH CAROLINA, landlocked across from Wilmington, N.C., adjacent to the Cape Fear River, was emplaced in 1961 in what was then a swamp. The ship has since become a major tourist attraction and a large parking lot has been constructed next to it. No difficulty has been experienced with respect to the stability of the ship, but the parking lot has a tendency to revert to swamp.

A final case, shown in Fig. 12-d is a battleship which has been completely buried underground to provide a civil defense headquarters. A battleship was chosen for this usage because (1) a few obsolete battleship are now available; (2) a battleship inherently has the structural strength to withstand the weight of the overburden; and (3) the design of a battleship is adaptable to headquarters-shelter use. The design criteria for such an installation, shown in detail in Drawing No. 6, Appendix F, are the ability to withstand 35-psi overpressure and to afford a shielding factor of 0.001. Prior to emplacement, the entire superstructure of the battleship is removed, all top openings are sealed, and internal strengthening members are added. The hull is then floated into a dredged slipway, in a manner similar to that described for the landlocked ship. The slipway is sealed off and a sand slurry is pumped around and under the ship to form a sand foundation. (Because of hydrostatic pressure the ship cannot be placed too low in its final resting place.) Finally, the excess material from the dredging operation is mounded over the ship to bury it to a minimum depth of 5 ft; access tunnels from the surface lead to the now buried structure. The cost of such an emplacement at Norfolk, Va. is estimated to be $525,000, almost seven times as expensive as beaching one Liberty ship-shelter. To this figure must be added the costs of conversions within the battleship. It is estimated that this conversion cost would be one-third to one-half that of the conversion of the Liberty ship. Thus, for approximately $1,000,000, a community could obtain an excellent blast shelter capable of housing vital functions as well as many evacuees, (5,000 to 10,000 as a rough approximation). Other classes of ships, such as cruisers and aircraft carriers, which might become surplus in the foreseeable future, could also be similarly emplaced.

The comparative costs of ship shelters in various emplacements are listed in Table 13. The cost of the Liberty ship conversion is so high that differences in the costs of emplacement methods are relatively insignificant. The average cost per occupant, when the ship shelter is at maximum occupancy of 10,000 persons, is about $92 for any coastwise location in the country. A buried battleship used only to house personnel would compare favorably in cost at approximately $100 per person but would provide considerably more protection against both blast and radiation.*

In summary, converted Liberty ships appear to have considerable merit as ship shelters, especially in those areas where existing shelters are inadequate and local construction conditions, such as high water tables, preclude use of underground shelters. Another probable benefit of ship shelters is the unlikelihood of involvement in a firestorm. Ship shelters would always be bounded by water on one side, and in most emplacement conditions, they would be located at the fringe of any built-up areas. Hence, the lack of combustible materials in the vicinity of the ship would mitigate against a firestorm.

Civil Defense Headquarters. A Liberty ship could probably be converted to serve as either a civil defense headquarters or a civil defense hospital at little or no additional cost. However, the former

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*According to Ref. 11, an NRDL-type underground shelter would cost from $142/person for the most-austere 10-psi shelter to $198/person for the least-austere 35-psi shelter, based on 100 man occupancy.

Table 13

Comparative Costs of Ship Shelters in Various Emplacement Conditions

	Liberty Ship Berthed at Pier	Liberty Ship Beached on Shore		Liberty Ship Landlocked	Buried Battleship
		1 Ship	3 Ships		
Cost of Ship Conversion, $	860,000	860,000	2,580,000	860,000	500,000 (est)
Emplacement Cost, $	25,000*	80,000	180,000	124,000	525,000
Total Cost, $	885,000*	940,000	2,760,000	984,000	1,000,000 (est)
Minimum Occupancy	5,100	5,100	15,200	5,100	5,000 (est)
Maximum Occupancy	10,000	10,000	30,000	10,000	10,000 (est)
Cost at Maximum Occupancy, $/Person	88*	94	92	98	100 (est)
Estimated Reduction Factor (with washdown)	0.0005	0.0005	0.0005	0.0015	< 0.001

* Does not include yearly pier rental.

usage would seem to merit a truly blast-resistant shelter, such as a buried battleship. Although the Public Health Service does not countenance use of ships as hospitals, certain modifications (at admittedly high costs) might make such usage more attractive. We can only recognize that such utilization is possible.

Floating Storage. Approximately 100 Liberty ships at three NDRF locations (Astoria, Hudson River, and James River) are now used for the storage of grain. In this program, reactivated in 1953, the deep holds of a sound Liberty ship are partially filled with wheat (approximately 7000 tons or 233,000 bushels) and then the ship is moored, in the NDRF, with other grain-filled ships. Department of Agriculture personnel monitor the wheat continually, checking for insect infestation, water leakage, mildew, etc., and periodically, in the eastern fleets, the wheat is turned to promote aeration. The keeping quality of the grain is apparently excellent, some ships having been loaded with the same cargo for six or more years with the wheat showing little or no deterioration according to protein and moisture content. If, on occasion, trouble is spotted, it is necessary move the ship to a grain elevator, which may be many miles away, and unload the entire hold, salvaging as much grain as possible. Since loading and unloading costs are an expensive part of this program, as can be seen from Table 14, it is desirable to load and unload ships infrequently.

Table 14

Costs for Storage of Wheat on Surplus Liberty Ships*

	East Coast Fleet	West Coast Fleet
Loading costs, ¢/bushel per year	5.57	7.22
Unloading costs, ¢/bushel per year	7.60	10.34
Storage costs, ¢/bushel per year	4.48	5.20

*Average for 1953-60 from Ref. 2.

Just within recent months, the Department of Agriculture has made the decision, quite unexpectedly, to phase out grain storage on ships in the two east coast fleets. This reversal of policy has resulted from the discovery of subtle downgrading in the stored wheat, which has resulted in sales at 10% or more below the market price. This downgrading does not involve the nutritional value of the wheat, but it does affect the baking qualities for breadmaking. A re-evaluation of this program, in terms of civil defense requirements is in order, since these grain reserves on ships have long been thought of as mobile granaries for any possible disaster. It is conceivable that this program might be continued under OCD aegis in order to maintain this important reserve. It should be understood that, even though the grain so stored is not suitable for first quality bread products, it is entirely adequate, nutritionally speaking, for feeding survivors after a nuclear attack. Further, a market for this downgraded wheat will continue to exist in those nations that use wheat in a less refined manner than ours. However, the question should be asked: Is wheat the best grain to store for possible disaster use?

Recent studies of the U.S. Department of Agriculture's Western Regional Research Laboratory (WRRL) suggest that bulgur, a deglutinized form of wheat which stores very well and requires little or no cooking prior to consumption, may be a more ideal food.[12] Bulgur costs almost a cent a pound to prepare from wheat. Although it has a longer storage life than wheat, unlike wheat, it has practically no resale value. Thus, assuming bulgur was stored for 10 years and sold for an 80% loss whereas wheat was rotated every 5 years and sold at a 10% loss, the comparative yearly costs of storing these two commodities would be:

Wheat

	Net cost of wheat	$0.40/bushel
	Storage costs for 10 yr	0.448
	Loading and unloading (twice)	0.263
	Total	$1.11/bushel

or 11.1 cents per bushel per year

Bulgur	Total cost of bulgur	$2.10/bushel
	Storage costs for 10 yr	0.448
	Loading and unloading (once)	0.131
	Total	$2.68/bushel

or 26.8 cents per bushel per yr

These approximate figures indicate that the storage of bulgur would be considerably more expensive for civil defense use. However, as previously noted, bulgur is an available food and needs no cooking--hence no fuel-- probably an important consideration in any postattack situation. If the additional cost can be tolerated, this concept can be carried further and consideration could be given to the bulk storage on ships of a pelletized survival ration of the type developed by WRRL. Further research would be necessary regarding the stability of this ration, its adaptability to bulk storage, and its cost (estimated to be 10 cents a pound in bulk).[12]

If a food-storage program were undertaken by OCD, the question of the optimum distribution of such food stores would arise. Keeping grain ships in their present locations in the NDRF has definite advantages, including centralization of inspection effort and lowered ship maintenance costs. However, even if the full storage capacity of the three established grain fleets was fully utilized, distribution in a postattack situation could present an overwhelming problem. For example, a study[13] has shown that, under certain attack patterns, San Francisco would be completely cut off from rail transportation for some time, during which period food stocks could become dangerously low. Movement of a grain-laden Liberty ship from the Astoria NDRF to San Francisco to alleviate such a shortage would require 4 to 6 days _if_ a sea-going tug were available. However, many major metropolitan areas, including San Francisco, are within 150 miles of established reserve fleets and it would seem plausible to use such fleets as bases for food-storage centers whenever possible. For example, the present facilities at the Naval Reserve Fleet at San Diego could accommodate sufficient grain ships to provide an emergency food reserve for both the Los Angeles and San Diego metropolitan areas. Distribution could probably best be accomplished by off-loading the grain* onto barges and lighters, which could then supply numerous coastal points. There are certain waterside metropolitan locations, however, that are isolated from established facilities. Such waterside areas could also utilize Liberty ship storage, although at additional effort and expense, by the establishment of small fleets at scattered locations. Figure 12-c illustrates how a nest of six ships moored together in midchannel for stability and safety, might appear. In this arrangement a security watch would be maintained at all times on the ships, and ship-maintenance and grain-inspection personnel would commute to the site as required.

Two significant costs enter into expanding the grain-storage

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*Small vacuum-type grain unloaders operated by diesel engines are commercially available and would be well suited for this task.

program to meet civil defense needs: site construction and maintenance. The 28-ft draft of a loaded grain ship would require additional dredging at most fleets operated by the Maritime Administration. The estimated cost for such dredging for a six-ship emplacement is $275,000 (App. F); amortized over a 10-yr period, this expenditure would represent 1.97 ¢/bushel per yr. Additional expenditures would be required for site acquisition if established facilities were not used. Maintenance costs in the reserve fleet would be in line with present costs; in smaller nests, the costs might be at least 50% higher. Thus, the cost of storing wheat under a civil defense sponsored program would range from the present 11.1 ¢/bushel per yr up to at least 16 ¢/bushel per yr. In contrast, the cost of storing wheat inland under the Uniform Grain Storage Agreement is 13.5 ¢/bushel per yr; over a 10 year period the estimated total cost would be 14.3 ¢/bushel per yr.

Ships loaded with grain have a potential for the storage of other civil defense material in the 'tween deck space of approximately 170,000 cu. ft. This storage space might be better utilized if dehumidified to prevent the deterioration of stored items. Also, if the grain holds were dehumidified, it could conceivably increase the storage life of the grain appreciably. Liberty ships so equipped would then truly be used for floating storage.

Storage of water or fuel on Liberty ships shows no merit, and can certainly be more profitably done on other types of vessels.

Floating Utilities. Liberty ships offer insignificant electrical-generating capacity (60 kw, dc) and little water distillation capacity (9000 gal/day); hence, their activation for such use is not recommended. However, the Liberty hull can serve as the vehicle for power-generation or water-distillation plants. The most recent such conversion involves a Liberty ship, the WALTER F. PERRY, which, under a recently announced 17.4 million dollar contract between the U.S. Army Corps of Engineers and the Martin Company, will be converted into a floating nuclear power plant. Briefly, the Liberty hull will be cut in two, and a new mid-section containing the reactor will be inserted. A great deal of versatility is designed into the power plant so that it can produce 11,274 kva at 50 cycles or 13,259 kva at 60 cycles, all at 13,800 volts; this voltage can then be transformed upwards to match the shoreside voltage. The obvious advantage of a floating nuclear power plant is its ability to generate power indefinitely without the need for fuel supply lines. The Strategic Army Command currently has floating power plants in operation in two harbors, one at Thule, Greenland and the other at Okinawa. Table 15 lists comparative costs for floating power plants and conventional shoreside steam installations.

Table 15

Estimated Costs for Floating and Conventional Power Plants and Conventional Shoreside Steam Installations[a]

ITEM	FLOATING			SHORESIDE		
	Nuclear (Martin)	Nuclear[b]	Conventional[b]	Conventional[c]	Conventional[d]	Conventional[d]
Output, KWe	11,500	10,000	10,000	34,500	10,000	100,000
Original cost, millions of $	17.4	11.0	4.7	8.1	---	---
Cost, $/installed KW	1510	1100	470	235	210	115-170
Operating cost, mil/KW	---	19.4	14.2	---	5.1-5.3	---

[a]None of these cost figures are corrected for inflationary factors.

[b]From NYO-2945, Study of Remote Military Power Applications, Report No. 9 - Inchon Korea, 1960. Prepared by Kaiser Engineering.

[c]Specifications for Conversion of a Liberty Ship to a 34,500 KW Floating Power Plant, 15 Dec 1954. Philadelphia District, Corps of Engineers.

[d]B.G.A. Skrotzki and W.A. Vopat, Power Station Engineering and Economy. McGraw Hill, New York. Pages 608, ff.; p. 666.

Two Liberty ships and two T2 tankers, fitted out as distilling vessels, remain in the NDRF. The evaporator plants on each of these Liberty ships can produce 63,000 gal/day of potable water which can then be stored in the 2,500,000-gallon tank capacity of the vessel. Although the distillation capacity of these ships is significant, it is important to note that passenger vessels and troop transports have appreciably greater water-producing capacity and that they utilize the more efficient double-effect evaporators.

3.3.3 S4 Type

The S4-SE2-BD1 and S4-SE2-BE1 class ships were built for the Navy in World War II as shallow-draft attack transports and attack cargo ships, respectively. Because of their light construction they proved unusable for peacetime commercial service and, consequently, were placed in the NDRF after the war. The S4's are nonpriority ships, and the 40 in the NDRF will ultimately be sold for scrap. Of the 40 S4's, 15 are S4-SE2-BD1 troop carriers and 25 are S4-SE2-BE1 cargo carriers. Reactivation would be a difficult problem because of a shortage of spare parts; perhaps cannibalization of one or more ships would be necessary.

Shelters and Civil Defense Headquarters. An S4 attack transport designed originally to carry about 1100 troops could be made into a habitable shelter merely by renovation of the existing facilities. At some additional cost, the capacity would be increased 30-50%. However, the light construction of this ship would probably require much additional shielding and internal strengthening. Further analysis would be required before any firm recommendations could be made as to the advisability of using S4 vessels for shelters and/or headquarters.

Floating Storage. The S4 attack cargo ship, in attaining its goal of a shallow draft, sacrificed its carrying capacity. Consequently water and fuel capacity are small and even the cargo space is limited. Use for storage is not recommended.

Floating Utilities. The S4's are of most interest for floating utilities because of their propulsion systems--twin turboelectric generators. Unfortunately, these generators cannot be used at maximum power, because the cycle rate is too high; however, they can be throttled back to produce 3600 kw at 60 cycles. Fuel consumption would then be about 375 kwh per barrel of fuel, or 9,700 gal of fuel per 24 hr. The ship would have to be refueled about once a month since it has a fuel storage capacity of only 410,000 gal.

Removing a ship from the reserve fleet and reactivating the engineroom components, including the evaporators, is estimated to cost $325,000 and to require 25 days. Allocating this entire cost to the generating capacity of 3600 kw, the cost per installed kw is found to be $90. This cost compares favorably with the cost of building new floating power plants at $235 to $470 per installed kw (Table 15). However, because of the age of this equipment, maintenance costs would be expected to be higher and equipment reliability poorer.

S4's have an appreciable water-distillation capacity (20,000 gal/day) which could operate simultaneously with the power-generating system. The S4's should be studied in more detail to determine the costs involved in their utilization as shelters, headquarters, and floating power stations. Further, the study should ascertain the relative merit of reactivating these ships prior to attack vs holding them until a need develops.

3.3.4 General Cargo Ships

Cargo ships in the NDRF appear to have only one role they might play in the civil defense effort: storage. Cargo ships in the fleet have no "as is" shelter potential, and they cannot be considered for any type of converted use because they have an assigned priority. Such utilities as a cargo ship has would never be justification for reactivating it. Priority cargo ships can be used for grain storage as some Liberty ships are used, although such utilization has limitations. Priority cargo ships have two or more 'tween decks that decrease the deep hold space in which grain is stored. Further, these ships have an assigned mission that might detract from such a secondary use. Basically, however, priority ships can be used for the storage of grain or other civil defense materiel, but probably only if the ships remain in their present locations in the reserve fleet.

3.3.5 Passenger, Troop and Hospital Ships

In the NDRF there are 7 hospital ships, about 10 troop ships which are basically passenger vessels and about 250 cargo-type ships, which have been modified, to varying degrees, to carry troops. Although responsibility for reactivation of these ships is divided between MARAD and the Navy, all could be expected to be used as troop transports in the event of war. Of all the vessels in the NDRF, ships in this class would come the closest to serving as "as is" shelters, since the basic living accommodations are present. It is conceivable, for example, that a limited number of evacuees equipped with bedding, food, and water could reside in the lower compartments of a passenger vessel until outside radiation levels dropped to acceptable levels. With some pre-planning and at considerable expense, these ships could be made into quite satisfactory "as is" shelters -- although the problem of getting people to the ship would still exist. Minimum modifications that would be required include: activation and regular maintenance of emergency generator sets on all ships to provide a modicum of light within the ship; stockpiling of bedding, food, and water; installation of additional access platforms to the ships; and installation of self-powered washdown systems. Further study would be required to determine the feasibility, usefulness, and cost of any such program.

Since all ships in this **class** have an assigned priority and, presumably, a mission in the event of a national emergency, it is difficult to assess their postattack life-sustaining role. If available and if reactivated, many of these vessels could be used for headquarters, floating hospitals, emergency hosuing, power generation, etc. A better understanding of the relative importance that civil defense might have in a postattack situation would be required for any further speculation.

3.3.6 Tankers

Tankers in the reserve fleet, like their counterparts in active service, have no potential usefulness as shelters or headquarters. Inactive tankers could, however, make an important contribution to the nation's fuel reserve, particularly of those fuels likely to be in short supply. Currently, NDRF tankers are stored empty. Should not this capacity in the 77 tankers in the NDRF be used for the storage of petroleum products? Several arguments against such use include:

1. A fire hazard would be created.

2. Additional dredging would be required to accommodate the increased draft of the loaded tankers.

3. The tankers might be targets themselves.

These objections, all valid, can be answered as follows:

1. The fire hazard can be reduced greatly by storing liquids of low combustibility. Significantly, a Stanford Research Institute study[10] found that distillate stocks (diesel fuel, primarily) could be the petroleum fraction in shortest supply after attack. These heavier fractions could be stored indefinitely on tankers with little likelihood of fire.

2. Funds would have to be made available for dredging (estimated at $30,000/tanker).

3. The tankers could be relocated, perhaps adjacent to emergency food supply centers (cf. 3.8.4) which are out of target areas.

The 8,000,000 barrels of distillate that might be stored in NDRF tankers would represent an appreciable addition to the estimated 95,500,000 barrels that would survive a 1965 military and population attack (Ref. 14, Table 12). Moreover, diesel fuel is such a vital factor in our economy and would continue to be in any postattack recovery scheme, that this potential additional storage source should not be overlooked.

The storage of water on dead tankers does not appear promising because (1) all tanks would have to be cleaned and coated at considerable expense prior to such use, and (2) the water in the tanks would either have to be specially purified or changed every few months. Either process would be quite expensive.

The 47 T2 tankers in the NDRF could be used for generating electrical power for shoreside use. Assuming that these ships would be available for such service, activation would be advisable, since these ships, if fueled, could serve indefinitely as floating utilities, easing the strain on what might be a critical link in the recovery chain.

3.3.7 Naval Reserve Fleets

The locations of the Naval Reserve Fleets, generally naval shipyards or other military installations, are shown on Fig. 4. These fleets contain the combat vessels (battleships, cruisers, destroyers, etc.) that are not currently needed for our military mission. These so-called "mothball" fleets are characterized by webbing and plastic sprayed on exposed elements of the ship. These ships have cathodic protection of the hulls; corrosion of the interiors is inhibited by maintaining low relative humidity throughout the ship. The latter is accomplished by dehumidification (d-h) machines that circulate dry air to all spaces. This regime practically eliminates corrosion and the interior of a d-h'd ship can be expected to be spotless, even to the mattresses on the bunks. Shore electrical power is available on each ship for lighting and for the d-h machines, but the sanitary, firefighting and ventilation systems are not operable. It would require several days of concerted effort, plus the availability of a water supply (the sea chest, the normal source of water, might be blanked off) to put the ship in shape for normal habitation. The reactivation of the engineroom and the power plant would be considerably more time consuming. It is probable that few of these reserve ships would be activated in the days immediately following an attack. However, most or all of the ships in such reserve fleets have assigned priorities and will probably be unavailable for long-range civil defense utilization.

It is perhaps presumptuous to discuss the use of fighting ships for civil defense, since such ships, even though inactive, have well-defined roles to play in wartime. If available, however, larger ships, such as a cruiser, could (1) make excellent civil defense headquarters, (2) provide appreciable utility service to a shore contact, and (3) provide, in their present condition, a vast amount of dry storage space for civil defense items. In one area, however, it appears that Naval Reserve Fleets could be most useful for civil defense purposes without disrupting their intended mission: "as is" shelters. The rugged construction, ready accessibility, and inherent livability make Naval Reserve Fleets most attractive for this use. It is somewhat surprising that the Navy has not utilized this potential, but at bases visited by the senior author this use, although contemplated, has not been implemented. On the other hand, several negative elements enter into the use of Naval Reserve Fleets for shelters: shore power might fail, and plunge the ships into darkness, sanitation and firefighting systems are inoperable, and ventilation is inadequate. However, considering the thousands of excellent shelter spaces that each reserve fleet represents, further investigation seems merited.

3.3.8 Miscellaneous

Several other types of "vessels" may also be considered for possible civil defense use. Surplus submarine hulls (cf. 1.1) could be buried, at a cost of about $220 per occupant, to provide small but rugged blast and fallout shelters. Unfortunately, the number of surplus hulls is small, probably less than 50, so that the total shelter capacity would only be of the order of 10,000 persons. For this reason, as well as the high cost, this program is not recommended. However, some communities might find it expedient to use a buried submarine for the local civil defense headquarters.

A few floating metal drydocks are still available, but will probably be scrapped in the near future; such docks might conceivably be used in a variety of civil defense functions. A typical dock[15] is 410 ft in length and 100 ft in width and can lift a small ship. The interior of a dry dock is hollow (to give the necessary buoyancy), and a portion of this space is devoted to enginerooms, machine shops, and crew's quarters. In an emergency, these spaces could undoubtedly be used to house personnel; also, some of the ballast spaces could be converted to housing facilities. A dry dock has elaborate utilities--electrical generators, pumps, air compressors, and steam, that might be of value for shore use. The usefulness of floating dry docks in the civil defense effort can be properly evaluated only with considerable additional study.

A third possibility is the "double bottoms" left after a Liberty ship has been partially scrapped.* The Maritime Administration has suggested[2] that these double bottoms, which are currently being cut up and disposed of, be retained in the NDRF for possible future emergency use as pontoons or finger piers. Double bottoms could also be used to store a small amount of liquid fuel, but because they offer no overhead cover, would be unsuitable for dry-cargo storage. None of the purposes envisioned for the double bottoms is particularly noteworthy, and when compared to the utility of a whole Liberty ship (which would only cost $40,000 more), it can only be concluded that it would be far better to utilize the entire Liberty ship than to try and get some residual value from the double bottoms.

* A double bottom would result from the removal of all of the structure above the Load Water Line (Fig. 9).

SECTION 4

CIVIL DEFENSE UTILIZATION OF SHIPS AND BOATS - BY FUNCTION

4.1 GENERAL

An evaluation of the potential use of ships and boats in the total civil defense effort is discussed in this section. Although this appraisal is preliminary, such an overall presentation will be helpful in elucidating those areas of endeavor of particular interest upon which further research seems merited.

4.2 SHIPS FOR LIFESAVING

4.2.1 Active Ships

Active shipping has an appreciable potential in the evacuation of persons from target areas, this mission being superimposed on the primary goal of saving the ships themselves. Passenger liners could offer some degree of shielding from fallout and also provide housing, but their potential is minor with respect to total shipping activity. A very rough approximation of the nationwide evacuation potential can be obtained from Table 2. Passenger and dry-cargo ships with a total capacity of 1.027×10^9 net tons (1 net ton = 100 cu ft) passed through all continental U.S. ports in the year 1960. This figure includes domestic and foreign ships and does not indicate the amount of cargo loaded or unloaded, only the capacity of the ships in terms of volume space available. Assuming for simplicity that ship movement is constant throughout the year and that a ship stays in a given port for an average of 2.5 days (see 2.3), we find:

$$1.027 \times 10^9 \text{ net tons/yr} \times \frac{2.5 \text{ days (stay time)}}{365 \text{ days/yr}}$$

$= 7.02 \times 10^6$ net tons of capacity in ports of the U.S. on the average at any given time.

Assuming that, at the time of an alert, evacuees would board all ships in port, and using a capacity of 1 person per net ton (of 100 cu ft), we find that 7,000,000 persons could theoretically evacuate to the safety of open waters. An additional 2,000,000 might be evacuated on inland waterways using tugs, non-self-propelled dry-cargo vessels, and pleasure cruise ships. The estimated 560,000 larger boats (cf. 3.2.5), carrying an average of six passengers each, would account for another 3,500,000 evacuees. The approximately 4,500,000 small boats (rowboat to 15 ft cabin-cruiser class) are not deemed to be of sufficient value in an evacuation scheme to be considered here. The total number of persons who might be evacuated from target areas over water routes is then:

Ocean-going vessels		7,000,000
Inland vessels		2,000,000
Boats		3,500,000
	Total	12,500,000

Such a total is impressive but is immediately open to criticism, ranging from the validity of the evacuation concept to the number of people who would actually be able to use this escape route. Callahan et al,[1] estimated a total ship and boat shelter space capacity of 19,000,000, which agrees reasonably well with our value, especially since we discount the use of boats under 16 ft for evacuation use while they did not. Callahan's concept of using ships and boats as "isolation" shelters is questioned, since it was shown in 2.1.1 and Appendix A that deposit and transit doses are much more important than the water or land doses that he considered. Time has not permitted a detailed study to be made of the possible availability of ships and boats throughout the nation. For such a study, information on population distribution, available shelter distribution, number and type of vessels available in a port, and their cyclic pattern, length of shipping season, probable evacuation routes, etc., would have to be obtained and analyzed. Table 4 gives some such data for selected port cities, but does not attempt to fully analyze their significance. Future work, therefore, might well be concentrated on a detailed analysis of several of those ports that show, qualitatively, a potential for evacuation by ships and boats. A rough index of this potential can be obtained as follows:

$$\frac{\text{Maximum population} - \text{Shelter spaces available}}{\text{Inbound waterborne commerce, net tons (excluding tankers)}}$$

Of those ports listed in Table 4, Brooklyn, Seattle, New Orleans, and Norfolk might merit further study, based on this index.

In summary, we find that as many as 12,000,000 persons could be evacuated from port cities via water routes using available ships and boats. This figure, however, is not directly useful because of the many variables involved, and we have recommended that, if evacuation by water is deemed acceptable, an intensive study of selected port cities be made.

4.2.2 Inactive Ships

The 8 National Defense Reserve Fleets include a total of 260 passenger-type vessels that, with considerable modification of existing preservation techniques, could be made available as "as is" shelter spaces for a population of nearly a million persons. These people would almost certainly have to use small boats to reach the reserve fleets. Naval reserve fleets, which can be reached from nearby population centers by overland routes, could house perhaps half as many persons as the NDRF, but with greater comfort and protection.

The greatest shelter potential exists for ship shelters made by converting surplus Liberty ships. If 800 of the Liberty ships in the NDRF were converted and emplaced, at an approximate cost of $860,000 per ship, firm fallout shelter spaces for 8,000,000 persons would be created. These spaces could be distributed in those locations where conventional shelters are in shortest supply and where underground construction costs are unusually high. The few remaining battleships do not represent many shelter spaces, but they do offer a unique opportunity to construct massive underground headquarters at a reasonable cost.

The logical sequence in further evaluation of ship shelters would be to actually undertake such a conversion in order to evaluate concepts and determine realistic construction costs. Under the auspices of some organization, such as the National Association of Civil Defense Directors, the converted ship could serve as a model shelter and a training center. Because of its mobility, the ship shelter could be moved about coastwise and inland.

4.3 SHIPS AS STOREHOUSES

4.3.1 Active Ships

In calendar year 1960 approximately 66,000,000 tons (2000 lbs.) of edible animal and vegetable products passed through U.S. ports.[16] Assuming that all ships that are headed for port, in port, and leaving port safely evade any nuclear damage, approximately 1,000,000 tons of edible food products would be available for consumption. In actuality, the amount of food available might be much smaller because of ship losses or return of foreign ships to their home ports. However, these mobile food reserves could well serve a lifesaving role in destitute areas.

Appreciable stores of petroleum products could likewise be salvaged from tankers and barges. Of the 440,000,000 tons of petroleum products that pass through U.S. ports each year (Table 10), a 1 week's supply, equivalent to 8,400,000 tons (56,000,000 barrels) might be saved.

4.3.2 Inactive Ships

Inactive ships could be used for the storage of grain and petroleum products without any modification of the vessels involved, hence at minimum cost. Considering first the storage of grain, we find that sufficient wheat to supply most of the diet for 60,000,000 people for 6 months could be stored in 800 Liberty ships. Further, these Liberty ships could be dispersed among the established reserve fleets or, if required, at newly prepared sites in order to serve as food supply centers for metropolitan areas located on waterways (23 of the largest SMSA's are so located--see Table 3). The cost of the entire program, at an estimated 16¢/bushel per yr. (3.3.2), would be $30,000,000 per year. This figure includes cost of movement and emplacement of the ships, their maintenance, the cost of the wheat (which must be rotated every 5 years), loading, unloading, and inspection costs.

Petroleum products could be stored in all of the 77 tankers while at their present locations in the various MARAD fleets, although dredging to accommodate the 30-ft draft would be required at most sites. However, if the tankers were dispersed in conjunction with the grain-laden Liberty ships, either in the established MARAD and Naval reserve fleets or in specially created nests, the postattack distribution problem would be considerably lessened. Further, the 47-T2 tankers could be located near major population centers where their power generating capacity might be most useful in time of disaster. The implementation of such a program, including the filling and dispersal of all 77 tankers, might cost between 30 and 40 million dollars; of course the fuel cost, which is the major item, is ultimately recoupable. The 8,000,000-barrel fuel reserve so created could be an appreciable addition to the nation's fuel reserves following enemy attack, especially if it consisted of those fuels that preplanning indicated might be in shortest supply.[14]

4.4 SHIPS AS FLOATING UTILITIES

4.4.1 Active Ships

It has not been possible to make an estimate of the nationwide potential of ships as floating utilities, but it may be just as well since the more important consideration is not "How Much?" but "Where?". For example, 10,000 kw of power may be inconsequential in a port that has suffered little or no damage, whereas the same amount of power might be all-important in a badly damaged target area where power lines are down. Some indication of the relative importance of using ships as floating utilities might be obtained by briefly considering the Port of New York. Assume a total of 100 ships in the port of which 4 are passenger liners, 6 are T2 tankers, 14 are larger tankers, 16 are modern cargo ships, 40 are Victory or Liberty ships of various flags, and 20 are miscellaneous types. The estimated usable power that these 100 ships might deliver to shore is 58,000 kw; the estimated water-distillation capacity is 1,630,000 gal/day. Such use, of course, does not take into account the normal utilization of the ship or the efficiency of the individual vessel as a utility source.

4.4.2 Inactive Ships

Only two types of inactive ships, the T2 tankers and the S4's, have sufficient utility potential to consider reactivating them for use as floating utilities. The total capacity of all 47 T2's plus all 40 S4's is 425,000 kw of power and 800,000 gal/day of distilled water. The distilling capacity of these ships is appreciable though not outstanding; but their power output is most significant (compare with the Port of New York above), and future planning for civil defense should recognize this most important resource.

SECTION 5

CONCLUSIONS

Ships and boats offer both a lifesaving and a life-sustaining potential to large numbers of people. Much of this potential is not being considered in current civil defense planning. Specifically, it is concluded (following the listing of Fig. 5) that:

1. Merchant ships are presently limited to a doctrine of "ship saving" which eliminates any civil defense use. However, if merchant ships were available, they could be extensively used in an alert for the evacuation of personnel from possible target areas.

2. Larger boats could be used for the evacuation and housing of evacuees; a washdown system would be of value for such usage.

3. With minor expenditure, Naval Reserve Fleet ships could be made into excellent shelters at their respective bases. The 8 Maritime reserve fleets could, at best, serve only as mediocre shelters and then only with considerable expenditure of money.

4. Surplus vessels could be converted into excellent ship shelters or headquarters. The cost for the conversion of a Liberty ship, including emplacement into a ship shelter, is approximately $860,000. The converted ship would provide accommodations for up to 10,000 persons.

5. Civil defense headquarters could be set up to good advantage in an active passenger or cargo ship following an attack, or in a converted Liberty ship prior to an attack. The best civil defense headquarters, however, would be a buried battelship which would be highly resistant to both blast and radiation. The estimated total cost: $1,000,000.

6. Active ships, by virtue of water supplies carried for internal consumption and cargos carried for hire, represent a reserve of food, water, and fuel that could survive nuclear attack.

7. Inactive ships from the Maritime reserve fleet could be utilized very effectively to create emergency food and fuel centers near population centers. Such utilization would entail moderate expenditure of funds, but would not destroy the usefulness of the ships.

8. Active ships could provide shoreside populations with significant quantities of potable water by use of their distillation equipment. Storage of water in inactive tankers does not appear justified.

9. Most active ships can supply only limited quantities of 60-cycle power to shore installations. However, some passenger liners and all T2 tankers are individually capable of powering small cities.

10. Those T2 tankers and S4 vessels currently in the NDRF could, if activated, provide a total of 425,000 kw to shoreside installations.

11. Many of the programs found to have promise for the civil defense effort are based on the availability of surplus ships. Hence, a moratorium should be placed on the scrapping of nonpriority ships, particularly Liberty ships and battleships, until a decision can be made on their value in the civil defense effort.

12. In many areas, further study is required before final judgments can be made.

13. In all areas, it was found that many government agencies and, often, private firms are involved; utilization of ships would require working agreements between OCD and the interested parties.

SECTION 6

FUTURE RESEARCH POSSIBILITIES AND RECOMMENDATIONS

This study has revealed several problem areas that appear to merit further investigation. Listed below are some possibilities that are recommended for future study.

1. Comprehensive Study of a Port City. If the various suggested uses of ships and boats are to have real value, they must be applicable to the civil defense needs of an actual situation. An evaluation of such needs was attempted on a small scale for New York and San Francisco, but only the surface could be touched in a broad-scope study, such as this one. A future study in depth of one or two port cities should be undertaken in which as many as possible of the considerations discussed in this report should be investigated. Such a study should include: population distribution in relation to accessibility to waterways; availability of ships and boats for evacuation of personnel, taking into account cyclical variations; possible sites for ship shelters; utilization of reserve fleets as shelters; requirements for emergency storage centers (including food, fuel, and utilities) and dispersal points for such centers near the subject city. Port cities that appear to have special qualifications for a study of the magnitude indicated include Brooklyn, New Orleans, Norfolk, and Seattle.

2. Shielding Provided by Ships and Boats. The shielding studies done for a Liberty ship and the SS INDEPENDENCE should be extended to include living and engineroom spaces on modern cargo ships and tankers. These results are needed to fully evaluate the radiation hazards to the crews of merchant ships caught in a fallout field. The shielding provided by small boats should be more fully analyzed to establish the useful limits of these craft in a fallout situation.

3. Washdown Systems for Ships and Boats. It was shown that washdown systems could be profitably used on passenger ships and small boats. In order to ascertain engineering requirements and costs, a feasibility study should be made using available data.

4. S4 Utilization. The feasibility and economics of utilizing the 40 surplus S4 vessels in a dual role as personnel shelters and power-generating stations, or only as a floating utility, should be evaluated.

5. Reserve Fleets as Shelters. Naval Reserve Fleets, which possess excellent features for shelter use, should be further evaluated as to the economics and logistics involved in such use. The utilization of troop and hospital ships in the NDRF as in situ shelters might be of limited research interest.

6. Blast Effects on Ship Shelters. Although the effects of blast on ships moored in deeper water or at sea are known, blast effects in the situations here envisaged (at a pier, beached, landlocked, in a reserve fleet configuration, etc.) need investigation. In addition, the possible effects of a weapon-created tidal wave should be considered.

7. Conversion of a Liberty Ship to a Ship Shelter. The feasibility of converting a Liberty ship into a shelter has been demonstrated. The construction of such a ship shelter should be undertaken to fully evaluate the economic, political, engineering, physiological, and psychological factors involved. An additional study should be made to determine the locations throughout the nation where such ship shelters could be best used.

8. A Buried Battleship as a Blast-Resistant Civil Defense Headquarters. A detailed engineering feasibility study of the conversion of a battleship to an underground headquarters should be made.

9. Emergency Storage Centers. The use of NDRF vessels to store food and fuel supplies near population centers appears very attractive, but further studies of the following are indicated:

(a) Food. Possible foods for bulk storage, including bulgur, or one of its derivatives, should be considered from stability and cost aspects.

(b) Fuel. The problems associated with the storage of fuel should be further evaluated and postattack utilization considered.

(c) Power generation. The usefulness of the turboelectric generator vessels (T2s and S4s) for providing shoreside power should be fully evaluated.

REFERENCES
(All Unclassified)

1. Callahan, E.D., Rosenblum, L., and Coombe, J.R., Shelter from Fallout, Technical Operations, Inc., Report No. TO-B-60-30 (revised), 7 April 1961.

2. Rubenstein, B., A Task Force Report on the Use of the National Defense Reserve Fleet for Civil Defense Purposes, OCD, 1961.

3. Mobile Treatment Units, Public Health Service, Submitted to OCD as completed research project 2409 on June 30, 1962.

4. Swalley, R.F., Submarine Hulks as Protective Shelters, U.S. Naval Civil Engineering Laboratory Report No. 128, 21 February 1961.

5. Brown, W.M., Strategic and Tactical Aspects of Civil Defense with Special Emphasis on Crises Situations, Hudson Institute, 7 January 1963.

6. TM 3-225 or NAVDOCKS TP-PL-13, Radiological Recovery of Fixed Military Installations, 16 April 1958.

7. Executive Order 10999, Assigning Emergency Preparedness Functions to the Secretary of Commerce, 16 February 1962.

8. Powell, C.A., Principles of Electric Utility Engineering, New York, John Wiley, 1955.

9. Boating, 1962; A Statistical Report on America's Top Family Sport, Presented jointly by the Nat. Assoc. of Eng. and Boat Manufacturers et al.

10. Recreational Boating in the United States, Annual Report 1 January to 31 December 1961, CG-357, 1 May 1962, U.S. Coast Guard, Treasury Dept.

11. Porteous, L.G., Design Modifications and 1962 Cost Analysis for a Standardized Series of Fallout Shelters, USNRDL-TR-582, 17 September 1962.

REFERENCES (cont.)
(All Unclassified)

12. Private communication from A.D. Shepherd, Western Regional Research Laboratory, Albany, California.

13. Dixon, H.L., et al., A Systems Analysis of the Effects of Nuclear Attack on Railroad Transportation in the Continental United States, Stanford Research Institute, IU-3084, April 1960.

14. Thayer, S.B., and Shaner, W.W., The Effects of Nuclear Attacks on the Petroleum Industry, Stanford Research Institute, IU-3084, July 1960.

15. NAVDOCKS DM-29, Design Manual: Drydocking Facilities, Vol. II.

16. Waterborne Commerce of the United States, Calendar Year 1960, Part 5, National Summaries, Dept. of the Army, Corps. of Engineers.

APPENDIX A

RADIATION DOSE STUDIES

For a land surface nuclear burst, the free-field fallout radiation dose at a point offshore can come from 4 sources, 3 of which are interrelated. The transit dose is that received from the radioactive cloud as it passes overhead; this dose is independent of the surface over which the cloud travels. As the radioactive cloud passes it deposits radioactive particles. If these particles settle on the deck of a ship they give rise to the deck-deposit dose; if the particles settle on an adjacent land surface they give rise to the land-deposit dose. Finally, if the particles settle on and in the water surrounding the ship they produce the waterborne dose. This waterborne dose can be further subdivided into a water settling dose, which is received during the time that the particles are falling from the surface of the water to the bottom and a water-solution dose, which results from dissolution of a portion of the radioactivity as the particles fall through the water and thereafter.

In order to determine the relative importance of land deposit, deck deposit, and waterborne dose, contribution factors, which are dependent on the placement of the ship in relation to the land water areas, must be calculated. In this report we have used Ref. 1, which is based on experimental data from a La-140 radiation field, to calculate the contribution factors for land-, deck-and water-deposit radiation.

Finally, in order to determine the dose to a person on a vessel, we must consider the structural shielding of the vessel itself as well as the time over which the sources contribute to the total dose. Transit radiation irradiates the ship from all sides, but only while the cloud is passing near the vessel. Deck-deposit radiation penetrates from the horizontal surfaces of the ship from the moment of deposition until it is removed -- either by washdown or decontamination. Land-deposit radiation, both direct and indirect, penetrates the ship through the hull and the deck from the moment of deposition until the land surface is decontaminated. Waterborne radiation contributes primarily through the submerged hull, the water-settling component contributing only during the period of actual fallout, the water-solution component remaining as a contributor for an indefinite time or until dispersed by tidal action and dilution.

Transit dose was calculated using a model developed at NRDL.[2] Deposit dose was calculated using the NRDL D-Model,[3] and was then split into its three possible components -- deck deposit, land deposit or waterborne -- by inspection of the geometry of the situation. The water settling and water solution doses were calculated using the data of Ref. 4. It was assumed[5] that 10% of the radioactivity of the falling particles dissolved as they fell through the water, creating the water-solution dose. The time to fall 1 meter in quiescent water, was taken as:[6]

$$\text{Time, hrs} = \frac{312}{(\text{particle size, microns})^2}$$

which time defines the water settling dose. It was found that a depth of 9 ft was an adequate limit to which to carry the calculation of both water-settling and water solution doses.

The contributors to the total free-field radiation dose received up to 1 yr after burst time are presented in Figs. A.1,2, and A.2 as a function of downwind distance along the hotline for total yields of 1 MT, 5 MT, and 20 MT, respectively. An effective wind of 15 knots is assumed and all downwind distances are measured along the hotline. An idealized pattern of total-dose contours resulting from such a wind structure would be similar to those illustrated in The Effects of Nuclear Weapons (p. 445).[7] In any actual case, the doses received would generally be less than those indicated in Figs. A.1, 2, and A.2, since any actual winds encountered would be less uniform and more widely dispersed than those specified here. Actual winds would tend to distribute the radioactivity over a greater area and result in radiation intensities less than those predicted, even though isolated "hot spots" might be encountered. Actual doses received would be less for two other reasons. First, fission yields would normally range from 40% to 60% (p. 23, Ref. 7) for the total weapon yields used here, and doses would be reduced proportionately. Second, most points under consideration would probably not be on the hotline, and doses would also be reduced accordingly.

The radiation dose to occupants of any type vessel can be calculated, using Figs. A.1, 2, and A.2. We shall consider a converted Liberty ship as an example (Fig. A.3), using the data for a 5 MT

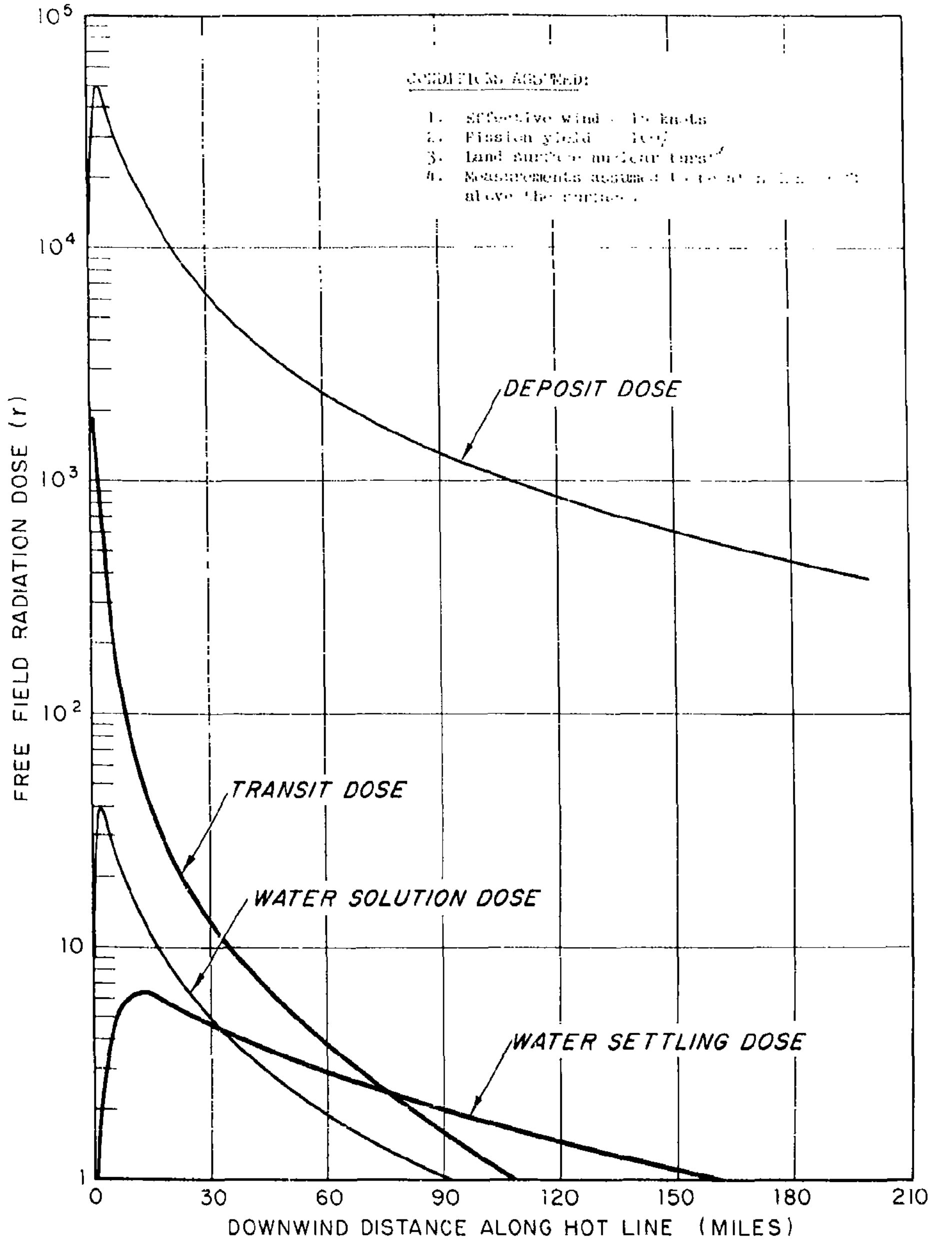

Fig. A.1 Radiation Dose Studies - 1 MT Weapon Yield

Various Components of the Free Field Radiation Dose Received up to One Year After Burst vs Downwind Distance Along the Hot Line

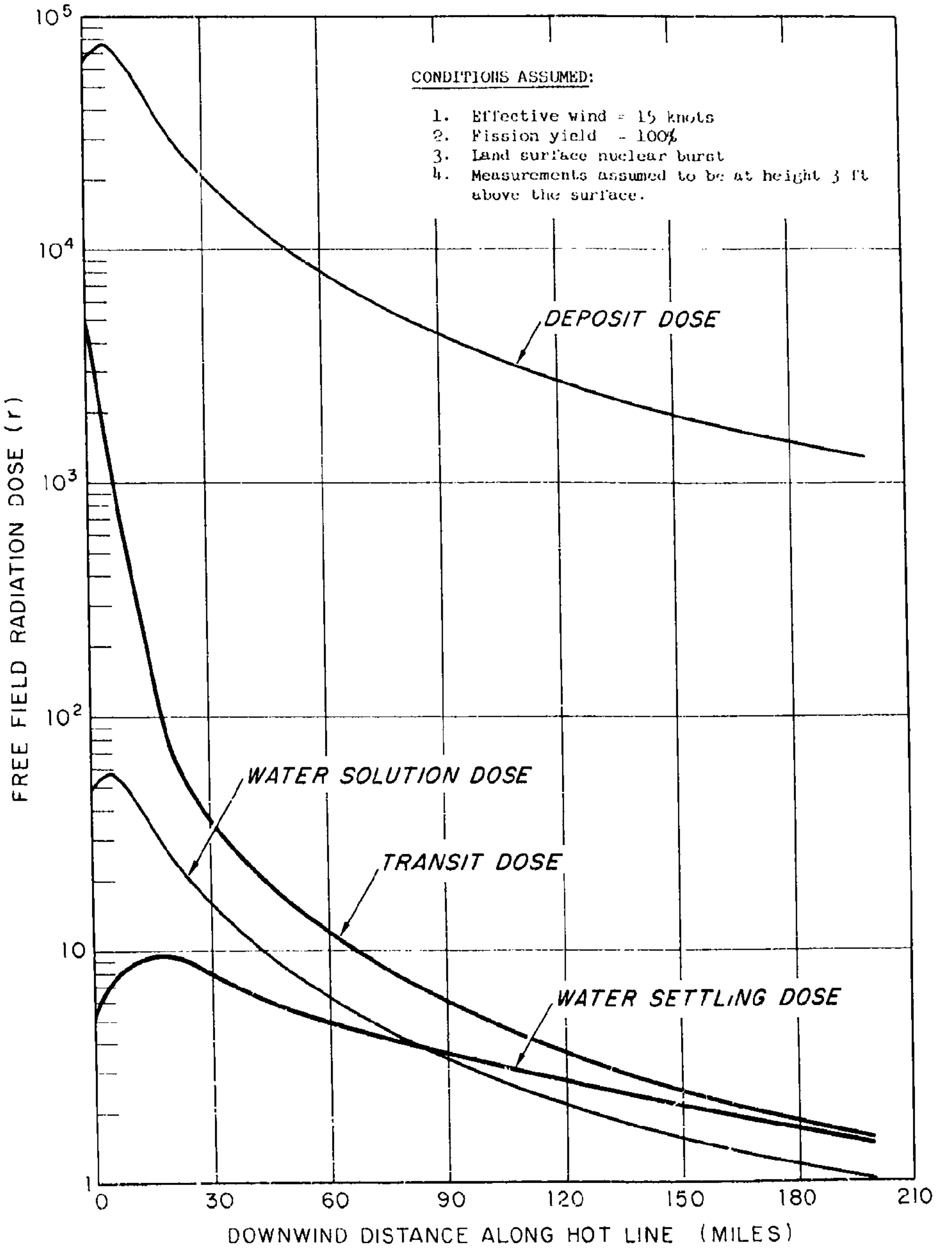

Fig. A.2 Radiation Dose Studies - 20 MT Weapon Yield

Various Components of the Free Field Radiation Dose Received up to One Year After Burst vs Downwind Distance Along the Hot Line

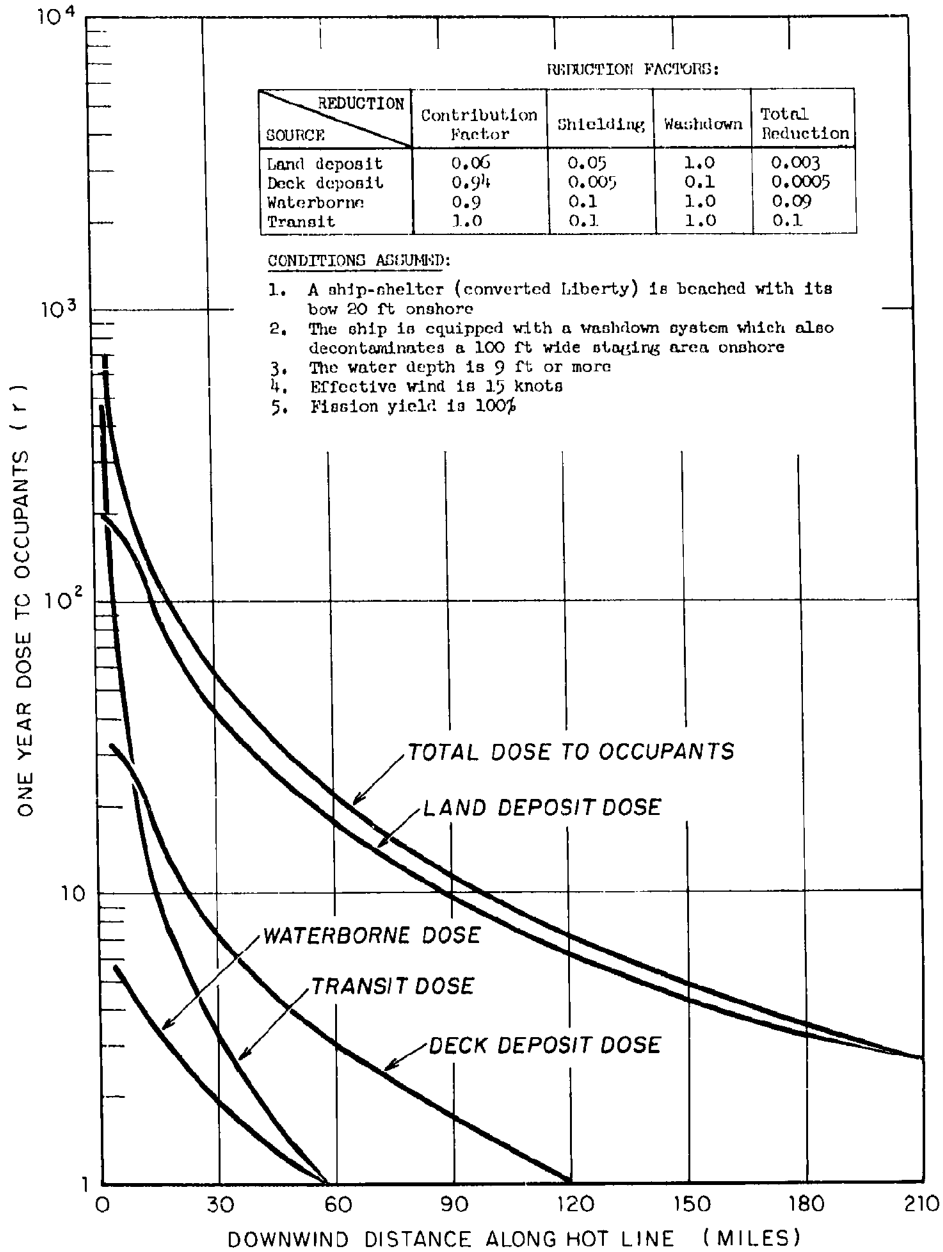

Fig. A.3 Hot Line Radiation Dose from Several Sources to Occupants of a Beached Converted Liberty Ship Downwind from a 5-MT Land-Surface Burst weapon (Fig. 2). The assumed conditions are that the converted Liberty is beached with its bow 20 ft onshore (as shown in Fig. 12b) and that the ship is equipped with a washdown system that continuously decontaminates the top surface of the ship as well as a 100-ft-wide staging area shoreside of the bow of the ship. With this configuration, we find that the contribution factor from deposited fallout will be, for a point in the center of the ship, 94% from the ship's deck and 6% from the shore. The radiation from the 4 sources is reduced by the shielding of the ship itself; the reduction factors range from 0.005 for the deck-deposit dose, which must penetrate 4 inches of concrete and several thicknesses of deck, to 0.1 for the transit and waterborne doses, which penetrate primarily through a 1-inch hull thickness. Finally, the washdown system provides continuous decontamination of the ship's upper surfaces, reducing the deck deposit dose by another 90%. The overall reduction factors then range from 0.1 for transit radiation to 0.0005 for deck-deposit radiation. From Fig. A.3 it is apparent that, the land deposit dose is controlling except near the point of burst. However, the deck-deposit dose would be equally high if (a) the ship had no washdown system, or (b) the ship did not have a 4-inch layer of concrete on the weather deck. Waterborne radiation is negligible; so too is transit radiation except at close-in distances. Figure A.3 suggests that a converted Liberty would adequately safeguard its occupants against fallout radiation as close as 6 miles from a 5 MT burst. This safe distance could be decreased to 3 miles by either adding expedient shielding to the hull of the ship or by moving the ship into midchannel prior to arrival of fallout.

Curves similar to Fig. A.3 can be drawn up for any weapon yield and for any particular configuration of any type vessel. If the vessel is within a half-mile of land, the contribution of land-deposit radiation must be taken into account. The total dose to occupants from transit, deck deposit, land-deposit, and waterborne radiation can then be determined.

Figures A.4 and A.5 show, for 3 types of vessels, the total dose to occupants for 1-MT and 20-MT land-surface bursts, respectively. The first case, a fishing boat of 15-ft beam, is located in the middle of a 1600-ft-wide river that is 9-ft deep. The boat has a reduction factor of only 0.8 but it is equipped with a washdown system that removes 80% of deck-deposit fallout. The second case is the SS INDEPENDENCE, which is assumed to be at sea when fallout arrives. A reduction factor of 0.02 (from Fig. 8) is supplemented by a washdown system with an effectiveness of 80% (higher effectivenesses are not assumed, because of the relatively high holdup of particulate matter that might be expected on wooden decks). The third case, already

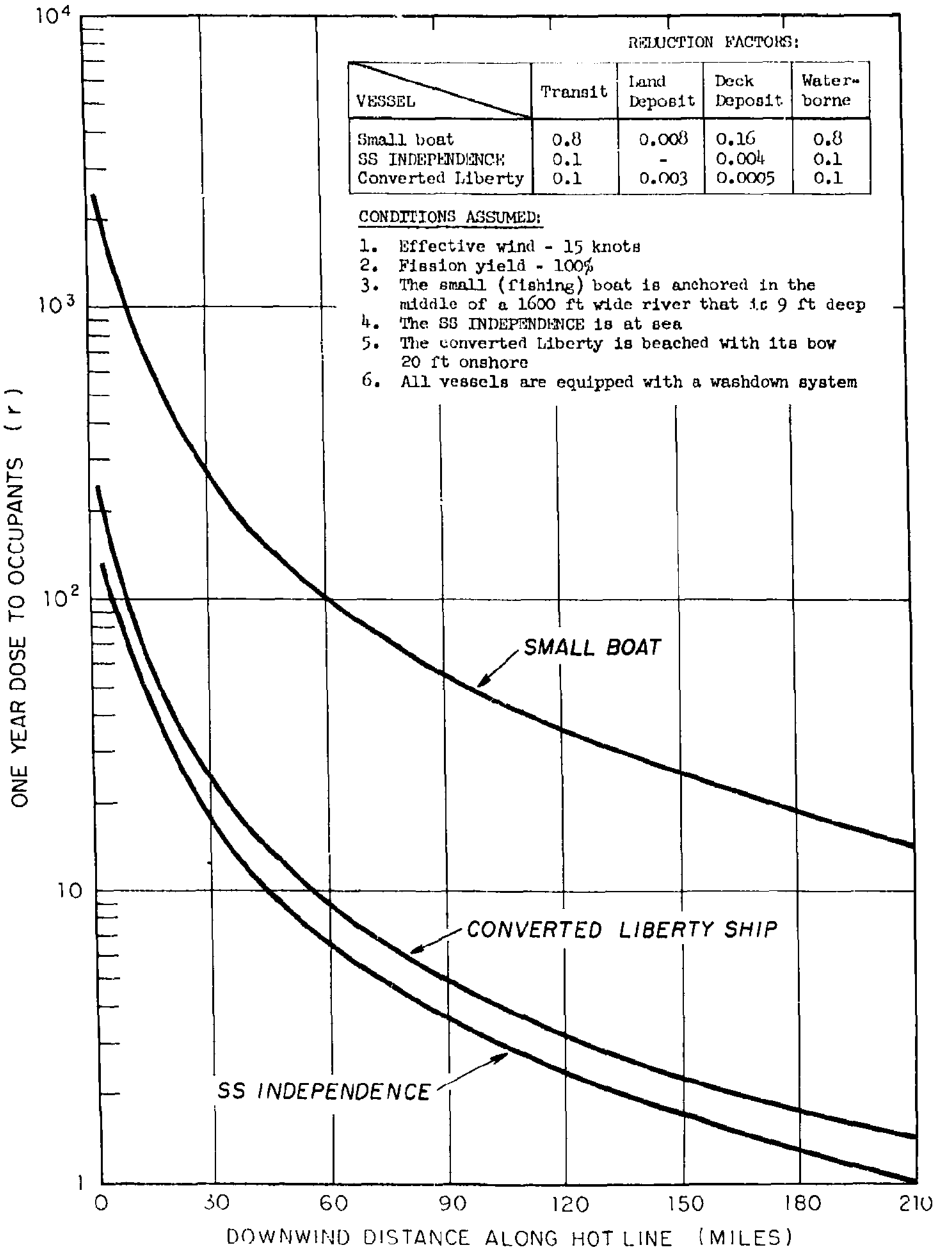

Fig. A.4 One Year Doses to Occupants of Various Type Vessels Downwind from a 1-MT Land-Surface Burst

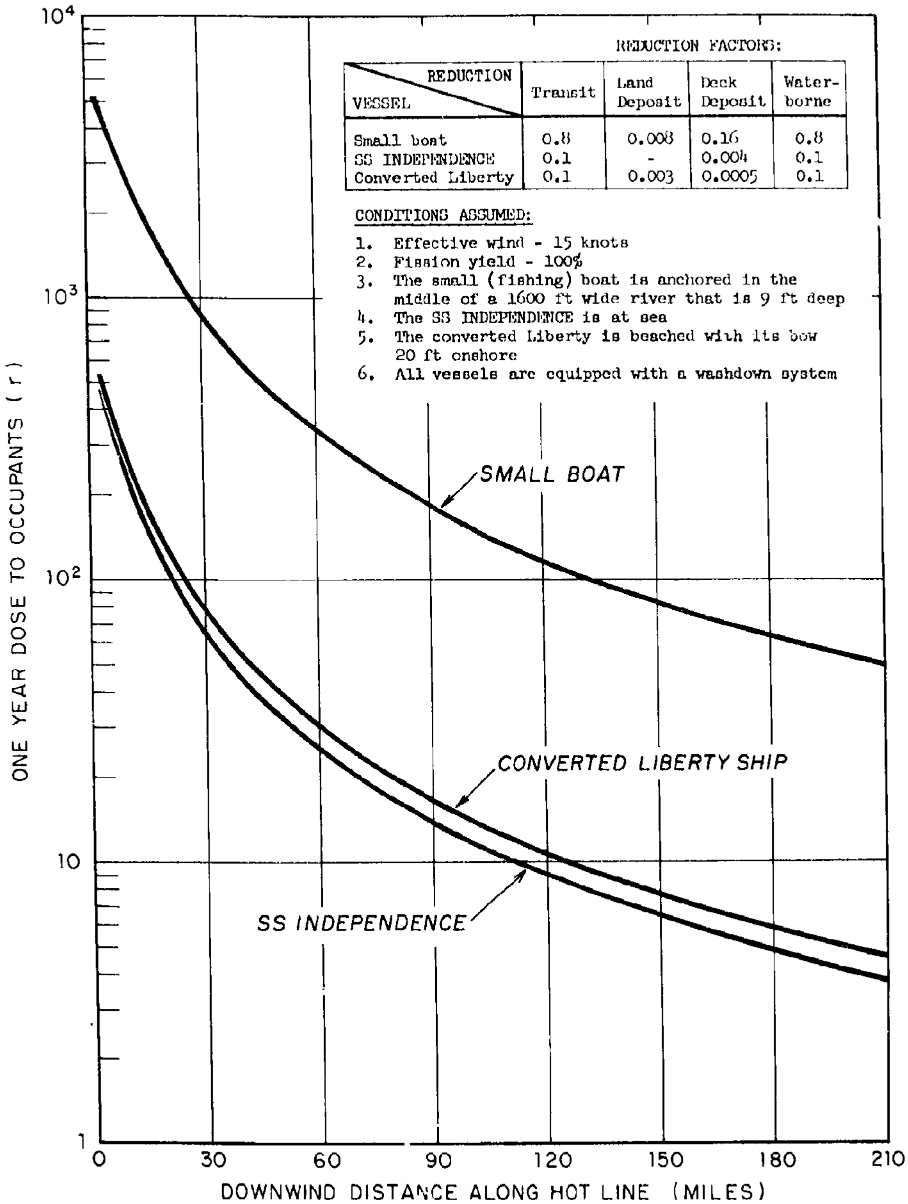

Fig. A.5 One Year Doses to Occupants of Various Type Vessels Downwind from a 20-MT Land-Surface Burst considered in detail in Fig. A.3, is the converted Liberty ship beached on a shore.

From these figures, it is apparent that the converted Liberty ship beached on shore and the SS INDEPENDENCE at sea are about equivalent in protection afforded against fallout radioactivity. The fishing boat, as might be expected, provides only limited protection against fallout. However, a comparison of Figs. A.1 and A.4 does show the boat to have a definite protective value. At 30 miles downwind, the free-field dose would be 7500 r whereas occupants of the fishing boat would receive only 300 r.

REFERENCES

1. Schlemm, C.L., and Anthony, A.E., Scattered Gamma Radiation Measurements from a Lanthanum-140 Contaminated Field, June 1959, AFSWC-TN-59-18.

2. Huebsch, I.O., USNRDL Technical Report in preparation.

3. Anderson, A.D., The NRDL Dynamic Model for Fallout from Land Surface Nuclear Bursts, USNRDL-TR-410, 5 April 1960.

4. Ksanda, C.F., Cohn, S.M., et al., Gamma Radiations from Contaminated Slabs and Planes, USNRDL-TM-27, 10 Jan 1955.

5. Hawkins, M.B., Procedures for the Assessment and Control of the Shorter Term Hazards of Nuclear Warfare Fallout in Water Supply Systems, 1 March 1960. University of California, Institute of Eng. Research, Berkeley.

6. Callahan, E.D., et al., Shelter from Fallout, 7 April 1961. Technical Operations, Inc.

7. Glasstone, S., Editor, The Effects of Nuclear Weapons, April 1962.

APPENDIX B

GENERAL DESCRIPTION OF REDUCTION-FACTOR CALCULATIONS FOR FALLOUT GAMMA RADIATIONS

By Endel Laumets

The method used to calculate the reduction factors against fallout gamma radiation for various ship locations is described by C.F. Ksanda in the paper "Ship Shielding Calculations."[1]

This paper states the following: "The general problem of computing ship shielding factors involves: (1) specification of the radioactive source characteristics, particularly geometric configuration and radiation energy spectrum; (2) specification of the major ship characteristics, particularly configuration and nature of materials; (3) development of methods for computing the interaction of the radiation with the ship. To arrive at a practicable solution, it has been necessary to idealize and generalize into static situations the dynamic source configurations produced by a variety of nuclear detonations and to idealize the complex structures and components of naval ships, as well as to devise sufficiently simple approximations to the transmission of gamma rays through attenuating media -- which may consist of air and water as well as the material of the ship."

Ksanda states further: "Basically, the approach that has been followed is a point-by-point calculation. The radioactive source region is considered to be made up of an aggregate of point isotropic sources. The dose rate from each source is calculated at a given location by estimating the radiation attenuation along the entire path length, and the total dose is found by summing over all sources. In practice, the summation process is replaced to the extent possible by integration. The calculations are made for monoenergetic sources of different energies. By properly weighting and adding the results for different energies, an estimate may be made for the spectrum from mixed fission products at any time after fission."

Calculations of ship shielding effectiveness against transit, deck-deposit, and waterborne radiations for any interior (below-decks) location are complicated and numerous, and when done manually, are tedious, time consuming, and subject to human error. Past and current calculation methods have proved unsatisfactory because the calculations have necessarily had to be done manually. The complications of ship shielding calculations arise from numerous factors: (1) configuration of the radiation source (deck-deposit plane source, transit or waterborne volume source); (2) nonuniform distribution of activity in the source; (3) source-shield-receiver geometry; (4) gamma-ray energy spectrum change with time after fission; (5) effect on the gamma-ray energy spectrum of various kinds of attenuating material; and (6) thicknesses of materials providing shielding to different interior locations. Further complicating the calculations are the many parameters and their relatively wide ranges of values that have to be considered.

The calculations for a given interior location have to take into account (a) all the gamma radiations arriving there from all the points of a plane source, a volume source, or both; (b) all the significant aspects of the particular source-shield-receiver geometry; (c) all the gamma-ray energy spectra for the respective times of interest after fission; and (d) all the significant interactions of the radiation and the intervening air shielding materials (air, water, steel, etc.).

A method of calculating shielding factors was therefore devised* with its procedural steps formulated to provide a computational sequence for a high-speed electronic computer program. Then, a computer program of the method was written. This program evaluates the basic equations derived from the theoretical equations given in Ksanda's "Ship Shielding Calculations" paper. This program can calculate shielding factors for any interior location in any ship type, and is applicable for fallout gamma radiations from airborne transit-or waterborne sources, and from deck-deposit sources; for an assumed uniform distribution of activity in the source; for any time after fission; for any source-shield-receiver geometry; and for any number of partial shields (deck-plating sections, bulkheads, etc.) contributing to the total shielding provided the location.

The program is not specifically applicable to the waterborne case because of the uncertainty about the subsurface distribution of fallout activity deposited in the water; and the settling and mixing rates for

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* Laumets, E., A Method of Determining Ship Shielding Factors for Fallout Gamma Radiation, USNRDL-TR in preparation, Unclassified.

the various-sized fallout particles. The waterborne case is expected to be of relatively minor importance because of the rapid reduction in dose rate due to the appreciable attenuation of radiation by water. Also, the program is not applicable to the fallout activity deposited on vertical or near-vertical weather surfaces, or to base-surge transit radiation, or to the initial radiation from the fireball (radiation emitted during the first minute after the burst).

For a given interior location and for a given time after fission, the program first computes the shielding contribution of each partial shield. For a partial shield, the program first obtains, by numerical integration, a shielding factor for each of 5 gamma-ray energies of the pseudospectrum* used to represent the "true" spectrum for that time after fission. Then, the 5 shielding factors are multiplied by the corresponding pseudospectrum weighting fractions for that time, and the products are summed to get the total shielding factor for the partial shield. This computation is repeated for each other partial shield for the location, and all the partial-shield shielding factors are summed to get the shielding factor for the location for the given time after fission.

For radiation reaching the interior location from above, only the deck-plating thicknesses are considered. To account for shielding material other than deck plating, such as major bulkheads, beams, pipes, equipment, machinery, and supplies, the shielding factors is computed for double deck-plating thicknesses. The computed shielding factor should be close to the expected or "true" shielding factor. For radiations entering through the sides of the ship, the hull, intervening major longitudinal and transverse bulkheads, and any liquid loading between them are considered, along with any intervening deck plating.

A technique was developed for obtaining the necessary dimensional values of a given source-shield-receiver geometry and for combining the thicknesses of the various shielding materials. This technique is explained in detail in Ksanda's paper. Shielding factors obtained with computer program of the method were compared with experimental shielding factors and agreed by a factor of less than 2. Details are given in Ref. 2.

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* Laumets, E., Gamma-Ray Energy Pseudospectrum for U^{235} Fission Products at Various Times After Fission, USNRDL-TR in preparation (Uncl).

REFERENCES

1. Ksanda, C.F., Ship Shielding Calculations, Proceedings of Tripartite Symposium on Technical Status of Radiological Defense in Fleets, Vol. I, May 1960 (Uncl).

2. Haggmark, L.G., Ship Shielding Factors - Computational Method Compared to Experimental Results, USNRDL TR-514, 7 June 1961

APPENDIX C

SAN FRANCISCO POPULATION DENSITY AND POPULATION MOBILITY STUDY

This study was conducted to determine (1) San Francisco's population distribution and (2) the speed and ease with which any part or all of this population, after being warned of an impending disaster, might move on foot to ships located at the water's edge. These ships might either be landlocked or beached vessels located on the western and northern perimeter of the city or docked vessels located along the city's eastern shore.

These data were then used to determine, as a function of time, the cumulative percentage of the total city population able to reach each given dockside loading zone. These dockside loading zones (Fig. C.1), six in number and designated zone A through zone F, should be clearly distinguished from the nine population areas into which the city has been divided. The population areas are designated area 1 through area 9. Daytime and nighttime populations in each area are listed in Table C.1.

Figures C.2 and C.3 show the relative numbers of people that might be expected at various loading zones as a function of time after the sounding of a warning signal, and for the daytime and nighttime cases, respectively. In the "daytime" case the employed population is assumed to be at work; the "nighttime" case (identical with the "weekend" situation) assumes the population to be at home. Such information could also be used to calculate the time required to move the entire San Francisco population to ship shelters or to help determine the optimum location and number of these ship shelters.

Figures C.2 and C.3 compare the relative percentage of the population that could, in any given length of time, be brought to any of the six loading zones during the day (Fig. C.2) or night (Fig. C.3). These curves could help locate optimum shelter locations for either a day or night attack situation, but any actual location selected must be satisfactory for both of these cases. During the day, zone D appears to be the best ship shelter location because large numbers of people are close to this waterfront loading zone. Following, in

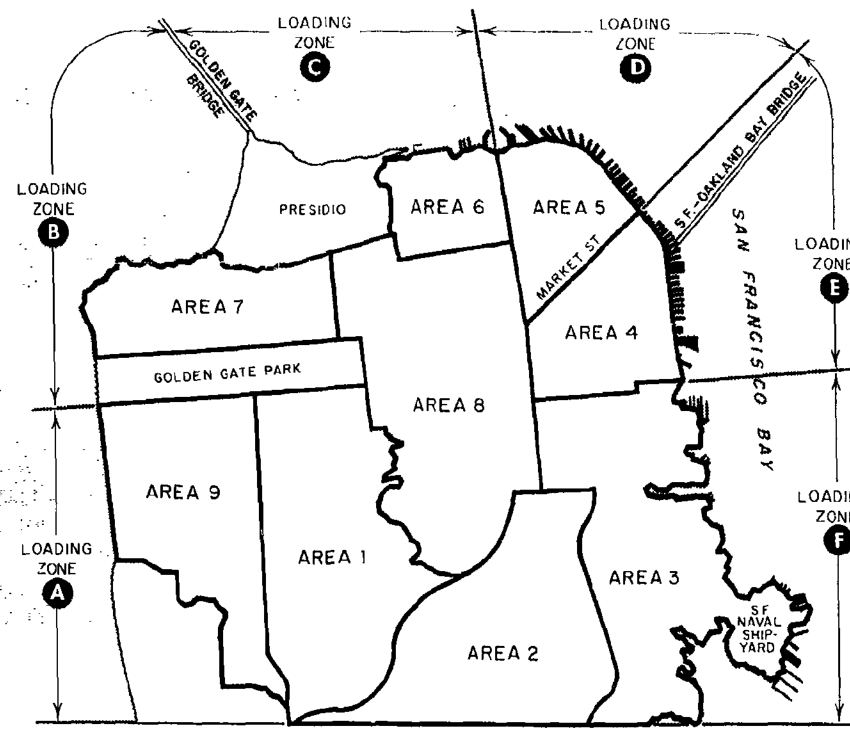

Fig. C.1 San Francisco Population Areas

Areas 1, 2, 6, 7, 8, and 9 are primarily residential.
Area 3 is primarily light industrial.
Area 4 is both residential and light industrial.
Area 5 is residential, business, and contains the central business district.

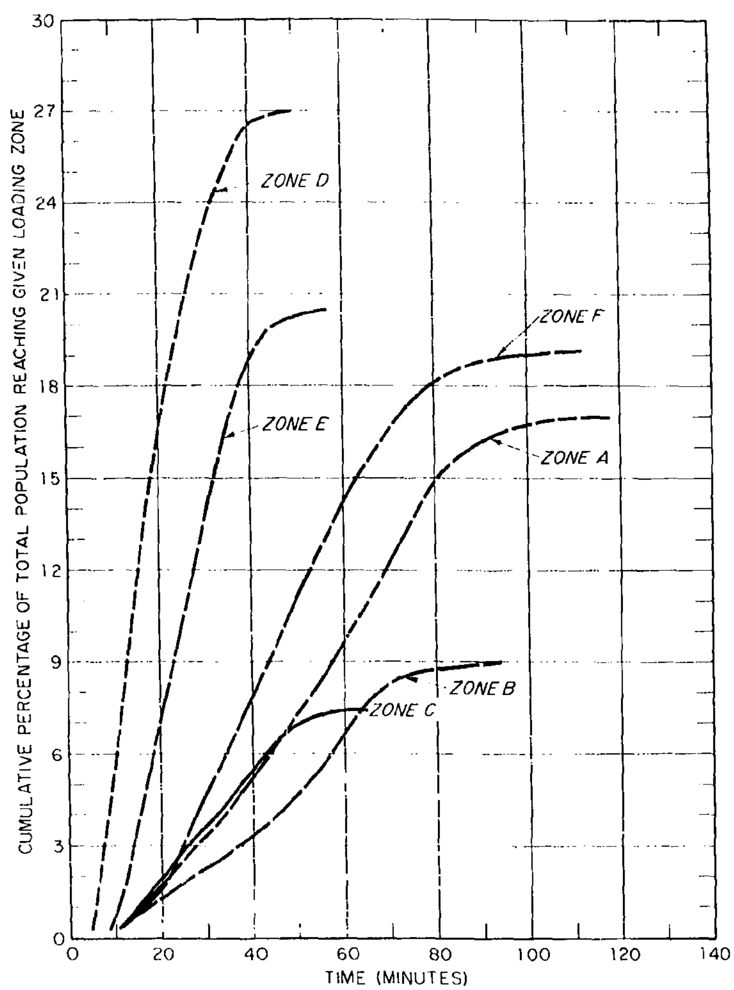

Fig. C.2 Time for Evacuees to Reach San Francisco "Loading Zones" Daytime. (Use with Fig. C.1 and Table C.1)

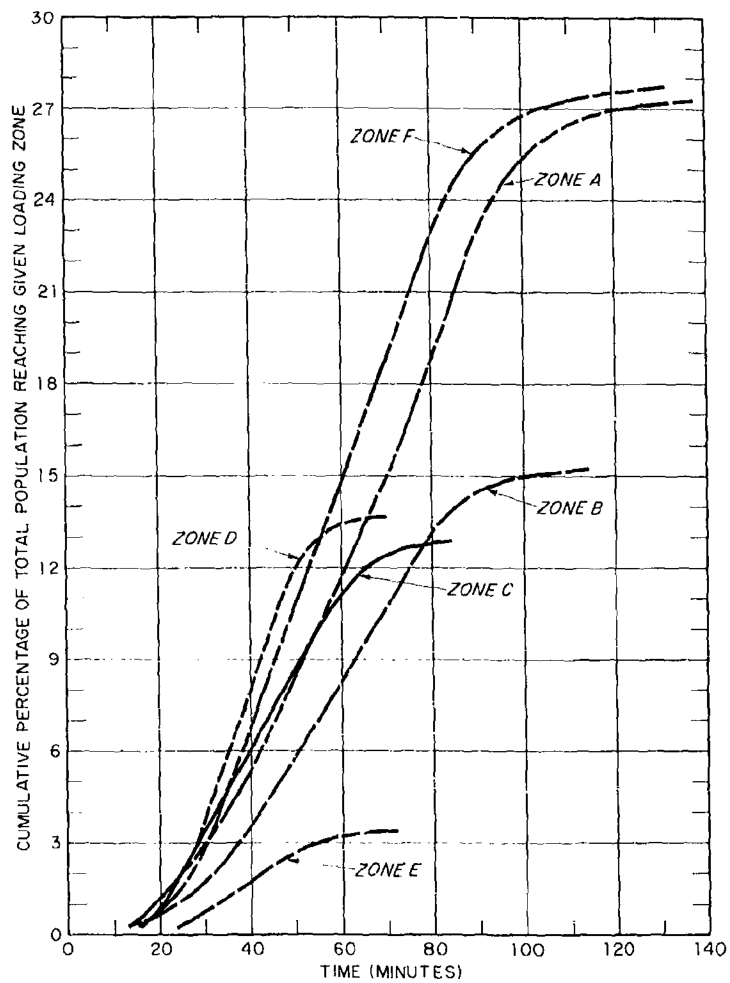

Fig. C.3 Time for Evacuees to Reach San Francisco "Loading Zones" Nighttime. (Use with Fig. C.1 and Table C.1)

Table C.1

SAN FRANCISCO DAYTIME AND NIGHTTIME POPULATIONS BY AREA

AREA	DAYTIME POPULATION		NIGHTTIME POPULATION	
1	59,200	(6.5%)	85,200	(11.2%)
2	72,600	(8.0%)	89,700	(11.8%)
3	64,100	(7.1%)	71,200	(9.4%)
4	185,300	(20.3%)	25,000	(3.3%)
5	244,900	(27.0%)	101,000	(13.3%)
6	31,500	(3.5%)	49,300	(6.5%)
7	44,100	(4.8%)	64,800	(8.6%)
8	150,700	(16.5%)	190,200	(25.2%)
9	57,200	(6.3%)	81,000	(10.7%)
TOTAL	909,600	(100.0%)	757,400	(100.0%)

decreasing order, would be zones E, F, and A. Zones C and B appear to be of little or no use as mooring places due to the small number of people in the population areas from which these zones would draw their evacuees and the slow rate of their arrival. During the nighttime, zone D appears to be a good location for ship shelters because of the rapid influx of people possible into this zone; a disadvantage is the relatively small total number of people living close to this loading zone. Zones F and A are both good, each having almost double the number of potential evacuees of zone D. Zone E, at night, would be a poor ship shelter location. Zones C and B are both fair to poor nighttime choices, due to the relatively slow rate at which people would arrive at these loading zones. It should be noted that the nighttime curves tend to bunch together far more than the daytime curves; one reason for this is the longer assumed nighttime reaction times that tend to mask differences in walking speeds and distances to shelter that would apply to the daytime situations.

Figures C.2 and C.3 are quite encouraging and show that a large part of San Francisco's population could quickly reach ship shelters. Within 15 min nearly 22% of the city's daytime population could reach ship shelters. Loading zones D and E account for two-thirds of this total. Unfortunately, because of the longer assumed nighttime reaction times, less than 1% of the nighttime population would have reached ship shelters at this time. By 30 min after warning, however, 16% of the nighttime population could be at a ship shelter (about three-fourths of this number would be evenly distributed at loading zones A, C, D, and F). The corresponding 30-minute daytime figure is 51% of the total population, with loading zones D and E accounting for 70% of this total. If 1 hr warning time could be provided, 86% of the daytime population and 63% of the nighttime population could be at ship shelters. Loading zones D and F would account for over one-half of this 1-hr nighttime figure in approximately equal proportion. People would begin arriving at the ship shelters after about 10 minutes after warning and arrival would be virtually complete two and a quarter hours after warning in both the daytime and nighttime cases.

The data analyzed consisted of (1) 1960 Census Tract Totals, (2) General Social and Economic Characteristics of the San Francisco-Oakland Standard Metropolitan Statistical Area: 1960, (3) Population and Housing Analysis for San Francisco: 1960, (4) Total 1960 Employment in San Francisco and Northern San Mateo Counties by Metropolitan Traffic Zones (collected by the California Department of Employment), (5) 1961 Student Population of San Francisco, (6) appropriate maps relating to the above items, and (7) various estimates from the San Francisco Visitors and Convention Bureau, San Francisco Hotel Association, and San Francisco

Chamber of Commerce.

The nighttime-population estimate was based entirely on Bureau of the Census data and Chamber of Commerce tourist and visitor estimates. The daytime-population estimate was deduced from all the data cited above. This estimation was complicated by the large daytime influx of workers into San Francisco from the suburbs and also by the daytime mobility of the resident San Francisco population. Oddly enough, even though San Francisco is an important tourist attraction, visitors to the city accounted for only about 3% of the population and were easily accounted for.

The daytime population was assumed to consist only of (1) persons employed in San Francisco, (2) persons attending college in San Francisco (3) San Franciscans who were neither working nor attending college and (4) tourists and visitors to the city. The distribution of persons from groups (1) and (2) within the 9 city population areas was determined from California State Department of Employment statistics. The number of people in group (3) was assumed equal to the total San Francisco nighttime population less the number of San Franciscans gainfully employed or attending college. Estimates of the number of tourists and visitors in San Francisco were gained from the San Francisco Chamber of Commerce, Hotel Association, and Visitors and Convention Bureau. People in group (3) were considered distributed within each population zone in proportion to the nighttime population distribution. People in group (4) were considered to be uniformly distributed in each area.

The objective of the population mobility study was to determine, as a function of time, the maximum number of people who could reach the nearest San Francisco waterfront loading zone on foot. The waterfront, in this study, was defined as that part of the perimeter of San Francisco touched either by the Pacific Ocean or San Francisco Bay. This perimeter was divided into six loading zones (zones A through F; see Fig. C.1). This perimeter will subsequently be called the "wetted perimeter." People from the nine <u>population areas</u> were assigned to one of the six <u>loading zones</u> closest to them. In the computation, it was assumed that the population was uniformly distributed within each of the 9 areas noted above unless the available data suggested otherwise. In these cases, this hypothesis was modified in the following way. Within each population area, two to four representative closest distances to the wetted perimeter were chosen and a proportional part of each area's population was assumed to traverse these distances on foot. An average walking speed of 85 yd/min,[1] normally distributed with a standard deviation of 12.5 yd/min, was chosen. Average speeds for each 5% of the population were determined using fractiles of the normal distribution.[2] It was further assumed that daytime reaction times (namely, the time after warning when movement to the wetted perimeter started) were 2, 4, 6, 8, and 10 minutes for each 20% of the population; the corresponding nighttime figures chosen were 6, 12, 18, 24, and 30 minutes.

Using the data and assumptions described above, the total number of people arriving at a given loading zone was calculated as a function of time after warning. These data, plotted in Figs. C.2 and C.3, indicate that, at times less than 30 to 40 min, the cumulative percentage of the total San Francisco population reaching a given loading zone is greater during the day than at night; this is primarily due to the shorter daytime reaction times assumed. This early lead is always maintained and even increased in loading zones D and E where evacuees are drawn from the heavily populated downtown areas. However, in the other loading zones, there is a cross-over point at about 35 min (this point occurs at about 60 min in loading zone F). After this time, the cumulative percentage of the total San Francisco population reaching the loading zone is greater at night than during the day. Loading zones D and E are exceptional for another reason. Only in these two loading zones are the daytime populations greater than the nighttime populations -- and by such a large amount, that the total daytime population of San Francisco is about 7% greater than the total nighttime population.

REFERENCES

1. Alexander, M.N., et al., Effect of Population Mobility on the Location of Communal Shelters, O.R.O., Johns Hopkins University, October 1957.

2. Oliver and Boyd, Mathematical Tables, Edinburgh.

APPENDIX D

NEW YORK AND SAN FRANCISCO PORT STUDIES OF SHIPPING

Waterborne traffic (commercial vessels, military passenger ships and military cargo vessels) at the Ports of New York and San Francisco was studied for periods of 4 weeks and 2 weeks, respectively, to determine traffic flow patterns, traffic volume and representative lengths of time that a ship remains in port ("turnaround time"). The collected data and the calculated statistics for these ports were then studied to see how waterborne commercial and nonfighting military ships might augment our civil defense capability during an emergency.

Traffic at the Port of San Francisco was studied in a preliminary project which covered the period from 23 May 1962 to 11 June 1962. Only those sections of the waterfront that are a part of the city of San Francisco were considered. Information and experience gained in this study were applied to a much larger study in which data from the 27 New York and New Jersey ports (Fig. 6) which comprise the Port of New York were analyzed.

The primary sources of information for the San Francisco port study were the "Shipping News" of the _San Francisco Examiner_ and _Lloyd's Register of Shipping_. Information sources used to study waterborne traffic at the Port of New York included _Lloyd's Register of Shipping_, _The Journal of Commerce and Commercial_, a daily newspaper containing much shipping news, and data received from The Port of New York Authority.

In the San Francisco study a record was kept for each ship entering the Port, the vessel's arrival date, pier where docked, and date of departure. For the time period studied, a record was also made of the number of ships in port on any given day (Fig. D.1). Tankers were not counted because they could not be used for lifesaving applications. The gross and net tonnage of each vessel listed was found in _Lloyd's Register_, and the concentration of pier activity at the Port was studied. Similar, but not identical, statistics were kept for the Port of New York. Those statistics that were felt to be most meaningful and most useful were collected and analyzed to obtain a picture of the Port's activity and the potential usefulness and capability of such

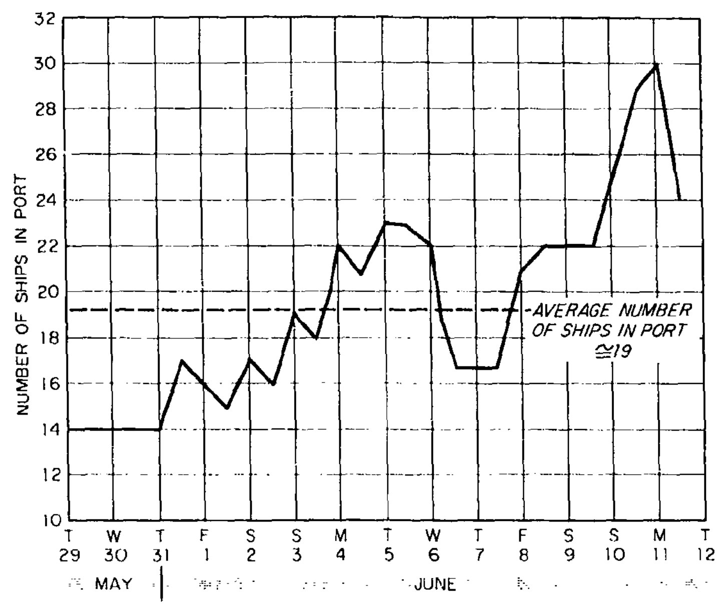

Fig. D.1 Number of Ships in the Port of San Francisco During the Period: 29 May 1962 - 11 June 1962 harbor traffic in the event of a local or national disaster.

The data collected for the first 7 days for both ports were not used when calculating the average number of ships in port, so that nearly all the ships logged out of each port were first recorded as arriving in port. The averages collected were for each 12-hr period and, for the Port of San Francisco, covered the period from 29 May 1962 to 11 June 1962, that is, after the first 7 days' data were eliminated. Figure D.1 depicts the number of ships in the Port of San Francisco during this period and illustrates the wide fluctuations from one part of the week to another and from one week to the next. Although this generalization is based on a very short period of time it was substantiated in the Port of New York both by the Port of New York Authority data and by the Port of New York data collected for this study (see below).

Table D.1 shows that the median ship turnaround time in San Francisco was 2.25 days, and the average (arithmetic) turnaround time was 3.75 days. The average turnaround time was greater than the median turnaround time both in San Francisco and at all of the ports comprising the Port of New York because of the very long turnaround time of a relatively small number of ships. It seems reasonable to expect this generalization to hold true for other ports as well as for those investigated in this study.

On the average, approximately 19 ships were present in the Port of San Francisco during the time of this study and these had an average net tonnage of 3700 tons and an average gross tonnage of 7000 tons. Figure D.2 shows that ship activity is not uniformly distributed throughout the San Francisco harbor area but, rather, is concentrated in four or five piers or groups of piers. This nonuniform ship-traffic concentration also occurs in the Port of New York.

Table D.1 summarizes much of the data collected for the entire Port of New York for the period, 17 July 1962 to 21 August 1962. This table illustrates both the great amount of port activity and also how this activity is heavily concentrated in only a few of the harbors which comprise the Port of New York. This study indicates that Brooklyn alone accounts for 46% of the number of ships in the Port of New York, and Manhattan (North River) accounts for over 17% of all the ships in port. Thus, these two ports together account for nearly two-thirds of all of the traffic (by number of ships) in the Port of New York. In addition, at the Port of Brooklyn, the shipping activity is far greater at certain selected docks or groups of docks than at others. For instance, the Brooklyn Army Terminal, the Erie Basin, and the Bush Docks

Table D.1

Selected Statistics for Various Ports

Port Studied	Dates Checked	Total Vessels in Port	Number Passenger Vessels	Per Cent Passenger Vessels	Ship Median Turnaround Time (Days)	Average Turnaround Time (Days)
San Francisco	23 May - 8 June 62	126*	?	?	2.25	3.75
Port of New York						
Brooklyn, N.Y.	17 Jul - 21 Aug 62	345	5	1.5	2.75	3.25
North River, N.Y.	17 Jul - 21 Aug 62	130	62	47.7	1.85	2.40
Port Newark, N.J.	17 Jul - 21 Aug 62	87	0	0	2.25	3.75
Hoboken, N.J.	17 Jul - 21 Aug 62	42	11	26.2	3.00	4.10
East River, N.Y.	17 Jul - 21 Aug 62	24	0	0	1.50	2.32
22 Other N.Y. Area Ports	17 Jul - 21 Aug 62	122	2	1.6	2.05	3.38

* Extrapolation so that all time figures are comparable.

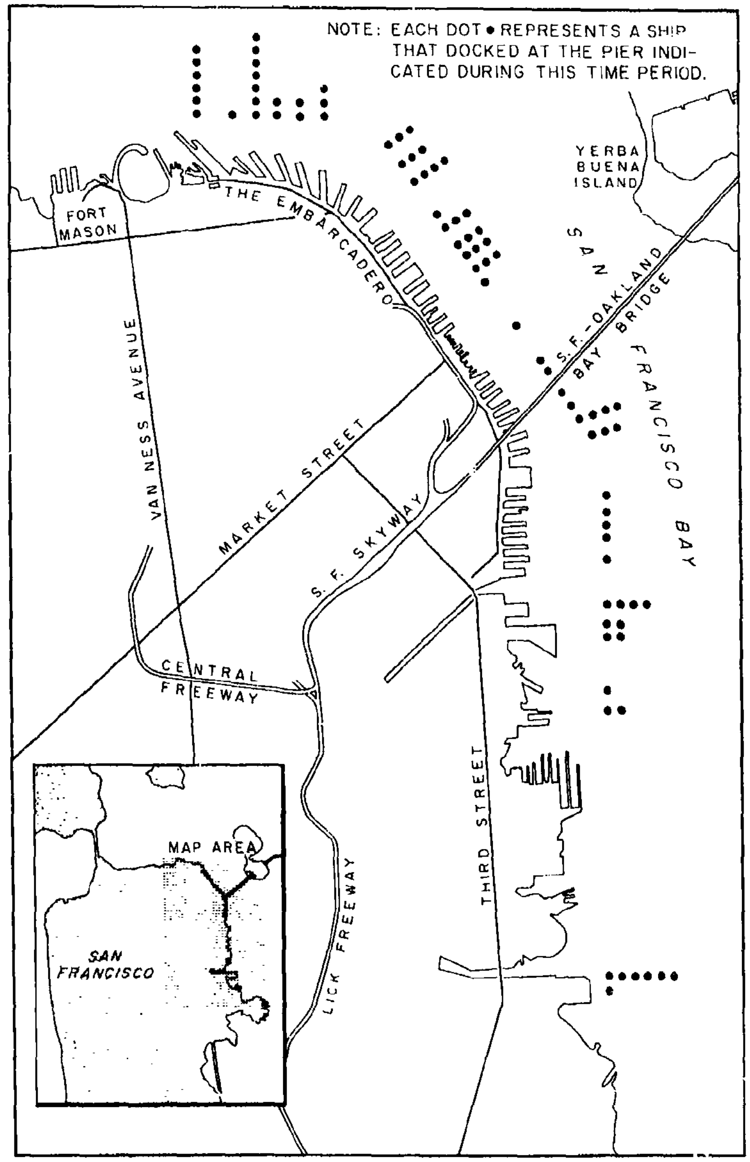

Fig. D.2 Pier Activity in the Port of San Francisco During the Period: 29 May 1962 - 11 June 1962 in Brooklyn accounted for 41.5% of all the ships except tankers that arrived in Brooklyn during the time period studied. Such congestion is less apparent in Manhattan (North River) where the distribution of the busiest piers seems to be more uniform.

Table D.1 also shows that passenger vessels that enter the Port of New York tend to be distributed nonuniformly. Of all the passenger vessels entering all of New York's harbors, 77.5% dock in Manhattan (North River) and more than 13.5% dock in Hoboken, New Jersey. Thus, these two harbors together account for over 90% of the passenger vessel activity in the Port of New York. This finding is extremely significant, since many of these vessels are larger than the average vessel, are particularly suitable for housing people, and have significant electrical-generating and water-distilling capability.

Figure 7 shows the daily totals of all ships (except tankers) in the Port of New York and also the daily totals for the component harbors of Brooklyn and Manhattan (North River) for the time period analyzed. These figures illustrate the wide weekly fluctuations and the even greater weekday fluctuations in the total number of ships in port. A definite midweek maximum and weekend minimum number of ships is evident, along with an increased number of ships at the beginning of the week and a tapering off toward the end of the week. These data, for the short period studied agree quite well with Port of New York Authority data collected for a 6 month period in 1955-1956 (Fig. D.3).

The Port of New York Authority has stated: "The number of commercial deep-sea vessels in port at any one time varies from a low of 90 (plus or minus 20%) over weekends, to a high of 175 (plus or minus 20%) in the later part of a week. These figures are based upon 1961 data and include all types of vessels. The average breakdown of this in-port count would be 50% general cargo common carrier; 27% tanker; 18% specialized or industrial carriers; and 5% passenger." In another part of this same communication they added: "On the average, 39 deep-sea vessels arrived daily in the Port of New York in 1961; typical breakdown of this traffic would be: Common Carrier General Cargo (19), Tankers (11), Specialized (banana, sugar, etc.) (7), Passenger (2), Total (39)."

The length of time these ships remained in the Port of New York is listed in Table D.1. The median turnaround times ranged from 2 to 3 days, whereas the arithmetic averages ranged from 2.5 to 4 days and are generally about 1 day more than the median times. This difference is due here (as in the San Francisco port study) to the disproportionate effect on the arithmetic average caused by a relatively small number

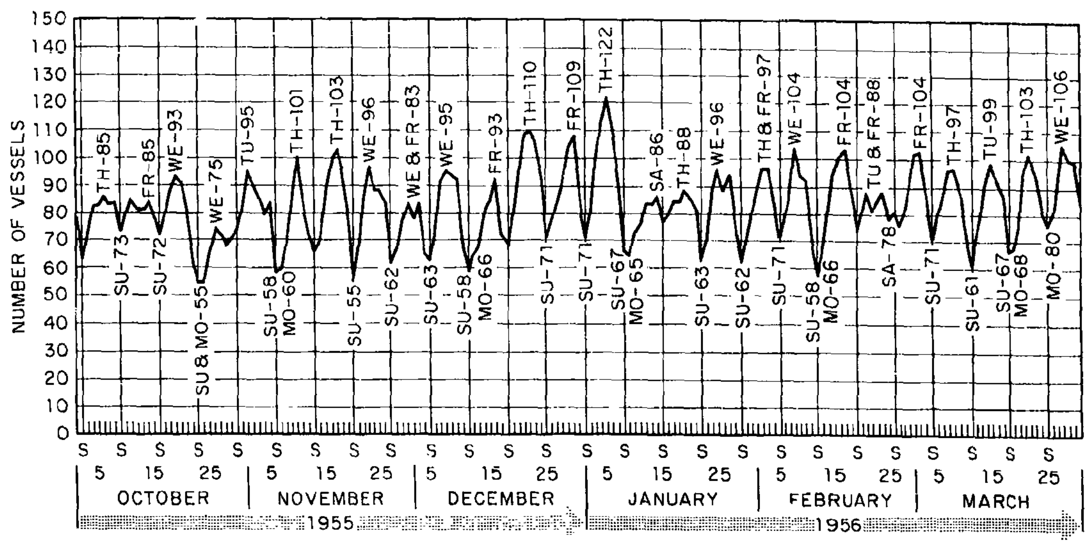

Fig. D.3 Daily Totals of General Cargo Vessels in the Port of New York

This chart covers only general cargo vessels which, in 1961, accounted for approximately 50% of the ship traffic at the Port of New York. (Source: The Port of New York Authority) of ships that remained in port for long time periods.

The Port of New York Authority stated further: "The turnaround time for vessels in the Port of New York varies by type of vessel. Common carrier general cargo ships average between 3.5 and 4.5 days in port; passenger liners average between 2.5 and 3.5 days; tankers 1 to 2 days; specialized vary widely - container ships 1.5 days; bulk sugar 5 days; lumber 5 days; scrap 8 days, etc." These figures are very close to those median values cited above for turnaround times. Figure D.4 depicts the ship turnaround times found in this study for three selected harbors in the Port of New York. Two essential features of this figure are (1) the similarity of the 3 curves and (2) the narrow range of stay times that includes most of the ships in each port.

The main point to bear in mind when assessing this mass of information and its possible application to civil defense purposes is that, on any given day in the Port of New York, there are probably 45 to 90 common carrier general cargo vessels, 24 to 48 tankers, 16 to 32 specialized carriers, and 5 to 10 passenger vessels.

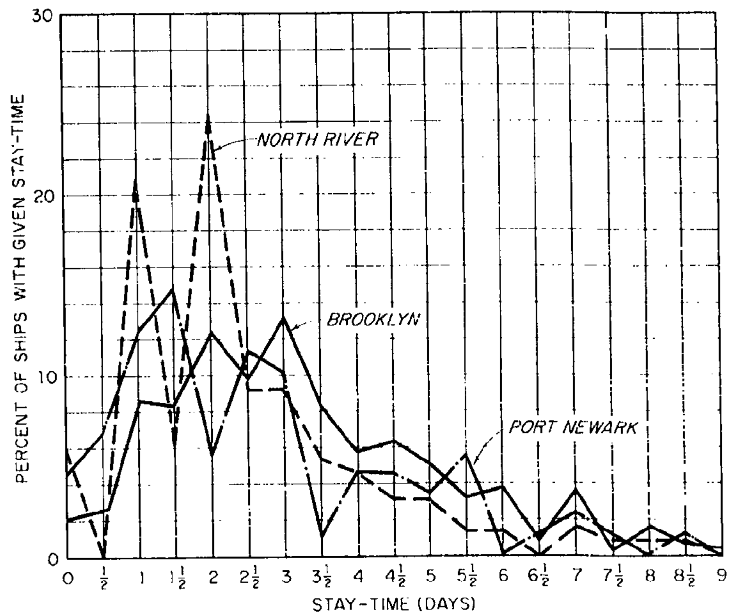

Fig. D.4 Ship Stay-Time at Selected Harbors of the Port of New York During the Period: 21 July 1962 - 13 August 1962

APPENDIX E

Proposed Conversion of EC2 (Liberty) Ships to Personnel Shelters

September 1962

An Engineering Feasibility Study
prepared by
Michael J. Ryan, Naval Architect
San Francisco, Calif.
under the supervision of
The San Francisco Naval Shipyard
San Francisco 24, Calif.

ABSTRACT

A study was made of the engineering feasibility of conversion of surplus Liberty (EC2) cargo vessels to personnel shelters. The conclusions indicate that stability of the converted vessels would be adequate and that from an engineering standpoint these vessels could be converted to the intended use as fallout survival shelters for 5000 persons.

CONTENTS

LIST OF ILLUSTRATIONS

REPORT OF INVESTIGATION

1. INTRODUCTION

1.1 USNRDL is investigating various proposals for providing personnel fallout shelters. As part of this project, a study was undertaken to determine the feasibility of converting surplus Liberty cargo ships to such service, based on a potential life of 5 - 10 years under minimal maintenance conditions. Evacuated personnel are to remain on the ship for a minimum of two weeks.

1.2 The study included the following:

1. Investigation of vessel stability after conversion.

2. Development of sketch plans and diagrams sufficient to permit an approximation of conversion costs (cost estimates are included as an appendix to this report).

2. DESCRIPTION OF VESSELS

2.1 Standard EC2 "Liberty" ships:

Length Overall -------------	441'-6"
Length betw. Perpendiculars	416'-0"
Breadth --------------------	57'-0"
Depth to Upper Deck --------	37'-4"

2.2 The standard EC2 has 2 complete decks, 5 cargo holds, machinery amidships. These are built of steel, welded and riveted. The extent of riveting varies, depending on where built.

2.3 The condition of these vessels can be expected to vary considerably depending, in part, upon the effectiveness of the preservation methods employed and length of layup. Condition of bottom plating will obviously be an important consideration in selection of vessels.

3. CONVERSION PROPOSALS

3.1 The conversion proposal involves the stripping of the vessel including all propulsive machinery and equipment, cargo gear including masts, navigating and lifesaving equipment, piping and electrical systems, crew outfit, and other equipment not required on a non-navigating dumb vessel. The midship deck-house structure would be retained, as would the mast houses. All other structure above the upper deck would be removed. The rudder would be retained and made fast to the hull. Anchor chain would be retained for emergency use. Machinery removals can be accomplished thru the engine and boiler hatches. Propeller shafting could be left in place if desired.

3.2 The vessel could accommodate a total of about 2000 persons in the lower holds and on the second deck, on the basis of 11-12 sq. ft. per person, without the addition of new structure in the holds. Addition of 2 complete platforms in the holds and 2 complete platforms in the machinery space will provide for an additional 3000, for a total of 5000 persons. The structural arrangement of the vessel under this proposal is illustrated on "Structural Modifications," Sheets 1-2-3.

3.3 Since these vessels are to be permanently moored, the U.S. Coast Guard, American Bureau of Shipping, and U.S. Public Health Service requirements applicable to self-propelled vessels will by bypassed. It is assumed that OCD would institute a minimal maintenance program, that would include protection of the newly installed ventilation fans and motors, diesel generators and electrical switchgear, and some provision for protection of the hull against accelerated corrosion. Since the vessel would be permanently moored, shore connections could be provided for the firemain, fresh water and electrical systems.

4. STABILITY

4.1 Stability of the vessel has been reviewed with the following assumptions considered:

1. No ballast of any description aboard.

2. All existing fuel, water and ballast tanks dry.

3. Stability criteria used is same as that which would be

applicable under USCG regulations for a passenger vessel in ocean service.

4. The USCG figure of 140 pounds as the average weight of a person with no baggage applies.

The investigation revealed that stability would be no problem for any condition of loading up to the maximum of an estimated 5100 persons accommodated aboard. No ballast would be required for this purpose. The standard USCG Wind Heel and Passenger Heel requirements would be met by a wide margin. It is estimated the converted vessel would have a trim by the stern of about 4'-0" in the light condition; 3'-9" when fully loaded. Should this be considered objectionable it could be modified somewhat by ballasting the fore peak tank.

4.2 It is estimated that the converted vessel would have a light ship weight of about 3600 long tons, loaded weight of about 3930 long tons. Under these conditions, the following would be the vessel characteristics:

	Light Ship	Full Load (5100 persons)
Mean Keel Draft	8.3'	9'-0"
GM (available)	10.6'	8 .6'
Draft, Forward Perp.	6.25'	8 .9'
Draft, Aft "	10.34'	10 .88'
GM Req'd, Wind Heel		2 .16'
GM Req'd to Limit Passenger Heel to 14° (all persons concentrated at 1/4 beam off center), all in assigned spaces		3 .11'
GM Req'd to Limit Passenger Heel Partial Load of 1500 persons, all on weather deck at 1/4 beam off center.		.96'

5. MODIFICATIONS, ACCOMMODATIONS AND FACILITIES

5.1 The proposed changes to the standard EC2 type vessel, discussed briefly above are indicated on the following diagrammatic-type drawings included in this report.

1. Structural - "Structural Modifications," Sheets 1-2-3.

2. Accommodations - "Accommodations Plan," Sheets 1-2.

3. Piping - "Diagram of Plumbing Drains, Deck Drains, Fresh Water System," Sheet 1.

4. Piping - "Firemain, ABC Washdown System and Sanitary System," Sheet 1.

5. Ventilation - "Ventilation Diagram," Sheet 1.

6. Electrical - "Power, Lighting, and Communication Diagram," Sheet 1.

Applicable general notes are included on the above plans.

6. CONCLUSION

6.1 Modification of standard EC2 type cargo vessels, on an austerity basis, to serve as radiation fallout shelters proved feasible from an engineering standpoint. For a potential ready-service life of 5-10 years, a preservation program for the newly installed components and for the bottom of the hull proper would be necessary.

CONVERSION COSTS FOR A LIBERTY SHIP*

1.	Systems	
a.	Electrical including diesel generators	$ 152,000
b	Washdown system	7,000
c.	Sanitary and firefighting	94,000
d.	Fresh water storage and distribution	13,500
e.	Ventilation	91,000
f.	Communication	12,500
		370,000
2.	Compartments (includes cost of painting and bunks)	
a.	Compartment B	15,000
b.	" C	26,000
c.	" D	18,000
d.	" E	16,000
e.	" F	13,000
f.	" G	13,000
g.	Command Center	2,000
		103,000
3.	Hull	
a.	Concrete (4") and steel plate (1/8")	54,000
b.	New decks and supporting structure	272,000
c.	New interior bulkheads	60,400
d.	Interior watertight doors and embarcation ports	11,700
e.	Access ladders	17,500
		415,600
4.	Miscellaneous	
a.	Engine ripout (incl. 2nd deck FR 88-108)	26,700
b.	Midship house ripout (maindeck and above)	3,000
c.	Removal of topside equipment	5,700
d.	Removal of shafting	3,100
e.	Docking	15,000
f.	Removing consol oil	11,500
		65,000
	SUBTOTAL	953,600
	Less 10% for multiple conversions	95,400
	TOTAL	$ 858,200

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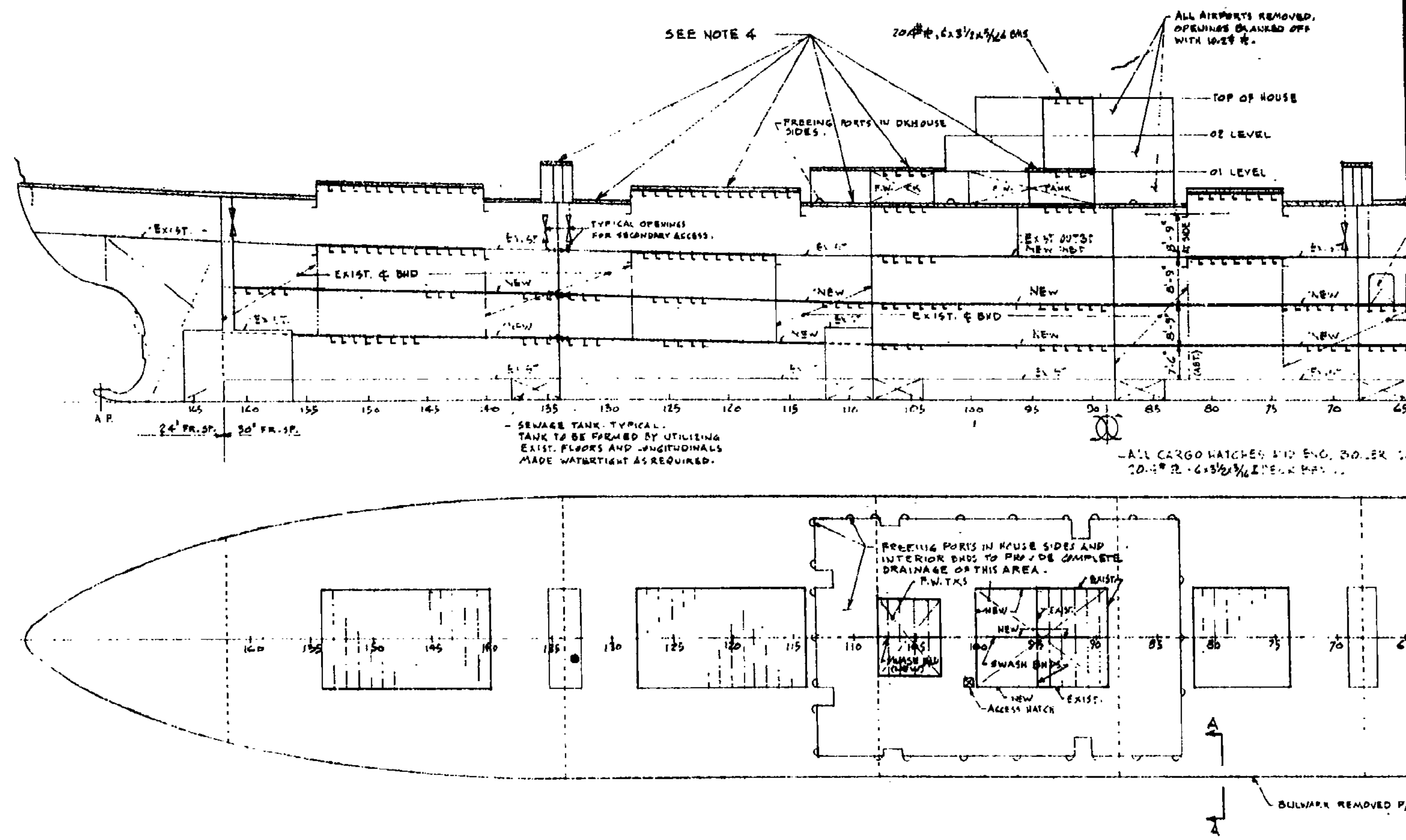
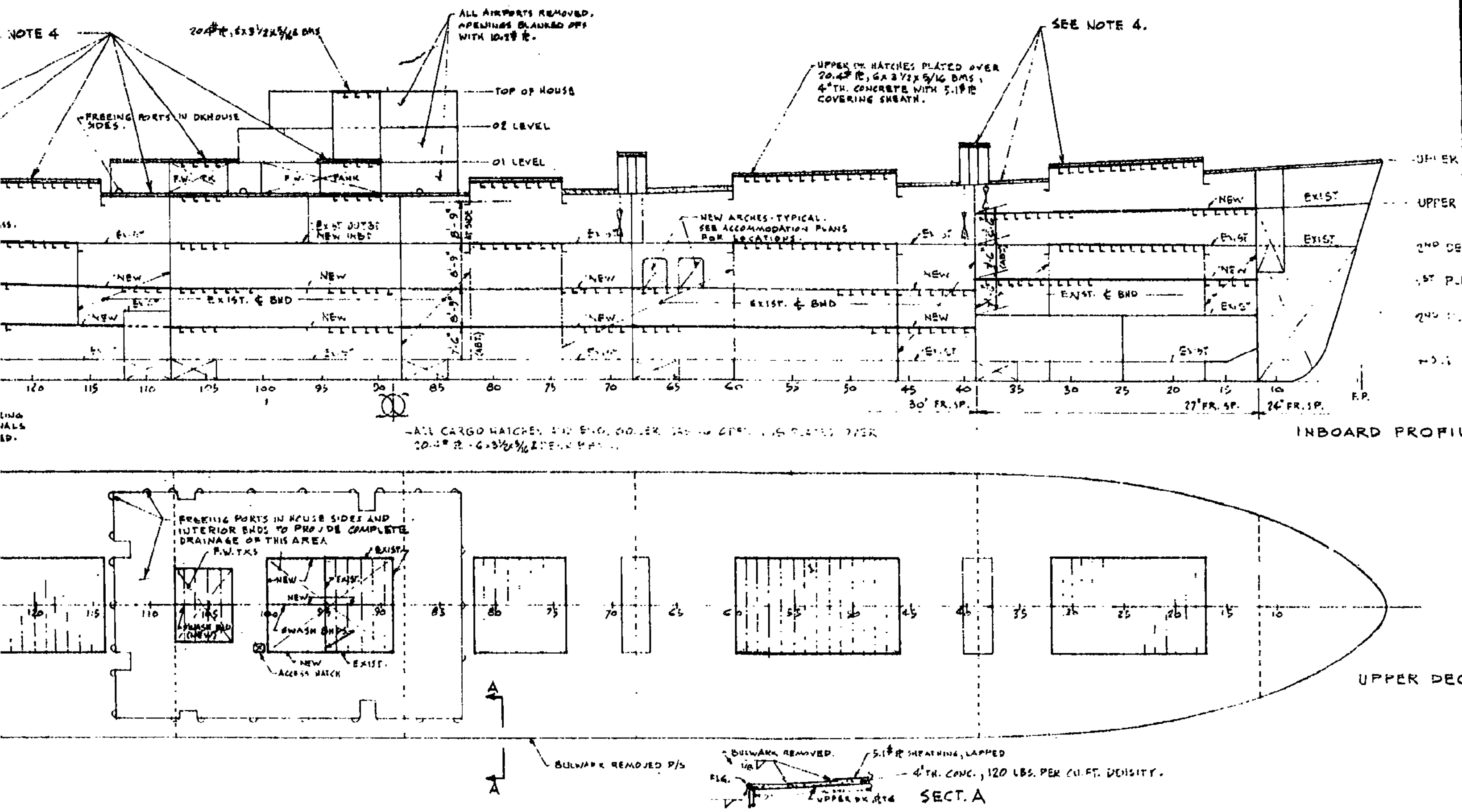
* This cost estimate was prepared by the The Planning and Estimating Division, San Francisco Naval Shipyard.

SHELTER CAPACITY OF A CONVERTED LIBERTY SHIP

Level \ Compartment		B	C	D	E	F	G	Total
2nd deck	level A	219	-	-	-	-	-	219
	level B	159	318	210	168	Hosp.	240	1095
1st platform		183	350	243	240	279	240	1535
2nd platform		180	349	243	229	264	164	1429
Hold		-	291	201	167	129	-	788
Total		741	1308	897	804	672	644	5066

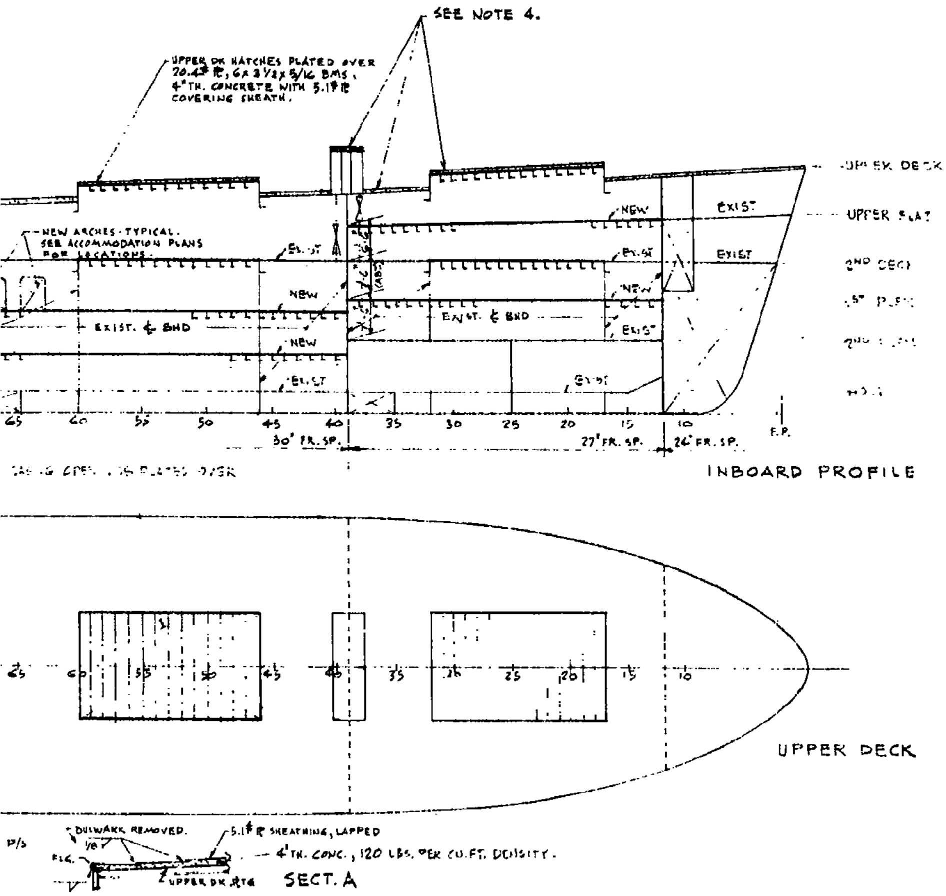

SEE NOTE 4
ALL AIRPORTS REMOVED, OPENINGS BLANKED OFF
TOP OF HOUSE
02 LEVEL
01 LEVEL
FREEING PORTS IN DKHOUSE SIDES.
TYPICAL OPENINGS FOR SECONDARY ACCESS.
EXIST.
EXIST. ⊄ BHD
NEW
F.W. TK
TANK
EXIST OUTBD NEW INBD
SEWAGE TANK TYPICAL. TANK TO BE FORMED BY UTILIZING EXIST. FLOORS AND LONGITUDINALS MADE WATERTIGHT AS REQUIRED.
A.P.
24" FR. SP.
30" FR. SP.
FREEING PORTS IN HOUSE SIDES AND INTERIOR BHDS TO PROVIDE COMPLETE DRAINAGE OF THIS AREA.
F.W. TKS
SWASH BHDS
ACCESS HATCH
A

1



Dwg. 1 Structural

2



1. COMPLIANCE WITH CLASSIFICATION SOCIETY RULES, US COAST GUARD RULES, OR US PUBLIC HEALTH SERVICE RULES WILL NOT BE REQUIRED. MATERIALS AND WORKMANSHIP NORMALLY EMPLOYED IN COMMERCIAL PRACTICE WILL BE ACCEPTABLE, SUBJECT TO OCD APPROVAL.

2. USE OF THE CONVERTED VESSEL AS A CARGO CARRIER IS NOT INTENDED. NEW STRUCTURE IN HOLDS WILL BE REQUIRED TO SUPPORT A MAXIMUM LIVE LOAD OF 75 LBS PER SQ. FT. WEIGHT OF PLATING SHOWN IS BASED ON MASS REQUIRED FOR RADIOLOGICAL SHIELDING. ALTERNATIVE CONSTRUCTION PROVIDING EQUALLY EFFECTIVE MASS MAY BE SUBSTITUTED, SUBJECT TO OCD APPROVAL.

3. ALL OPENINGS IN WAY OF REMOVED VENTILATION DUCTS, PIPING, ETC., ON UPPER DECK, SECOND DECK, TOPS OF MAST HOUSES, 01 LEVEL, 02 LEVEL, AND TOP OF MIDSHIP HOUSE, SHALL BE PLATED OVER WITH 20.4# ℔, LAP-JOINTED AND SEAL-WELDED.

4. FOUR INCHES OF CONCRETE HAVING A DENSITY OF 120 LBS PER CU. FT. AND SHEATHED WITH 5.1# ℔ (ABOUT AS SHOWN IN SECT. A, THIS SHEET), SHALL COVER THE ENTIRE AREA OF THE HORIZONTAL SURFACES LISTED BELOW.
   - (a) 01 LEVEL IN WAY OF FRESH WATER TANKS.
   - (b) TOPS OF MAST HOUSES.
   - (c) TOPS OF UPPER DECK HATCHES.
   - (d) UPPER DECK, INCLUDING SPACE WITHIN THE MIDSHIP HOUSE.

PROPOSAL

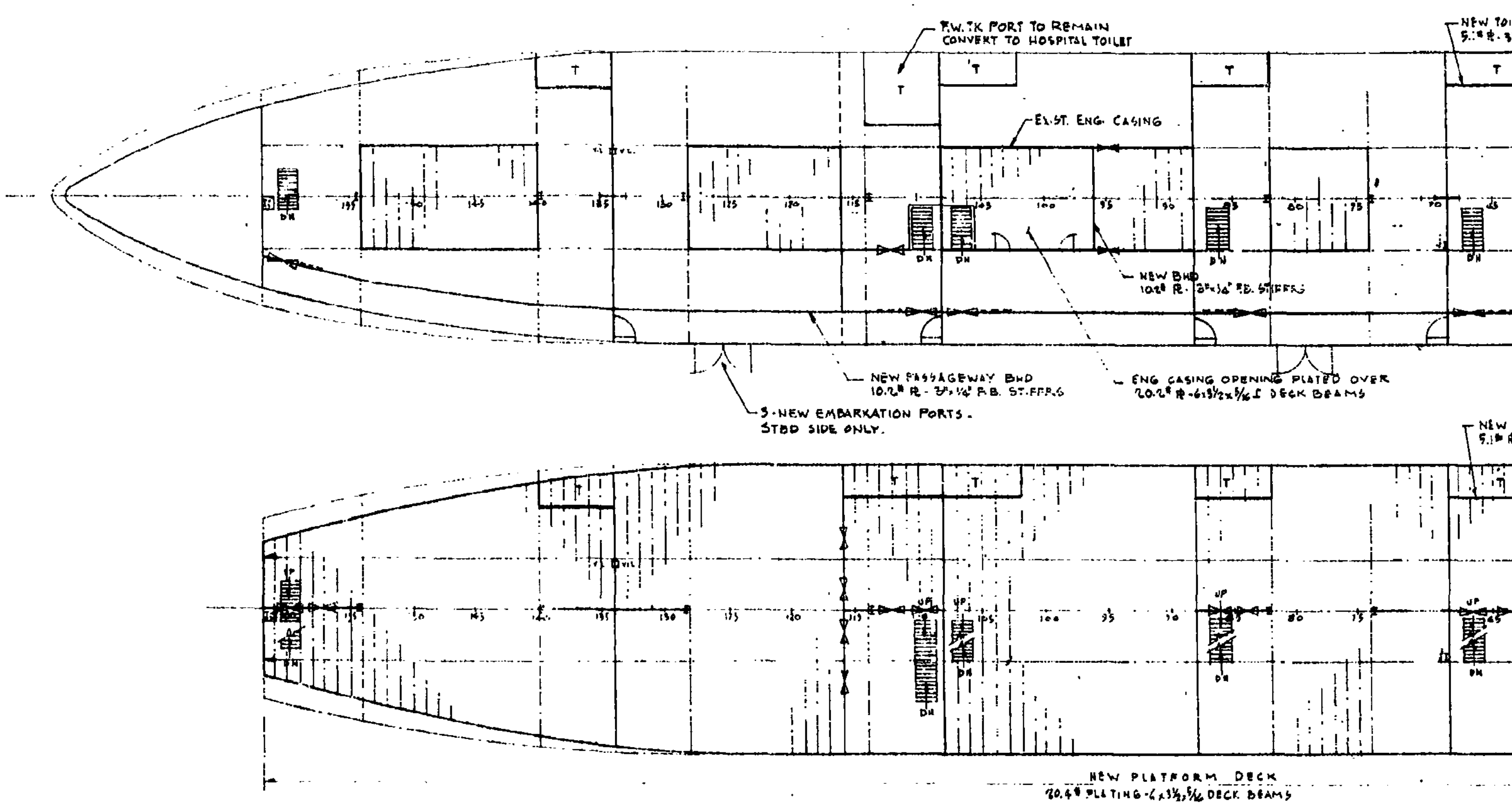
EC2 TYPE VESSEL TO PERSONNEL SHELTER

STRUCTURAL MODIFICATIONS

SHEET 1 of 3

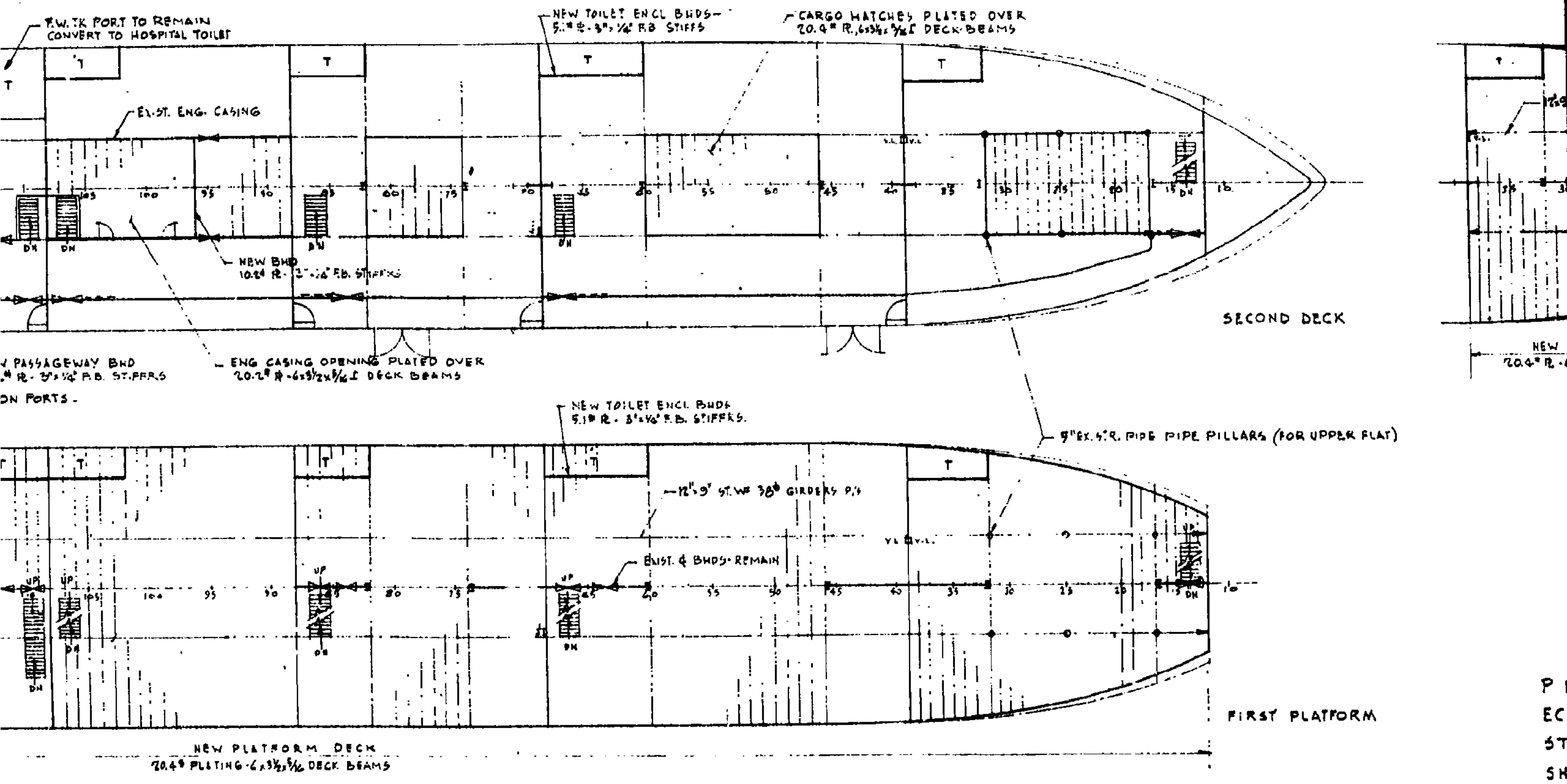
Dwg. 1 Structural Modifications - Sh #1

3



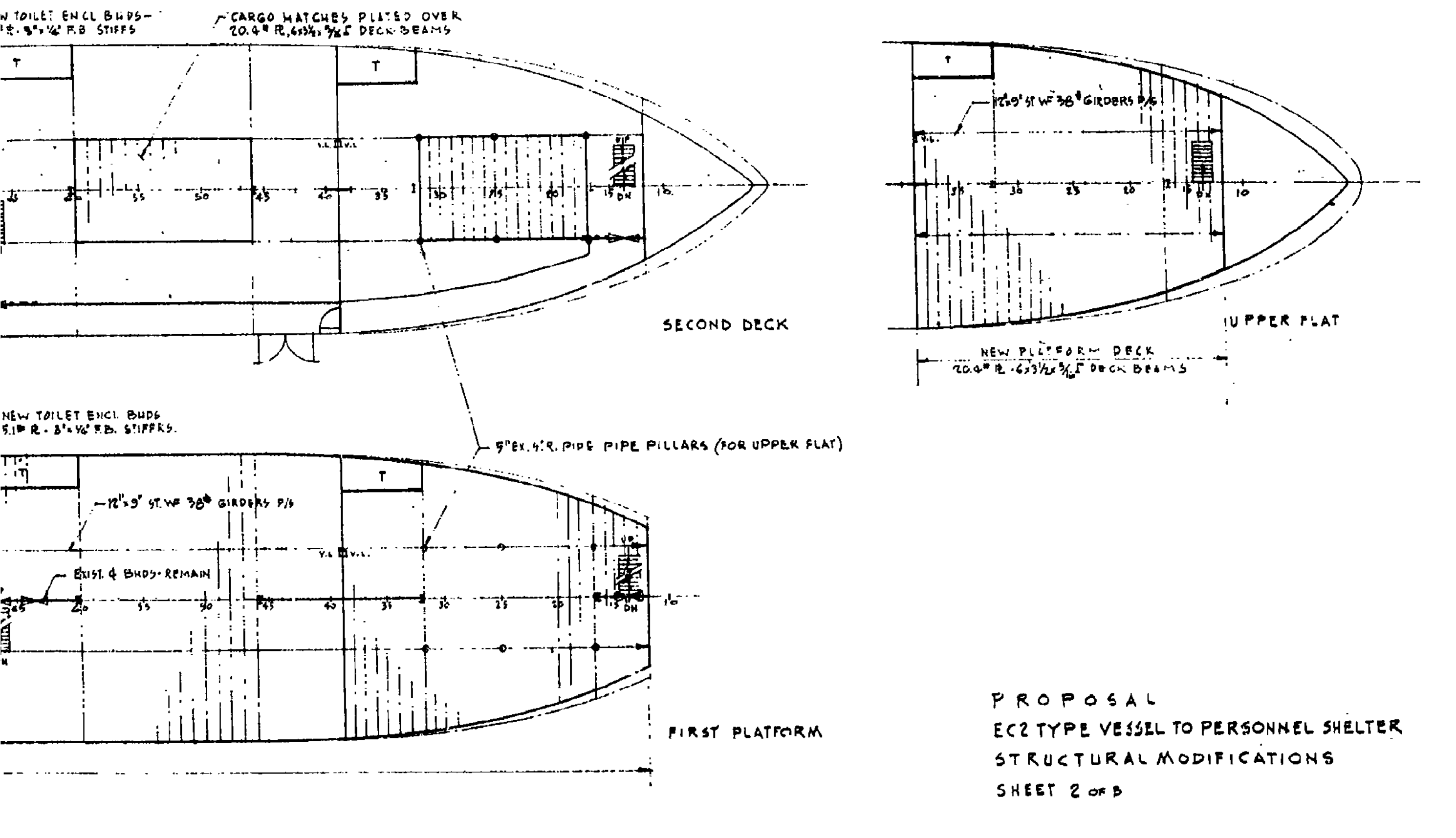
F.W. TK PORT TO REMAIN
CONVERT TO HOSPITAL TOILET
EXIST. ENG. CASING
NEW BHD
NEW PASSAGEWAY BHD
ENG CASING OPENING PLATED OVER
5-NEW EMBARKATION PORTS.
STBD SIDE ONLY.
NEW PLATFORM DECK

1



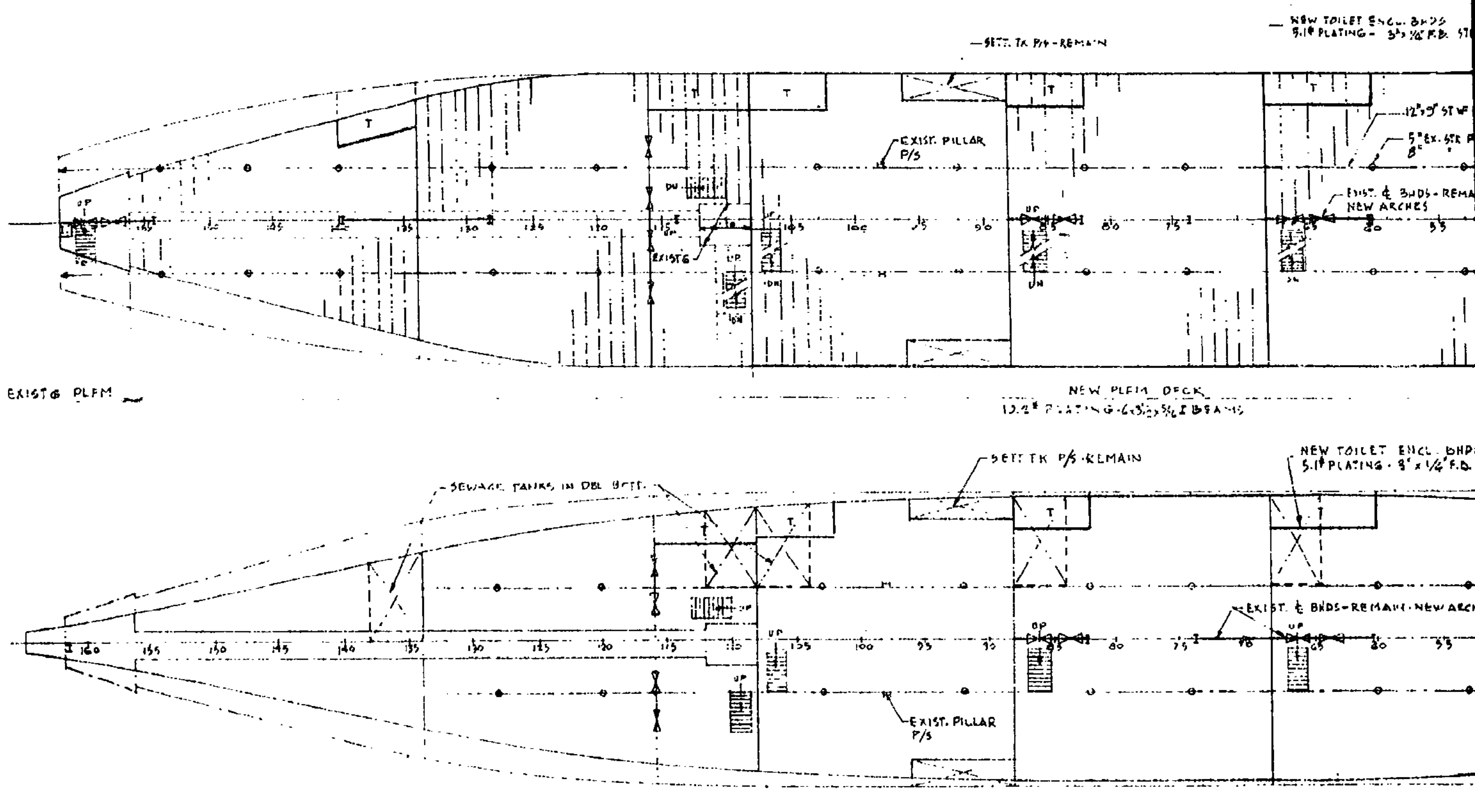
Dwg. 2 Structural Modificat

2



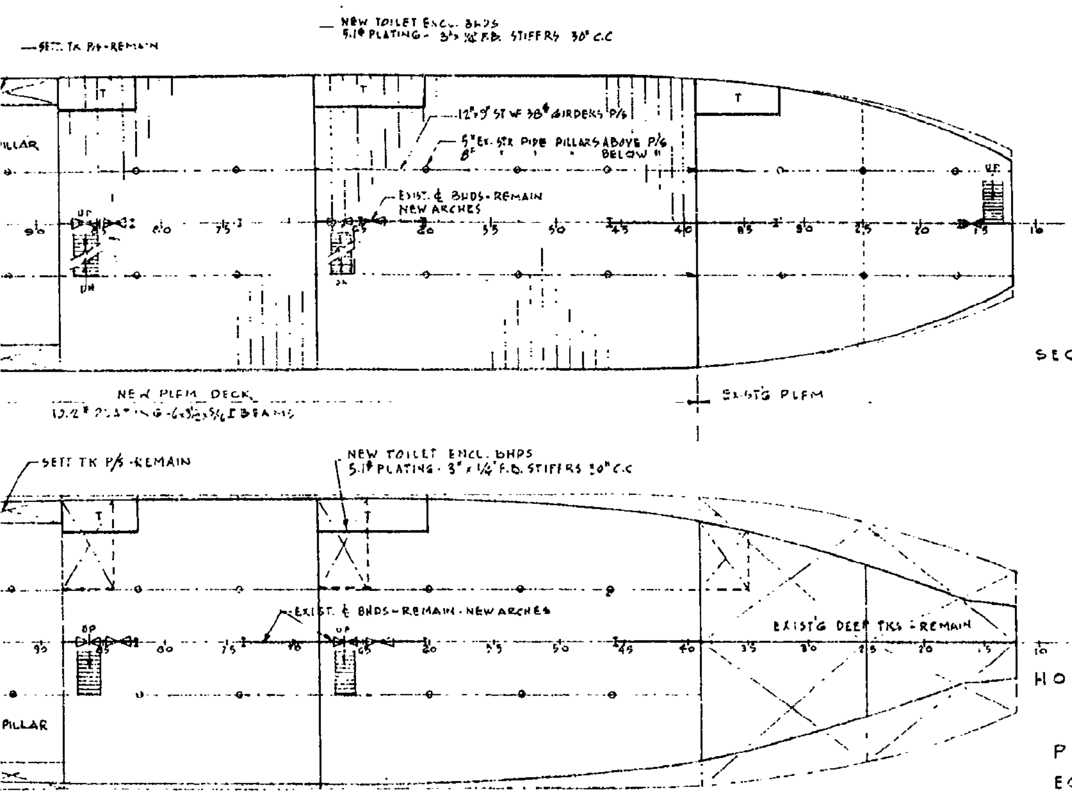
Dwg. 2 Structural Modifications - Sh #2

3



SETT. TK P/S-REMAIN
NEW TOILET ENCL. BHDS
EXIST. PILLAR
P/S
NEW ARCHES
EXISTG
EXISTG PLFM
NEW PLFM DECK
SEWAGE TANKS IN DBL BOTT.
SETT TK P/S REMAIN
EXIST. PILLAR
P/S

1



PROPOSAL

EC2 TYPE VESSEL TO PERSONNEL SHELTER

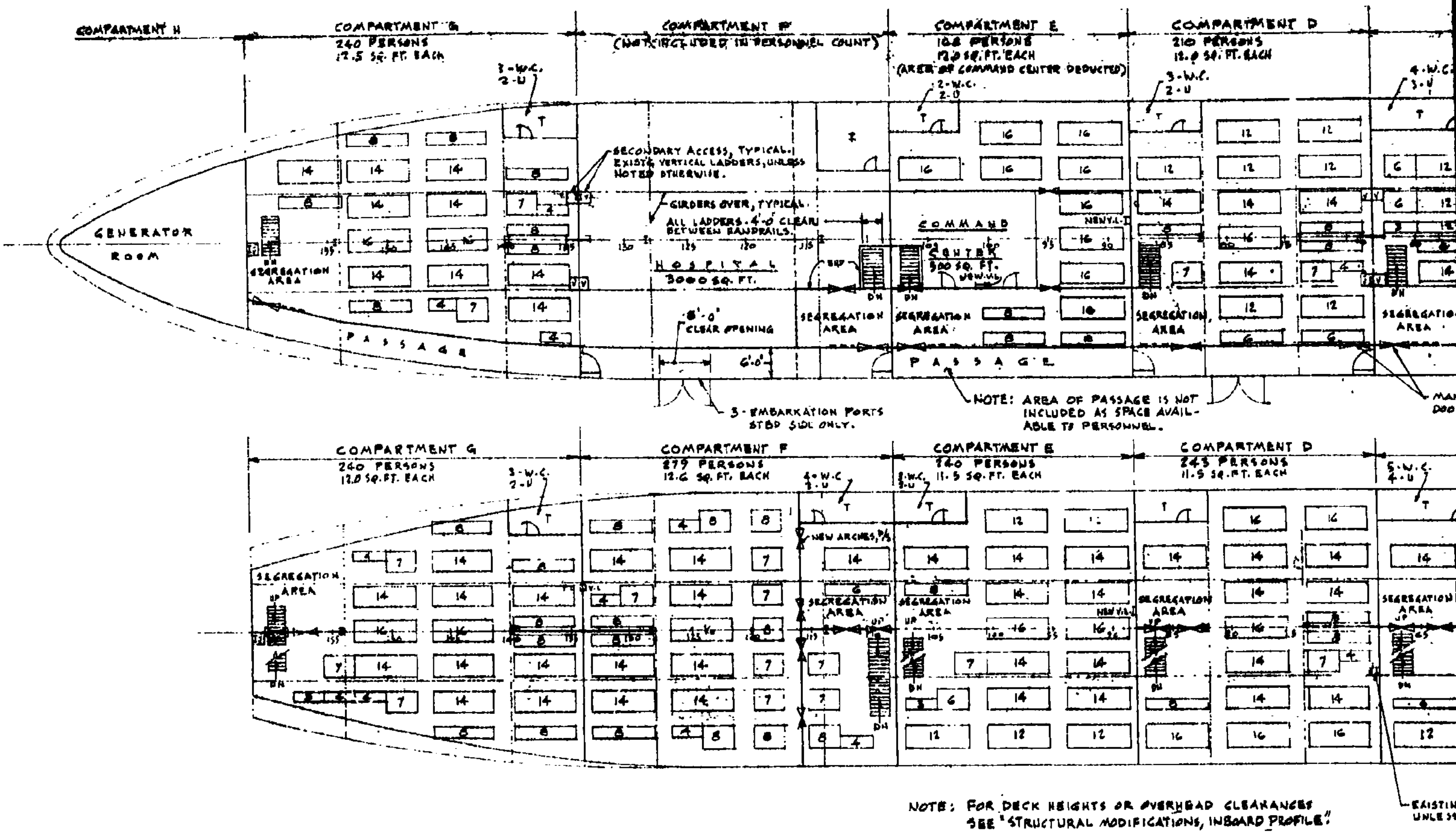
STRUCTURAL MODIFICATIONS

SHEET 3 OF 3

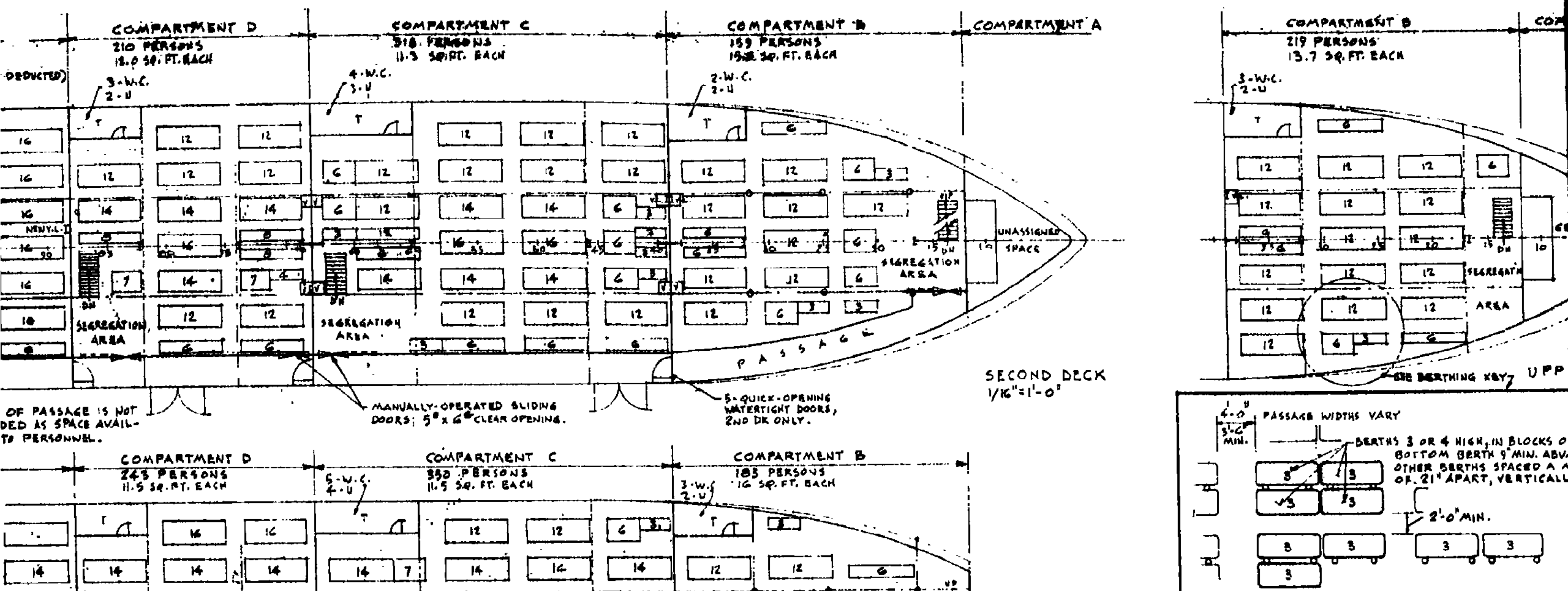
8/15/62

Dwg. 3 Structural Modifications - Sh #3

2

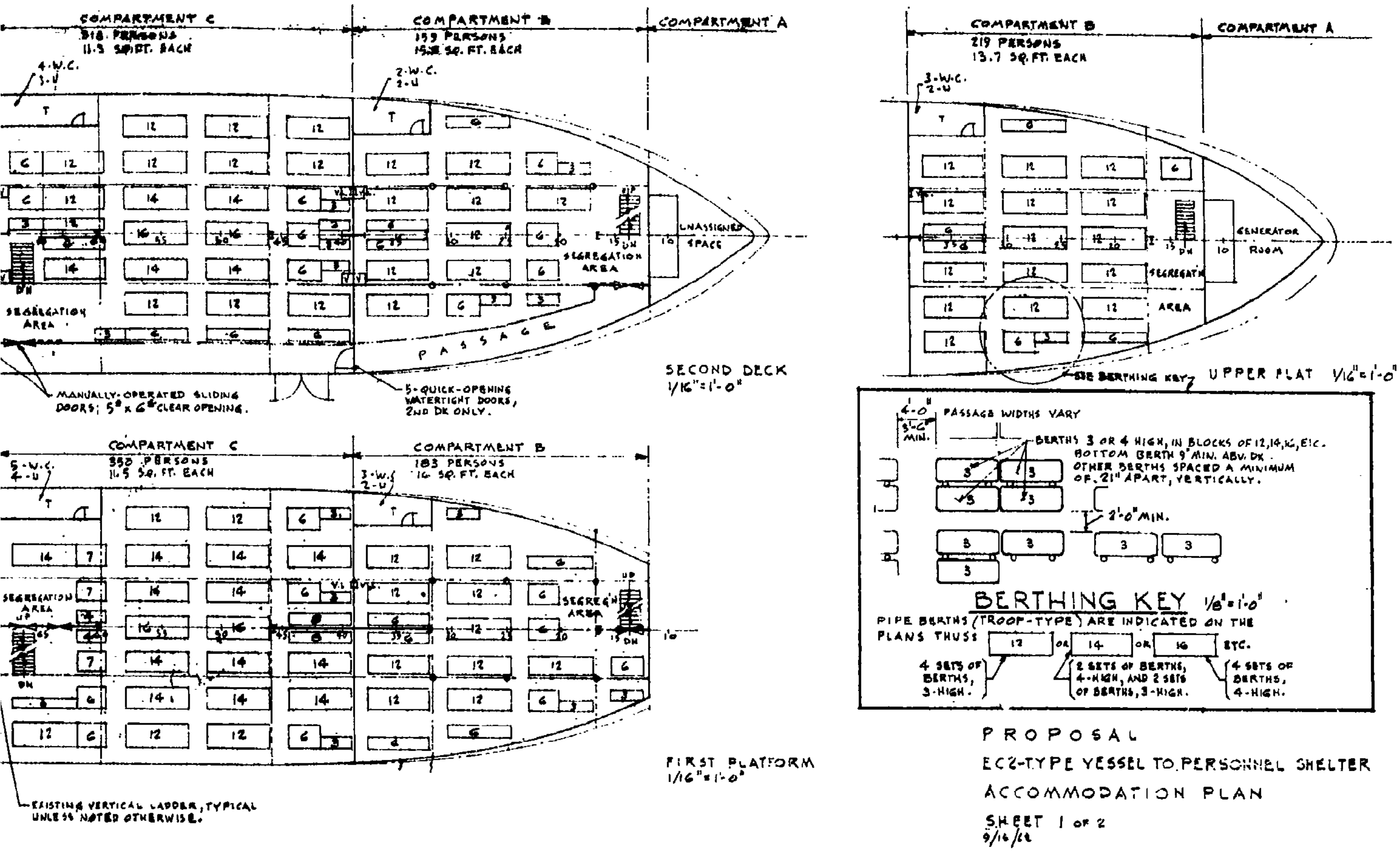

COMPARTMENT H
COMPARTMENT G
240 PERSONS
12.5 SQ. FT. EACH
3-W.C.
2-U
COMPARTMENT F
(NOT INCLUDED IN PERSONNEL COUNT)
COMPARTMENT E
168 PERSONS
12.0 SQ. FT. EACH
(AREA OF COMMAND CENTER DEDUCTED)
2-W.C.
2-U
COMPARTMENT D
210 PERSONS
12.0 SQ. FT. EACH
SECONDARY ACCESS, TYPICAL. EXISTG. VERTICAL LADDERS, UNLESS NOTED OTHERWISE.
GIRDERS OVER, TYPICAL.
ALL LADDERS 4'-0" CLEAR BETWEEN HANDRAILS.
GENERATOR ROOM
SEGREGATION AREA
HOSPITAL
3000 SQ. FT.
COMMAND CENTER
300 SQ. FT.
8'-0" CLEAR OPENING
6'-0"
PASSAGE
3-EMBARKATION PORTS STBD SIDE ONLY.
NOTE: AREA OF PASSAGE IS NOT INCLUDED AS SPACE AVAILABLE TO PERSONNEL.
COMPARTMENT G
240 PERSONS
12.0 SQ. FT. EACH
COMPARTMENT F
279 PERSONS
12.6 SQ. FT. EACH
4-W.C.
3-U
NEW ARCHES, P/S
COMPARTMENT E
11.5 SQ. FT. EACH
COMPARTMENT D
243 PERSONS
11.5 SQ. FT. EACH
5-W.C.
4-U
NOTE: FOR DECK HEIGHTS OR OVERHEAD CLEARANCES SEE "STRUCTURAL MODIFICATIONS, INBOARD PROFILE."

1



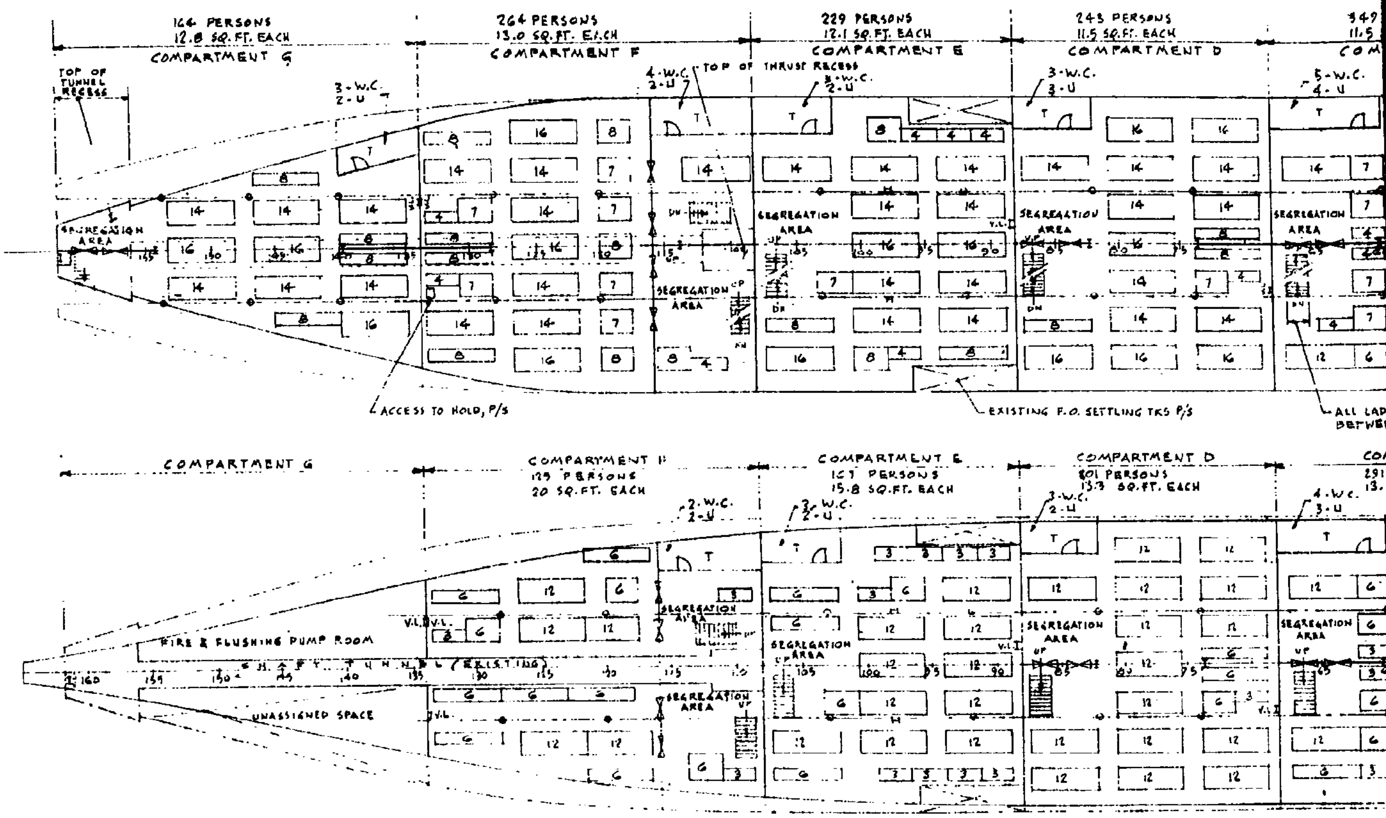
Dwg. 4 Accommodation Plan - Sh #1

2



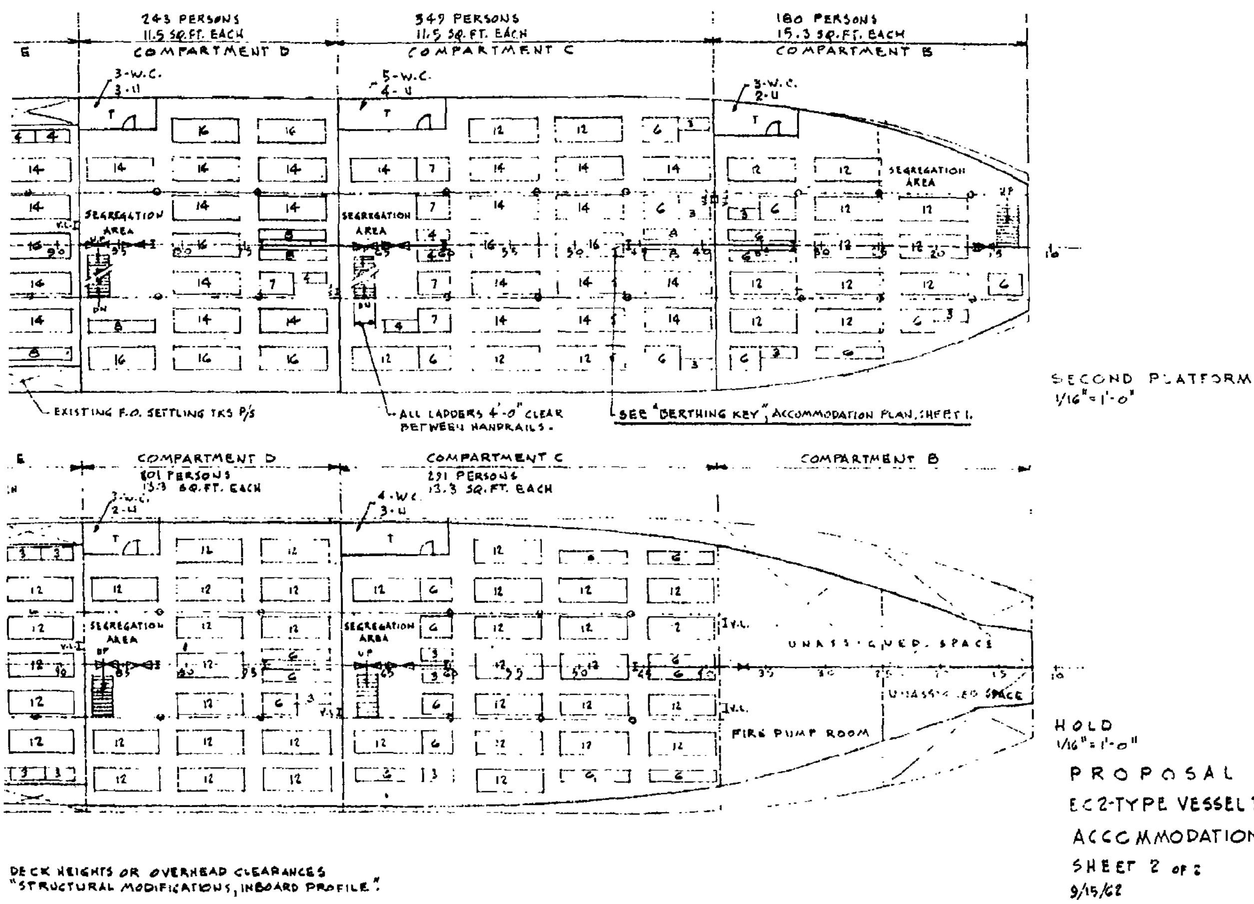
Dwg. 4 Accommodation Plan - Sh #1

3



NOTE: FOR DECK HEIGHTS OR OVERHEAD CLEARANCES SEE "STRUCTURAL MODIFICATIONS, INBOARD PROFILE".

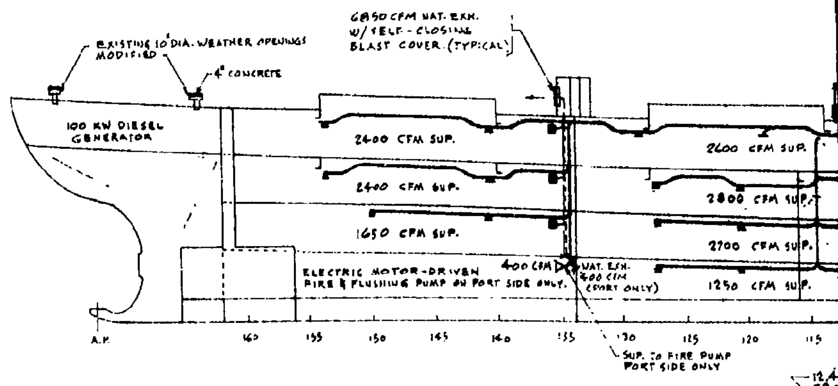
1

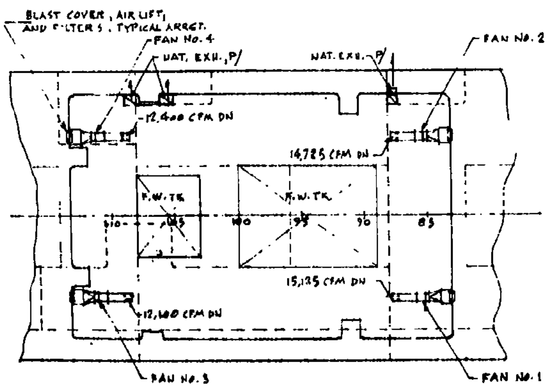


PROPOSAL
EC2-TYPE VESSEL TO PERSONNEL SHELTER
ACCOMMODATION PLAN
SHEET 2 OF 2
9/15/62

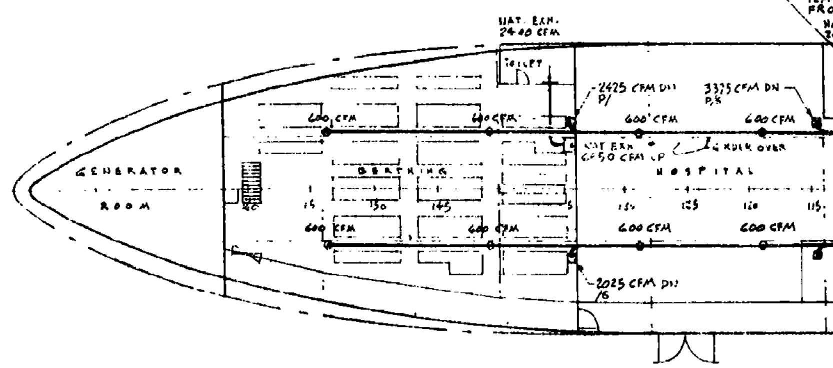
Dwg. 5 Accommodation Plan - Sh #2

2

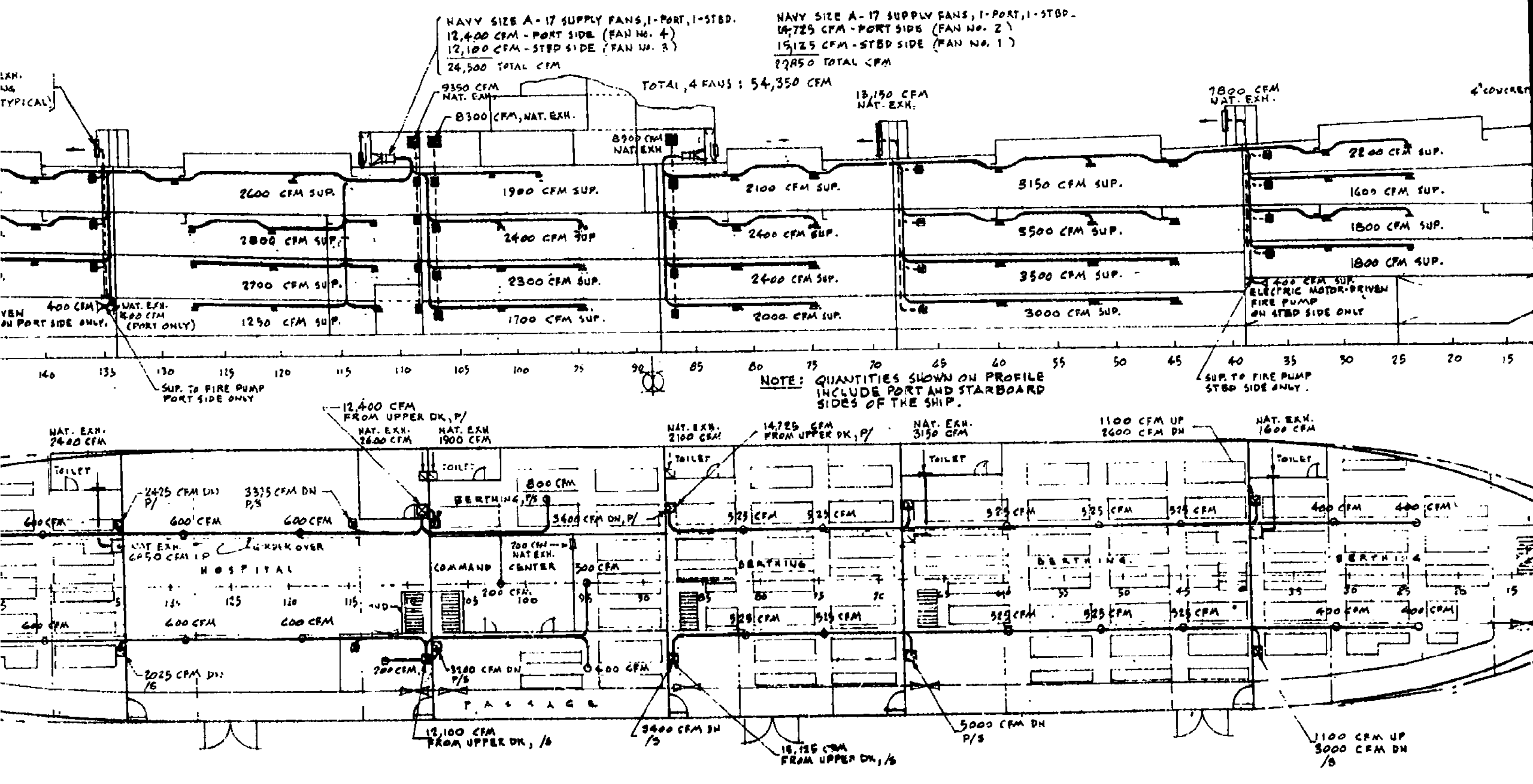

EXISTING 10" DIA. WEATHER OPENINGS MODIFIED
4" CONCRETE
6850 CFM NAT. EXH. W/ SELF-CLOSING BLAST COVER (TYPICAL)
100 KW DIESEL GENERATOR
2400 CFM SUP.
2400 CFM SUP.
1650 CFM SUP.
2600 CFM SUP.
2800 CFM SUP.
2700 CFM SUP.
1250 CFM SUP.
ELECTRIC MOTOR-DRIVEN FIRE & FLUSHING PUMP ON PORT SIDE ONLY
400 CFM
NAT. EXH. 400 CFM (PORT ONLY)
SUP. TO FIRE PUMP PORT SIDE ONLY
A.P.


BLAST COVER, AIR LIFT, AND FILTERS. TYPICAL ARRGT.
FAN No. 4
NAT. EXH. P/
NAT. EXH. P/
FAN No. 2
12,400 CFM DN
14,725 CFM DN
F.W.TK.
F.W.TK.
15,135 CFM DN
12,100 CFM DN
FAN No. 3
FAN No. 1

UPPER DECK


NAT. EXH. 2400 CFM
TOILET
2425 CFM DN P/
3375 CFM DN P,S
600 CFM
NAT. EXH. 6850 CFM UP
GENERATOR ROOM
BERTHING
HOSPITAL
2025 CFM DN /S

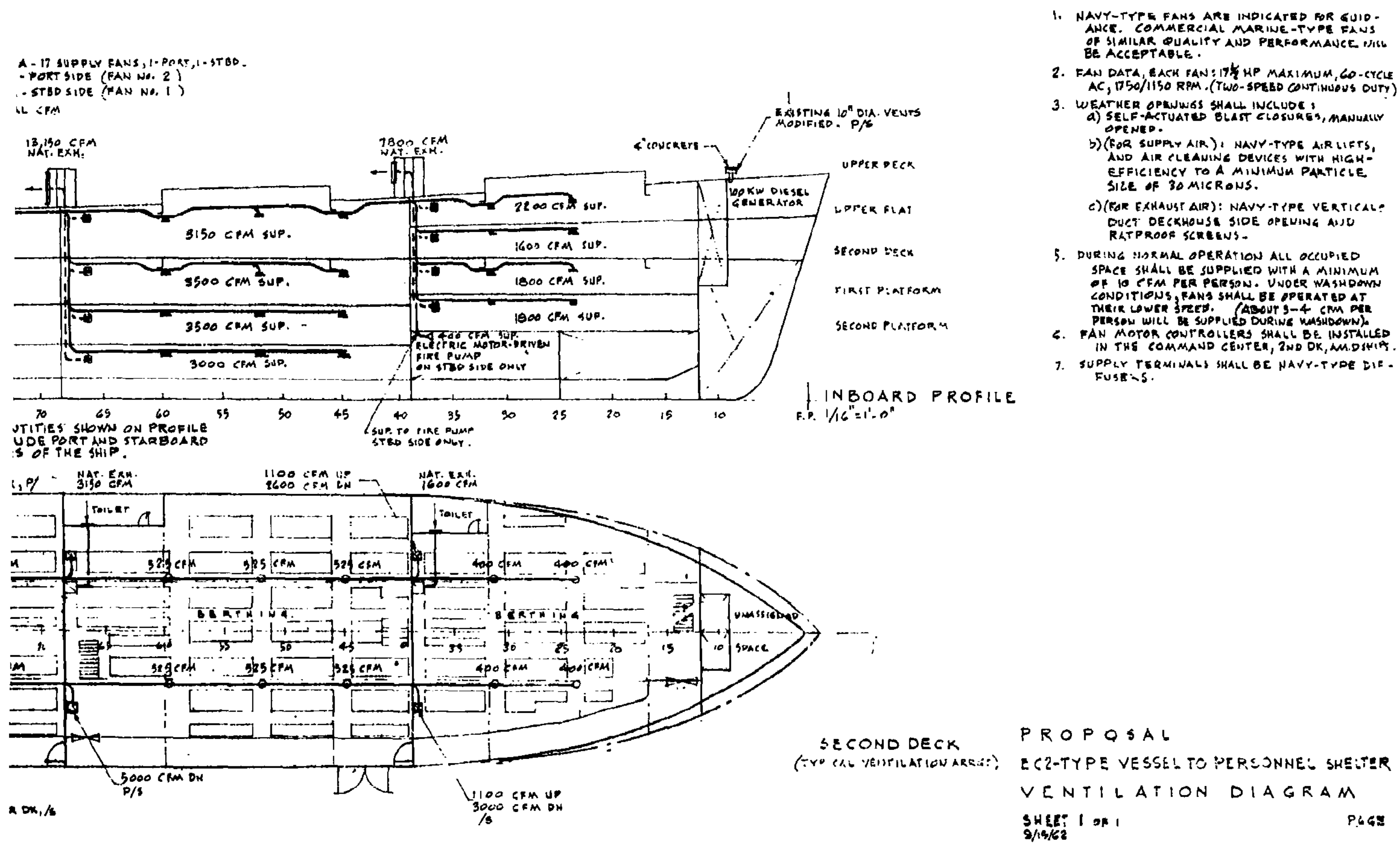
1



NAVY SIZE A-17 SUPPLY FANS, 1-PORT, 1-STBD.
12,400 CFM - PORT SIDE (FAN NO. 4)
12,100 CFM - STBD SIDE (FAN NO. 3)
24,500 TOTAL CFM
NAVY SIZE A-17 SUPPLY FANS, 1-PORT, 1-STBD.
14,725 CFM - PORT SIDE (FAN NO. 2)
15,125 CFM - STBD SIDE (FAN NO. 1)
TOTAL, 4 FANS: 54,350 CFM
9350 CFM NAT. EXH.
8300 CFM, NAT. EXH.
8900 CFM NAT. EXH.
13,150 CFM NAT. EXH.
7800 CFM NAT. EXH.
2600 CFM SUP.
1900 CFM SUP.
2100 CFM SUP.
3150 CFM SUP.
2200 CFM SUP.
1600 CFM SUP.
2800 CFM SUP.
2400 CFM SUP.
2400 CFM SUP.
5500 CFM SUP.
1800 CFM SUP.
2700 CFM SUP.
2300 CFM SUP.
2600 CFM SUP.
3500 CFM SUP.
1800 CFM SUP.
1250 CFM SUP.
1700 CFM SUP.
2000 CFM SUP.
3000 CFM SUP.
400 CFM SUP.
ELECTRIC MOTOR-DRIVEN FIRE PUMP ON STBD SIDE ONLY
SUP. TO FIRE PUMP PORT SIDE ONLY
SUP. TO FIRE PUMP STBD SIDE ONLY.
NOTE: QUANTITIES SHOWN ON PROFILE INCLUDE PORT AND STARBOARD SIDES OF THE SHIP.
NAT. EXH. 2400 CFM
12,400 CFM FROM UPPER DK, P/
NAT. EXH. 2600 CFM
NAT. EXH 1900 CFM
NAT. EXH. 2100 CFM
14,725 CFM FROM UPPER DK, P/
NAT. EXH. 3150 CFM
1100 CFM UP 2600 CFM DN
NAT. EXH. 1600 CFM
TOILET
BERTHING
HOSPITAL
COMMAND CENTER
PASSAGE
12,100 CFM FROM UPPER DK, /S
15,125 CFM FROM UPPER DK, /S
5000 CFM DN P/S
1100 CFM UP 3000 CFM DN /S

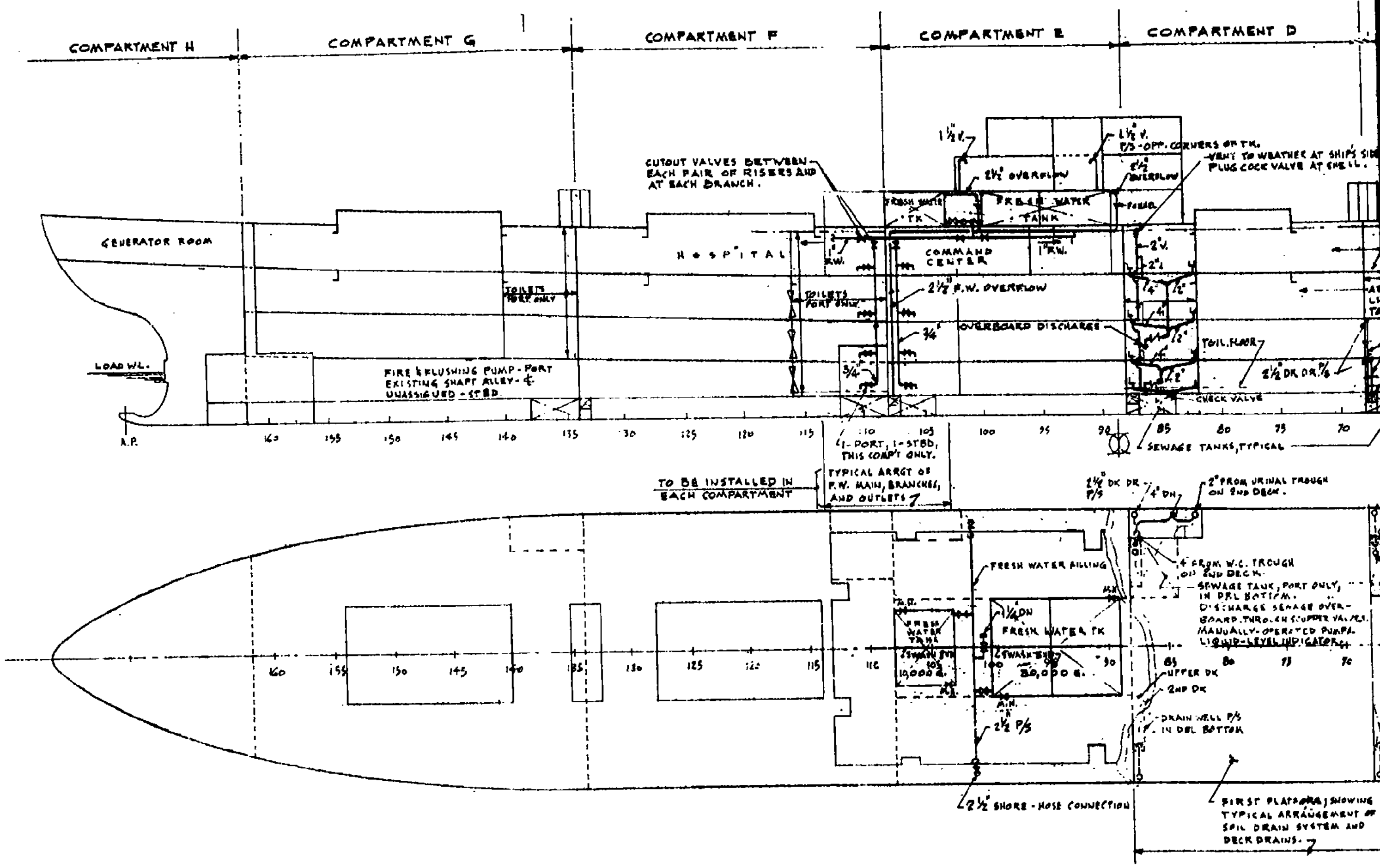
Dwg

2

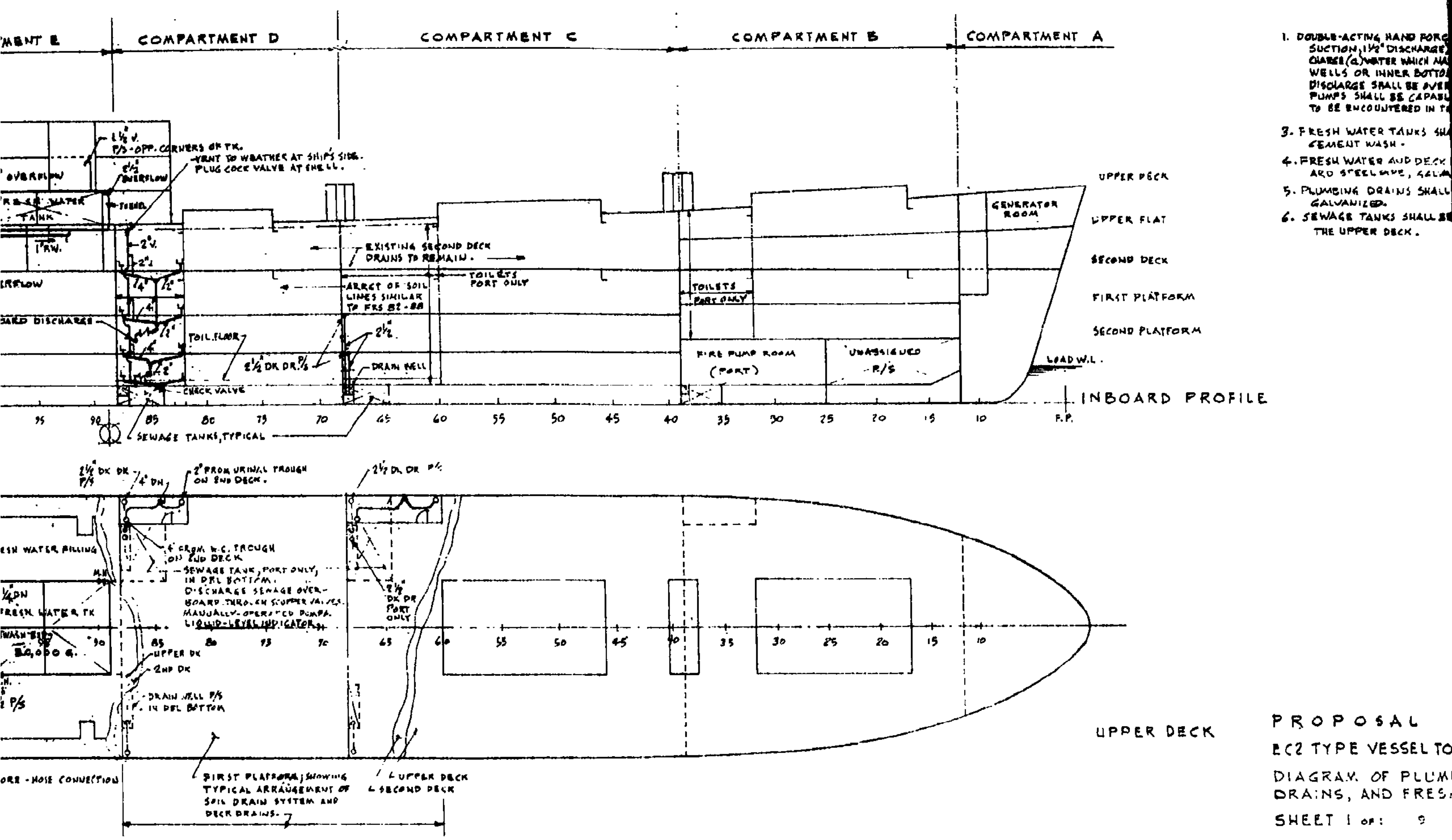


Dwg. 6 Ventilation Diagram - Sh #1

3

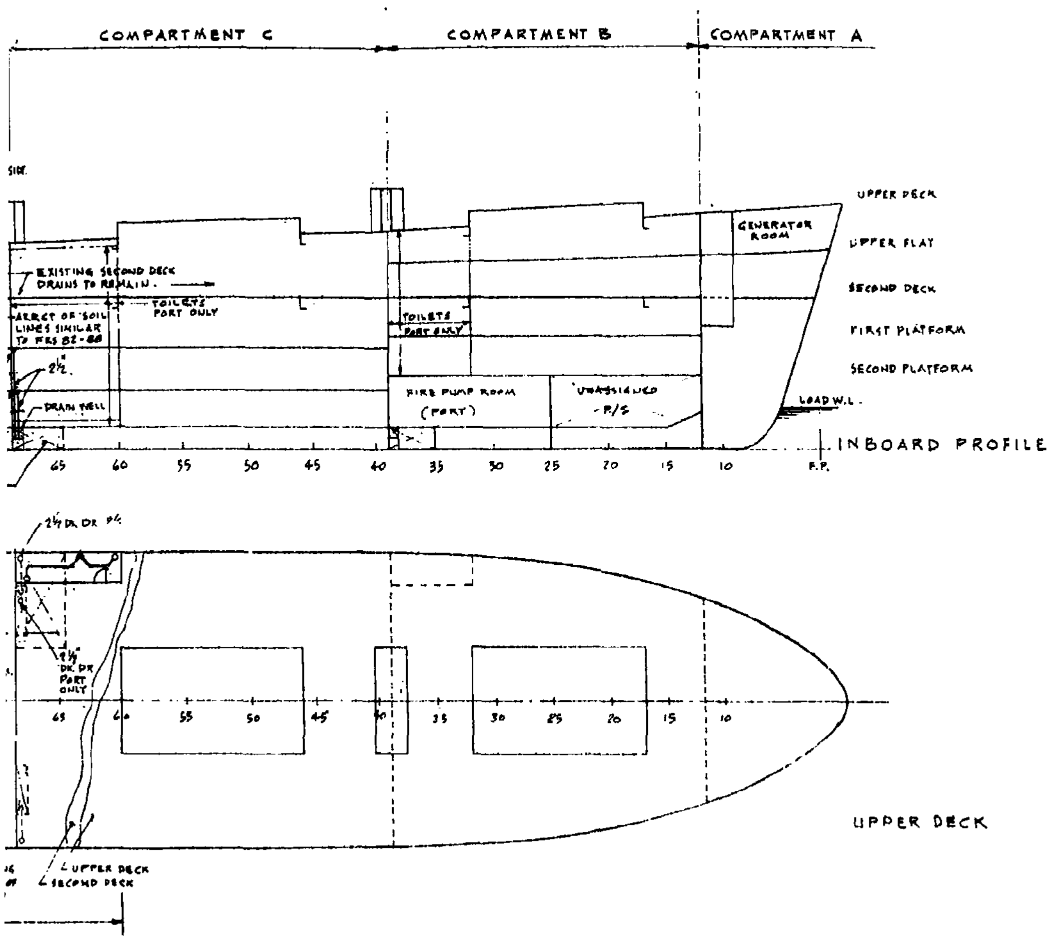

COMPARTMENT H
COMPARTMENT G
COMPARTMENT F
COMPARTMENT E
COMPARTMENT D
GENERATOR ROOM
LOAD WL.
A.P.
HOSPITAL
TOILETS PORT ONLY
FIRE & FLUSHING PUMP - PORT
EXISTING SHAFT ALLEY - ℄
UNASSIGNED - STBD.
CUTOUT VALVES BETWEEN EACH PAIR OF RISERS AND AT EACH BRANCH.
FRESH WATER TK
FRESH WATER TANK
COMMAND CENTER
2½" OVERFLOW
2½" F.W. OVERFLOW
OVERBOARD DISCHARGE
1½" V. P/S - OPP. CORNERS OF TK.
VENT TO WEATHER AT SHIP'S SIDE
PLUG COCK VALVE AT SHELL.
TOIL. FLOOR
2½" DK DR. P/S
CHECK VALVE
SEWAGE TANKS, TYPICAL
1 - PORT, 1 - STBD, THIS COMP'T ONLY.
TO BE INSTALLED IN EACH COMPARTMENT
TYPICAL ARRGT OF F.W. MAIN, BRANCHES, AND OUTLETS
2½" DK DR. P/S
4" DN
2" FROM URINAL TROUGH ON 2ND DECK.
FRESH WATER FILLING
4" FROM W.C. TROUGH ON 2ND DECK.
SEWAGE TANK, PORT ONLY, IN DBL BOTTOM.
DISCHARGE SEWAGE OVERBOARD THROUGH SCUPPER VALVES.
MANUALLY-OPERATED PUMPS.
LIQUID-LEVEL INDICATOR.
FRESH WATER TANK
FRESH WATER TK
10,000 G.
30,000 G.
UPPER DK
2ND DK
DRAIN WELL P/S IN DBL BOTTOM
2½" P/S
2½" SHORE - HOSE CONNECTION
FIRST PLATFORM, SHOWING TYPICAL ARRANGEMENT OF SOIL DRAIN SYSTEM AND DECK DRAINS.

1



Dwg. 7 Diagram of Plumbing Drains, Deck Drains and Fresh Water System - Sh #1

2



1. DOUBLE-ACTING HAND FORCE PUMPS (ABOUT 45 GPM, 2½" SUCTION, 1½" DISCHARGE) SHALL BE PROVIDED TO DISCHARGE (a) WATER WHICH MAY ACCUMULATE IN THE DRAIN-WELLS OR INNER BOTTOM AND (b) SEWAGE TANK EFFLUENT. DISCHARGE SHALL BE OVERBOARD THROUGH SCUPPER VALVES. PUMPS SHALL BE CAPABLE OF HANDLING SOLIDS LIKELY TO BE ENCOUNTERED IN THE INTENDED SERVICE.

3. FRESH WATER TANKS SHALL BE COATED INTERNALLY WITH CEMENT WASH.

4. FRESH WATER AND DECK DRAIN PIPING SHALL BE STANDARD STEEL PIPE, GALVANIZED.

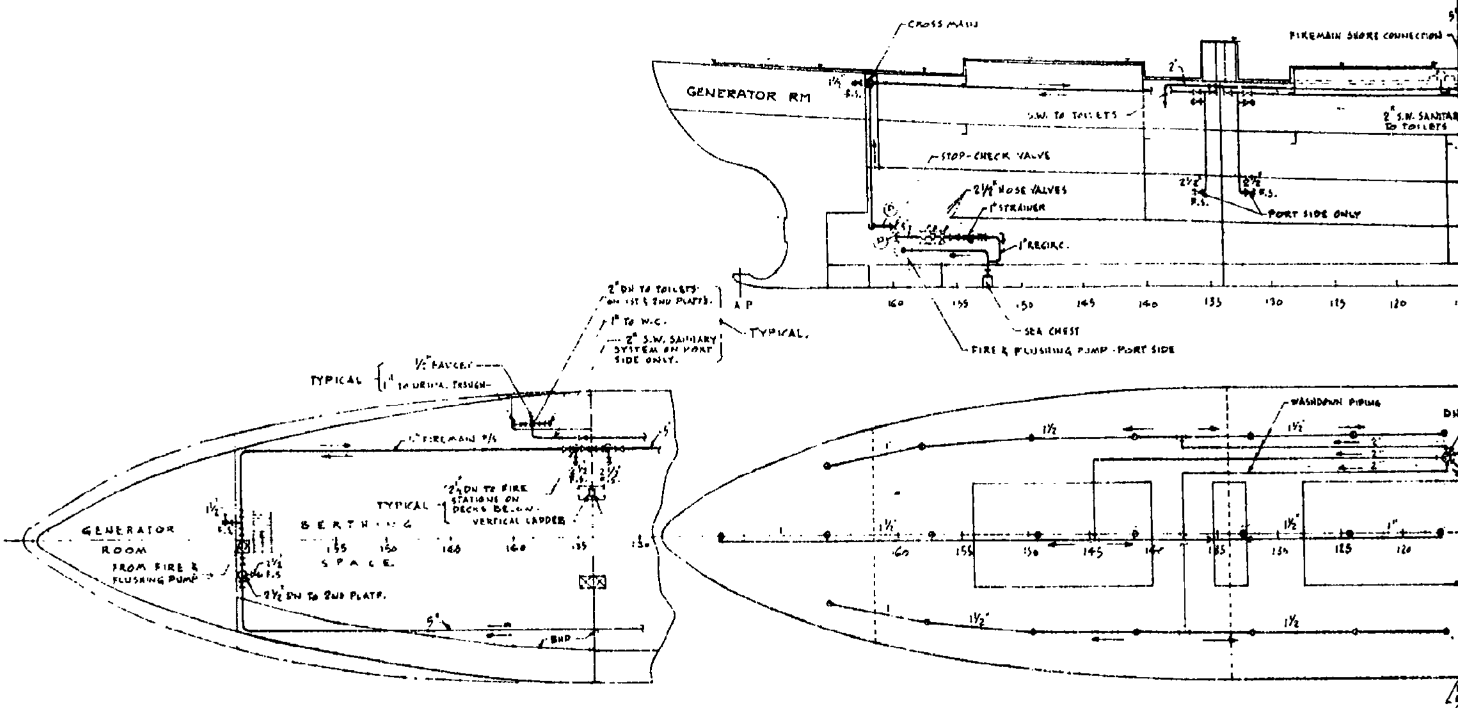
5. PLUMBING DRAINS SHALL BE STANDARD STEEL PIPE, GALVANIZED.

6. SEWAGE TANKS SHALL BE VENTED TO ATMOSPHERE ABOVE THE UPPER DECK.

PROPOSAL
EC2 TYPE VESSEL TO PERSONNEL SHELTER
DIAGRAM OF PLUMBING DRAINS, DECK DRAINS, AND FRESH WATER SYSTEM
SHEET 1 OF 9

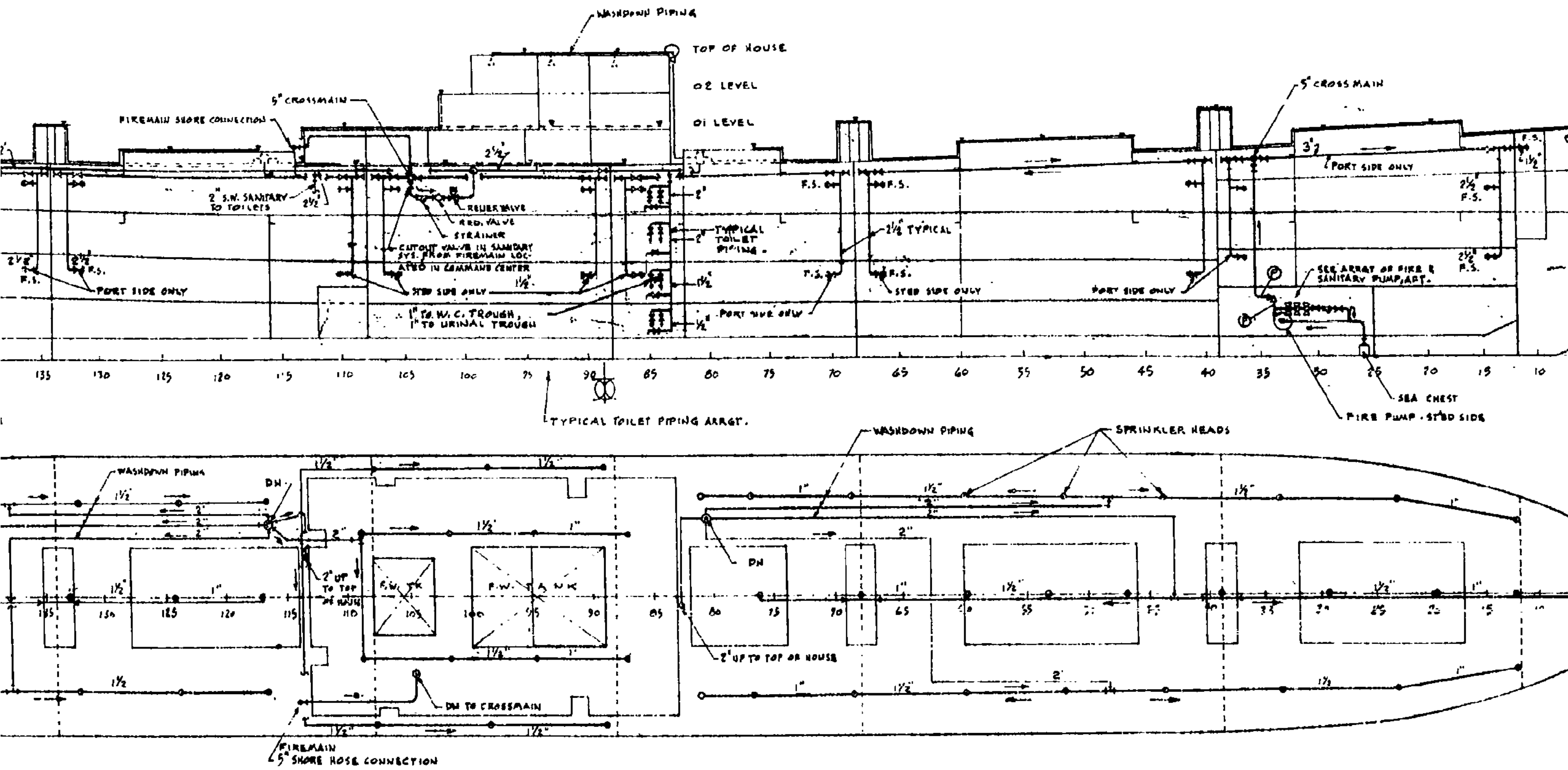
Dwg. 7 Diagram of Plumbing Drains, Deck Drains, and Fresh Water System - Sh #1

3



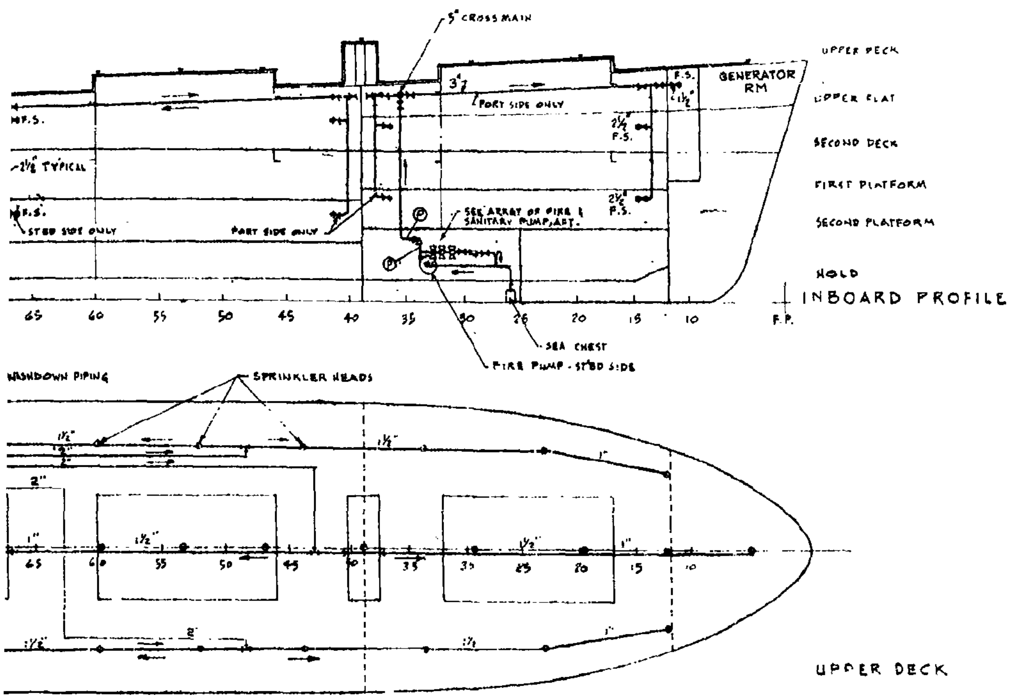
SECOND DECK

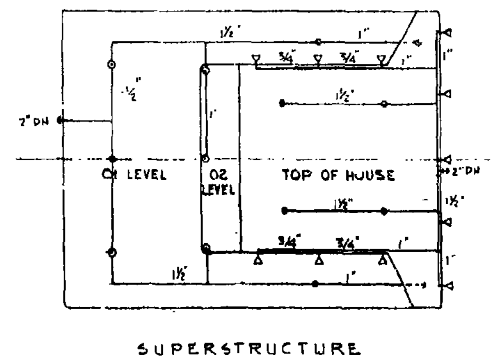
1



Dwg. 8 Firemain,

2





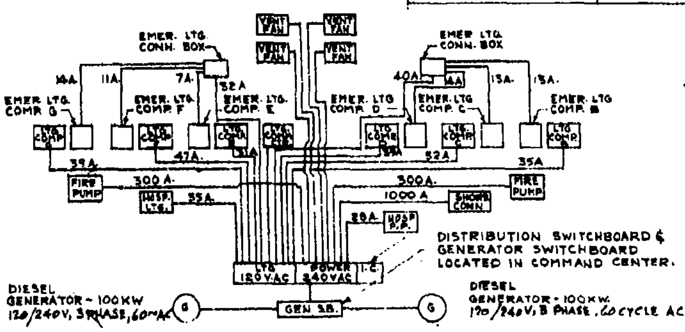
NOTES

1. EACH FIRE PUMP SHALL HAVE A CAPACITY OF 560 GPM AT 125 PSI.
2. PIPING SHALL BE STANDARD STEEL, GALVANIZED.
3. TWO 50 FT. LENGTHS OF 1½" FIRE HOSE, APPROVED BY THE OFFICE OF CIVILIAN DEFENSE, SHALL BE FURNISHED AND INSTALLED AT EACH FIRE STATION AS DIRECTED.
   THREE 100 FT. LENGTHS OF 2½" FIRE HOUSE, SIMILAR TO THE ABOVE, SHALL BE FURNISHED AND INSTALLED AT EACH FIRE PUMP, AS DIRECTED.
   ALL HOSE FITTINGS SHALL HAVE AMERICAN NATIONAL STANDARD FIRE HOSE THREAD.
4. FIRE HOSE REELS, SPANNERS, 2½" x 1½" x 1½" Y-GATE ADAPTERS WITH HOSE FITTING ENDS SHALL BE INSTALLED AT EACH FIRE STATION.
5. C-TYPE STRAINERS SHALL BE INSTALLED AT EACH FIRE STATION.
6. THE ABC WASHDOWN SYSTEM SHALL BE TAKEN FROM THE TOP OF THE FIREMAIN CROSS-CONNECTION IN THE COMMAND CENTER. A GATE VALVE, OPERABLE FROM THE COMMAND CENTER, AND A CHECK VALVE, SHALL BE PROVIDED IN THE WASHDOWN SYSTEM RISER.
7. 2-15# PORTABLE CO_2 FIRE EXTINGUISHERS SHALL BE PROVIDED IN EACH GENERATOR ROOM AND IN EACH PUMP ROOM.

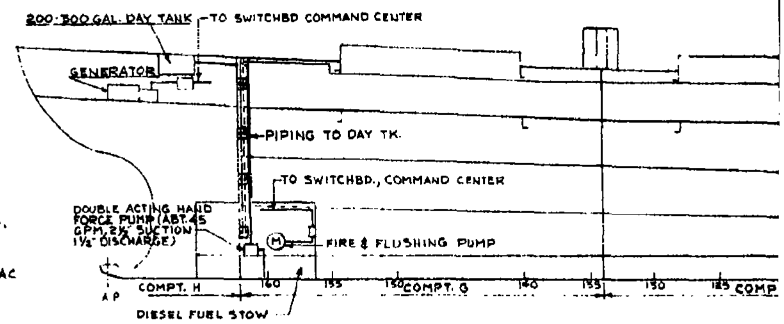
Dwg. 8 Firemain, ABC Washdown System and Sanitary System - Sh #1

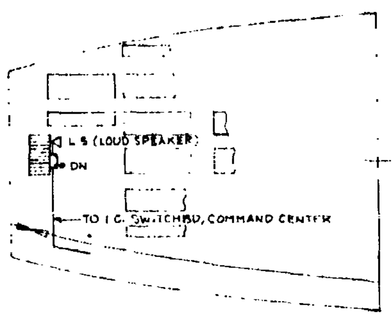
3

GENERATOR LOAD SUMMARY			
LOAD GROUP	TOTAL CONN. LOAD	NORMAL LOAD	WASHDN LOAD
FIRE & FLUSHING PUMPS(2)	130 KW	65 KW	130 KW
HOSPITAL LOAD	10	10	10
LIGHTING LOAD	30	30	0
EMER. LIGHTING LOAD	10	10	10
VENTILATION LOAD (4)	52	52	26
I.C. LOAD	3	3	3
TOTAL	235	170	165
2 GENERATORS OPER.	200	200	200

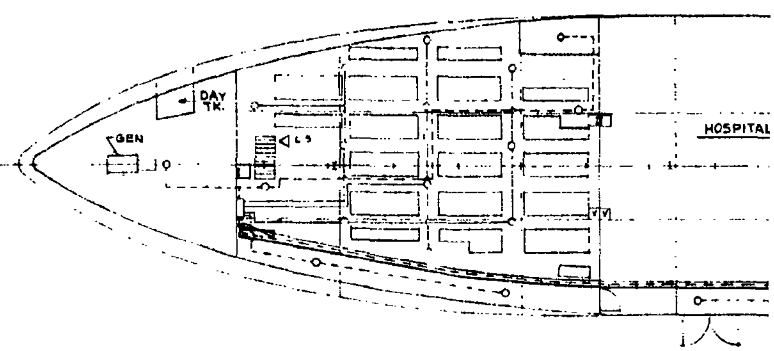


ELEMENTARY POWER DIAGRAM

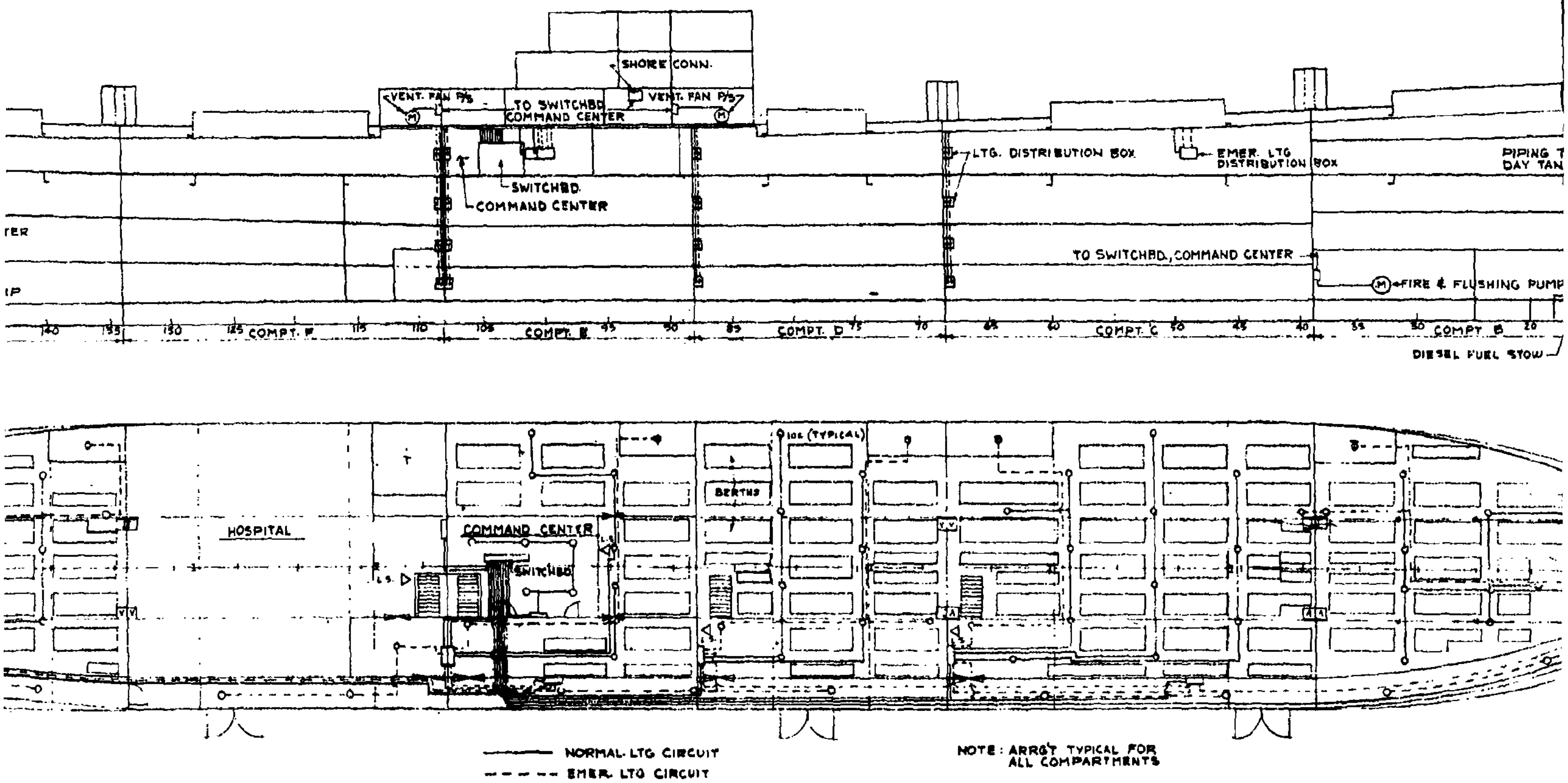




TYPICAL I.C. SYSTEM

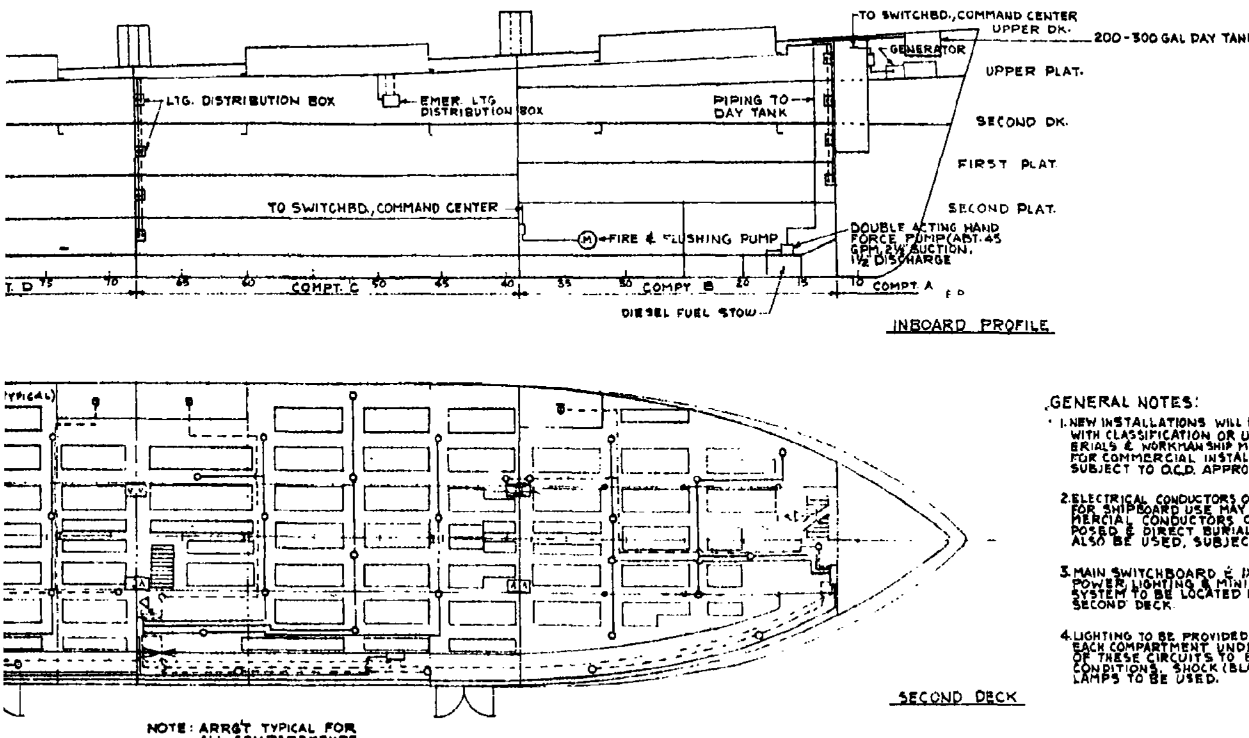


1


SHORE CONN.
VENT. FAN P/S
TO SWITCHBD COMMAND CENTER
VENT. FAN P/S
LTG. DISTRIBUTION BOX
EMER. LTG DISTRIBUTION BOX
PIPING T
DAY TAN
SWITCHBD.
COMMAND CENTER
TO SWITCHBD., COMMAND CENTER
FIRE & FLUSHING PUMP
COMPT. F
COMPT. E
COMPT. D
COMPT. C
COMPT. B
DIESEL FUEL STOW
HOSPITAL
COMMAND CENTER
SWITCHBD
BERTHS
(TYPICAL)
NORMAL LTG CIRCUIT
EMER. LTG CIRCUIT
NOTE: ARRG'T TYPICAL FOR ALL COMPARTMENTS

Dwg. 9 Power,

2



GENERAL NOTES:

1. NEW INSTALLATIONS WILL NOT BE REQUIRED TO COMPLY WITH CLASSIFICATION OR U.S.C.G. REGULATIONS. MATERIALS & WORKMANSHIP MEETING THE AIEE STANDARDS FOR COMMERCIAL INSTALLATIONS WILL BE ACCEPTABLE SUBJECT TO O.C.D. APPROVAL.

2. ELECTRICAL CONDUCTORS OF THE TYPE NORMALLY INTENDED FOR SHIPBOARD USE MAY BE USED, BUT STANDARD COMMERCIAL CONDUCTORS OF THE TYPES USED FOR EXPOSED & DIRECT BURIAL UNDERGROUND SERVICE MAY ALSO BE USED, SUBJECT TO O.C.D. APPROVAL.

3. MAIN SWITCHBOARD & DISTRIBUTION BOARDS FOR POWER, LIGHTING & MINIMUM GENERAL ANNOUNCING SYSTEM TO BE LOCATED IN THE COMMAND CENTER ON SECOND DECK.

4. LIGHTING TO BE PROVIDED BY MEANS OF 2 CIRCUITS TO EACH COMPARTMENT UNDER "NORMAL" CONDITIONS, ONE OF THESE CIRCUITS TO BE USED UNDER "EMERGENCY" CONDITIONS. SHOCK (BLAST)-RESISTANT INCANDESCENT LAMPS TO BE USED.

Dwg. 9 Power, Lighting and Communication Diagram - Sh #1

APPENDIX F

<u>Surplus Ship Emplacements for Shelters and Civil Defense</u>

January 1963

A Feasibility Study
prepared by
Frederic R. Harris, Inc.
Consulting Engineers
New York, N. Y.

SUMMARY

This study was authorized to determine the feasibility of emplacing surplus EC-2 (Liberty) ships in various assigned locations to serve as Personnel Fallout Shelters and Emergency Supply Storage centers. It was also authorized to investigate the feasibility of burying a surplus battleship of the Indiana (BB-58) class, to serve as a Civil Defense Operational Headquarters.

As a result of the study these emplacements appear to be entirely feasible from an engineering viewpoint. They can be accomplished in a comparatively short time. They would afford excellent protection against the hazards specified, for large numbers of personnel, for whole communities' emergency supply requirements, and for governmental and civilian defense functions. They would utilize ships in protective functions, for which they are ideally suited, as opposed to possibly scrapping them. Finally, these emplacements would add to the country's resources for thermonuclear defense.

CONTENTS

LIST OF DRAWINGS

INTRODUCTION

A number of merchant vessels, and some naval warships are currently being scrapped or are under consideration for scrapping in the near future. The largest potential source of surplus ships are the EC-2's (Liberty) of which some 900 remain afloat in the NDRF. Only 4 battleships remain extant in the Naval Reserve Fleet presently and their future is not clearly defined at the present time.

Studies have shown that the interior of the EC-2 can be safely converted to house between five and ten thousand persons during an emergency. Used as a fallout shelter, such a converted vessel would also afford some blast and thermal protection.

It is the purpose of this study to determine the feasibility of emplacing converted EC-2 ships in certain locations and under specified conditions where they could serve as Personnel Fallout Shelters and Emergency Supply Storage centers. The study is also authorized to investigate the feasibility of burying a surplus battleship for use as a Civil Defense Operational Headquarters with a "high probability of survival" in the event of a thermonuclear attack.

PROJECT SCOPE

The study is to investigate, discuss, and provide cost estimates for each of the three cases described below.

Case 1 - Personnel Fallout Shelter

For use in areas where underground protection is unavailable or inadequate, but which are accessible to waterways within one-half hour's walking distance of population centers. This application of converted EC-2's considers the following conditions:

a. One ship berthed at a pier.
b. One ship beached.
c. Three ships beached.
d. One ship landlocked.

Case 2 - Emergency Supply Storage

For use near major population centers where serious shortages in food and other vital supplies could develop following a massive thermonuclear attack. The emplacement condition considers six EC-2's, loaded with food and other supplies, moored and nested in deep water.

Case 3 - Civil Defense Operational Headquarters

For use as a centralized operations headquarters, during and after a thermonuclear attack, to protect and maintain the essential functions of government. The emplacement condition considers a battleship of the Indiana (BB-58) class buried near the downtown section of a metropolis and adjacent to a waterway. The study is to cover the preparation of the vessel for emplacement though the conversion of the interior is not within its scope.

The sites to be considered for Cases 1 and 2 are:

Norwalk, Connecticut
Charleston, South Carolina
Norfolk, Virginia
San Francisco Bay, California

New Orleans, Louisiana
Chicago, Illinois
New York, New York

For case 3 a single "good" site is to be selected from any of the above east coast locations.

DISCUSSION OF STUDY

The study directed itself towards isolating the problem that would be faced by the emplacements specified. These were then analyzed for solutions which are consistent with good engineering practice. Where more than one solution presented itself, the most economical solution was chosen in most cases.

Every effort was made to indicate the direction the emplacement designs should take. Drawings were based upon assumed conditions and these conditions were considered typical for each emplacement. The drawings were utilized to obtain "order of magnitude" cost estimates with no allowance made for possible differences in labor and materials costs in the various locations.

Since no on-site inspections were included in this study, it had to rely upon the extensive experience of Frederic R. Harris, Inc., with shore-front facilities, in many of the areas listed. Frequent reference was made to Frederic R. Harris' extensive library of U.S. Coast and Geodetic Survey maps, municipality and area maps, and soils and foundations studies previously conducted in the areas cited. The familiarity of certain staff members with these areas was of considerable help in analyzing the various sites. In addition, current literature was reviewed to obtain the latest thoughts on nuclear blast and fallout shelter design for possible application to this investigation.

The body of this report discusses each of the emplacements in detail. The potential sites are reviewed in connection with soils conditions. The Appendix tabulates the cost estimates for each emplacement and also lists the source of vessel and towing distance for each site. Finally, there is included a specialized solution for the relief of uplift in the case of landlocked and buried vessels.

PERSONNEL FALLOUT SHELTER - CASE 1

General

An EC-2 ship is to be prepared for use as a personnel fallout shelter. It is to be stripped of its main engines and the below deck spaces altered to accommodate between five and ten thousand persons. It is to be provided with diesel motor generator sets; fresh water in specially coated tanks; washdown, fire-fighting, and sanitary systems; filtered ventilation with blast-protected vents; and three access doors, about eleven feet wide, through the starboard side, leading to the second deck. During stand-by or readiness periods, the spaces below main deck are to be sealed and kept under dehumidification. The deck house is to be kept available for civic functions as described in Appendix E.

The vessel is to be towed to its prepared emplacement site, located within thirty minutes walk of a population center. The emplacement is to be designed for five pounds per square inch overpressure and four hundred calories per square centimeter, thermal radiation from a thermonuclear blast. It is assumed that all personnel are aboard prior to the blast, the vessel is sealed-off, and that the washdown system is in operation.

The emplacement site must provide an access route and staging area to handle ten thousand persons in one hour; a shore-based fifty kilowatt power source; a twelve hundred gallon per minute water supply for the washdown, firefighting and sanitary systems; and diversion of washdown and sanitary discharges where necessary.

Nuclear Blast

An overpressure of five pounds per square inch corresponds to a dynamic pressure of about eighty pounds per square foot. A peak overpressure of this magnitude would occur at a distance of two and one-quarter miles from ground zero for a one megaton free air burst. For a five hundred kiloton free air burst this distance would be one and eight-tenths miles. These pressures are of exceedingly short duration, measured in seconds.

The thermal radiation from a 500 kt free air burst corresponding to a dynamic pressure of five pounds per square inch is approximately 150 calories per square centimeter. The thermal radiation, like the blast pressures, is also of comparatively short duration. The mass of concrete and steel applied to all horizontal surfaces on the main deck will serve to keep down the temperature rise of the deck itself. All vertical steel plating, exposed to the thermal radiation would suffer an "instantaneous" temperature rise. Considering the mass of the interior grid-work of steel in contact with the exterior shell plating and the fact that the amount of thermal radiation reaching the vessel will fall off rapidly, the "instantaneous" temperature rise will dissipate itself quickly. At no time would the ship's hull be expected to become as hot as the surface of a heated steam radiator. As a safety measure it is recommended that all persons and flammable materials be kept out of contact with exterior shell plating. For comfort of personnel, of course, the ventilation system should function continuously.

Fallout which will be deposited on all horizontal surfaces will be adequately removed by the washdown system. The mass of concrete and steel plating deposited on the horizontal surfaces will prevent harmful radiation from penetrating to the interior.

The washdown water will actually serve two functions, the removal of fallout and the cooling of those surfaces with which it comes in contact. For this latter reason it is recommended that the washdown system be put into operation immediately after securing all personnel aboard.

One Ship Berthed at a Pier - Case 1a (Dwg. No. 1)

For the purpose of this study it is assumed that a suitable pier is available with sufficient depth of water, about eleven feet minimum. The pier is further assumed to be strong enough to secure the vessel during the pre-attack phase. The roads leading to the pier are considered adequate to handle ten thousand persons in one hour and the pier itself is assumed wide enough to handle this number of people preparing to enter the shelter.

The shelter is towed from the nearest MARAD fleet and moored with its starboard side adjacent to the pier. The effects of an eighty pound per square foot dynamic pressure will be similar to those experienced with the peak gusts of hurricane force wind velocities. A mitigating effect will be the short duration of the loading. Under such conditions inertia of the vessel will help absorb the energy imparted to it by the suddenly applied force. To assist the vessel in absorbing this energy, the lines should be slackened when securing for attack. This will permit the vessel to move and absorb some of the blast energy in this way, before the lines pick up the load and transfer it to the pier. Also, a camel is kept between pier and vessel, to prevent the vessel from damaging itself against the pier, should it be heeled over sharply by the blast.

During normal times the deck house is to be available for civic functions. It is assumed that conventional gangways are available for access to the main deck, for this purpose. Access to the shelter interior is by means of three five foot wide, light weight, metal gangways. These are to be bolted to the deck before and after boarding the shelter. In these stored positions they will be available when needed and be protected by the ship's washdown system during attack.

The required rate of access is ten thousand persons per hour. Since there are three access doors, this means about one person per second per doorway. Each eleven foot doorway opens on a six foot wide passageway leading forward and aft. Considering that people will be pressing to get aboard and that there will be none or little space between them as they mount the gangway, the arrangement specified should yield more than twice the desired capacity and at the same time keep any congestion on the pier deck, where it can be readily handled, rather than in the passageways, where many difficulties might arise.

The external power source is indicated as a fifty kilowatt diesel generator set with a one thousand gallon buried tank. This is specified in preference to a public utility line as being more general in its application. The generator set is housed within a reinforced concrete shelter with barred windows and conventional doors. It is assumed that under blast, the windows and door will be blown out but that the shelter and generator set will remain intact for restoration to service. The power line is to be physically disconnected from the ship prior to securing the shelter for attack, in order to avoid damaging the system.

The external water supply can be taken directly from the surrounding waters through the sea chests. For this study, however, it was assumed that the water depth is too shallow so that mud might foul the inlets. Provisions were, therefore, included to run a length of pipe, horizontally from each pump suction through the hull of the ship, about three feet above the bottom. The inlet is screened and provided with a shut-off valve. The installation of this intake can be made while the ship is moored alongside the pier.

The washdown effluent and sanitary discharge are allowed to flow directly into the surrounding waters.

<u>One Ship Beached - Case 1b</u> (Drawing No. 2)

A vessel could be beached by simply running her aground. Under such conditions it is likely that the stern would be afloat, even at low water, and the vessel would probably develop a list. In addition, a long causeway or other type of access route over water would be required. This means of access would have to be durable enough to be ready at any time, and should be available for disembarkation too. For these reasons, therefore, it was decided to dredge a slipway with enough depth so that the vessel would be beached at high water with its bow about one hundred feet inshore of the high water mark.

With the slipway prepared to receive the ship, the vessel is towed to the site from the nearest MARAD fleet. The vessel is trimmed to a near horizontal keel and at high tide is given enough headway by two tugs to beach itself in the slipway.

The external water supply for the washdown, firefighting and sanitary systems are obtained by running a line to ten feet of water, minimum depth. A ten inch diameter line is used terminating in a screened inlet, turned up. The line itself is laid in a trench with the outboard end anchored. The inshore end is connected to a ten inch diameter line strap-welded to the ship's starboard side about three feet above the bottom. This section of the water line is flanged at the forward end and tapped and connected to each pump suction inlet through the hull. All the laterals are fitted with valves.

A ten inch diameter sewage line is strap welded to the port side similar to the water line. The sewage line is connected to each sewage tank scupper. The aft end of this line is connected to a ten inch diameter sea line, laid as for the water line except that its outlet is horizontal and cut at a forty-five degree. The sewage line outlet is kept a minimum of one hundred feet away from the water intake.

After the pipework is completed the dredged material is backfilled against the hull on both sides from the bow aft, to about Frame #135. Surplus material is mounded to a height of about fifteen feet. On the starboard side the mound is extended to a width of about twenty-five feet minimum. This will serve as a staging area when assembling for entry into the shelter.

The shoulder is sloped off gradually, about one on four, to reduce the effects of dynamic pressure and practically eliminate the effects of thermal radiation in the shielded areas. After stabilizing, the surfaces are paved so that they can serve to catch and drain the wash-down effluent towards the aft end of the emplacement where it will be flushed out through the sewage line.

The ship will have to be ballasted after emplacement, to reduce uplift during storms and unusually high tides. The mounding against the vessel's sides will greatly assist in this stabilization but the ballast is specified for exceptional conditions. Stability against overturning due to lateral dynamic pressure is about eight to one. This is with the vessel light and without considering the effects of the mounding. When filled with people this stability will be further increased.

Access to the main deck, during normal times is by way of a stairway welded to the starboard side of the ship. For access to the shelter areas, three five foot wide stair-ramps are provided. These are of light-weight metal construction and bolted to the deck when not in use.

The external power source is a fifty kilowatt diesel-generator set as in the case of One Ship Berthed at a Pier. It is provided with a one thousand gallon buried tank and a reinforced concrete shelter. The power cable can be permanently connected to the ship's main deck power panel.

The site is assumed to lie near a highway and a twenty foot wide access road is laid on grade to connect the shelter with this highway, about fifteen hundred feet away. The pavement is designed for pedestrian and light vehicular traffic. A vehicle turning area is provided near the bow of the ship.

Three Ships Beached - Case 1c (Drawing No. 3)

All conditions and methods of emplacement are the same as for One Ship Beached.

The vessels will be beached about twenty-five feet apart (fifty feet maximum). The fill between the vessels will serve to add to the stability of the emplacement.

The water-supply lines for the vessels are combined into a common system. The same is done for the sewage-drainage lines. The size of the sea lines, however, are increased from ten to twelve inch diameter.

Separate auxiliary power systems are supplied for each shelter to keep them independent. In the event of a failure in one emergency power can be supplied by the other two units.

The ships are ballasted as with One Ship Beached, for unusually high tides and storms. A single access roadway services the entire emplacement. The width of this roadway is increased to thirty feet.

One Ship Landlocked - Case 1d (Drawing No. 4)

For purposes of this study the vessel is landlocked with its stern about one hundred feet inshore of the high water mark. All other conditions and facilities are the same as for One Ship Beached except that the sea lines are increased to twelve inches, no stair-ramps are required, and the need for ballast is eliminated by elevating the ship above its normal flotation level, at high tide.

Elevating the ship is accomplished in a manner similar to that used in canal-locks. The steps may be listed as follows:

a. The vessel is brought into the slipway at high tide.

b. The sea end of the slipway is sealed off with the dredged fill.

c. Additional fill is mounded around the rim of the basin as needed.

d. Portable pumps are used to raise and maintain the water level in the basin at about four feet above high tide.

e. Sand pumps are used to deposit fill under the keel. This is continued until the vessel is grounded. The water pumps are then stopped.

f. The previously dredged fill is backfilled into the basin and the surplus mounded against the vessel, all around.

The effect of elevating the ship's bottom in this fashion is to reduce uplift and eliminate the need for ballast. Sealing of the slipway and proceeding with raising the ship's elevation should be postponed until after the pipe work on the ship's hull is completed. Connection to the sea lines can be done after the backfilling is complete.

The landlocked ship has the inherent disadvantage that all fallout lighting in the surrounding "lake" (and possibly some of that not properly diverted from the decks of the ship out to open water) will accumulate, eventually causing the "lake" to be almost as radioactive as the surrounding terrain.

EMERGENCY SUPPLY STORAGE - CASE 2

General

Six EC-2 ships are to be loaded with food and other essential supplies and nested in a prepared mooring. The site is selected for proximity to a major population center where critical shortages might develop as a result of a thermonuclear attack.

The vessels are to be loaded to a draft of twenty-eight feet. A twenty-four hour guard is to be maintained on the ships. Existing inboard generators will be used to supply all necessary power. Fresh-water and sanitary facilities are included in one of the ships, designated the mother ship. Washdown is not required as any personnel aboard during attack can find adequate shelter from fallout in the shaft alley.

Emplacement (Drawing No. 5)

The vessels are to be towed to the nearest grain loading port and from there to the emplacement site. The appendix includes a tabulation of the MARAD fleet nearest to each emplacement site and the location of the grain loading port. The distances given are approximations only

For the purpose of this study, it is assumed that some dredging is required, an area of about seven hundred feet by one thousand feet, and an average depth of six feet. All dredging is assumed to be completed in advance of the emplacement.

The type of mooring and facilities selected will depend upon the kind of exposure to wind and tide and the kind of bottom at the site. For this study, conditions are assumed suitable for a spread-mooring system as detailed on Drawing No. 5. The four ton anchors are selectec as one possible example. In suitable bottom they should develop full strength of the chains and cable.

Comments

Nuclear fallout and thermal radiation will have no objectional effect on this emplacement. Careful storage of perishables will minimize spoilage due to any possible temperature rise. Concerning the dynamic pressure of eighty pounds per square foot, as was stated earlier, this is approximately equal to pressures resulting from peak gusts of hurricane weather. The proper selection of sites can mitigate these conditions. If a dredged site is selected, some future maintenance dredging may be required.

CIVIL DEFENSE OPERATIONAL HEADQUARTERS - CASE 3

General

A battleship of the Indiana (BB 58) class is to be buried near the downtown section of a large metropolis and adjacent to a waterway. The buried ship is to be used as an operations center and provide a shielding factor of 0.001 against nuclear fallout. It is also to provide protection against an overpressure of thirty-five pounds per square inch. Access to the operations center is to accommodate five thousand persons in one-half hour.

The use of thick armor plating and heavy high-tensile (HTS) and special-treatment (STS) steels to protect the vital areas of a battleship, makes it ideally suited for this assigned purpose. When buried, the thermal radiation and nuclear fallout will have little effect on the interior of the ship. The protected area offers an excellent chance for survival against the indicated overpressure of thirty-five pounds per square inch.

The battleship Massachusetts (BB 59) is now in Norfolk, Virginia. This vessel is surplus and part of the Naval Reserve Fleet. For this study it was decided to consider an emplacement in Norfolk, Virginia because of the availability of the vessel and the proximity to vital national functions.

Preparation of Ship

The entire superstructure above the main deck is to be removed. This includes the sixteen inch guns and rotating turrets. The stationary portion of the No. II turret is to be cut back to the deck. For this study, it is assumed that the cost of removing the superstructure will be balanced by the sale price of the scrap.

All deck openings, including the turrets are to be sealed with reinforced concrete slabs. The main deck forward of Frame #24 and aft of Frame #140 is to be strengthened with a reinforced concrete slab. The shell plating forward of Frame #24 and aft of Frame #140 is to be reinforced in way of living quarters and usable spaces.

An eight foot doorway is to be cut through the blister and armor plating, about midships, to provide access to the Third Deck from the outside. This doorway is to be enclosed with a blast-proof door, and will be about on level with grade after emplacement.

Any additional work required on the interior of the ship to enable the prescribed operations center to function are considered extra to this study.

Emplacement (Drawing No. 6)

The emplacement site is selected so that the vessel's stern will be about one hundred feet inshore of the high water mark. When buried, the rising tide can be expected to saturate the soil surrounding the vessel to approximately its flotation depth. This will result in uplift. Under unusually high tides or storm conditions the soil cover might be broached. To avoid this, the vessel is elevated so that it is grounded well above its flotation level.

The steps used to elevate the vessel are similar to those used for One Ship Landlocked. These are as follows:

1. A slipway is dredged for a distance of about eight hundred feet inshore of the high water mark. The depth of the excavation is to accommodate the vessel at high tide.

2. The vessel is towed from its storage site to the emplacement. Waiting for high tide, tugs are used to give it enough headway so that it moves into the slipway.

3. The sea end of the slipway is sealed off with the dredged fill.

4. Additional fill is mounded around the rim of the basin as needed.

5. Portable pumps are used to raise and maintain the water level in the basin at about six feet above high tide.

6. Sand pumps are used to deposit fill under the keel. This is continued until the vessel is grounded. The water pumps are stopped.

7. The previously dredged fill is backfilled into the basin and the surplus mounded over the vessel.

Nuclear Blast

A shielding factor of 0.001 against the radiation from nuclear fallout requires a cover of thirty inches of soil. To provide against future consolidation the minimum cover used in this study is five feet at the deck edge. The contour of the earth cover will provide a considerable depth in excess of the required minimum.

The earth cover is to be gradually sloped (minimum one on five) and faired to grade. With this type of cover the effects of dynamic pressure become negligible for the buried condition.

The entire area surrounding the buried ship will be subjected to the thirty-five pounds per square inch overpressure. Burying it any deeper than indicated would not materially affect this loading. As stated above, the battleship is particularly well suited to resist the overpressure, especially in way of the blisters. As a safety precaution, it is recommended that during attack, all personnel retire to the protected sections of the vessel.

Additional Comments

Access to the Third Deck opening is via reinforced concrete tube or tunnel. The tunnel rests on grade at its outboard end and is supported by the ship's side, on its inboard end. The entrace is closed with a blast-proof door and there is a paved area in front. This will act as a staging area for personnel and a turning area for vehicles. The wing walls are sloped upwards towards the ship to reduce the effect of dynamic pressure. A paved access roadway is laid directly on grade to the adjacent highway.

SITE SELECTION AND SOILS CONDITIONS

Indications are that each of the locations has one or more sites suitable for both Case 1 - Personnel Fallout Shelter and Case 2 - Emergency Supply Storage. The tabulation below lists suggested emplacement sites for each.

Location	Case 1	Case 2
Norwalk, Conn.	off Seaview Park	South of Wilson Point
Charleston, S.C.	near Yacht Basin	near Yacht Basin
Norfolk, Va.	Lynn Haven Beach	Lynn Haven Beach
San Francisco Bay	south of Hunters Point	south of Hunters Point
New Orleans, La.	south of Huey Long Bridge	south of Huey Long Bridge
Chicago, Ill.	Lake Shore Forest, East Chicago	Lake Shore Forest, East Chicago
New York, N.Y.	Plum Beach, Jamaica Bay	East Rockaway Point Jamaica Bay

The soils conditions in each of these locations (see Appendix) would probably lend themselves to emplacement procedures similar to the ones described above. It would be essential to survey the sites and study the soils, tides, and weather conditions before deciding upon the emplacement and proceeding with the designs.

For Case 1a - One Vessel Moored at a Pier - locating a suitable pier would be the most important aspect of the site survey. Weather and tide would also be of some consideration as well as the accessibility of the pier to adjacent roadways.

COST ESTIMATES

All costs are "order of magnitude" costs only and are tabulated in the Appendix. To arrive at these costs, however, quantities were used in each case based upon the assumed conditions outlined in the applicable chapter. The towing charges are going rates based upon estimates secured from established towing concerns. The towing distances used for this estimate are also given in the Appendix and are approximate, only. Note that the trip to Chicago has to be made from the MARAD Fleet in the Hudson River via the St. Lawrence Seaway. This route is about twenty-nine hundred miles and raises the cost of this emplacement, under some conditions, to about four times that of closer sites.

The table that follows tabulates the per capita emplacement cost for each of the four conditions assumed under Case 1 - Personnel Fallout Shelter. Because of its long towing distance, Chicago is treated separately. All the other locations are combined and a single average cost shown for the six sites.

Per Capita Emplacement Cost

Case 1 - Personnel Fallout Shelter

Condition	Chicago Only	Average Cost All Other Sites
a	$ 8.00	$ 2.42
b	13.70	8.07
c	11.37	5.74
d	17.80	12.17

The average cost for the emplacement of six vessels under Case 2 - Emergency Supply Storage at each of the sites except Chicago, is Two Hundred Ninety Thousand Dollars. For Chicago, again because of the long towing distance, this cost is higher, Six Hundred Twenty-Six Thousand Dollars.

The cost of burying the battleship Massachusetts on a site in Norfolk, Virginia is Five Hundred Twenty-Five Thousand Dollars. This cost includes preparation of the ship as well as emplacement.

CONCLUSIONS

The emplacement of surplus ships in carefully selected and prepared sites, offers economical solutions to some of the highly complex problems of national defense. At comparatively low cost per capita, they can provide personnel fallout shelters for small communities that are accessible to waterways. Food, medical and other essential supplies could also be readily stock-piled, with a good chance of being available for use when needed after the attack phase had passed. Used as "hardened" civil defense headquarters, they could be made safe against nuclear blast except for a direct hit. In addition to the above, the surplus ships are readily available and their emplacements could be accomplished in relatively short times, while their utilization would put the vessels to better use than their present methods of disposal.

As a result of this study, therefore, it is concluded that the plan to utilize surplus ships as Personnel Fallout Shelters, Emergency Supply Centers, and Civil Defense Operational Headquarters, is entirely feasible.

APPENDIX

Cost Estimates

CASE I - PERSONNEL FALLOUT SHELTER EMPLACEMENT COST ONLY				
Item	1a One Ship Berthed At Pier	1b One Ship Beached	1c Three Ships Beached	1d One Ship Landlocked
Site Preparation	10,000	15,000	40,000	28,000
Ship Preparation	1,500	20,000	35,000	25,000
Shore Utilities	8,500	8,500	25,500	8,500
Earthwork	-	10,000	25,000	30,000
Surfacing	-	7,500	17,500	10,500
Roadway	-	15,000	15,000	15,000
TOTALS	20,000	76,000	158,000	117,000

CASE I - PERSONNEL FALLOUT SHELTER TOTAL COST-EMPLACEMENT PLUS TOWING								
Case	Item	Norwalk Conn.	Charl. S.C.	Norfolk Va.	San Fr. Cal.	New Orl. La.	Chicago ILL.	New York N.Y.
1a	Towing	3,400	6,900	2,000	3,100	6,700	60,000	3,000
	Emplacemt.	20,000	20,000	20,000	20,000	20,000	20,000	20,000
	TOTAL	23,400	26,900	22,000	23,100	26,700	80,000	23,000
1b	Towing	4,000	7,500	2,500	3,500	7,500	61,000	3,500
	Emplacemt.	76,000	76,000	76,000	76,000	76,000	76,000	76,000
	TOTAL	80,000	83,500	78,500	79,500	83,500	137,000	79,500
1c	Towing	12,000	22,500	7,500	10,500	22,500	183,000	10,500
	Emplace-ment	158,000	158,000	158,000	158,000	158,000	158,000	158,000
	TOTAL	170,000	180,500	165,500	168,500	180,500	341,000	168,500
1d	Towing	4,000	7,500	2,500	3,500	7,500	61,000	3,500
	Emplace-ment	117,000	117,000	117,000	117,000	117,000	117,000	117,000
	TOTAL	121,000	124,500	119,500	120,500	124,500	178,000	120,500

Cost Estimates (Continued)

CASE 2 - EMERGENCY SUPPLY CENTER TOTAL COST - EMPLACEMENT PLUS TOWING	Norw. Conn.	Charl. S.C.	Norfolk Va.	San Fran Calif.	New Orl. La.	Chicago Ill.	New York N. Y.
Towing to Grain Port	20,500	12,000	12,000	18,500	40,000	360,000	18,000
Towing to Site	16,000	46,000	12,600	17,000	14,500	16,000	15,000
Mooring Facilities	100,000	100,000	100,000	100,000	100,000	100,000	100,000
Dredging Basin	150,000	150,000	150,000	150,000	150,000	150,000	150,000
TOTALS	286,500	308,000	274,600	285,500	304,500	626,000	283,000

CASE 3 - CIVIL DEFENSE OPERATIONAL HEADQUARTERS
NORFOLK, VA.

1.	Site Preparation	$175,000
2.	Shipwork	100,000
3.	Towing and Positioning	7,000
4.	Earthwork	230,000
5.	Access	13,000
	TOTAL	$525,000

Towing

Case 1 - Personnel Fallout Shelter

MARAD Fleet	Emplacement Site	Miles
John's Pt., Hudson River, New York	Norwalk, Conn.	100
Wilmington, N.C.	Charleston, S.C.	150
Fort Eustis, James River, Virginia	Norfolk, Va.	20
Suisun, California	San Francisco, Cal.	75
Mobile, Alabama	New Orleans, La.	150
John's Pt., Hudson River, New York	Chicago, Ill.	2900
John's Pt., Hudson River, New York	New York, N.Y.	75

Case 2 - Emergency Supply Storage

MARAD Fleet	Grain Loading Port	Miles	Emplacement Site	Miles
John's Point	New York, N.Y.	55	Norwalk	40
Wilmington	Norfolk, Va.	350	Charleston	500
Fort Eustis	Norfolk, Va.	10	Norfolk	10
Suisun	San Francisco, Cal.	75	San Francisco	30
Mobile	New Orleans, La.	150	New Orleans	10
John's Point	Chicago, Ill.	2900	Chicago	20
John's Point	New York, N.Y.	55	New York	20

Case 3 - Civil Defense Operational Headquarters

NRF	Emplacement Site	Miles
Portsmouth, Va.	Norfolk, Va.	30

Typical Soils Data

The general foundation conditions encountered at the sites investigated are:

1. Norwalk, Conn.

(a) Norwalk River at Connecticut Turnpike; up to 30 feet of soft organic silt extending to El. -30; underlain by dense sand and gravel.

(b) Along Long Island Sound - sand.

2. Charleston, S.C.

(a) Cooper River - U. S. Naval Shipyard. Few feet of soft silt underlain by still silty clay marl.

(b) Cooper River - Columbus Street Terminal, approximately one mile downstream (south) of Naval Base. Seventy feet of very soft organic clay to El. -80 underlain by hard marl.

3. Norfolk, Va.

U. S. Naval Shipyard (Portsmouth); soft clayey silt extending to approximately El. -50, underlain by dense shell sand.

4. San Francisco Bay, Cal.

(a) U. S. Naval Shipyard, Hunters Point; very soft bay mud to approximately El. -110.

(b) Carquinez Strait, Martinez, Cal. - Shell Refinery; very soft mud to approximately El. -80.

5. New Orleans, La.

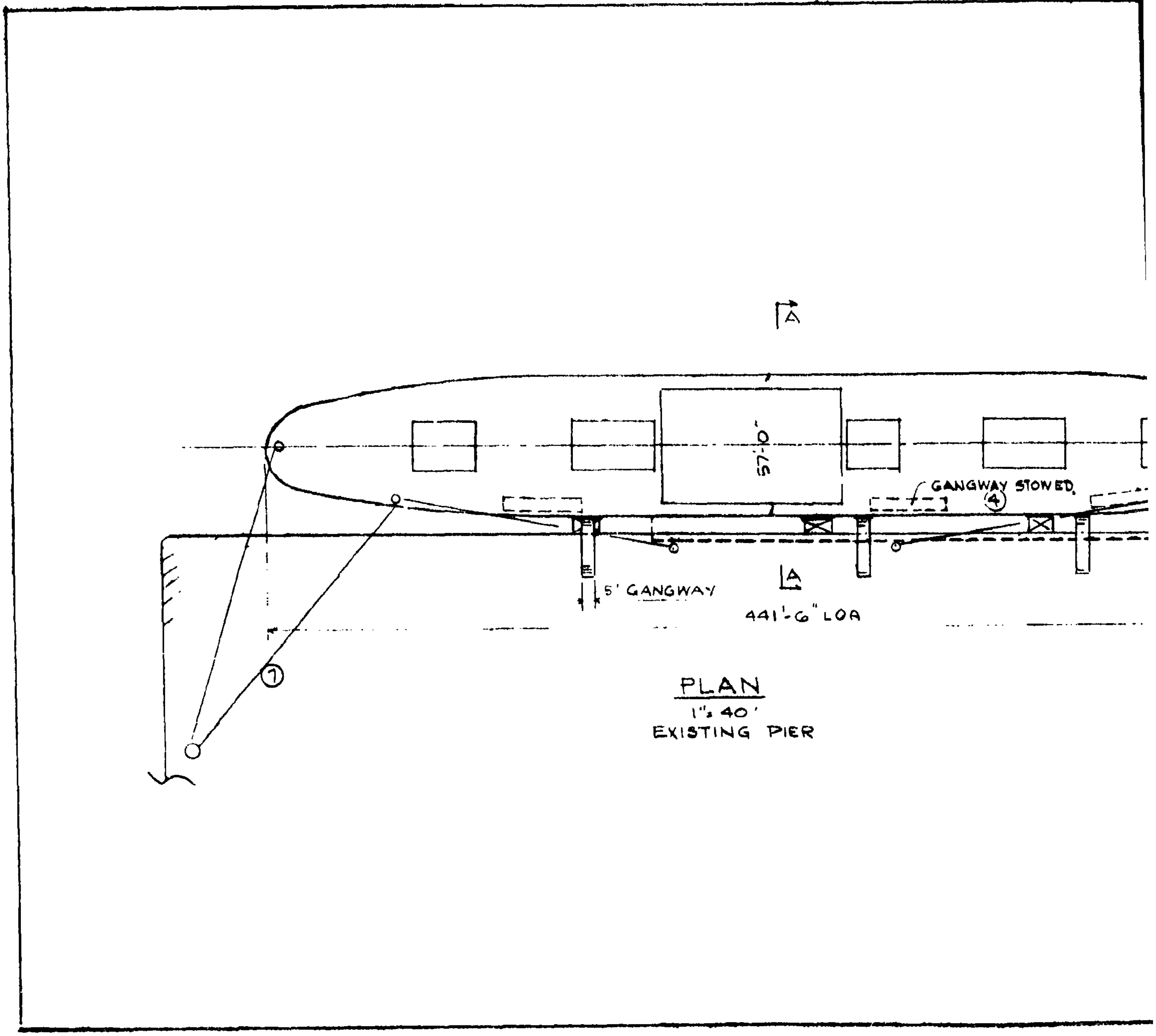
(a) Mississippi River, Algiers, adjacent to U. S. Naval Reservation; soft silty clay with varying strata of fine sand.

6. Chicago, Ill.

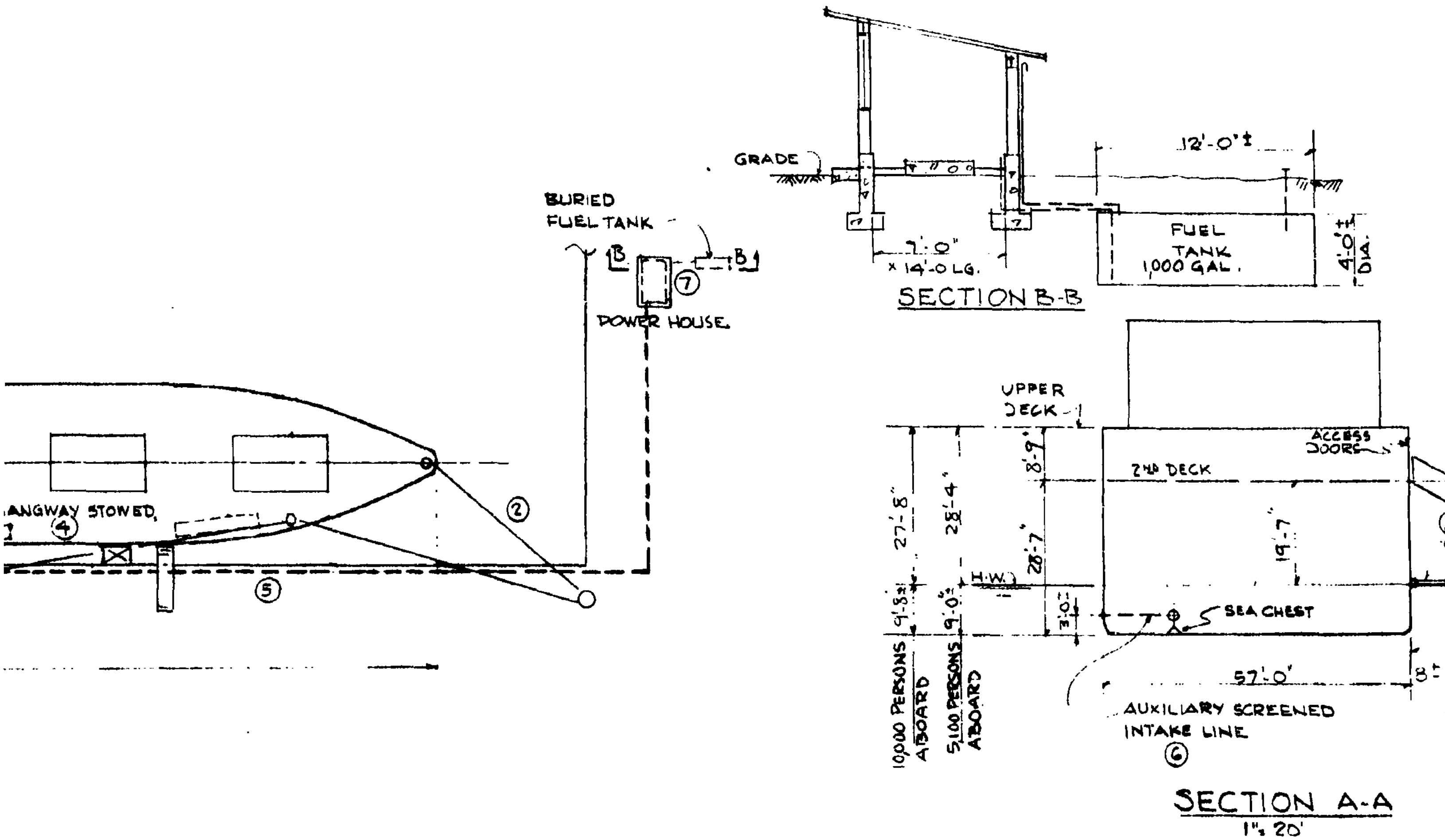
(a) Soft clay to approximately El.-50, underlain by very hard clay and silt.

7. <u>New York, N. Y.</u>

(a) Hudson River; very soft organic silt of varying thickness; representative depth to El. -50, underlain by sand and gravel.

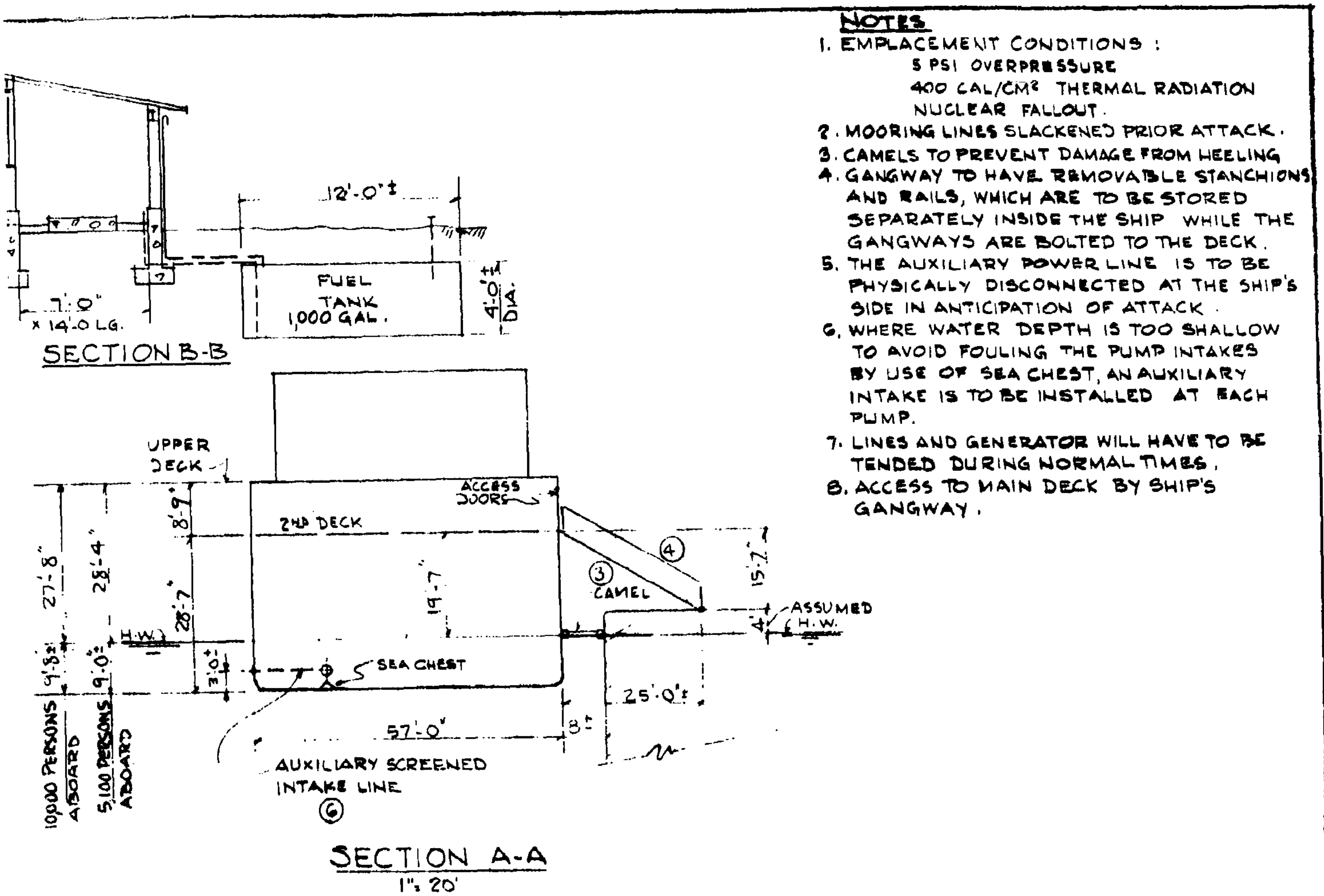

A
57'-0"
GANGWAY STOWED
4
A
5' GANGWAY
441'-6" LOA
7
PLAN
1" = 40'
EXISTING PIER

1



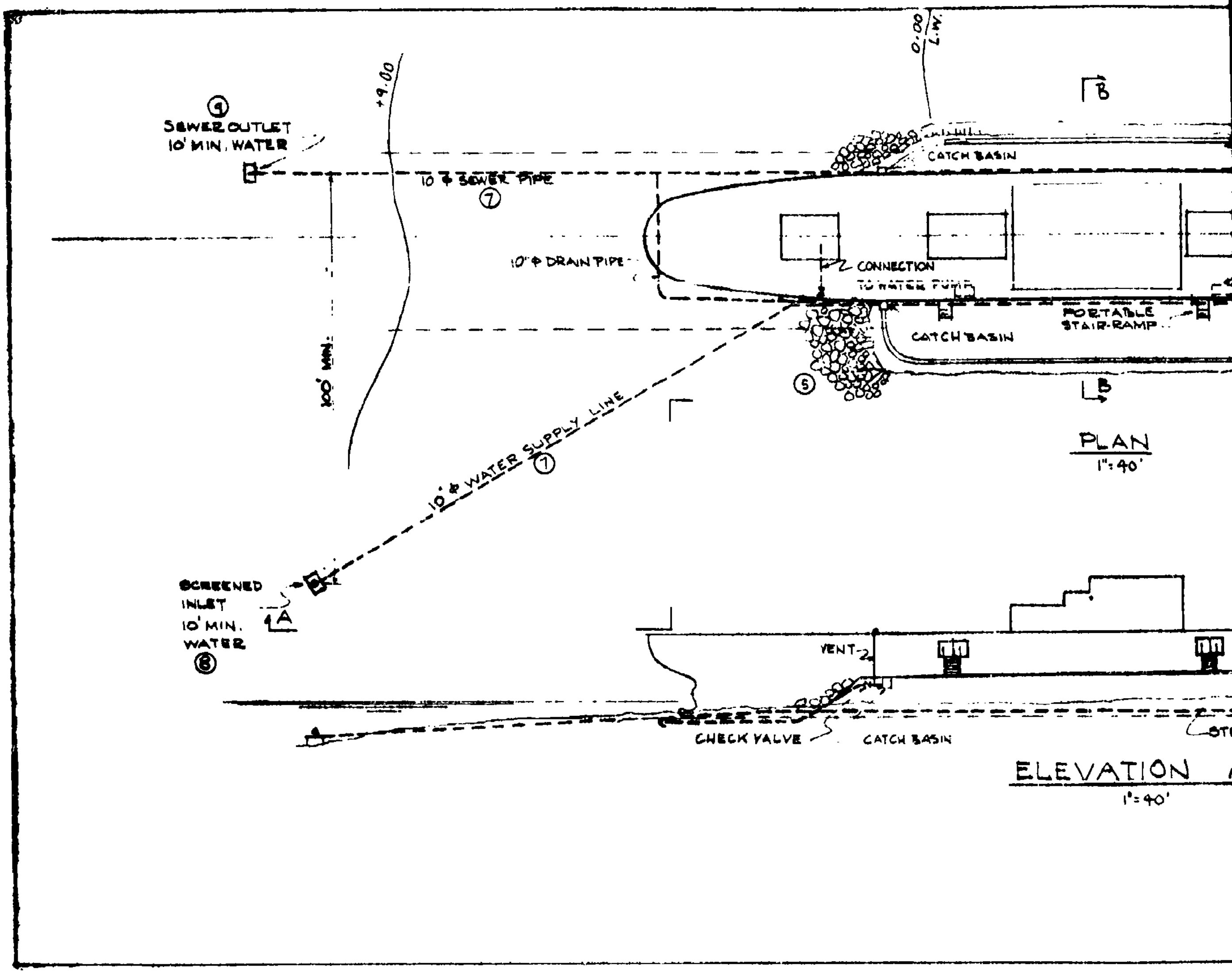
2

Dwg. 1 Person

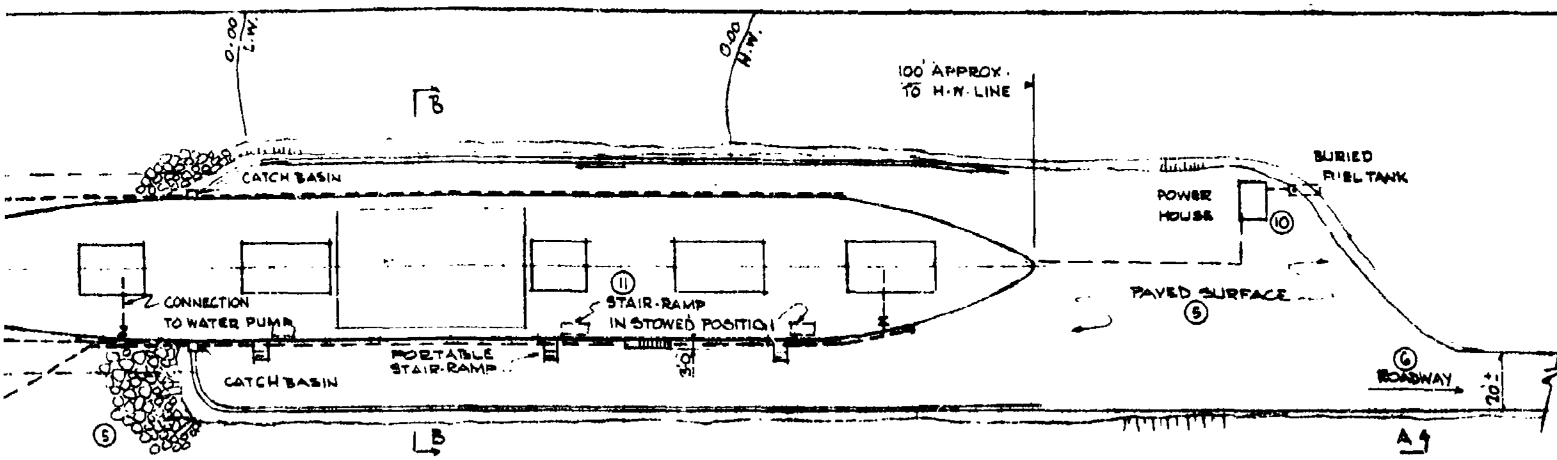


Dwg. 1 Personnel Fallout Shelter - One Ship Berthed at a Pier

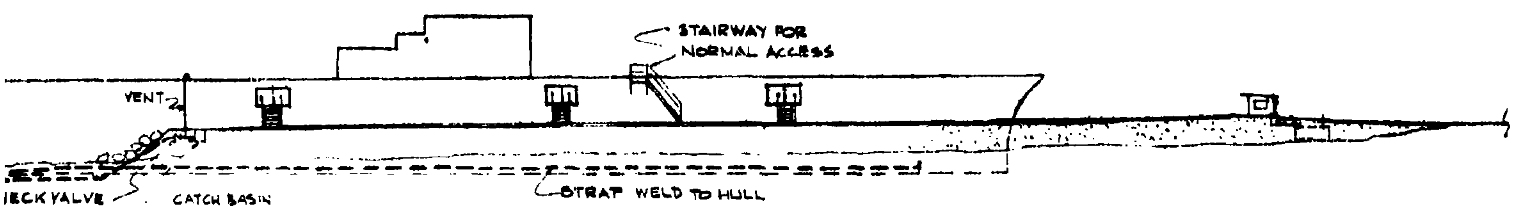
3


0.00 L.W.
+9.00
B
9
SEWER OUTLET
10' MIN. WATER
10 Φ SEWER PIPE
7
CATCH BASIN
10" Φ DRAIN PIPE
CONNECTION
TO WATER PUMP
PORTABLE
STAIR-RAMP
CATCH BASIN
100' MIN.
5
B
PLAN
1"=40'
10" Φ WATER SUPPLY LINE
7
SCREENED
INLET
10' MIN.
WATER
8
A
VENT
CHECK VALVE
CATCH BASIN
ELEVATION
1"=40'

1

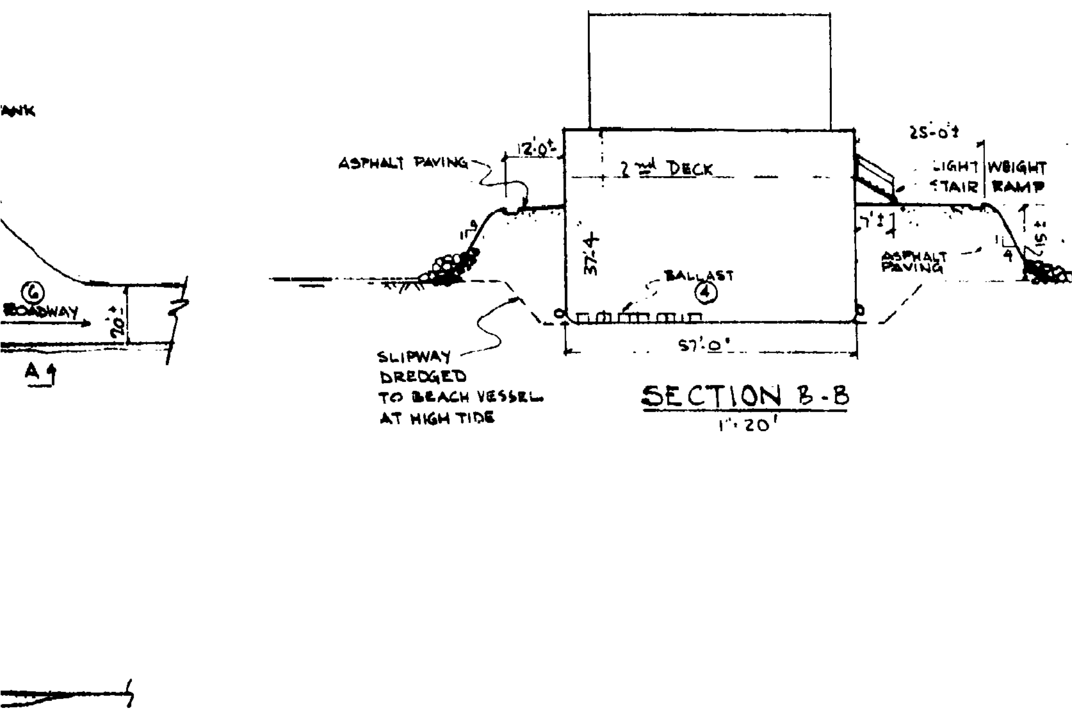


PLAN
1"=40'



ELEVATION A-A
1"=40'

2

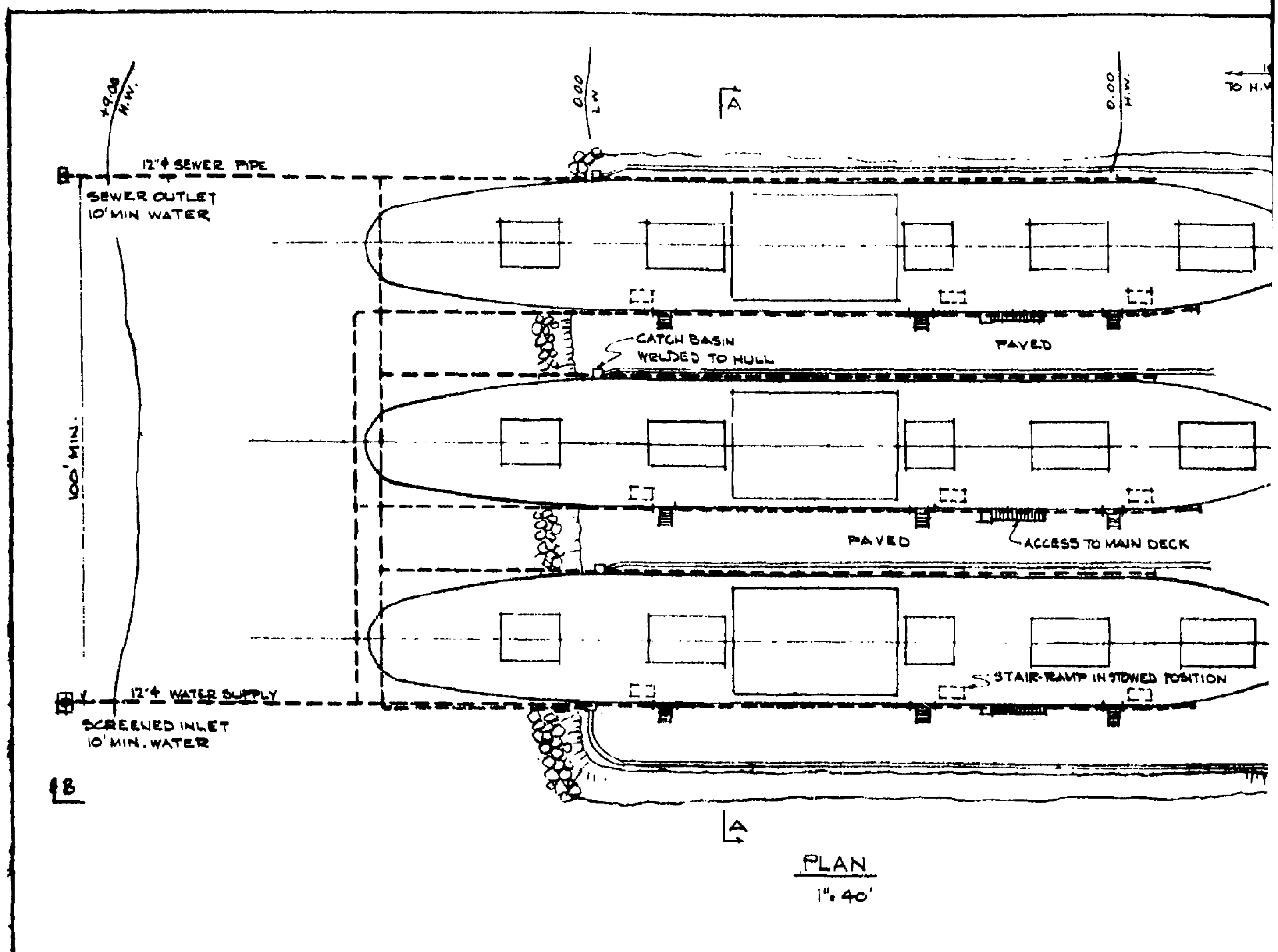


NOTES

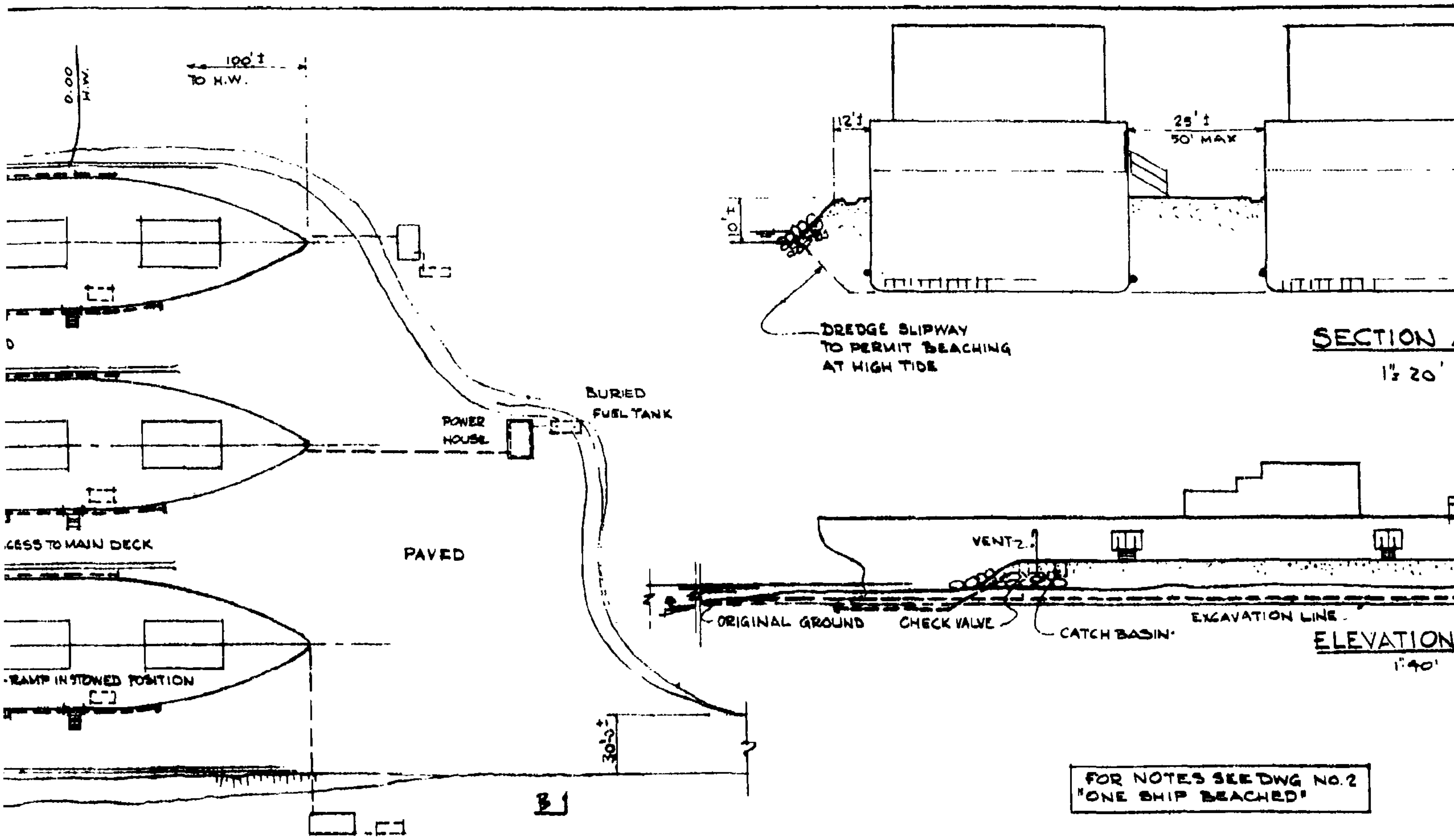
1. EMPLACEMENT CONDITIONS:
   5 PSI OVERPRESSURE
   400 CAL./CM² THERMAL RADIATION
   NUCLEAR FALLOUT.
2. EMPLACE DURING HIGHTIDE, VESSEL TRIMMED.
3. BACKFILL DURING HIGHTIDE AND MOUND ALONGSIDE.
4. INSTALL BALLAST AFTER EMPLACEMENT IS COMPLETED.
5. MOUNDING IS TO BE STABILIZED TOE PROTECTED AGAINST WAVE ACTION, SURFACE PAVED WITH ASPHALT.
6. ASPHALT PAVING IS TO BE CONTINUED OVER BEACH AREA AND CARRIED TO ADJACENT HIGHWAY. THIS IS TO BE SUITABLE FOR PEDESTRIAN AND LIGHT VEHICULAR TRAFFIC.
7. THE PIPE LINES RUNNING TO DEEP WATER ARE TO BE LAID IN TRENCHES AND ANCHORED AT THE SEA END.
8. THE WATER SUPPLY INTAKE IS TO BE TURNED UP AND SCREENED AND LOCATED IN A MINIMUM OF 10 FT. OF WATER.
9. THE DRAIN OUTLETS ARE TO EXTEND TO A MINIMUM DEPTH OF 10 FT. OF WATER AND KEPT MINIMUM DISTANCE OF 100 FT. FROM THE WATER SUPPLY INTAKE.
10. FOR POWER HOUSE DETAIL SEE DWG. NO. 1.
11. PORTABLE STAIR-RAMPS ARE TO BE BOLTED TO DECK WHEN STORED.

Dwg. 2 Personnel Fallout Shelter - One Ship Beached

3

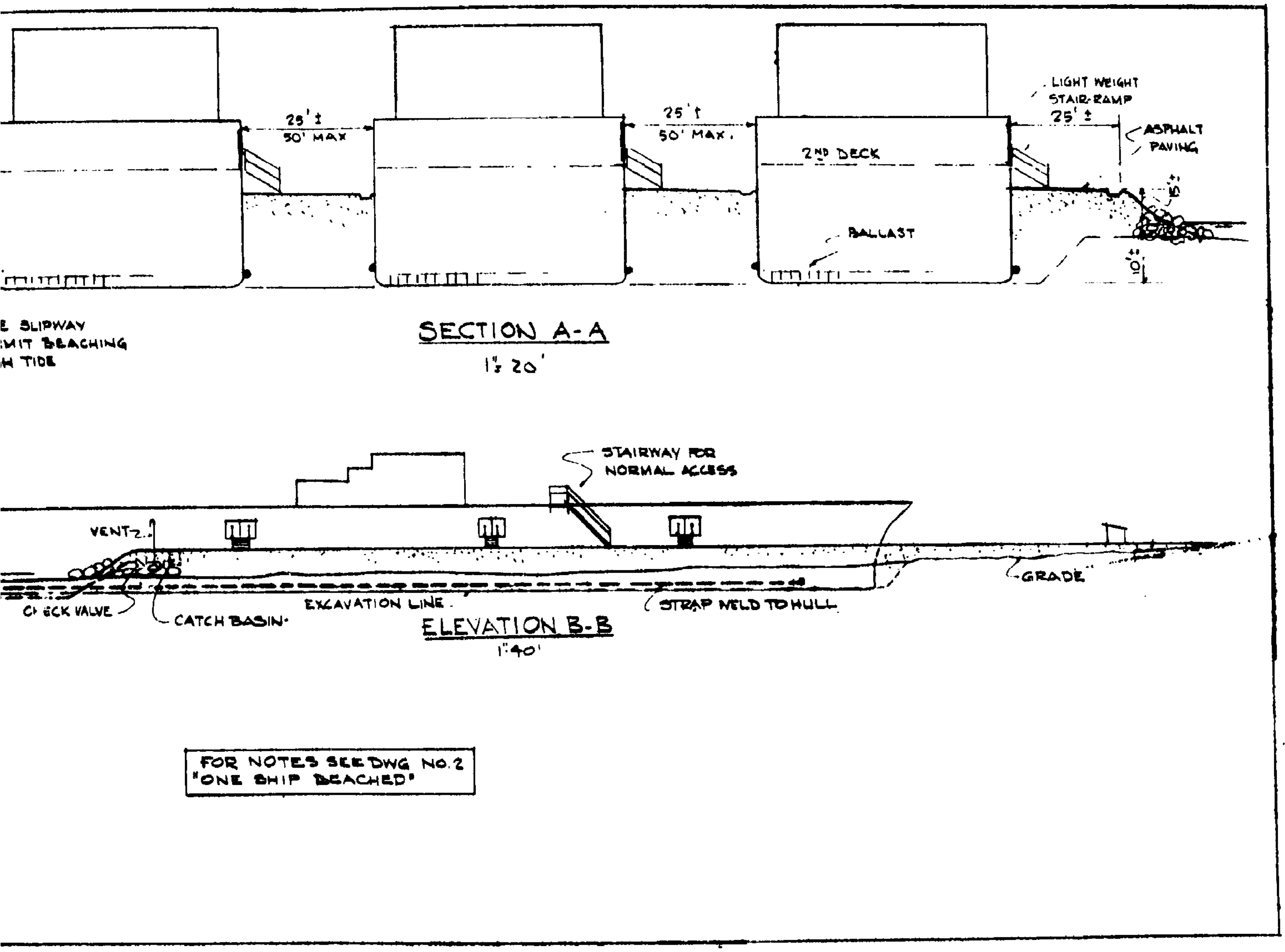

+9.08 H.W.
0.00 L.W.
0.00 H.W.
TO H.W.
A
12"ϕ SEWER PIPE
SEWER OUTLET
10' MIN WATER
CATCH BASIN
WELDED TO HULL
PAVED
100' MIN.
PAVED
ACCESS TO MAIN DECK
12"ϕ WATER SUPPLY
STAIR-RAMP IN STOWED POSITION
SCREENED INLET
10' MIN. WATER
B
A
PLAN
1" = 40'

1


0.00 H.W.
100' ±
TO H.W.
ACCESS TO MAIN DECK
RAMP IN STOWED POSITION
PAVED
POWER HOUSE
BURIED FUEL TANK
30' ±
B
12' ±
25' ±
50' MAX
10' ±
DREDGE SLIPWAY
TO PERMIT BEACHING
AT HIGH TIDE
SECTION A
1" = 20'
VENT
ORIGINAL GROUND
CHECK VALVE
CATCH BASIN
EXCAVATION LINE
ELEVATION
1" = 40'
FOR NOTES SEE DWG NO. 2
"ONE SHIP BEACHED"

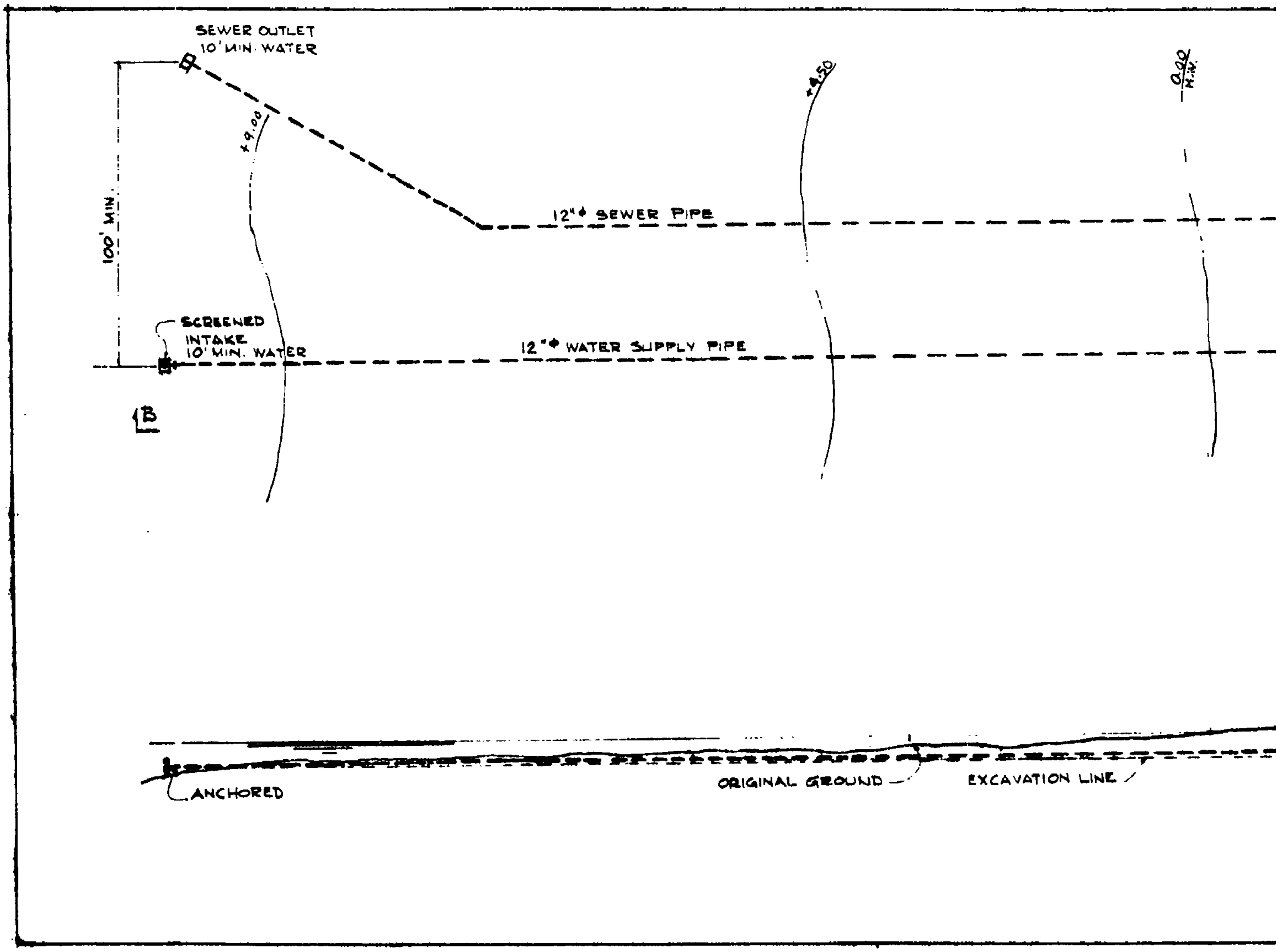
2

Dwg. 3 I



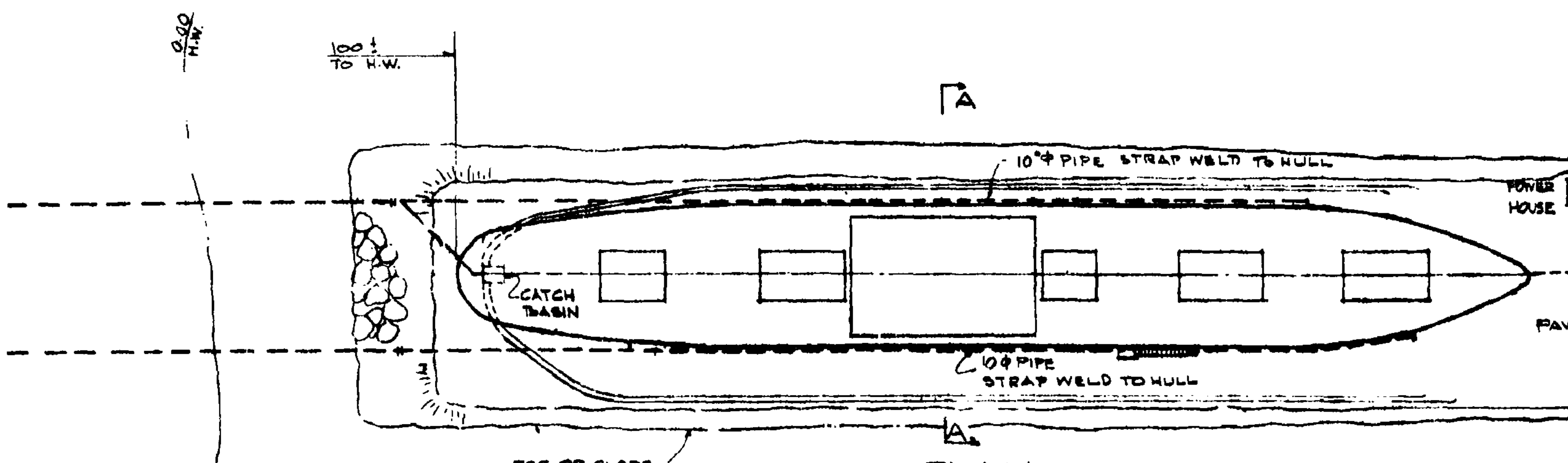
Dwg. 3 Personnel Fallout Shelter - Three Ships Beached

3

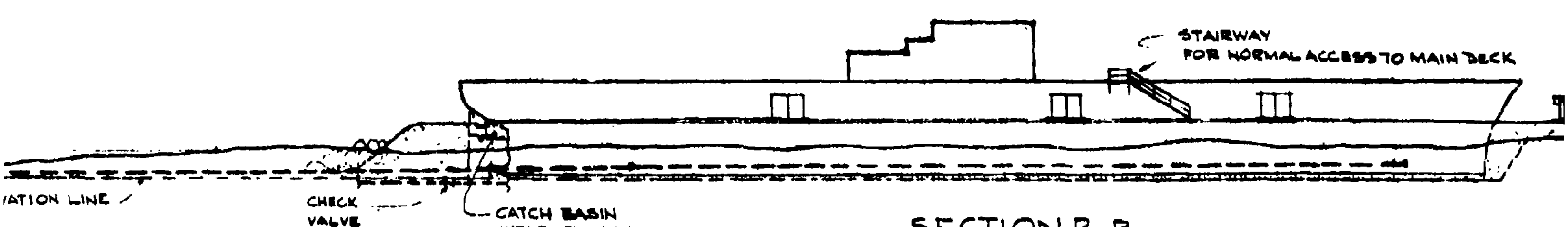


SEWER OUTLET
10' MIN. WATER
+9.00
+4.50
0.00
100' MIN.
12"φ SEWER PIPE
SCREENED
INTAKE
10' MIN. WATER
12"φ WATER SUPPLY PIPE
B
ANCHORED
ORIGINAL GROUND
EXCAVATION LINE

1



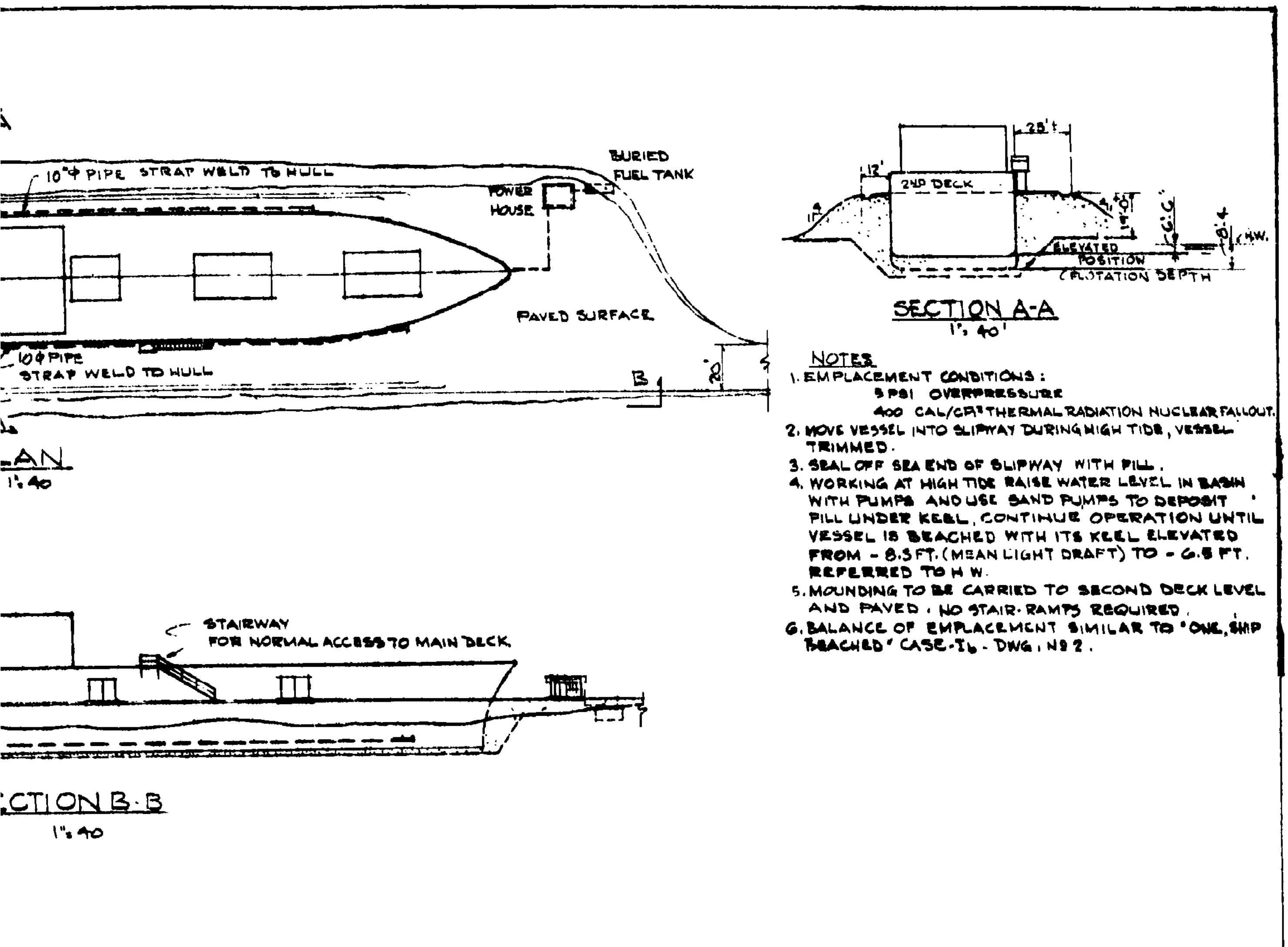
PLAN
1"=40



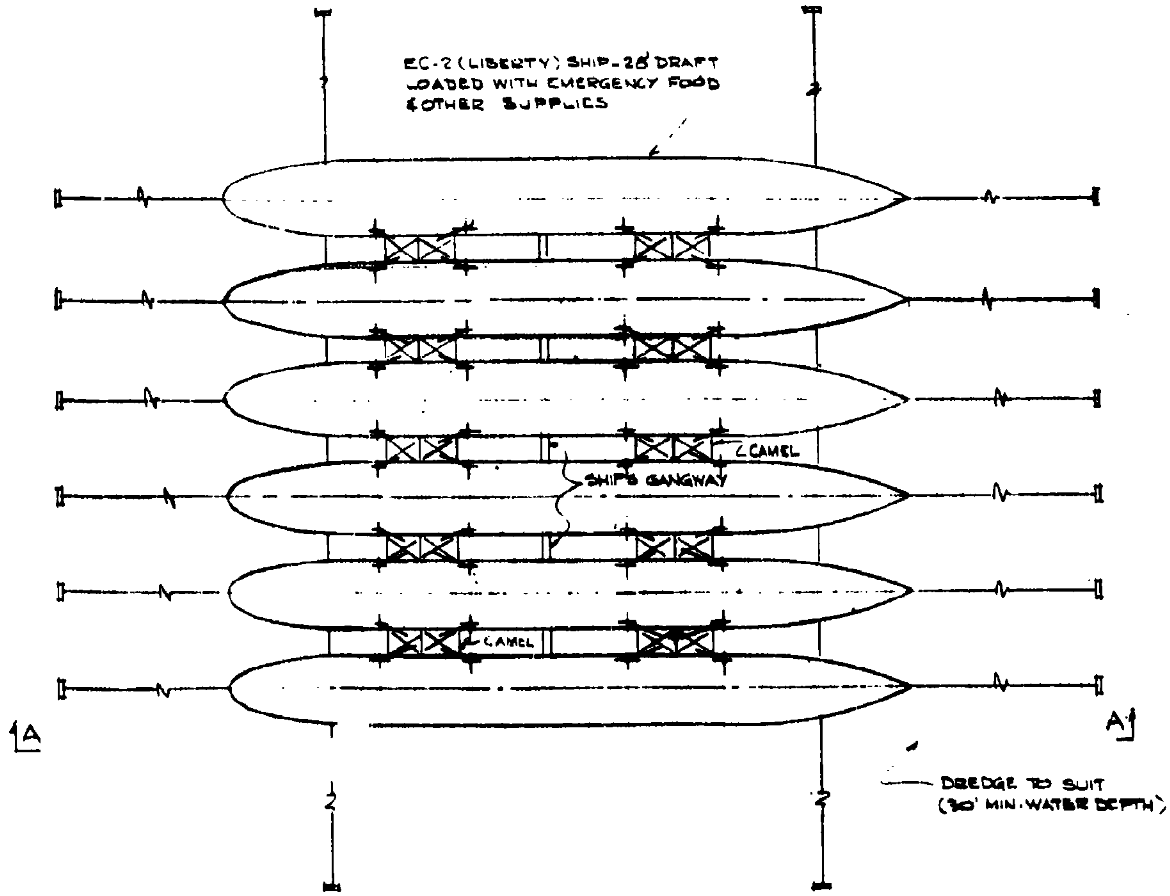
SECTION B-B
1"=40

2

Dwg. 4 F



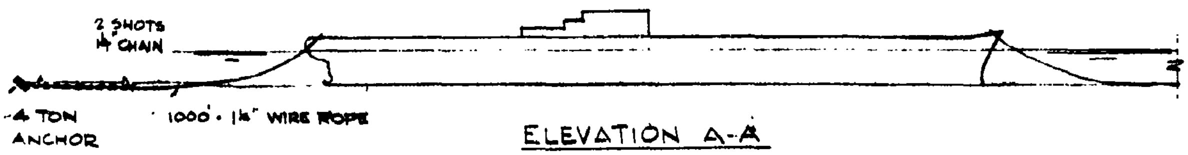
Dwg. 4 Personnel Fallout Shelter - One Ship Landlocked



EC-2 (LIBERTY) SHIP-28' DRAFT LOADED WITH EMERGENCY FOOD & OTHER SUPPLIES
CAMEL
SHIP'S GANGWAY
CAMEL
A
A
DREDGE TO SUIT (30' MIN. WATER DEPTH)

PLAN

1



ELEVATION A-A

NOTES

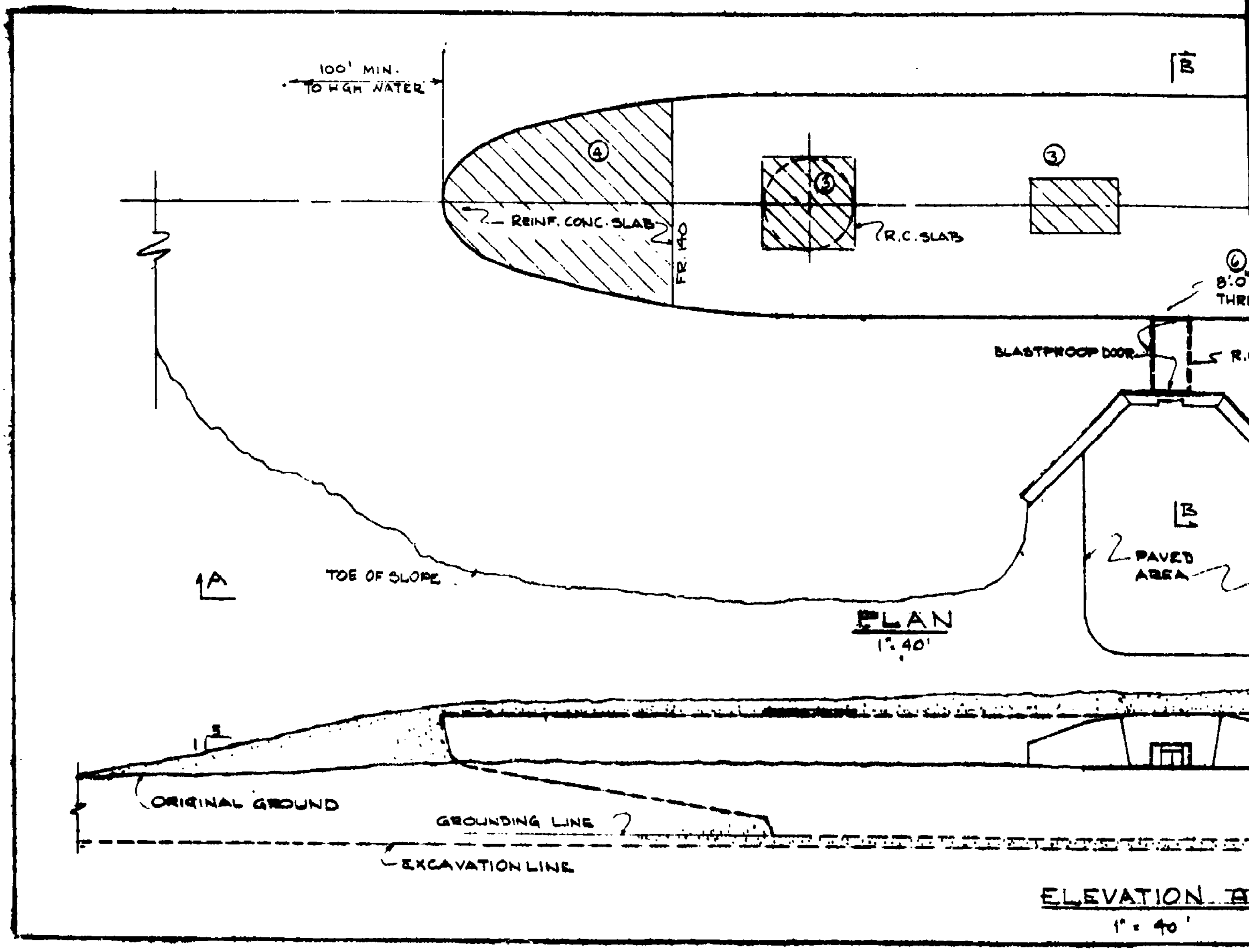
1. SPREAD MOORING SYSTEM, SUITABLE FOR THIS TYPE OF EMPLACEMENT - TYPICAL EXAMPLE.
2. SIZE OF ANCHOR, CHAIN, AND LINES WILL VARY WITH EXPOSURE AND TYPE OF BOTTOM.

BILL OF MATERIAL

ITEM NO.	DESCRIPTION	QUANTITY REQ'D.
1	CAMEL	10
2	ANCHOR 4 TON	16
3	CHAIN - 1¼" BREAKING STRENGTH: 94000 LBS.	32 SHOTS
4	WIRE ROPE 1¼" DIA. - 6×19 PLOW STEEL 144,000 LBS BREAKING STRENGTH	16,000 LIN. FT.
5	WIRE ROPE - 1⅛" DIA. FIBRE CORE 6×24 - PLOW STEEL	700 LIN. FT.
6	WIRE ROPE - ¾" DIA. FIBRE CORE 6×7 - PLOW STEEL	4,000 LIN. FT.
7	MISCELLANEOUS FITTINGS	TO SUIT

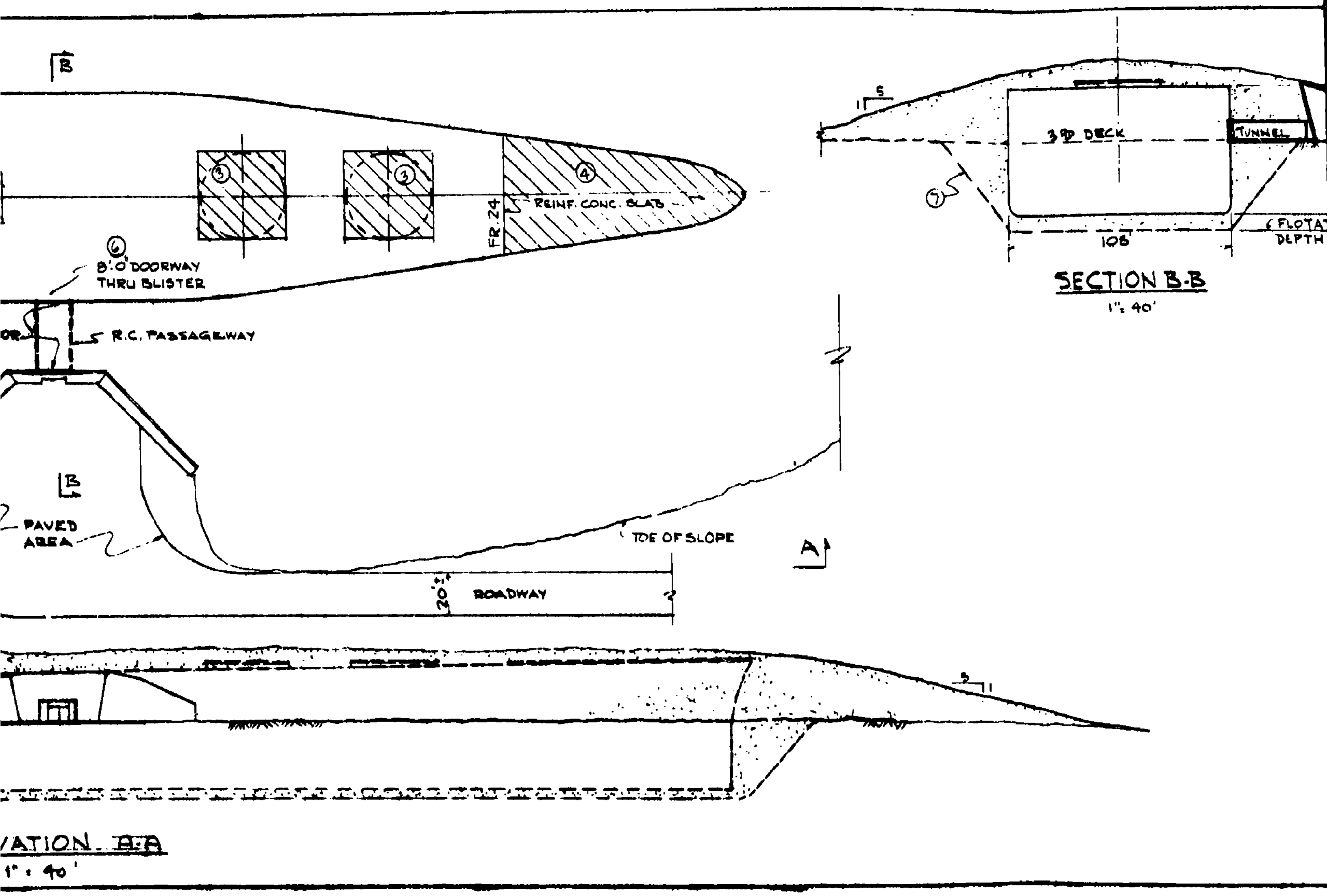
2

Dwg. 5 Emergency Supply Storage



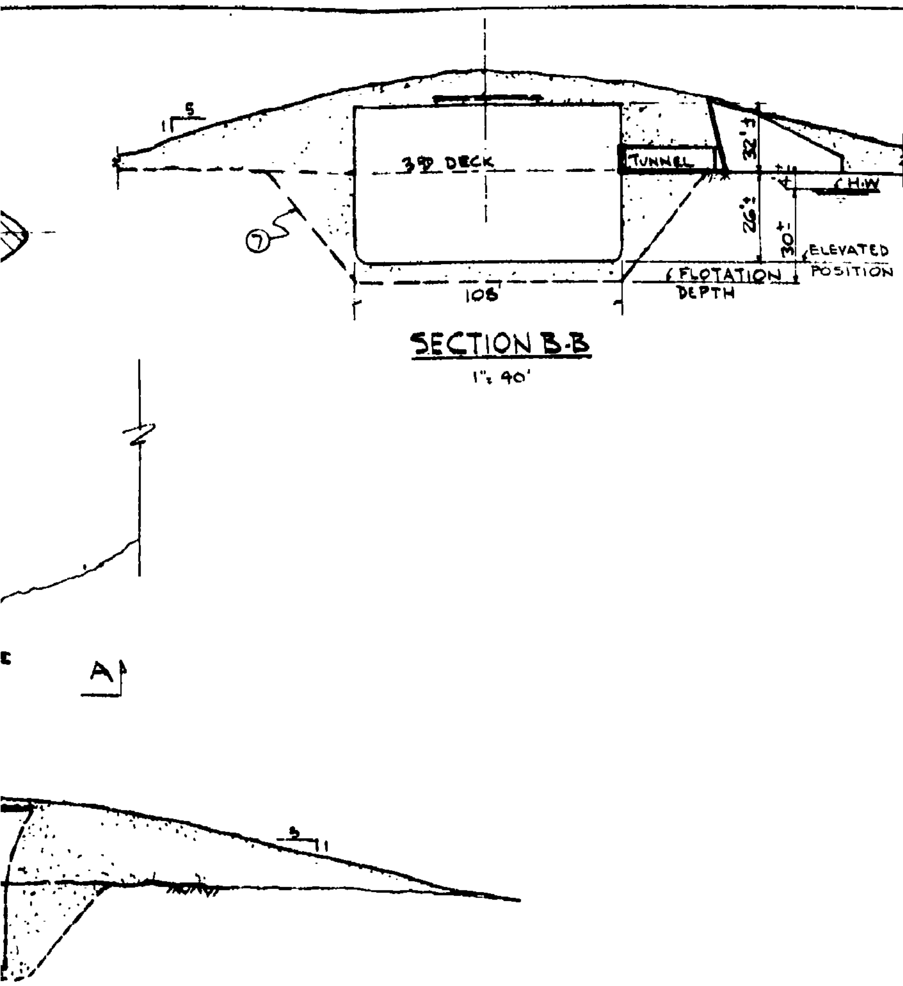
100' MIN. TO HIGH WATER
4
3
3
R.C. SLAB
REINF. CONC. SLAB
FR. 140
6
BLASTPROOF DOOR
B
B
PAVED AREA
A
TOE OF SLOPE
PLAN
1" = 40'
ORIGINAL GROUND
GROUNDING LINE
EXCAVATION LINE
ELEVATION
1" = 40'

1


B
3
3
4
REINF. CONC. SLAB
FR. 24
6
8'-0" DOORWAY THRU BLISTER
R.C. PASSAGEWAY
B
PAVED AREA
TOE OF SLOPE
A
20'±
ROADWAY
5
1
3RD DECK
TUNNEL
7
108'
FLOTAT
DEPTH
SECTION B-B
1" = 40'
5
1
VATION. A-A
1" = 40'

2

Dwg. 6 Civil



NOTES

1. EMPLACEMENT CONDITIONS ;
   35 PSI OVERPRESSURE
   1000 PF AGAINST FALLOUT
2. PRIOR TO EMPLACEMENT, ENTIRE SUPERSTRUCTURE TO BE REMOVED, INCLUDING MAIN GUNS AND ROTATING TURRETS. THE STATIONARY PORTION OF NO. II TURRET TO BE CUT BACK TO HEIGHT OF NO. I TURRET.
3. ALL DECK OPENINGS TO BE SEALED WITH REINF. CONC.
4. MAIN DECK FORWARD OF FR. #24 AND AFT OF FR. # 140 TO BE REINFORCED WITH R.C. SLABS.
5. SHELL PLATING FORWARD OF FR. # 24 AND AFT OF FR # 140 TO BE REINFORCED IN WAY OF LIVING QUARTERS AND USABLE SPACES.
6. CUT 8'-0' DOORWAY THRU BLISTER AND ARMOR PLATING FOR ACCESS THRU HULL TO 3RD DECK, REINFORCE AND INSTALL BLAST-PROOF DOOR.
7. EXCAVATE SLIPWAY TO ACCOMODATE DRAFT OF VESSEL AT HIGH WATER.
8. MOVE VESSEL INTO SLIPWAY AT HIGH WATER.
9. SEAL OFF SEA END OF SLIPWAY WITH BACKFILL.
10. RAISE AND MAINTAIN WATER LEVEL IN BASIN 5 TO 6 FT. ABOVE H.W.
11. USING SAND PUMPS DEPOSIT DREDGED FILL UNDER KEEL UNTIL VESSEL IS GROUNDED AT AN ELEVATION HIGH ENOUGH TO OVERCOME UPLIFT, SAY 4'-0 MIN.
12. BACKFILL AND MOUND OVER VESSEL TO MINIMUM COVER OF 6 FT. SLOPING MOUND TO GRADE WITH MAXIMUM SLOPE OF 1 ON 5.
13. ACCESS PASSAGEWAY TO BE OF HEAVY REINF. CONC. CONSTRUCTION WITH BLAST-PROOF DOORS. WINGWALLS TO BE SLOPED TO REDUCE EFFECT OF DYNAMIC PRESSURE.

Dwg. 6 Civil Defense Operational Headquarters

3

APPENDIX G

The Utilization of Active and Inactive Merchant Vessels as Floating Utilities and as Liquid Storage Facilities

January 1963

A Feasibility Study
prepared by
Michael J. Ryan
Naval Architect
San Francisco, Calif.
under the supervision of
The San Francisco Naval Shipyard
San Francisco 24, Calif.

ABSTRACT

A study was made of the feasibility of utilizing vessels of the active commercial and of the inactive MARAD reserve fleets as sources of - (1) electrical power; (2) water distillation plants; (3) facilities for storage of fuel or water. The conclusions indicate that turbine electric drive tankers are superior for all three purposes with geared turbine drive tankers next most suitable.

Turbine/electric drive passenger/transport vessels have excellent potential for power generation. Liberty vessels, under the assumed conditions, must be considered as unsuited for anything other than storage of modest quantities of fuel or water. Vessels from the active commercial fleet offer the best potential because of ready availability; this includes the many comparatively large bulk carriers operating in the Great Lakes region.

CONTENTS

REPORT OF INVESTIGATION

1. INTRODUCTION

1.1 USNRDL is investigating the feasibility of utilization of commercial vessels from the active world fleets and from the MARAD reserve fleets as sources of electric power, water distillation plants, and for fuel and water storage. Vessels of the active commercial fleet are assumed to be in or near American ports during a local or national emergency, and in ready service condition. MARAD reserve fleet units are assumed to have been reactivated and placed in such condition as would permit operation of the auxiliaries required for the above stated services under minimal conditions, but not necessarily as units ready for seagoing service.

1.2 The study included the following:

1. Investigation of vessel capabilities to perform the stated functions under emergency conditions.

2. Tabulation of the characteristics of the various vessels considered including data pertinent to electric power, water distillation and liquid capacities.

2. TYPES OF VESSELS - GENERAL

2.1 The vessels included in the study are shown in the accompanying TABLES I thru IV, which give the basic characteristics such as size, cargo deadweight (or payload capacity in long tons of 2240 lbs), liquid capacities, and electric generating and salt water distilling capabilities.

2.2 Basic characteristics of the commercial passenger/transport vessels included are shown in TABLE I, commercial tankers in TABLE II, commercial cargo vessels in TABLE III, and the same types in MARAD reserve fleet status in TABLE IV. Other types, such as the Great Lakes carriers, are mentioned without tabulation.

2.3 The characteristics of the electric generating plants of the same vessels are given in the accompanying TABLES Ia, thru IVa; data on the salt water and distilling plants are given in TABLES Ib thru IVb.

2.4 Specific data on other than vessels of the United States Flag (or Liberian or Panamanian Flags in the case of tankers) have not been included.

3. GENERAL CONSIDERATIONS

3.1 Vessels from the active commercial fleets, whether passenger, tanker, or dry cargo types have obvious advantages over like vessels taken from the MARAD reserve fleets by virtue of ready availability and in a great majority of cases superior capabilities in regard to electrical generating and salt water evaporation potential.

3.2 Active commercial fleet vessels normally would require no extensive preparation and could be expected to be ready for service for extended periods in an emergency, barring the breakdown of an important machinery component, especially when not operating at full normal power levels. In addition, such units could be moved under their own power to locations where the need was urgent, even with a minimal crew and under conditions of a local or national emergency. This is obviously not the case with vessels taken from reserve fleet status and placed in a condition suitable for service as an emergency source of electric power, water evaporation plant, or as a fuel or water storage facility. Also, they might otherwise be unsuited for ocean or coastal service under their own power (or even if towed).

3.3 TABLES I thru IV set forth basic physical dimensions of the various type vessels. These will indicate some of the factors to be considered when planning to berth or anchor a ship, or to moor two vessels (either similar or dissimilar units) together to combine their facilities. Although the mean light drafts given are an indication of the depth of water required for the ships it must be strongly emphasized that many vessels, especially tankers in light condition, usually have considerable trim by the stern. That is, they draw far more water at the stern than at the bow. Full load drafts, which are usually associated with little or no trim, should be kept in mind when selecting mooring sites for vessels-especially tankers - when they are to be employed for storing large amounts of water or fuel oil. If utilized as reserve liquid storage units tankers will generally require far greater depths of water than dry cargo or passenger vessels. Their full load drafts range from 30 feet for a 16000 deadweight ton T-2 to over 47 feet for the largest more modern tankers.

3.4 Regardless of type, all vessels moored in open water will require stern anchors, as well as those provided at the bow, to prevent the ships from swinging and turning, thus fouling power and utility lines which have been rigged for shore connections. Stern anchors are not required on merchant vessels, and are generally installed at the owners option depending on the vessels trade. Therefore, it cannot be expected they will be found on all vessels available for emergency service. When installed, the weight of a stern anchor is usually about only a third of that of a standard bow anchor.

Depending on tidal, weather, and current conditions additional stern anchors will probably be required (even where one is presently carried) on any vessel moored in open water. Stern anchor windlasses are rare. In the event a vessel moored with stern anchors must be shifted, a means of lifting these anchors must be provided. In some cases a jury rig employing cargo gear, towing winches (if installed) etc, could accomplish this. In others, a floating crane might be required. The latter procedure probably would also be necessary for handling bow anchors on some MARAD reserve fleet vessels where only minimal reactivation is accomplished. The BE-1 type vessels are fitted with stern anchors.

3.5 The commercial fleet passenger/transport types have excellent potential. Being in ready service status such vessels not only could produce large amounts of power (especially the turbine electric types) and water, but would be suited for use as living quarters for large numbers of persons, would provide emergency hospital facilities, and could be moved under their own power. There are currently 33 sea going passenger vessels in service under the American flag. This number does not include ferries, excursion boats or passenger vessels operating on The Great Lakes. It also excludes transports under control of MSTS. Of this number, two are combination cargo-passenger ship versions of the old C3s; three are converted Mariners of the 1950 C4 type; nine others are primarily cargo carriers with accommodations for 52 passengers, and three are basically cargo liners carrying 120 passengers. A number of the larger and newer vessels, however, have significant auxiliary electrical generating capacities and fresh water capabilities. Of the 33 ships only two (President Cleveland/Wilson) have electric drive propulsion. All the others are geared turbine.

3.6 The modern commercial tanker fleet types also have excellent capabilities. Modern types range from 30,000 to 80,000 deadweight tons, with the trend continuing upwards to 130,000 deadweight tons. Designed for long voyages, with alternating current, generating capacities usually in the range of 1200-1600 KW, plus standby. Water evaporators are usually 2 - 10,000 gallons per day units. Most American owned vessels of this type fly Liberian or Panamanian flags. The following tabulation gives the approximate number of tankers of 30,000 deadweight tons and over in the world fleet. The larger sizes are steadily increasing in number.

30,000 - 40,000 - -	480
40,000 - 50,000 - -	150
50,000 - 60,000 - -	150
60,000 and over - -	30

3.7 The modern commercial cargo vessels also have excellent capabilities, with considerably greater generating and water producing capacity than World War II vessels. Generating plants are a-c and usually have capacities of 1000-1500 KW, plus standby of 75-100 KW.

3.8 All capacities shown in the following TABLES I thru IV, pages 8 thru 12, are in long tons of 2240 lbs.

CONVERSION TABLE

1 Ton fresh water	=	269.0 gallons
1 Ton salt water	=	261.9 gallons
1 Ton fuel oil	=	278.5 gallons
1 Ton diesel oil	=	6.63 barrels
1 Ton fresh water	=	36.0 cubic feet
1 Ton salt water	=	35.0 cubic feet
1 Ton fuel oil*	=	37.22 cubic feet
1 Barrel	=	42 gallons

*Based on fuel oil gravity of 15 degrees API

NOTE: The "PEAK" tanks noted on the following tabulations include both the fore peak tank (at the bow) and the aft peak tank (at the stern). Usage varies but they can be voids, or used as water or liquid fuel spaces.

Table I

Vessel Characteristics - Commercial Passenger Vessels

	PRES. CLEVELAND PRES. WILSON	PRES. ROOSEVELT	CONSTITUTION INDEPENDENCE
MARAD DESIGNATION	P2 - SE2 - R3	P2 - S2 - R2	P3 - S2 - DL2
TYPE	Passenger	Passenger	Passenger
DEADWEIGHT CAP. (Cargo Only)	400 Dry Cargo		
DIMENSIONS (LOAxBxD)	609.4'x75.5'x43.5'	622.6x75.5'x51.5'	682.5'x89'x52.9'
DRAFTS - Light	18'-6"		
- Full Liquids Only			
- Full Load	30'-10½"	25'-1"	30'-2"
TRIM - Light	11'-10½"A	8'-5" A	
PROPULSION- No. of Screws	Twin- 2 Eng.Rms.	Twin - 2 Eng.Rms.	Twin
Type	Turbo Electric	Geared Turbine	Geared Turbine
SHP	20,000	18,000	55,000
Boilers -No. & Wk.Press.	4 w.t. - 625 Psi	4 w.t. - 500 Psi	4 w.t. - 680 Psi
FUEL OIL CAPACITY			
Double Bottom Tks.	2237	2137	
F. O. Settlers	404	131	
F. O. Deep Tks.	1700	774	
Total F. O. Capacity (Long Tons)	4341	3042	8100
LUB. OIL	11	18	
DIESEL OIL	49	8	
FRESH WATER CAPACITY (Long Tons)			
Reserve Feed) Potable Water) Wash Water)	387	291	
Distilled Water)		22	
Total F. W. (No Peaks)		313	760
PEAK TANKS	300	280	300
Total Water Capacity	690	590	1060
DEEP TANKS - Cargo or Other	760	none	
TOTAL POTENTIAL WATER CAPACITY Excluding F.O.Tks. (Long Tons)	1450	590	1060
EST. SHIPS IN LAY UP (% of Reserve fleet)	0	See under P2 Geared Transports	0
EST. SHIPS IN SERVICE	2	None as converted	2

Table II

Vessel Characteristics - Commercial Tankers

	30-35000 DWT.	45-50000 DWT.	60-80 DWT	T2-STANDARD & "Mission"Class
MARAD DESIGNATION	None	None	None	T2 -SE- A2
TYPE	Bethlen Std.Design	Tanker	Tanker	Tanker
DEADWEIGHT CAPACITY (Cargo Only)	32,000	45-50000	60-80,000	15,640 Max.
DIMENSIONS (LOAxBxD)	661.'x90.'x45.25'	725' x100' x50'	825' x110'x60'	533.'x68.'x39.25
DRAFTS - Light				8'-11¼"
- Full Liquids Only				29'-11½"
- Full Load	33'-11"	36'-38'	42'-46'	29'-11½"
TRIM - Light				13'-0"
PROPULSION - No. of Screws	Single	Single	Single	Single
Type	Geared Turbine	Geared Turbine	Geared Turbine	Turbo-Electric
SHP	15,000	18,000	22,000	10,000 Mission, 6600 Std.
Boilers -No. & Wk.Press.	2 w.t. - 700 Psi	2 w.t. - 680 Psi	2 w.t.-680 Psi	2 w.t. -675 Psi
FUEL OIL CAPACITY				
Double Bottom Tks.	None	None	None	None
F. O. Settlers	388			756
F. O. Deep Tks.	2782			1476
Total F.O. Capacity (Long Tons)	3170	6,000	6,000	2232
LUB. OIL				
DIESEL OIL		125	125	
FRESH WATER CAPACITY (Long Tons)				
Reserve Feed	-			222
Potable Water	96			99
Wash Water	40			-
Distilled Water	36			36
Total F. W. (No Peaks)	172			357
PEAK TANKS	1000			385
Total Water Capacity	1170			740
CARGO TANKS - (Long Tons)	30-35,000	45-50,000	60-80,000	15,640
TOTAL POTENTIAL WATER CAP. excluding F.O.Tks.(Long Tons)	42,000 100% full water	50-55,000	65-85,000	16,000
EST. SHIPS IN LAY UP (% of reserve fleet)				50 inc. T2-SE-A1's (2.7%)
EST. SHIPS IN SERVICE (About)	450	150	150	300

Table III

Vessel Characteristics - Commercial Cargo Vessels

	1950 Mariner	1960 Mariner	1960 - C3	C 3 Old
MARAD DESIGNATION	C4 - S - 1_f	C4 - S - 1_t	C3-S-38 a	C3 - S - A2
TYPE	Dry Cargo	Dry Cargo	Dry Cargo	Dry Cargo
DEADWEIGHT CAP. (Cargo Only)	13,000	12,000	10,700	9690
DIMENSIONS (LOAxBxD)	563.6'x76.'x44.5'	563.'x76'.x44.5'	492.5 x73' x42.1'	492.'x67.5'x42.5'
DRAFTS - Light	12'-5"	14'-2"	14	10'-4"
- Full, Liquids Only				
- Full Load	29'-10"	31'-6"	28'-0'	28'-6½"
TRIM - Light				6'-9" A
PROPULSION - No. of Screws	Single	Single	Single	Single
Type	Geared Turbine	Geared Turbine	Geared Turbine	Geared Turbine
SHP	19250 Max.	19250 Max.	13,750 Max.	9350 Max.
Boilers - No. & Wk. Press.	2 w.t. - 600 Psi	2 w.t. - 600 Psi	2 w.t. - 600 Psi	2 w.t. - 525 Psi
FUEL OIL CAPACITY				
Double Bottom Tks.	2274	2449		1361
F. O. Settlers	377	199		135
F. O. Deep Tks.	387	112		112
Total F. O. Capacity (Long Tons)	3038	2750	2700	1608
LUB OIL				10
DIESEL OIL	7			
FRESH WATER CAPACITY (Long Tons)				
Reserve Feed)		25		309
Potable Water)	232	58		70
Wash Water	-	75		-
Distilled Water	25	-		18
Total F. W. (No Peaks)	257	158		397
PEAK TANKS (Long Tons)	203	220	450	198
Total Water Capacity	460	378		595
DEEP TANKS - Cargo or Other	770	2600	1400	2009
TOTAL POTENTIAL WATER CAPACITY Excluding F. O. Tks. (Long Tons)	1230	2990	1900	2604
EST. SHIPS IN LAY UP (% of reserve fleet)	none	none	None	21 (1.1%)
EST. SHIPS IN SERVICE (About)	32	30	40	

Table IV

Vessel Characteristics - MARAD Reserve Fleet Types

	C3 (Old)	C4 (Old)	Liberty Ship	P2 Electric "Admiral" Class	P2 Geared "General" Class	BD1-BE1
MARAD DESIGNATION	C3 - S - A2	C4 - S - A1	EC2 - S - C1	P2 -SE2- R1	P2 - SE - R2	S4 -SE2- BD1
TYPE	Dry Cargo	Troop Transport Minor	Dry Cargo	Troop Transport Minor	Troop Transport Minor	Troop Transport Minor
DEADWEIGHT CAPACITY (Cargo only)	9690		9320			
DIMENSIONS (LOAxBxD)	492.'x69.5'x42.5'	500.'x71.5'x43.5'	441.5x57'x37.33'	608.'x75.5'x52.5'	622.6x75.5'x51.5'	426.'x58.'x28.5'
DRAFTS - Light	10'-4"	14'-0"	7'-7"	15'-9½"	15'-10½"	11'-6"
- Full, Liquids Only						
- Full Load	28'-6½"	25'-10"	27'-8-3/4"	29'-1"	26'-1"	16'-0"
TRIM - Light	6'-9" A	17'-3" A	4'-9" A	8'-9" A	3'-9" A	2'-1" A
PROPULSION-No. of Screws	Single	Single	Single	Twin(2 Eng.Rms.)	Twin(2 Eng.Rms.)	Twin(2 Eng.Rms.)
Type	Geared Turbine	Geared Turbine	Recip. Steam Eng.	Turbine Electric	Geared Turbine	Turbo Electric
SHP	9350	9900 Max	2500	20,000	18,000	6600
Boilers.No.& Wk.Press.	2 w.t.-520 Psi	2 w.t.-522 Psi	2 w.t.-250 Psi	4 w.t.-675 Psi	4 w.t.-500 Psi	2 w.t.-475 Psi
FUEL OIL CAPACITY						
Double Bottom Tks.	1361	1992	1018	2397	2137	873
F. O. Settlers	135	73	100	417	131	594
F. O. Deep Tks.	112	-	733	1243	774	
Total F.O. Capacity	1608	2065	1851	4057	3042	1467
LUB. OIL	10	18	2	11	12	6
DIESEL OIL (Long Tons)		6		49	65	49
FRESH WATER CAPACITY (Long Tons)						
Reserve Feed	309	232	132	22	341	269
Potable Water	70	491	56	387	882	
Wash Water	-	1204	none	1336	21	
Distilled Water	18	13	-	-		
Total F.W. (No Peaks)	397	1940	188	1745	1244	269
PEAK TANKS	198	249	296	299	279	170
Total Water Capacity(L.T.)	595	2189	484	2044	1523	439
DEEP TANKS -Cargo or Other			630	none	none	
TOTAL POTENTIAL WATER CAP. excluding F.O. Tks.(L.T.)	595	2190	1115	1635	1520	440
EST. SHIPS IN RESERVE FLT. (% of reserve fleet)	21 (1.1%)	41 (2.1%)	985 (50%)	1	6	40 (2.1%)
EST. SHIPS IN ACTIVE SERV.				7	4	2

Table IV (Continued)

Vessel Characteristics - MARAD Reserve Fleet Types

	T2	T2 "Mission"Class	VICTORY	VICTORY	LIBERTY TANKER
MARAD DESIGNATION	T2 -SE- A1	T2 -SE- A2	VC2 -S- AP3	VC2 -S- AP5	Z-ET1-S-C3
TYPE	Tanker	Tanker	Dry Cargo	Troop Transport	Distilling Ship
DEAD WEIGHT CAPACITY (cargo only)	14545 Norm., 16281 Max.	13569 Norm., 15640 Max.	7436	Minor	8856
DIMENSIONS (LOAxBxD)	533'x68'x39.25'	533'x68'x39.25	455'x62'x38.	455'x62.'x38.'	441.5'x57.'x37.33'
DRAFTS - Light	8' -7¼"	8'-11½"	9'-10"	14'-0" Ballasted	8'-5"
- Full, Liquids Only	30'-2"	29'-11½"	28'-6-3/4"	28'-6-3/4"	27'-8-3/4"
- Full Load	30'-2"	29'-11½"			27'-8-3/4"
TRIM - Light	12'-0"	13'-0"	5'-6"	0'-4"	5'-6"
PROPULSION- No. of Screws	Single	Single	Single	Single	Single
Type	Turbo Electric	Turbo Electric	Geared Turbine	Geared Turbine	Recip. Steam Engine
SHP	6600 Norm.	10,000	8500 Norm.	8500 Norm.	2500
Boilers-No. & Wk. Press.	2 w.t.-500 Psi	2 w.t.- 675 Psi	2 w.t.- 525 Psi	2 w.t.-525 Psi	2 w.t.- 250 Psi
FUEL OIL CAPACITY					
Double Bottom Tks.	none	none	1236	1053	1018
F. O. Settlers	756	756	128	124	100
F. O. Deep Tks.	714	1476	1519	none	956
Total F. O. Capacity	1470	2232	2863	1177	2074
LUB. OIL	11	12	17	11	2
DIESEL OIL (Long Tons)	1	1	5	131	
FRESH WATER CAPACITY (Long Tons)					
Reserve Feed	265	222	178	178	132
Potable Water	99	99	96	96	56
Wash Water	-	-	-	416	-
Distilled Water	36	36	21	21	-
Total F.W. (No Peaks)	400	357	295	711	188
PEAK TANKS	374	386	140	140	296
Total Water Capacity (L.T.)	774	743	435	851	484
DEEP TANKS - Cargo or Other	16,000	16,000	none	none	8856
TOTAL POTENTIAL WATER CAP. excluding F.O. Tanks(L.T.)	16,500	16,500	435	990	9350
EST. SHIPS IN LAY UP (% of Reserve fleet)	------ 50 both classes ------(2.7%)		44 (2.1%)	103 (5.5%)	2
EST. SHIPS IN SERVICE	----------About 300----------				0

4. REACTIVATION - MARAD RESERVE FLEET TYPES

4.1 Estimation of reactivation costs involve a number of variables, including the location of the reserve fleet, proximity to and availability of repair facilities, the work load in such facilities, the effectiveness of the preservation program for the specific vessel and its machinery auxiliaries, the condition of the hull, and availability of spare parts in the case of special types such as the BD1 - BE1 class.

4.2 Assuming that all of the various reserve types are in the same general condition, cost of reactivation would be approximately the same for all essentially similar vessels i.e., (1) single screw turbine electric types; (2) single screw geared turbine; (3) twin screw double engine room turbine electric types; (4) twin screw double engine room geared turbine types; (5) Liberty ship types. This estimate is predicated on putting in good operation condition, the boilers, together with associated auxiliaries, fire and bilge pumps, auxiliary generators, and evaporation plants on all vessels. Only on turbine electric powered vessels would the turbines and main propulsion generators with their necessary auxiliaries be activated. The propulsion motor on turbo-electric type, the turbines on geared drive vessels, the main engine on Liberty's, cargo gear machinery, ventilation systems (other than in machinery spaces), steering gear, windlass, galleys, and primary life saving equipment would not be reactivated. Portable fire extinguishers should be provided and the fixed fire fighting systems put in working order where possible. Vessels generally would not require drydocking prior to operation as electrical power and distilling units unless sea chests, sea valves and underwater overboard discharges are badly fouled or damaged.

4.3 The 40 BD1-BE1 class vessels are in various reserve fleet locations, and have not been operated since World War II. These were designed as attack transports and attack cargo vessels, intended for shallow draft (about 15' loaded) and were built with exceedingly light scantlings. They are considered unsuited for commercial service due to American Bureau of Shipping classification restrictions. There are two in operation as school ships, one for the California and one for the New York Maritime Academy. The physical condition of 40 ships which have been in layup for an extended period is unknown, and costs of previous reactivation, if any, are also unknown. Reactivation difficulties would include the possibility of delay in obtaining repair parts for this more or less special type of vessel. If necessary, one or more vessels not selected for reactivation could be used as one source of needed parts. The same would be true for post-reactivation maintenance.

4.4 The T-2 type tanker has great potential for generating electric power, storage of fuel or water, and water purification. The great majority of these have the "standard" T-2 power plant of 6600 shaft horsepower; the so-called "Mission" class have 10,000 shaft horsepower and have not been privately owned. All are turbine electric drive. In addition to the standard T-2 types in MARAD reserve status, it should be noted that some operators of this type have such vessels in layup. A great many are in commercial service. Some of these have been converted to special service as chemical carriers with special tanks. One is an edible liquid foods carrier with special stainless steel tanks. Some have been jumboized from the standard 16,000 deadweight tons cargo capacity to 20,000 and 24,000 deadweight tons. Any of the MARAD reserve fleet standard T-2 type vessels should be considered superior to the BD1-BE1 class because of their probably better condition, greater capability in electric power generating, and far greater liquid storage capacities.

4.5 Approximately 550 T-2 Tankers, including both "Standard" and "Mission" classes, were built by MARAD during World War II. Less than 300 remain today including those under foreign flag, those in active condition under American registry and those in the MARAD reserve fleet. War losses, marine casualties, and scrapping have accounted for the balance. Twenty-one were scrapped in 1959 and 55 in 1960 and the program of disposing of those in the poorest condition continues. Only about 50 remain in the reserve fleet; this is about 2.7% of the vessels in the reserve fleet. As noted above, a considerable number of T-2s have been "jumboized" by installing new midbodies (i.e., that portion containing the cargo tanks) of greater length beam and depth than the original sections, thus increasing their deadweight capacity. The machinery plant, including electrical and distillation facilities, however, remain unchanged.

4.6 Costs for minimal reactivation of the MARAD reserve types included in the study, assuming sound structural hull condition, and limiting the work to those engine room auxiliaries necessary to permit operation of generators and evaporators, are estimated at an average of $325,000.00 per vessel, and after breakout from the reserve fleet and towing to the repair site, about 25 working days. Costs for tankers selected for cleaning of their tanks for water storage will exceed the above by perhaps 25%.

Complete reactivation would average 3 to 4 times the above.

5. MANNING OF UTILITY VESSELS

5.1 Reserve fleet vessels activated and moored solely for the purpose of producing electrical power and fresh water would probably not be required legally to be inspected by the Coast Guard, the Agency that customarily certificates merchant vessels and establishes the minimum manning standard on such ships. It is appreciated that the urgency of a local or national emergency may be such as to preclude concern over what is legally required. It is important, however, that the machinery plants on these vessels be adequately and competently manned to insure their continued and efficient operation with a minimum of break down in service. Personnel should be, preferably, Coast Guard licensed merchant marine engineers and certificated crewman or U.S. Navy personnel having experience on generally similar type power plants. The minimum manning per watch suggested for each engine room is substantially that required by the Coast Guard on inspected vessels, viz:-

1- Licensed engineer
1- Fireman/watertender
1- Oiler

5.2 P-2 and BD1 transports having two complete and independent machinery spaces will require double the number listed above. Each vessel should have a chief or supervising engineer with overall responsibility for the power plant. One chief engineer could probably supervise more than one vessel if moored in close proximity to one another. In general the manning of a single engine room vessel, based on a three watch operation, would be 4 engineering officers and 6 engine crewmen, a total of 10 men in the machinery space.

5.3 The need for, and number of, deckcrew would depend on several factors; security of the vessel if moored at anchor; need for line handling if berthed at a dock in areas having a significant tidal range; need for line handling due to change in draft and trim resulting from off loading large amounts of water or fuel oil, and need for personnel to assist in water and fuel transfer operation - if applicable. The deck crew could range from a minimum of 1 to possibly 4 or 5.

6. ELECTRICAL POWER GENERATION-DISTRIBUTION

6.1 In reviewing the characteristics of the various merchant type commercial vessels, and comparing the modern cargo ships with those in the MARAD reserve fleet, two significant differences stand out which are of interest in this study. One concerns electrical power generation; the other, methods of producing and using fresh water. (The latter is discussed in Section 7.)

6.2 At the time the majority of the MARAD reserve fleet was designed electrical engineering technology had not yet satisfactorily solved all the problems associated with alternating current when used to drive cargo winches, windlasses and various other shipboard machinery. Accordingly, most of these ships have steam driven winches and auxiliaries. Electrical power requirements were limited to shipboard lighting and miscellaneous electrical equipment. The generating capacities therefore are generally modest, and the voltage usually 240/120 d-c. Modern cargo ships on the other hand use primarily A-C motors for virtually all deck machinery and many auxiliaries, hence are provided with generating plants of considerable capacity. As an example, the new Pacific Far East Line Mariners (C4-S-1t) class can produce a total of 2150 KW, 450 volts, A-C electrical energy.

6.3 Liberty (EC2-S-C1) ships, which make up over half of the MARAD reserve fleet (985 of this class as of December 1962) have a total generating capacity of only 60 KW, 120 volt, D-C. With this meager capacity, these ships are of no significant value as a source of electrical power.

6.4 The exceptions to this rule in the MARAD fleet are the turbo electric drive T-2 tankers and certain transports (P2 and BD1) with similar type propulsion. They have very significant useable generating capacities. Two T-2 tankers (Donbass at Eureka, California, and Sacketts Harbor at Anchorage, Alaska) served very successfully for a number of years as major sources of electrical power when connected with shoreside municipal utility facilities. The "Mission" class T-2 tankers can produce up to a maximum capacity of 6890 KW, 3500 volt, 60 cycle, A-C, plus 1600 KW, 450 volt, 60 cycle A-C. There are 8 "Admiral" class electric drive P-2 (see Table 1-A) all transports, of which only one is presently laid up. Seven are being operated by MSTS.

In the event they were not needed for transport duty during an emergency, they would be capable when moored of delivering substantially all of their high voltage power for use ashore without effecting their capability to serve as hotel or hospital facilities suitable to accommodate large numbers of people.

6.5 The BD1-BE1 class of vessels are turbine electric drive. These are twin screw, with 2 separate engine rooms. Main generator data follows:

	Normal	Maximum	At 60 Cycles
KW	2310	2550	1510
Speed	4800	4950	3600
Phase	3	3	3
Cycles	80	82-1/2	60
Volts	2140	2210	1310
Amp	660	660	660
Power Factor	1.0	1.0	.80

There are 2 auxiliary generators, each 312 KVA, 450 volts, 400 amps, 60 cycle. Fuel consumption is about the same as the T-2, in terms of kilowatt hours per barrel of fuel. One of the auxiliary generators would be required for plant operation. The other unit could be utilized as a source of power to shore, and as a standby unit for ship generation when needed. As shown in the tabulation, operation of the main generators at a frequency of 60 cycles is operationally possible, but a loss of about 41% in kilowatt output and voltage results.

6.6 The characteristics of the auxiliary generators and the emergency generators installed on the various vessels are shown in the accompanying tabulations. The output of one of the auxiliary generators should be retained for ship plant operation, the output of the remaining one (or more) could be diverted to shore use. Where capacity of the emergency unit warrants, this could also be diverted to shore use. On some vessels, where generator capacity is abnormally large, the normal generated power in excess of the ship plant requirements could also be diverted to shore use.

6.7 For shore power use, most voltages will have to be increased by transformers to be useable. The most general and useable distribution voltage for use ashore is at least 12 KV; however distribution voltages ranging from 2.3 KV to 66 KV might be encountered, depending upon geographical location. Turbine electric drive vessels which can generate 2200 to 3500 KV could be directly coupled (without transformers) to very small distribution systems, but in general power transformers will be required to convert to higher voltages. A typical usage of this type vessel would be the P.G.&E. operation of the stern of the T-2 tanker Donbass at Eureka, California. This power plant was used successfully as a power source and was operated 24 hours a day. The net output, without the 2-400 KW auxiliary generator was 4900 KW at 2300 volts, 60 cycles. This power was converted to 12 KV before distribution. Fuel consumption for this 4900 KW average 374 kilowatt hours per barrel of fuel.

6.8 Ships that produce 450 V a-c power could, in instances where the mooring is close to a vital plant, be directly coupled to the plant secondary distribution panels without need for transformers. For most applications however, transformers to convert to higher distribution voltages will be necessary.

6.9 The older geared Turbine drive vessels generate direct current power. This power, except for very special applications, will have to be converted by motor generator sets. Transformers will also be required to convert to distribution voltages.

6.10 As indicated above, the power generated by the vessels studied will require conversion to higher distribution voltages. Major utility companies have portable unit substations which can accept several voltage ranges and which are capable of switching and transforming the voltages to the various system voltages. These voltage ranges, however, are all very high so that shipboard voltages would have to be put thru transformers either aboard ship or ashore before they could be converted by the portable substations. Being integrated units with high voltage switching capabilities, these mobile substations would be of great value. Where a vessel can be moored adjacent to shore, the transformers required to convert power to the range required can be placed either ashore or on the vessel. Where the vessel must be moored off-shore the transformers would normally be placed aboard. Conductors to bring power from the ship to shore need not be of the type normally associated with marine applications. These might be of the newer types used in commercial practice, and placed either on the bottom or carried along the surface on floats. In addition to the transformers and conductors, delivering power to shore will require installation of the necessary switchgear, regulating, and indicator devices to suit the particular vessel involved. Operationally, it will be necessary that the watch engineers be familiar with parallel operation of generators, which in all cases will involve at least one ship generator and the shore plants.

6.11 Fuel consumption for electrical power generation is estimated as follows: For turbine electric drives, the main generators at about 375 kilowatt hours per barrel of fuel; for auxiliary generators on geared turbine drives at about 250 kilowatt hours per barrel of fuel.

6.12 Given a ship in port, moored, lighting only being provided by the emergency generator, and the boiler plant in a "cold" condition, about 8 hours would be required to deliver the full generation power capabilities of such a ship.

Table I A

Electric Plant Characteristics - Commercial Passenger Vessels

	P2 - SE2 - R3 P2-ELECTRIC A	P2 - SE - R2 P2- GEARED B	CONSTITUTION, INDEPENDENCE C
1. MAIN PROPULSION GENERATORS		None	None
TYPE NO/SHIP CAPACITY (Total) PARTICULARS	Turbine Drive Two* 13,780 kw 3500 v a-c 3 ph 60 cyc *(1 6890 kw) (each eng.rm.)		
2. AUXILIARY GENERATORS			
TYPE NO/SHIP CAPACITY (Total) PARTICULARS	Turbine Drive Four 1600 kw 450 v a-c 3 ph 60 cyc (4 turbo drive) (totaling 800 kw) (240/120 d-c)	Turbine Drive Five 2100 kw 240/120 - 3 wire d-c	Turbine Drive Four 4400 kw 450 v a-c 3 ph 60 cyc .80 pf
3. STAND-BY (EMERGENCY) GEN.			
TYPE NO/SHIP CAPACITY (Total) PARTICULARS	Diesel Drive One 75 kw 450 v a-c 3 ph 60 cyc	Diesel Drive One 75 kw 240/120 v d-c	Diesel Drive One 100 kw 450 v a-c 3 ph 60 cyc
4. MAX. EXCESS ELEC. PWR AVAILABLE FOR SHORE USE	15,000 kw	1700 kw	4000 kw

Table II A

Electric Plant Characteristics - Commercial Tankers

	30-35 M dwt [d]	45-50 M dwt [e]	60-80M dwt [f]	T2, standard [g]
1. MAIN PROPULSION GENERATORS TYPE NO/SHIP CAPACITY (Total) PARTICULARS	None	None	None	T2, SE-A1 Turbine Drive One 5400 kw 2300 v a-c 60 cyc 3 ph 1.0 pf
2. AUXILIARY GENERATORS TYPE NO/SHIP CAPACITY (Total) PARTICULARS	Turbine Drive Two 1000 kw 450 v a-c 3 ph, 0.8 pf 60 cyc	Turbine Drive Two 1200-1400 kw 450 v a-c 3 ph, 0.8 pf	Turbine Drive Two 1200-1400 kw 450 v a-c 3 ph, 0.8 pf	Turbine Drive Two 800 kw 450 v a-c 3 ph, 0.8 pf 60 cyc
3. STAND-BY (EMERGENCY) GEN'S. TYPE NO/SHIP CAPACITY (Total) PARTICULARS	Diesel Drive One 75 kw 450 v a-c 3 ph 60 cyc	Diesel Drive One 100-200 kw 450 v a-c 3 ph 60 cyc	Diesel Drive One 100-200 kw 450 v a-c 3ph 60 cyc	Diesel Drive One 75 kw 450 v a-c 3 ph 60 cyc
4. MAX. EXCESS ELEC. PWR. AVAILABLE FOR SHORE USE	600 kw	800 -1000 kw	800-1000 kw	5400 kw

Table III A

Electric Plant Characteristics - Commercial Cargo Vessels

	1950 Mariner h	1960 C4 j	1960 C3 k	C3 ("old") l
1. MAIN PROPULSION GENERATORS	None	None	None	None
TYPE				
NO/SHIP				
CAPACITY				
PARTICULARS				
2. AUXILIARY GENERATORS				
TYPE	Turbo-Drive	Turbo-Drive	Turbo-Drive	Turbo-Drive
NO./SHIP	Two	Two	Two	Three
CAPACITY (Total)	1200 kw	1200- 2500 KW	1200 kw	750 kw
PARTICULARS	450 v a-c 3 ph 60 cyc 0.8 pf	450 v a-c 3 ph 60 cyc 0.8 pf	450 v a-c 3 ph 60 cyc 0.8 pf	120/240 d-c 1040 amps
3. STAND-BY (EMERGENCY) GEN'S.				
TYPE	Diesel Drive	Diesel Drive	Diesel Drive	Diesel Drive
NO./SHIP	One	One	One	One
CAPACITY	75 kw	150 kw	100 kw	15 kw
PARTICULARS	450 v a-c 3 ph 60 cyc	450 v a-c 3 ph 60 cyc	450 v a-c 3 ph 60 cyc	120 v d-c
4. MAX. EXCESS ELEC. PWR. AVAILABLE FOR SHORE USE	800 kw	800-2100 kw	800 kw	400 kw

Table IV A

Electric Plant Characteristics - MARAD Reserve Fleet Types

	EC2-"LIBERTY" m	Z-ET1("Liberty") (wtr.-distilling) n	VC2 - S - AP3 VC2-"VICTORY" o	C4 - S - A1 C4, ("old") p	P2-SE-R2 P2-GEARED q
1. MAIN PROPULSION GENERATORS TYPE NO./SHIP CAPACITY PARTICULARS	None	None	None	None	None
2. AUXILIARY GENERATORS TYPE NO./SHIP CAPACITY (Total) PARTICULARS	Steam Recipro- Eng. Drive Three 60 kw 120 v d-c	Steam Recipro- Eng. Drive Three 60 kw 120 d-c	Turbine Drive Two 600 kw 240/120 v d-c 3 wire	Turbine Drive Three 1200 kw 240 v -2 wire, d-c; also, 3 - 75 kw 230/115, d-c M.G. Sets	Turbine Drive Four 1600 kw 240/120 V 3 wire, d-c
3. STAND-BY (EMERGENCY) GEN'S. TYPE NO./SHIP CAPACITY PARTICULARS (Total)	None	None	Diesel Drive One 15 kw 240/120 v 3 wire, d-c	Diesel Drive One 75 kw 240/120 v 3 wire, d-c	Diesel Drive One 75 kw 240/120 v d-c
4. MAX. EXCESS ELEC PWR. AVAILABLE FOR SHORE USE	——	——	300 kw	1000 kw	1200 kw

Table IV A (Continued)

Electric Plant Characteristics - MARAD Reserve Fleet Types

	T2- SE - A1 T2, standard r	T2 - SE - A2 T2, "Mission" s	SD1, BE1-Transport t (at 60 cycles)	P2-Transport u	C3("Old") v
1. MAIN PROPULSION GENERATORS				None	None
TYPE	Turbine Drive	Turbine Drive	Turbine Drive		
NO./SHIP	One	One	Two		
CAPACITY (Total)	5400 kw	6890 kw	3020 kw		
PARTICULARS	2300 v a-c 60 cyc 3 ph, 1.0 pf.	3300 v a-c 60 cyc 3 ph 1.0 pf	1310 v a-c 60 cyc, 660amp 3 ph .80 pf		
2. AUXILIARY GENERATORS					
TYPE	Turbine Drive	Turbine Drive	Turbine Drive	Turbine Drive	Turbine Drive
NO./SHIP	Two	Two	Two	Four	Three
CAPACITY (Total)	800 kw	800 kw	620 kva	1600 kw	750 kw
PARTICULARS	450 v a-c 3 ph 60 cyc	450 v a-c 3 ph 60 cyc (2-85 kw,) (120 v d-c for) (generator) (excitation)	450 v a-c 60 cyc 400 amp	120/240 v d-c 3 wire	120/140 v d-c 3 wire
3. STAND-BY (EMERGENCY) GEN'S.					
TYPE	Diesel Drive			Diesel Drive	Diesel Drive
NO./SHIP	One			One	One
CAPACITY (Total)	75 kw			75 kw	15 kw
PARTICULARS	450/120 v a-c 60 cyc			120/240 v d-c	120 v d-c
4. MAX. EXCESS ELEC. PWR. AVAILABLE FOR SHORE USE	5400 kw	7000 kw	3600 kw	1200 kw	400 kw

7. WATER PURIFICATION - STORAGE

7.1 In the 1930's and early 1940, when most of the MARAD reserve fleet was designed, it was customary to segregate the fresh water supply into potable, distilled, wash and reserve feed systems and to carry relatively large amounts of water. On these types, both salt water evaporators and distillers were provided. The function of the latter is the distillation of raw fresh water for greater purity; the rated capacities of these units as shown in the accompanying tabulations are based on such service. These capacities are customarily reduced 50% if these units are placed in salt water service.

7.2 The current trend is to have water for all purposes stored in common tanks and to rely more heavily on evaporators, thus reducing the amount of fresh water carried. Feed water requirements are met by redistilling, for greater purity, water from the common source.

7.3 It is probable that the present condition of evaporator plants on many of the laid up ships is far from optimum. They cannot, therefore, in all cases be expected to produce at their rated capacity. The fact that scaling and corrosion properties of harbor water are generally worse than ordinary sea water will contribute further to diminish the output.

7.4 Although the laid up T-2 tankers have considerable capacity for storing liquids, extensive tank cleaning would be required in many cases to make suitable for storage of potable water. Ideally, they should be sand blasted and given a cement wash. Should extreme circumstances not permit carrying out work of this type, they should at least be steam washed using the ship's Butterworthing system and the scale and debris manually removed from the bottom of tanks.

7.5 Many of the modern tankers and a few T-2s in active service have exotic coatings on their cargo tanks which should be relatively easy to clean and make acceptable for emergency water storage. A few special service ships and a number of the new Mariners have stainless steel clad tanks and are particularly well adapted for this service although the capacity of these tanks on the Mariners is small (430,000 gallons) compared to tanker capacities. One active modified T-2 tanker, Angelo Petri, is fitted with stainless steel cargo tanks, flush plated inside, having a total capacity of 2,5000,000 gallons. This vessel which carries primarily edible products would be ideal for water storage in addition to its ability to generate electrical power if its unique design and facilities did not render it more valuable for other services.

7.6 Of the 62 Liberty ship tankers (Z-ET1-S-C3) built during World War II only two remain in the MARAD fleet. Both are distilling vessels converted by the Navy for that purpose. S.S. NORMAN D. PEDRICK, ex USS Stagg, AW1, is laid up in the James River; S.S. LEON GODCHAUX, ex USS Wildcat, AW2, is in the Astoria, Oregon reserve fleet. They would be invaluable as emergency water producers but cannot be counted on as a source of electrical power as previously noted. Each is fitted with 3 - 20,000 gallon per day evaporator units.

7.7 TABLES IB thru IVB indicate average capacities of the evaporator and distilling plants presently installed aboard the ships being considered. The source of energy is boiler fuel oil in all cases. Shipboard storage tank capacities will be found elsewhere in this study.

7.8 The tabulated daily output must be regarded as representing distilling plant capability under ideal conditions, which would be: sea water temperature 85°F evaporators in cleantube condition; pumps, other auxiliaries, salinity indicator-alarms, piping systems, etc. in good working order; clean sea water as feed-water, and experienced operators in attendance. All units, including standbys, would be continuously operated. Average or normal output would fall below the maximum by about 30 per cent. The reduction allows for normal progressive build-up of scale in the evaporators and minor malfunctioning of pumps, etc. Output would be reduced by operation in a harbor contaminated by oil or other volatile substances.

7.9 Any distilling unit would be shut down necessarily at intervals of 30 to 50 days or more in order to remove scale and accomplish repairs. For high pressure units, this would be necessary at more frequent intervals. The frequency and duration of down-time would depend upon the initial condition of the unit, operating steam pressure and temperature, degree of feedwater salinity and oil-contamination, and the amount of care taken to prevent scale formation. The installation of HAGEVAP units on low pressure evaporators would permit continuous operation without down-time for scaling and cleaning.

7.10 Limitations to continuous operation would be confined to the unlikely possibility of concurrent failure of all units of a ship's distilling plant. Inasmuch as low-pressure evaporators and distillers are designed for continuous operation no unusual over-heating problems should occur. Maximum efficiency is obtained when operating at relatively low steam pressure and temperature. Maximum capacity is obtained (in terms of water/fuel ratio) when operating at higher steam pressure and tempera- However, at higher temperatures scale builds up much more rapidly and will be of the hard "porcelain" sulfate type rather than the more easily-removed soft carbonate.

7.11 Distilling plant output per barrel of fuel oil will vary widely as between turbine electric drive and geared turbine vessels. In the first instance, the evaporators can be operated using steam extracted from the main turbine, while in the latter case, auxiliary steam is used. For single effect plants, output per barrel of fuel oil will average about 375 gallons on geared turbine electric; for double effect plants, about 800 gallons and 1700 gallons, respectively.

7.12 Almost all commercial vessels have low pressure evaporators. Water produced by such units from contaminated harbor waters cannot be considered potable, hence vessels intended for operation in such areas will require chlorinating equipment for water purification.

7.13 General service pumps presently installed on the vessels could be utilized to provide ship-to-shore pumping in addition to the normal fresh water pumping capacity.

Table I B

Evaporator and Distilling Plant Characteristics - Commercial Passenger Vessels

	P2-SE2-R3 P2-ELECTRIC a	P2-SE-R2 P2-GEARED b	CONSTITUTION, INDEPENDENCE c
1. TYPE	Cleveland, Wilson Horizontal, Double, Effect. Low Pressure, Submerged Type	Pres. Roosevelt Low Pressure Submerged Type Double Effect	
2. NO./SHIP	Two	Two	Two
3. RATED CAPACITY TOTAL, SEA WATER TO F.W.	121,500 gpd	61,000 gpd	240,000 gpd
4. DISTILLER	Two Units Total Capacity 121,500 gpd	One Unit Total Capacity 81,000 gpd	
5. CONTAMINATED WATER EVAP.	One - 8000 gpd @ 70% clean tube factor		
6. TOTAL WATER, GALS PER DAY, EXCLUDE CONTAM. EVAP.	182,000 gpd*	121,500 gpd*	240,000 gpd

* Distiller at 50% of tabulated raw water capacity.

Table II B

Evaporator and Distilling Plant Characteristics - Commercial Tankers

	30-35 M dwt [d]	45-50 M dwt [e]	60-80 M dwt [f]	T2, standard [g]
1. TYPE	Low Pressure, Horizontal, Single Effect, Submerged Type			See Table IV B
2. NO./SHIP	Two	Two	Two	
3. RATED CAPACITY (Total)	12,000 gpd	18,000 gpd	18,000 gpd	
4. TOTAL WATER, GALS PER DAY	12,000 gpd	18,000 gpd	18,000 gpd	

Table III B

Evaporator and Distilling Plant Characteristics - Commercial Cargo Vessels

	1950 Mariner h	1960 C4 j	1960 C3 k	C3, ("Old") l
1. TYPE	Low Pressure, Double Effect, Submerged Tube Type	Low Pressure, Double Effect, Flash Type	Low Pressure, Double Effect	Vert. Submerged
2. NO./SHIP	Two	Two	Two	One
3. RATED CAPACITY (Total)	24,000 gpd	13,000 gpd	14,000 gpd	8,000 gpd
4. DISTILLERS	—	—		One vert. submerged Marine Type 5,900 gpd
5. CONTAMINATED WATER EVAP.	One Submerged Type Single Pass 11,000 gpd	One Submerged Type 11,000 gpd		One Vert. Submerged Marine Type 7,000 gpd
6. TOTAL WATER, GLAS. PER DAY, EXCLUDE CONTAMINATED EVAP.	24,000 gpd	13,000 gpd	14,000 gpd	11,000 gpd *

* Distiller at 50% of tabulated raw water capacity.

Table IV B

Evaporator and Distilling Plant Characteristics - MARAD Reserve Fleet Types

	EC2 - 5 - C1 EC2-"LIBERTY" m	Z-ET1("LIBERTY") (wtr.distilling) n	V62 - S - AP3 VC2 -"VICTORY" o	C4 - S - A1 C4, ("Old") p	P2-GEARED q
1. TYPE	Vertical Submerged Marine Type	Vertical Submerged Marine Type	Vertical Submerged Type	Vertical Submerged Type	Low Pressure Submerged Double Effect Type
2. NO./SHIP	One	Three	One	One	Two
3. RATED CAPACITY TOTAL, SEA WATER TO F.W.	6,000 gpd	60,000 gpd	7,200 gpd with a clean tube factor of 70%	8,100 gpd with a clean tube factor of 70%	81,000 gpd
4. DISTILLER	One -6,000 gpd	One -6,000 gpd	7,200 gpd with a clean tube factor of 85%	One -6,000 gpd	One -81,000 gpd
5. CONTAMINATED WATER EVAP.				One Vert. Marine Submerged Type 6,000 gpd with a clean tube factor of 70%	
6. TOTAL WATER, GALS PER DAY EXCLUD. CONTAM. EVAP.	9,000 gpd*	63,000 gpd*	10,800 gpd*	11,100 gpd*	121,500 gpd*

* Distiller at 50% of tabulated raw water capacity.

Table IV B (Continued)

Evaporator and Distilling Plant Characteristics - MARAD Reserve Fleet Types

	T2, standard r	T2, "Mission" s	BD1, BE1-Transport t	P2-Transport Elec. u	C3, ("Old") v
1. TYPE	Low Pressure	Vertical Marine Type Low Pressure	Solo Shell Low Pressure	Low Pressure Submerged Double Effect Type	Vertical, Submerged Type Low Pr.
2. NO./SHIP	One	One	Two	Two	One
3. RATED CAPACITY TOTAL, SEA WATER TO F.W.	5400 gpd	5400 gpd based on clean tube factor of 70%	20,000 gpd	81,000 gpd 43	8,100 gpd
4. DISTILLER	One 4800 gpd (Distilling Raw Water)	One Vertical Marine Type 4800 gpd with a clean tube factor of 85%		One with Capacity of 8,600 gpd	One Vertical Submerged Marine Type 5,900 gpd
5. CONTAMINATED WATER EVAP.		One 8,600 gpd with a clean tube factor of 70%		One with capacity of 8,600 gpd	One Vertical Submerged Marine Type 7,000 gpd
6. TOTAL WATER, GALS PER DAY EXCLUD. CONTAM. EVAP.	7800 gpd*	7800 gpd*	20,000 gpd	85,300 gpd*	11,100 gpd*

* Distiller at 50% of tabulated raw water capacity.

8. CONCLUSION

8.1 Vessels from the active commercial fleet offer the best potential as sources of emergency electric power and for water purification. Reactivation of older vessels from the MARAD reserve fleets is feasible from an engineering standpoint, but except for types with turbine electric drives reactivation and post-reactivation operating and maintenance costs, because of the relatively small amounts of electric power made available, create doubt as to economic feasibility.

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