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PLANNING FOR SHELTER USE IN SAN DIEGO

Prepared for:

THE OFFICE OF CIVIL DEFENSE
DEPARTMENT OF DEFENSE
WASHINGTON 25, D.C.

UNDER CONTRACT NO. OCD-OS-62-135

STANFORD RESEARCH INSTITUTE

MENLO PARK, CALIFORNIA

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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.

CONTENTS

CONTENTS

LIST OF FIGURES

LIST OF TABLES

FOREWORD

This research was performed under Contract OCD-OS-62-135 between Stanford Research Institute and the Office of Civil Defense, Department of Defense.

The research was performed in the Management Sciences Division of the Institute under the direction of Rogers S. Cannell, Manager of the Operations Planning Research Center. Attack simulations were carried out by Richard H. Spence, Operations Analyst, under the direction of George D. Hopkins, Manager of Operations Analysis.

I INTRODUCTION

The Unified San Diego County Civil Defense and Disaster Organization is the agency of local governments in the county assigned the responsibility of organizing and planning to cope with major emergencies. Its sphere of endeavor ranges through all natural- and war-caused disruptions of the normal day-to-day pursuits of the some one million people in San Diego County. In partial fulfillment of its responsibilities, the County Civil Defense Office has prepared an Operations Plan which has subsequently been approved by the County Board of Supervisors and the city councils of the incorporated cities in San Diego County.

Although the Operations Plan deals exclusively with the organization and duties of the various agencies of the county and city governments during an emergency, it pivots on the following recommended course of action to be taken by citizens during a war-caused emergency:

> Dispersal of citizens to shelters or to their homes is recommended in accordance with the policies of the Unified San Diego Civil Defense and Disaster Council, of which the County is a Member. Mass evacuation is <u>not</u> recommended. However, relocation of citizens may be necessary either during or after a war-caused disaster.

Although no public shelters have been put into service in San Diego County for use during a war-caused emergency, progress is being made. For example, the federal government has recently sponsored and financed a program that will enable local governments to take the first step toward providing fallout shelters for their citizens. This activity is titled the National Fallout Shelter Survey, Marking, and Stocking Program. San Diego County is taking part in this program, and, so far, all potential fallout shelter spaces in commercially and publicly owned buildings have been identified and measured for fallout-protection values. Succeeding steps in this program will include the stocking of the shelters with survival supplies and the marking of the shelters with distinctive signs that will identify them as official fallout shelters approved for public use.

In addition to the National Fallout Shelter Survey, Marking, and Stocking Program, the federal Office of Civil Defense has sponsored a detailed study to determine the best use that can be made of the fallout shelters that have been and will be identified. The latter study,

of which this report is one part, includes an investigation of the problems that may be encountered when identified fallout shelters are incorporated into the operations plans of local governments.

The city of San Diego has been selected as one of four cities to be studied in detail, and the resulting findings and recommendations are expected to provide a basis for decision in other cities throughout the United States.

This report is intended to show how the facilities found in the survey and marking program can be used most effectively as a first step toward a more adequate shelter program for the City of San Diego. The report appraises the effectiveness of the present stage of defense, and points out the direction of an extended program. Accordingly, the report analyzes the threat of nuclear war as it pertains to San Diego, inventories the potentially available shelter spaces, suggests an interim plan for utilizing the presently available shelter spaces, suggests a method of stocking these shelters, and discusses an ideal shelter system.

To the extent that survey-identified shelters are the only ones that can be utilized by those people who can reach them, analysis of the nuclear threat to San Diego is superfluous. The magnitude and nature of the threat will not particularly affect how these existing shelters will be used. However, to the extent that more and better shelters are needed, and therefore must be provided, such an analysis is important. It provides guidance as to the type, location, and effectiveness of various shelter alternatives, and it assists in selecting among them. At present there are, in numbers, less than one shelter space for every six people in San Diego, and, since most potential life-saving programs are necessarily future programs, such an analysis is particularly important.

San Diego has several characteristics that distinguish it as a possible direct target for nuclear attack. Extensive military installations are located in and adjacent to the city. The population of approximately 650,000 makes it the 18th largest concentration of people in the United States, and it ranks 50th as an industrial center. (The predominant industrial activity is oriented toward the producing and servicing of military equipment.) Thus, San Diego can be seen by an attacker as a military, a population, or an industrial target, or as all three. Without regard to the attacker's targeting philosophy, to the size of attack, or to the designer of the attack, San Diego is likely to be a direct target in a nuclear conflict.

Because of its location, San Diego is also a possible indirect target, via radioactive fallout, of weapons aimed at the imposing number of important military and industrial installations within Southern California, installations that present an attractive target for a potential enemy. Individually, each performs a service to the defense and maintenance of the United States that an enemy would try to eliminate.

Added to this is a certain vulnerability inherent in San Diego because of its climate and site. The climate has made possible a light-frame type of home construction, and basements are rare. Even commercial buildings are of less substantial construction than is found in harsher climates. The result is a lack of structures in which the population can find shelter from the blast, heat, and fallout caused by nuclear explosion.

As to site, San Diego is characterized by extensive flat-topped mesas, and the arroyos between them are deep; the result is that the connections between mesas are confined to relatively few streets. This, in itself, restricts rapid travel into areas where shelter may be available. Also, movement out of the city would be defeated by the lack of places in which to find shelter, because the country east of San Diego is arid and mountainous, with few roads, and is sparsely settled. Beyond is desert.

Thus, San Diego presents both an invitation to attack and an arrangement of circumstances that offer, at present, little built-in protection from the effects of an attack.

No one, of course, can say which of the individual installations in Southern California would be attacked. However, by simulating a large number of hypothetical attacks on the entire United States, and by using a wide range of assumptions as to enemy objectives and capabilities, a pattern emerges. For the purposes of this analysis, the pattern made it possible to identify three representative attacks that might be experienced in San Diego and is useful for describing the range of civil defense problems and for estimating the effectiveness of various protective measures.

The three attacks, as they would affect San Diego, are designated "light," "medium," and "heavy." The light attack was assumed to be primarily against national strategic military targets; the medium attack against strategic targets plus their logistic support; and the heavy attack against strategic, population, and industrial targets combined.

The three simulated attacks were taken from a panel of hypothetical attacks designed by a committee of military analysts who represent, besides the Department of Defense and the Office of Emergency Planning, certain other nonmilitary defense agencies of the federal government. In designing the attacks, the committee took into account the capabilities of the enemy to deploy and deliver the assigned weapons during the next few years as well as the ability of the United States to defend itself against such attacks. The committee also considered the reliability of the enemy's weapons-delivery system.

In each attack, San Diego "received" the effects of a number of weapon detonations, either within the city limits or immediately adjacent to them. In addition, since ground bursts were used against other targets upwind of San Diego, San Diego received high intensities of radioactive fallout. In each attack, the population was assumed to be distributed according to the normal night-time pattern, with the exception that one-sixth of the population was assumed to have found protection in the existing shelters--those identified by the National Fallout Shelter Survey.

An interesting note is that, while both the total megatonnage delivered to the nation and the strategy or targeting philosophy varied among the attacks, the over-all effects on San Diego did not vary widely. This is because there is such a wide variety of targets within the local area.

The details of the attack analysis are classified. Therefore, identification of individual targets, weapon sizes, and methods of delivery may not be described here. However, the potential effects on the population may be described with no breach of security regulations.

The attacks brought out the picture of nuclear attack effects on human life in San Diego (population 650,000) that is shown in Table I.

At first glance, there appears to be very little difference among the three attacks as far as results are concerned. In each attack a large portion of the population requires protection from blast, and, with an adequate system of fallout shelters, a significant number could be saved. But the attacks also show that, with only the existing shelters found by the survey and marking program, comparatively few lives can be saved.

In the light attack, out of 516,000 potential casualties only 19,000 are prevented by the present shelters; this is a reduction of about 4 percent. The greatest number of lives, 45,000, are saved by the

Table I

SUMMARY OF RESULTS OF
THREE SIMULATED NUCLEAR ATTACKS ON SAN DIEGO

No Shelter	Light Attack[a]	Medium Attack[b]	Heavy Attack[c]
Fatalities			
Blast	339,000	347,000	466,000
Fallout	177,000	303,000	184,000
	516,000	650,000	650,000
Survivors			
Injured[d]	54,000	---	---
Uninjured	80,000	---	---
	134,000		
Present Shelter			
Fatalities			
Blast	334,000	344,000	462,000
Fallout	163,000	261,000	149,000
	497,000	605,000	611,000
Survivors			
Injured[d]	39,000	6,000	4,000
Uninjured	114,000	39,000	35,000
	153,000	45,000	39,000
30 psi Shelter			
Fatalities			
Blast	71,000	110,000	143,000
Fallout	---	---	---
	71,000	110,000	143,000
Survivors			
Injured[d]	15,000	12,000	20,000
Uninjured	564,000	528,000	487,000
	579,000	540,000	507,000

a Assumed to be directed primarily against strategic military targets in the San Diego area.

b Assumed to be directed against strategic targets plus their logistic support.

c Assumed to be directed against combined strategic, population, and industrial targets.

d Includes radiation sickness.

existent shelters in the medium attack, but even this number is small compared with the attack's 305,000 casualties.

Clearly, San Diego's present shelter program is only a start; most of what can be done remains to be done. For example, in the medium attack a modest program of blast-protection that included 30 psi shelters would increase the number of survivors from 45,000 to 540,000. Such a possible program for increasing the number of survivors is described in Part V of this report.

Both the light and the heavy attacks concentrated more on the destruction of military targets than the medium attack did, although the major difference between the light and heavy attacks was the number of weapons delivered. Also, while some ground bursts were employed in both attacks, the San Diego area received mostly nonfallout-producing air bursts. Although more ground bursts were delivered in the light attack than in the heavy, the heavy attack included a greater total number of delivered weapons.

The vulnerability of the San Diego area, therefore, is illustrated by the large number of fatalities that result regardless of the intensity and nature of the attack. The numbers of people killed by both blast and fallout were calculated under the assumption that the survey-identified shelters would all be filled to capacity; this would not necessarily be true. Also, whatever the size or nature of an attack, and even with the use of this "favorable" assumption, the protection presently afforded is obviously small in relation to the number of people who need shelter.

The attacks and their effects described are merely hypothetical; they are not predictions. Nevertheless, they do indicate the range and degree of destruction that could be experienced in San Diego should war come, even given rather optimistic assumptions. The threat exists, and it should be reckoned with.

II AVAILABILITY OF SHELTER

At present, the only passive defense the people of San Diego have against nuclear attacks, such as those described in the previous section, is to seek out whatever shelter exists. But, for a population of 650,000, only 191,000 shelter spaces are available, according to the National Fallout Shelter Survey and Marking program. The Survey assigned San Diego's present shelters to three major OCD protection-category groupings: Categories 4 through 8, with protection factors (PF) of 100 to 1,000 or higher; Category 3, with protection factors between 40 and 100; and Category 2, with protection factors between 20 and 40. In all categories, only facilities with a capacity of 50 or more shelter spaces were regarded as potential shelters for Survey purposes.

When the Survey program was initiated, only shelter spaces suitable to Categories 4 through 8 were regarded as "shelter" for the purposes of the marking and stocking effort. Since October 1962, Category 3 facilities have been admitted to the national marking and stocking program.

But the gain for San Diego was very low. The numbers of Survey-identified shelter spaces are:

Protection Factor	Shelter Type	Capacity
100 or more	"Survey"	105,000
40 - 100	"Interim"	11,000
20 - 40	"Expedient"	75,000
	Total	191,000

Of these 191,000 spaces, only 105,000 can be considered "available" shelter spaces for the purposes of this study. Although the federal government now includes the Interim shelter categories in the national marking and stocking program, present San Diego civil defense plans do not contemplate taking advantage of the change. This is because the 11,000 Interim spaces are mostly in the same facilities as the high-category spaces, and thus present the same access problems.

Nor has San Diego made any local plans for marking or otherwise utilizing the 50,000 to 75,000 Expedient Shelter spaces found by the

Survey. About 75 percent of the total (combined Interim-Expedient) spaces have a high probability of being either destroyed by direct effects or rendered useless by extremely high fallout radiation intensities since they are in downtown areas and within 3 miles of North Island and 9 miles of other high-value military targets.

In any direct attack on the San Diego area, the 105,000 shelter spaces would afford protection for less than one-sixth of the city's 650,000 population, even assuming that all shelters were fully occupied. Also, the protection they would give is mainly against fallout radiation, not blast, although some degree of blast protection is inherent in any "fallout" shelter.

The shelter facilities, moreover, are so distributed that it would be difficult for them to be fully utilized. Figure 1 is a diagram of the facilities, that is, the 105,000 shelters having high protection factors that were noted in the Survey as being available for immediate use.

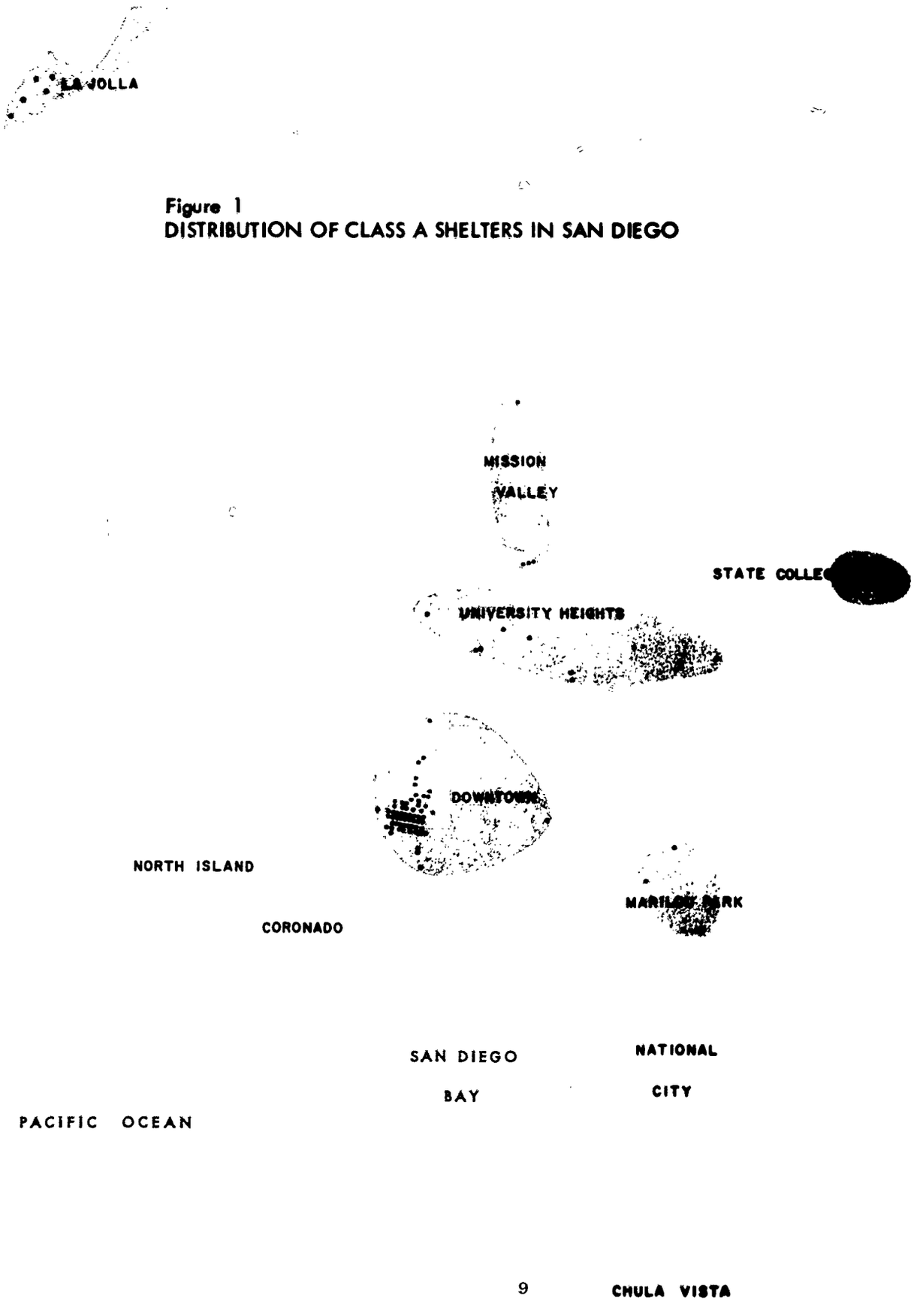
Additional shelter spaces having high protection factor numbers might be identified if a further survey effort were made under either federal or local auspices. Such a survey would investigate possible shelter facilities having capacities of fewer than 50 people, which was the capacity minimum in the federal Survey selection criteria.

Especially at night, many of the identified shelters cannot be reached conveniently--either by foot or by automobile--within the "reasonable" warning times, of less than 30 minutes, that could be had with missile delivery. San Diego's mass transportation depends on a bus system that probably would not be fully operational in the event of an alert, and the freeways through Balboa Park and up Mission Valley are barriers to movement by persons on foot because the chain link fences on their borders make crossing the roads difficult. The many canyons and arroyos in the city are also serious barriers to free movement.

During business hours, on the other hand, it is expected that in downtown San Diego, where 64 percent of all the shelters are located, the shelter spaces would be filled in a matter of minutes by shoppers and employees already in the neighborhoods.

The dangerously heavy ratio (six to one) of persons to presently available shelter spaces is being worsened by the fact that the population of San Diego is increasing rapidly. Between 1950 and 1960 the population grew by 71 percent, and within the last two years (1961-62)

Figure 1
DISTRIBUTION OF CLASS A SHELTERS IN SAN DIEGO



it increased an additional 7 percent. New residents, settling on the fringes of the city, are living in areas where no shelter now exists.

Nor is future construction expected to provide any substantial number of new shelter spaces. Specific measures would have to be adopted by San Diego to accomplish this end. In any new buildings, the architectural design will most likely continue to tend toward the use of thin walls and facings, with only rare construction of basement space. Without some form of official direction the present trend is not likely to be reversed, because the mildness of the climate and economic factors influence builders toward the selection of lightweight, pre-formed construction materials.

However, building code amendments could help; they could prescribe and require architectural designs and construction practices that would provide or increase the shelter potential of all new buildings. Tax-incentive programs might also help. The possibilities of such deliberate shelter-building programs, in which shelters would automatically be part of new buildings although they were erected for other purposes, are discussed in Section V.

Another difficulty is that the largest concentration of presently available shelters is in the area closest to the Naval Base target. In an emergency, many people would resist a civil defense plan that directed them to move even closer to a possible source of danger.

Five clusters of Survey shelters in addition to those in the downtown area are arbitrarily grouped as follows for the purposes of this study. They are:

Area	Shelter Facilities	Spaces	Percent
Downtown	67	66,879	64
University Heights	11	8,076	8
Marilou Park	5	622	1
Mission Valley	4	16,171	15
State College	11	9,862	9
La Jolla	9*	3,397	3
	107	105,007	100

* See text on La Jolla Shelter Area No. 16 in Section III.

As noted earlier, 86,000 (about 75 percent) of the total of 191,000 spaces identified in the Survey are not only in the lower categories (Interim and Expedient, with protection factors between 20 and 100); they are located in the downtown area, that is, near target points. These spaces, therefore, are excluded from consideration in this report. Some 5,000 (about 25 percent) of the spaces with lower protection factors could, possibly, be upgraded in a shelter improvement program; this is discussed in Section V.

III INTERIM PLAN FOR SHELTER USE

In spite of the threat and the lack of complete protection from that threat, action can be taken to save lives in San Diego by making more efficient use of the high protection factor shelter spaces identified in the Survey. This should be considered an interim plan, however, and one to be modified as the two classes of shelter with lower protection factors and any newly built shelters are brought into use.

The first phase of such an interim plan for shelter use would examine each shelter facility, or group of shelter facilities, and identify the population areas each could serve.* This method accomplishes three purposes. First, it provides a clear picture of just where the city's people have a chance to find public shelter. Second, it identifies any sections of the city that are at present totally unprotected. Third, it provides a data base against which present plans can be tested and on which future plans can be made.

Shelter Service Areas

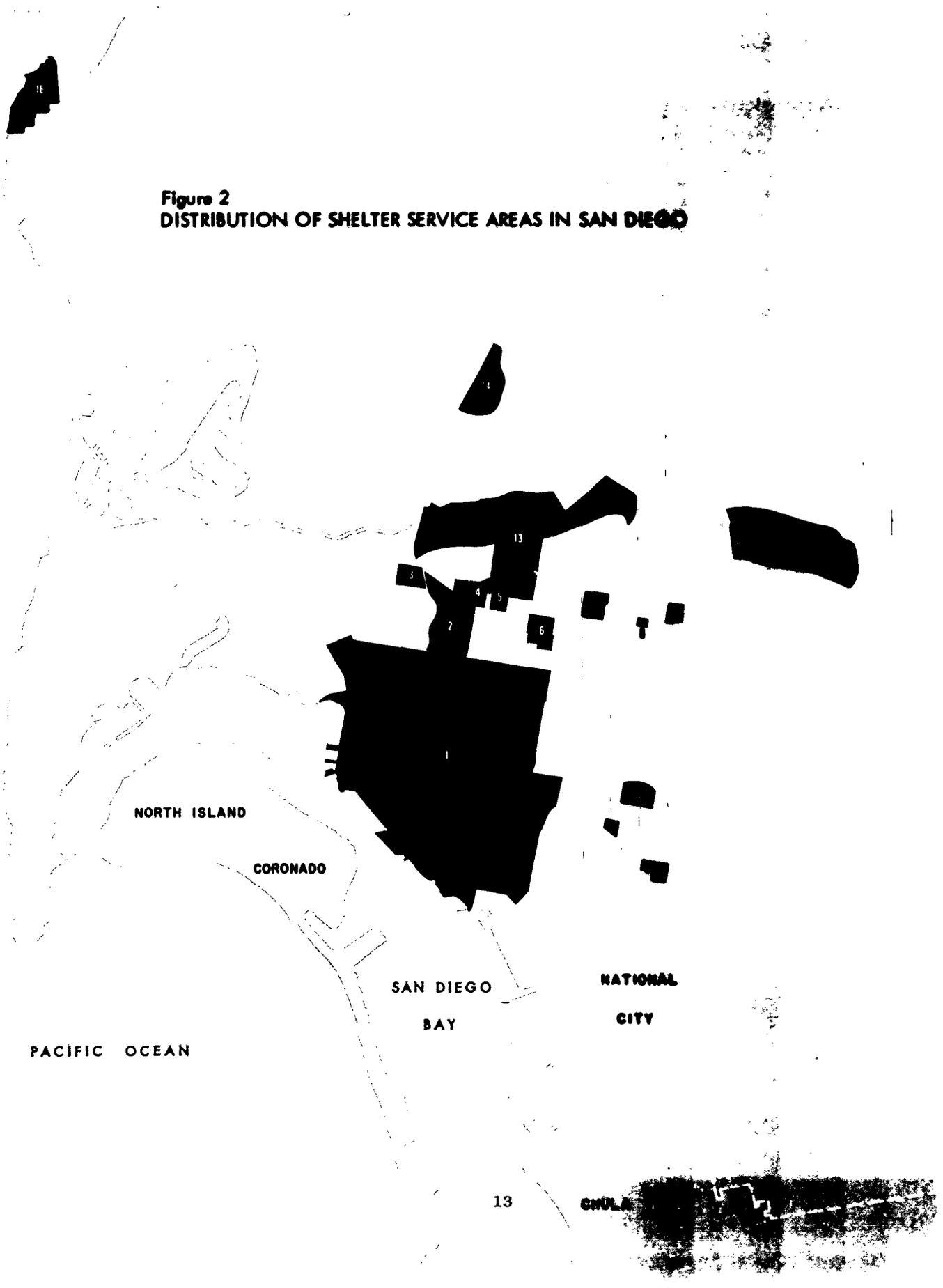
For this study, 16 individual, or groups of shelter facilities were singled out as the basis for an interim plan for shelter use. A Service Area was identified for each of the 16; that is, an estimate was made of the immediately surrounding population area in which the number of people that each facility could accommodate now work or reside. The sizes of the service areas varied, depending on the number of available shelter spaces and the number of people in the vicinity. The results are shown in Figure 2.

Identification of these 16 areas was, of course, only the first step, and it should be pointed out that in some instances a different set of boundaries could have been established. However, the boundaries shown can serve as a starting point for more thorough study.

The method of area delineation used in this report was quite simple. Knowing the capacity of each shelter, or group of shelters, and using census population figures compiled on the basis of city blocks, a search ran outward from each shelter facility (or group) until it encompassed enough people to fill the shelters. Since it was not always possible to exactly match the shelter spaces with the total population of the nearby

* These shelter Service Areas are discussed in more detail in the following pages.

Figure 2
DISTRIBUTION OF SHELTER SERVICE AREAS IN SAN DIEGO



blocks an overloading of the shelters by 10 percent of their capacity was allowed for in the calculations.

Downtown Area--No. 1

The Downtown Service Area, as identified in Figure 1, contains 67 presently usable high Survey-category shelters, with spaces for 66,879 people. These shelters are clustered within a small part of the city, which makes it possible to consider them, for the immediate purposes of this study, as a single unit called Service Area No. 1. In this case, because the area has a high business-hour population and low nonbusiness-hour population, it was possible to plan only for the nonbusiness-hour situation. (No specific boundaries can be defined for an area's business hours because it is expected that during such hours all available shelter spaces would be filled in a matter of minutes by shoppers, employees, and transients.)

During nonbusiness hours, however, quite a large population area could be served by these downtown shelters, as indicated by Figure 3. But the people living in this area would have, in their homes, approximately the same vulnerability to blast--not fallout radiation--as they would have if they were in downtown shelters. Thus, even by moving into the shelters they would not appreciably decrease their vulnerability to blast. On the other hand, they would reduce their vulnerability to fallout, and, since fallout might be the only effect experienced, they could improve their chances of surviving by using the shelters.

University Heights Area--Nos. 2 through 9

The University Heights Service Area has spaces for 8,076 people in 11 facilities. These are grouped into eight Service Areas (numbered 2, 3, 4, 5, 6, 7, 8, and 9 in Figure 2) and are more clearly defined in Figure 4.

For each of the eight Service Areas, the limits of the population area it can serve is shown.

Marilou Park Area--Nos. 10, 11, 12

Five shelters, with total spaces for 622 people, are available in the Marilou Park Service Area; these are the only shelters available to serve the entire southeast part of San Diego. Two of the 5 shelters are in the areas numbered 10 and 11, and can serve only 108 and 100 people, respectively (see Figure 5).

Figure 3

SHELTER SERVICE AREA 1

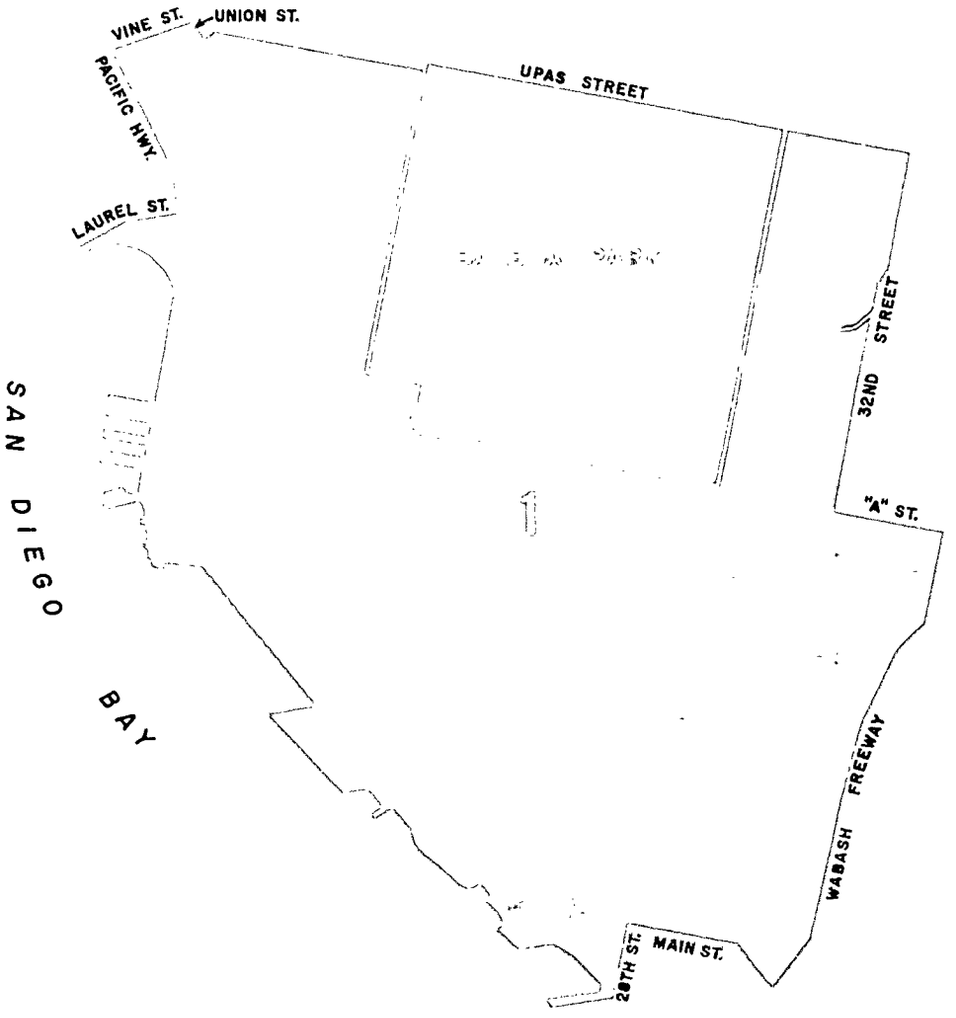


Figure 4 defines, for each of the eight Shelter Service Areas, the limits of the area that can be served by each shelter or group of shelters.

Figure 4
SHELTER SERVICE AREAS 2 THROUGH 9

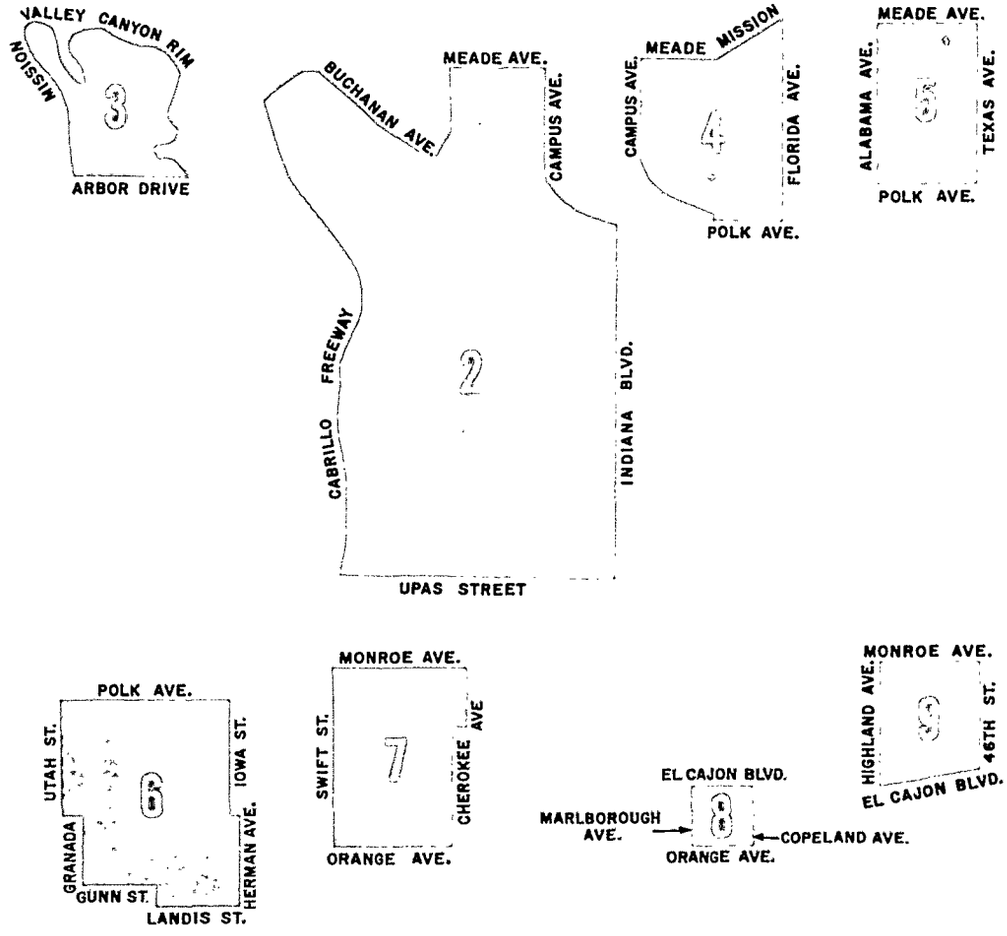
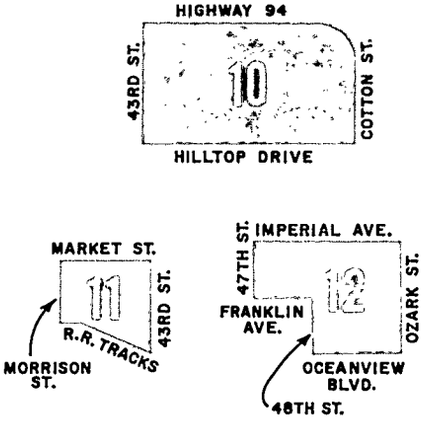


Figure 5

SHELTER SERVICE AREAS
10 THROUGH 12



Area No. 12 has space in three school buildings for 414 people. But, during school hours, Area No. 12 could not shelter even the number of students enrolled. Therefore the boundaries for these three Service Areas were calculated for a nonschool-hour distribution of population.

Mission Valley Area--Nos. 13, 14

The Mission Valley Service Area can be divided into two, numbered 13 and 14 respectively, that are shown in Figure 6. The two areas contain four facilities whose total capacity is 16,171 people.

Service Area No. 13, which encompasses the area whose population can be protected in the Mission Valley Shopping Center, contains three shelters with spaces for a total of 15,861 people. These three shelters are all within a broad canyon cut between high mesas whose edges are a natural barrier to people moving toward the shopping center. A man-made barrier exists, also, in the chain-link fences on both sides of the freeways that limit the access of pedestrians to the three shelters.

As shown in Figure 6, Service Area No. 13 extends mainly along the axis of the canyon but includes small areas to the north and south. As is true of the Downtown Shelter Area, it has a large business-hour

population of shoppers and employees, and it is expected that during these hours about one-third of the shelter spaces would be occupied immediately by the people already in the shopping center. Therefore, no specific shelter area boundaries can be defined for the business hours, but during nonbusiness hours people from the area shown could find shelter in one of the three facilities.

People living in Murray Canyon would flow into the 310 spaces of Service Area No. 14, which consists of a single shelter in Sharp Memorial Hospital. Although this small Service Area's boundaries are clearly defined on the west, north, and east in Figure 6, the south boundary is an arbitrary line north of and parallel to Mockingbird Way. Generally, access to this shelter would be via Cabrillo Freeway.

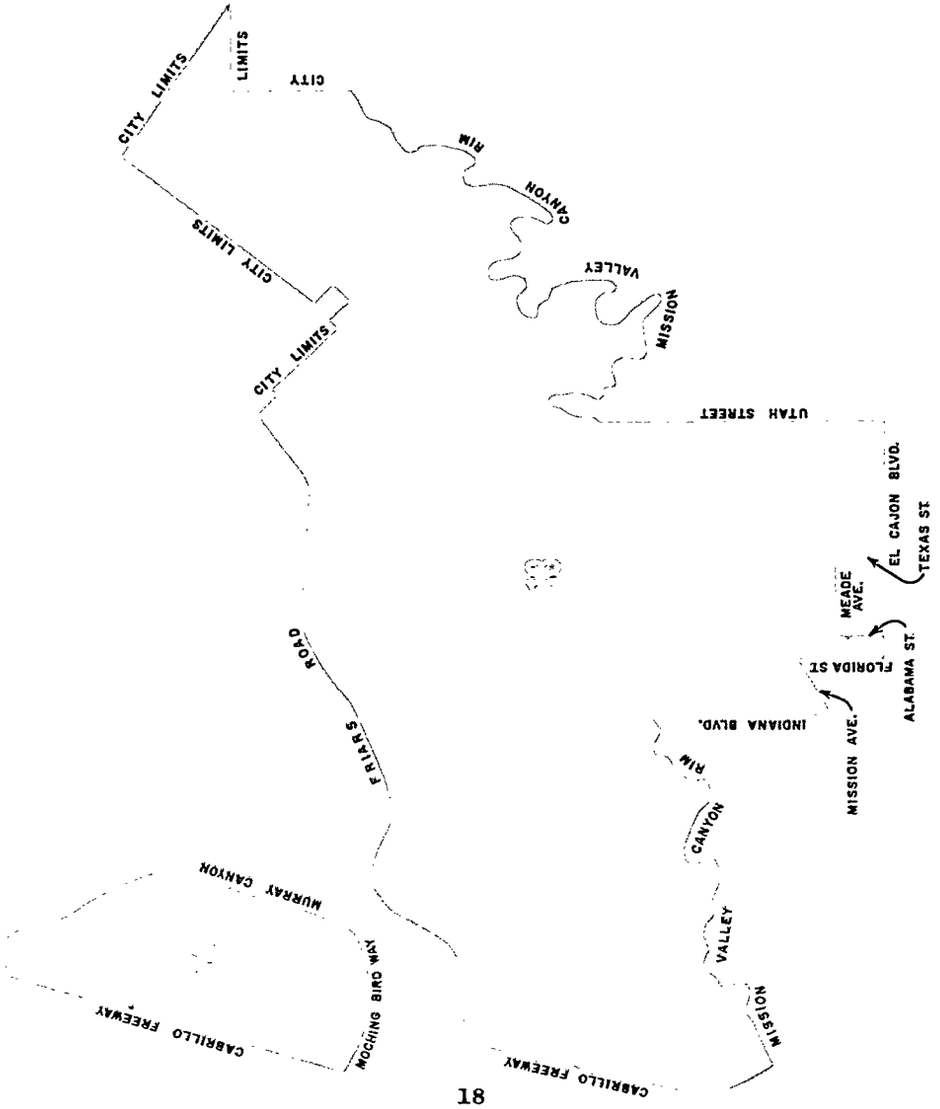


Figure 6
SHELTER SERVICE AREAS 13 AND 14

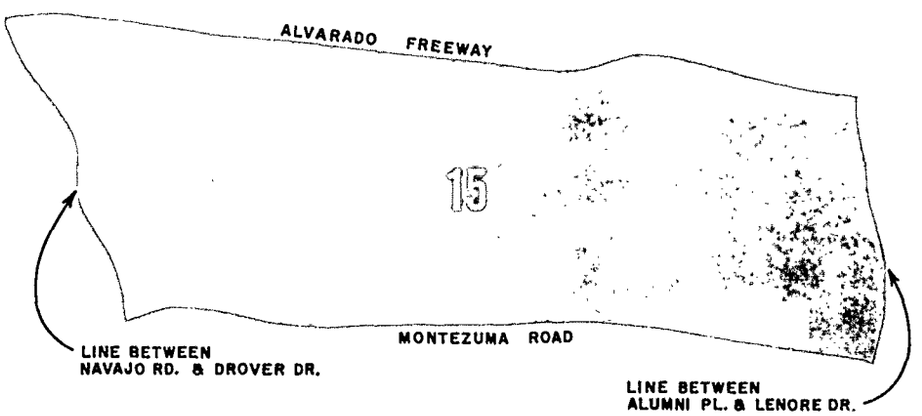
State College Area--No. 15

The State College Service Area, whose boundaries are shown in Figure 7, is centered on the ten shelters at San Diego State College. These ten shelters have a total capacity of 9,495 people, and an additional 367 spaces are available at the medical clinic on the access road to the east of College Avenue.

Due to the large enrollment at the college--approximately 15,000 students--school-hour use of the shelters would limit the boundaries of Service Area No. 15 to the college campus only. However, during non-school hours, the boundaries shown in Figure 7 define an area containing people who would have their best chance of finding shelter in one or another of the ten shelters or in the one at the medical clinic.

Figure 7

SHELTER SERVICE AREA 15

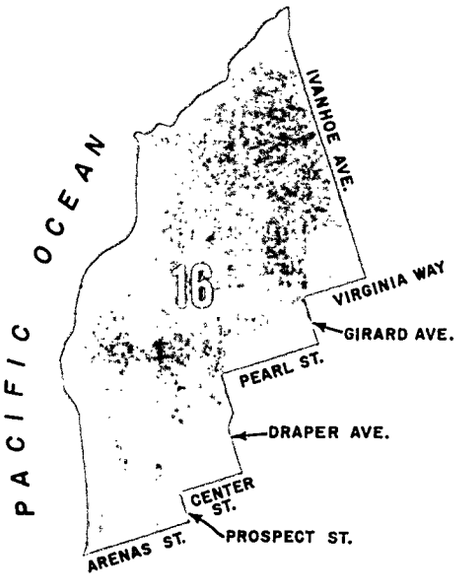


La Jolla Area--No. 16

The La Jolla Service Area, No. 16, contains 5 shelters with spaces for a total of 2,506 people. This is the number of people who reside within the area shown in Figure 8.

Figure 8

SHELTER SERVICE AREA 16



A note of explanation is necessary. In Figure 1, the La Jolla Service Area, No. 16, extends beyond the limits of the diagram; one group of three shelters at Scripps Institute of Oceanography and a single shelter at General Atomics Corporation are not shown. The three shelters at Scripps Institute contain space for 825 people, and the one at General Atomics contains 66 spaces.

Neither the group of three nor the single shelter have been assigned to a specific Service Area in this study. The General Atomics (single) facility is unassigned because of its remoteness, and the Scripps group of three shelters is omitted because the Institute's year-round enrollment is such that its personnel approximately equals the capacity of the shelters now on its grounds.

Shelter Occupancy

The second step in an interim plan for shelter use would be to decide on the method for assigning members of the population to the spaces in the individual shelters. Should the shelters be filled on a random, first-come first-served basis? Should people be assigned, by name, to specific shelters? Or should it merely be stated--as a preliminary to other action--that today there is space for only one-sixth of the population, that there are 16 defined shelter Service Areas, and that only those who reside or work or happen to be shopping within these boundaries have a definite chance of finding public shelter?

The third of these choices may be the best for an interim plan at the present time, so that the residents of San Diego can be alerted to the locations of the 16 Service Areas, and to the specific shelter locations. Also, they should be given information on the different chances for survival that residents of the areas have during business hours and nonbusiness hours, and on their likelihood of finding shelter in the Downtown Area and in the three department stores in the Mission Valley Shopping Center during either period.

Information should also be given to the population as to how the potentially unshelterable five-sixths can protect themselves in their own homes. Perhaps bringing to their attention the facts and implications of the suggested interim plan for shelter use will, of itself, save lives in San Diego. The population should be advised that 545,000 out of 650,000 people must seek their own means of survival while ways are sought to provide protection for everyone. The local civil defense authorities should be prepared to distribute, wholesale and on request, adequate information as to how individuals and families can best provide protection for themselves until the public shelter program can be improved.

Shelter Staffing

The third step in the interim plan for shelter use would be to select and train the individuals who would manage the shelters as temporary communities during transattack and post-attack periods. Such persons would include shelter leaders, medical personnel, police, firefighters, radioactivity monitors, communications equipment operators, and custodians, among others.

All persons identified as suitable for staffing a specific shelter ought to reside, or work, preferably both, close enough to that shelter to ensure their arrival within it within the first few minutes after an attack-warning signal. Also, as security against the possible absence of a single designated staff member, alternates should be assigned--and kept informed of their possible duties.

Shelter Leaders

Potential shelter leaders especially should be selected in sufficient numbers so that there will be a high probability of at least one's being available for each shelter. In rank order, to avoid confusion should several appear with the alarm, the names and addresses of these people should be entered on (1) the Facility Control Card kept in the County Civil Defense Office, (2) the shelter's own facility distribution list, and (3) the internal records kept by each shelter.

The numbers of leaders, alternates, and assistants required will depend on the size of the facility. A minimum of three persons for each staff post, if all reside nearby, would not be too many for the smallest (50 spaces) shelter. In larger shelters, the ratio of leaders to total occupants should be about 1 to 16.*

It can be expected that at least 7,000 shelter leaders will be required to staff completely the 107 Survey-identified shelters in San Diego. Each shelter's leaders should be nominated by the building owners, the tenants of large buildings, and from among the volunteers residing in that shelter's Service Area.

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* John B. Fink, "The Organization of Behavior in Civil Defense Fallout Shelters," Stanford Research Institute, Menlo Park, California, December 1962.

Medical Personnel

According to the County Civil Defense Office records, the following numbers of medical personnel were available in San Diego and vicinity at the time of this study:

Profession	San Diego City	San Diego County
Chiropractors	120	200
Dentists	304	800
Doctors	607	1,200
Osteopaths	270	400
Registered Nurses	1,500	2,500
Veterinarians	30	120
	2,831	5,220

It would be ideal if medical personnel could be assigned to shelters on the basis of at least one doctor per shelter, or one doctor per 1,000 spaces in shelters having a capacity greater than 1,000. In actual practice this may not be possible, and doctors will undoubtedly have to take their chances along with everyone else. But doctors can be notified of their closest shelter and urged to enter it as quickly as possible.

For every doctor assigned to a shelter, two alternates should be assigned to ensure the presence of at least one doctor. Other medical personnel, particularly nurses, should be assigned in similar ratios in order to obtain complete coverage in these skills. The individual assignments should be made by the the professional organization of which the person is a member, on the basis of skill as well as on proximity to shelter, and assigned medical personnel should reside or work in the immediate vicinity of the shelter. Where residence and place of work are widely separated, medical personnel ought to have two assignments, one for working hours, and one for "home" hours.

Police and Fire Service Personnel

Records in the City Manager's office indicate the availability of the following numbers of emergency-trained personnel in the city at the time of this study:

Uniformed Police	820
Police Reserves	200
Uniformed Firemen	490
	1,510

San Diego's police force is on a three-shift schedule of duty, and from 65 to 132 uniformed police are on either patrol or administrative duty at all times. The specific number depends on the time of day.

Policemen are a valuable resource; they are important to post-attack recovery and shelter management. But it may not be possible to assign policemen to shelters by name. Members of the police department would be delayed, no doubt, because of the many duties they would have to perform during the period between warning of an attack and arrival of the effects of an attack. Therefore shelter assignment would have to be made with consideration of any emergency duties an off-duty policeman might have. Only after such duties were completed could a policeman go to the shelter nearest his duty post, but each man should know where that shelter is.

The fire department is also on a three-shift schedule; on each shift approximately 132 firemen are on duty. During the day shift, an additional 40 firemen are at fire stations performing maintenance, administrative, and training tasks. But, as is true of the police, firemen would undoubtedly have emergency tasks that would delay their arrival and prevent their taking advantage of assignment to specific shelters. Again, as is true of the police, firemen should, as a general rule, go to the shelter nearest their duty posts.

Monitoring, Communications, and Custodial Personnel

The number of trained radiological equipment monitors and volunteer radio and communications specialists in the City of San Diego is not known because the roster of such specialists is kept on a county basis only. However, it is understood that at the present time radioactivity monitors are being trained for specific duty in fallout shelters.

For each shelter, at least two such individuals should be assigned by name. In the large shelters, those of over 1,000 capacity, one monitor per 500 occupants should be assigned. In like manner, each shelter should have assigned to it, by name, at least two communications operators, in order to provide for continuous manning of radio and other communications equipment.

In addition, for each shelter, two or more persons ought to have authority from the building owner (1) to open the doors in an emergency, (2) to keep the internal records and files of the shelter up to date, and (3) to retain custody of the supplies and equipment. These people

should be either in-building employees or residents of the immediate neighborhood of the shelters.

These recommendations for the assignment of responsibilities and of staff personnel are directed toward interim fulfillment of staffing needs only. These rules-of-thumb could serve until actual studies can be made of quantitative needs per shelter facility availability of requisite personnel by diurnal time period, etc.

IV STOCKING THE SHELTER FACILITIES

The fourth step of an interim plan for shelter use is quite independent of whatever method is chosen for assigning people to the shelters. This is the matter of storing and controlling the supplies with which the shelters must be stocked. It can be accomplished before the interim plan is put into effect.

These civil defense stocks should be made available as soon as the facility is identified, measured for its available spaces, and licensed as an official public shelter. Actions that should be taken by the local civil authorities before (and after) a given shelter facility can be considered completely operational are discussed in this section. The measures are graphed in Figure 9 according to the following groups, and the various simultaneous and sequential events listed here are cued into the graph by number.

Events in Stocking a Facility

Preliminary

1. Establish at the County Civil Defense Office a central file of the billets for each shelter facility. The file must have places for the names, addresses, telephone numbers, and relevant skills of:

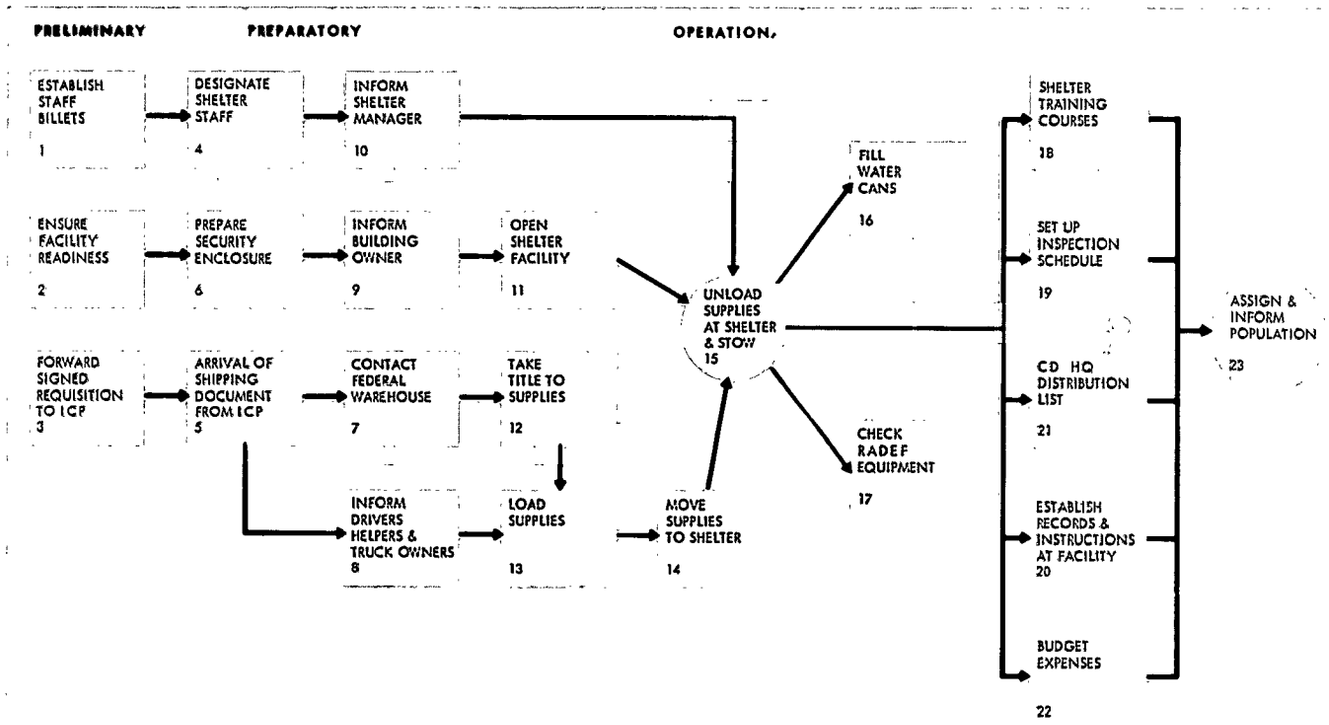
   a. Shelter managers,
   b. Manager alternates,
   c. Manager assistants,
   d. Medical personnel,
   e. Radioactivity monitors,
   f. Communications specialists, and
   g. Custodial personnel, among others.

2. Ensure that this facility will be open to receive supplies on the scheduled date by contacting the building owner or his representative.

3. Forward to Inventory Control Point the signed preprinted requisition for the facility's supplies and establish an inventory file.

Figure 9

STOCKING AND UTILIZING A SHELTER FACILITY



Preparatory

4. Designate, by name, the shelter manager, assistants, and other staff personnel, including radioactivity monitors, etc., and register their names, addresses, and tasks in the Central File along with the inventory of supplies.

5. Permit further action on arrival of shipping (authorization) documents from Inventory Control Point.

6. Prepare a secure enclosure or container in the facility for the expected radiological monitoring and communications equipment, and for the medical and other supplies; also prepare a floor-space allocation and access plan.

7. Arrange for the local federal warehouse to deliver the supplies, giving date, time, and name of authorized receiver.

8. Organize teams to assist in moving the supplies from the federal warehouse to the facility, alerting the truck owners, drivers, helpers, etc.

9. Inform the facility's building owner of the delivery plans so that access will be provided.

10. Inform the shelter manager and other interested personnel of the delivery plan so that they may cooperate as needed.

Operational

11. Have the shelter facility opened on the delivery date and, if necessary, provide adjacent locations for any supplies that cannot immediately be stored within the facility.

12. Have the civil defense representative take title to the supplies at either the federal warehouse, the local receiving point, or the shelter facility, as appropriate.

13. Load the supplies on trucks, using the prearranged equipment and manpower.

14. Move the supplies to the facility, using the preassigned drivers.

15. Unload the supplies at the shelter's storage facility, using the pre-alerted teams, and stow the supplies according to the prepared floor chart and access plan.

16. Fill the water cans, using available personnel.

17. Check RADEF and other utilities and equipment, being prepared to return any unusable equipment.

Post-stocking

18. Arrange for shelter managers, assistants, radioactivity monitors and communications personnel to attend appropriate training courses.

19. Prepare a semiannual inspection schedule for the stocked facility and for the inspection times and teams.

20. Establish record files at the facility, including:

    a. The rules and regulations that govern this facility's operation.
    b. A roster of staff assignments, giving names, addresses, telephone numbers, and tasks.
    c. A roster of all persons having authority for pre-emergency facility access.
    d. A register of all persons who enter the facility, showing date, hour, purpose, and signature.
    e. A chart of the agreed-upon method for emergency assignment of population to the facility.
    f. Instructions as to the location of, and rules for maintenance of, the facility's civil defense supplies.

21. Compile the facility's distribution list (i.e., building owners, shelter managers, etc.) giving its identification name or number, and use this list for forwarding announcements, such as changes in procedures, regulations, or assignments.

22. Add the facility's maintenance expenses to the budget for labor and for consumable supplies.

23. Assign (and/or inform) the population, according to the method selected, of the facility's readiness for use and of their assignment to it in an emergency.

Facility Stocking Procedures

Civil defense supplies are available to San Diego and are presently stored at the Naval Supply Depot downtown. Since the middle of October 1962, shipments from contractors have been arriving there at a rate of one carload each week. It was expected that sufficient supplies would have been received, at this rate, to fill all the needs of the entire county by the end of March, 1963.

The availability of the supplies to San Diego, however, is dependent on completion of procedures outlined in OCD Memorandum 52-62, dated 7 August 1962. The required procedures, as they apply to San Diego, are summarized here.

The Inventory Control Point, located in the Defense General Supply Center, Richmond, Virginia, provides preprinted requisitions showing the number of shelter spaces in each facility reported by the Navy Bureau of Yards and Docks, which is the agency having shelter cognizance over San Diego County. A separate requisition must be filled out for each shelter facility.

When the County Civil Defense Director determines by consulting with the building owner and others that a shelter facility is ready to be stocked, he signs the filled-out requisition for that facility and forwards it to the Inventory Control Point. The Inventory Control Point then computes the amounts and the values of each shelter item required to meet the needs of the designated shelter and prepares a shipping document. Copies of this document are sent to both the Naval Supply Depot in San Diego and to the County Civil Defense Office as notification that transfer of supplies is permitted.

The city of San Diego is a Type 1 requisitioner because all shelter facilities in the city are located less than 25 miles from the Naval Supply Depot. Since the city, not the supply depot, is responsible for delivering the requisitioned supplies to the individual shelter facilities, the transfer of responsibility for the supplies is made at the outgoing loading platforms of the Naval Supply Depot.

In their prior meetings with the building owners, the representatives of the city will have made appropriate arrangements for the selection of storage spaces and for access to them. Arrangements now have to be made with the shipping division of the Naval Supply Depot to schedule the transfer of title and movement of the supplies. Trucks and drivers must be available and teams for movement of the supplies from the trucks and into the shelter storage spaces have to be scheduled.

A sample check-off form for this movement planning is shown in Figure 10. It outlines each step so that when completed the form serves as a permanent record of the movement of the supplies into the shelter facility.

Appropriate (dated) notations on the Facility Control card must indicate not only the quantity and items requisitioned but the quantity and items actually delivered. These cards also serve as a permanent inventory control record for further use.

Naval Supply Depot personnel, after removing from bulk storage the quantity of each item shown on the shipping document for the designated facility, place the lot on the loading platform for transfer of title and delivery to the city's representative. The supplies are palletized for within-depot movement so that no manual handling by civil defense personnel is necessary until the actual movement, that is, the truck-loading, begins.

Supply Transport and Storage

However, the supplies do require transport to the shelter facility on vehicles provided by the County Civil Defense Office. The degree of difficulty of this transportation of supplies into each facility depends on (1) the availability and types of materials handling equipment, (2) the distance from the unloading point to the storage point, (3) the availability of elevators for vertical movement, and (4) the size of openings into the shelter area. (Much manual handling of the supplies will probably be necessary at most of the shelter facilities in San Diego, especially in the older buildings, because of the relative inaccessibility of the shelter's storage spaces.) It is important that, as soon as the supplies are received, the electrical circuits of the radiological monitoring equipment be checked, to ensure that the equipment is in working condition. Faulty equipment is returned for replacement.

For planning purposes, a summary of the estimated tonnage and man-hours that will probably be involved in the movement of supplies to the several Service Areas is shown in Table II. A total of 1,771 man-hours has been calculated for this task. At $20 per hour per two-man crew, which includes direct labor, overhead, and vehicle rental charges, it is expected that the total cost to the County Civil Defense Office for the movement of supplies for the 107 Survey-identified shelters, would be about $17,700.

Figure 10

SAMPLE CHECK-OFF FORM FOR PLANNING MOVEMENT OF SUPPLIES

Shelter Facility Number_____
Address_____
_____
Number of Spaces_____

Action	Scheduled Date & Hour	Actual Date & Hour	Responsibility of
1. Contact building owner[a] to ensure readiness of shelter			
2. Contact federal warehouse[b] and shipping division (NSD, San Diego)			
3. Pick up supplies at federal warehouse (NSD) Labor Equipment			
4. Receive supplies at federal warehouse (NSD)			
5. Open shelter facility			
6. Move supplies to shelter facility and stow supplies Labor Equipment			
7. Provide security enclosures Labor Equipment			
8. Check operability of RADEF equipment			
9. Fill water cans			
10. Public Health Department surveillance			

a One week before scheduled date of movement.
b When copy of ICP shipping document is received.

Table II

ESTIMATED TIME AND COST FOR MOVEMENT OF SUPPLIES TO PRESENT SHELTER FACILITIES

Shelter Area	Number of Spaces	Avg. Miles from Naval Supply Depot	Round Trip Travel Time (hours)	Tonnage[a]	Loading Time[b] (man-hours)	Travel Time by 2-man Crew[c] (man-hours)	Unloading Time[d] (man-hours)	Total (man-hours)
Downtown	66,879	3-5	1.0	348	105	280	695	1,080
University Heights	8,076	8-11	1.4	45	14	51	90	155
Marilou Park	622	5-7	1.0	5	7	4	10	16
Mission Valley	16,171	9	1.2	83	25	82	165	272
State College	9,862	13-15	1.6	50	15	64	100	179
La Jolla	3,397	12-14	1.8	4	5	29	35	69
Totals	105,007			535	166	510	1,095	1,771

a 5 short tons per 1,000 spaces.
b 1.5 man-hours per 1,000 spaces--employing fork-lift equipment and pallets.
c Average of 2-1/2 tons per truck load, times 2 men, times round-trip travel-time.
d At 10 man-hours per 1,000 spaces--manual handling in the majority of cases.

Cost at $20 per hour for a vehicle and a two-man crew = $17,710.

It is assumed in these calculations that all of the Survey-identified (high protection factor) spaces will be put into service. It should be kept in mind, however, that many of the 107 shelter facilities contain more than 1,000 spaces, and one, in the May Company downtown, has over 11,000 spaces. Storage space for civil defense supplies at the May Company would take over 15,000 cubic feet, or 3,000 square feet when aisles and fire lanes are included. At the current cost of construction of warehouse space, about $8 per square foot, this would represent a loss of approximately $24,000 to the building's owner.*

This figure is significant in considering the contribution that commercial building owners may be asked to make in furthering the civil defense program. In this case, and in similar cases, it may be possible to store the major portion of the supplies--the excess over the first 48 hours' need--in an adjacent location, one that would still be accessible, with only short exposure of human beings to fallout radiation, in an emergency.

Supply Inspection

The task of inspecting civil defense supplies in the shelters may be handled in the following manner. A paid, trained, civil defense employee would make a semi-annual visit to each facility; he would conduct a visual count of the supplies and, in addition, check the electrical circuits in the radiological monitoring equipment. Assuming that four shelters were close enough to each other so that they could be inspected in an average working day, the 107 stocked shelters in San Diego would require 54 working days per year to accomplish the task every six months. At the rate of $7,200 per year for an inspector, it would cost the County Civil Defense Office about $1,800 per year to maintain an adequate inspection program, and half of this (as well as of the supply-transportation costs) may be financed by the federal government under civil defense matching funds authority.

The semiannual inspection and periodic operational checking of radiological monitoring equipment is very important. Some types of this equipment have a high rate of failure when kept in storage for some time. For example, it was found, when they were inspected, that 17 percent of all stored V-700 Survey Meters were in need of repair.

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* Frederick DeB. Witzel, "Logistical Aspects of Radiological Monitoring Instrumentation," Stanford Research Institute, Menlo Park, California, February 1963.

Facility Stocking Costs

The actual cost to the County Civil Defense Office for labor and materials used in the stocking phase of the shelter program is expected to be negligible. Between the Cuban crisis (1962) and the writing of this report (1963), San Diego's residents had taken these actions:

1. The Real Estate Board offered to solicit building owners for shelter facility licenses and to recruit shelter managers and assistants.

2. Commercial sign companies offered to provide and erect signs marking each shelter facility.

3. Teamsters Union members offered their services free, on Saturdays, to drive trucks and to load, move, and unload shelter facility supplies.

4. Commercial truckers association members offered to provide equipment for this movement of supplies.

5. Carpenters Union members offered to erect enclosures and security cages with shelter facilities.

6. Local lumber and hardware merchants offered to provide materials for these enclosures.

7. National Defense Transportation Association local chapter members offered to coordinate the movement of the supplies from the Naval Supply Depot to the 107 shelter facilities.

V EXPANDING THE SHELTER PROGRAM

A byproduct of the main study for San Diego is presented in this section, which discusses what might be done to provide a greater degree of protection than now exists in the city. San Diego has 105,000 shelter spaces with protection factors of 100 or better, according to the national Survey and Marking program, that would save many lives in event of a nuclear attack. But five out of six of San Diego's residents would still have no effective shelter.

Nor is a significant amount of shelter likely to be added automatically in any new construction of ordinary buildings. San Diego's building practices--no basements, glass walls, etc.--tend to omit the particular features that give a building an inherent protection factor.

Some shelters could be added automatically, over time, if San Diego's building codes were modified. Then all new buildings would provide a degree of shelter just as building codes in the past have dictated degrees of fire resistance, earthquake resistance, and so on. But this is a slow process.

The only way to provide adequate shelter for all of San Diego's people, and in a reasonably limited time, is to institute a deliberate program of shelter building. The program might include modification and improvement of such shelters as already exist. New shelters could then be distributed according to population distribution. As past nationwide experience--as well as the current experience of San Diego officials--has shown, the attempts to encourage or stimulate house owners and tenants into providing their own (family) shelters are not likely to succeed.

Even if such an "encouragement" program did succeed private building of individual shelters would be many times more expensive than the building of large-capacity public shelters. Building costs alone of private shelters, whether per person, per survivor, or in total, would surpass those of even an elaborate public shelter building program. The same principle applies to shelter space as to business space: office space is cheaper, when aggregated into large buildings, than when it is separated into little separate cubicles, each occupying its own plot of ground, having its own foundation, and its own exterior walls, roof, and utilities.

Public Shelter Facilities

In undertaking shelter construction, the City of San Diego must consider, in its over-all design and planning, more than simply the kinds and degrees of protection needed, both in the city as a whole and in its various parts. These needs must be assessed in relation to not only the costs of construction but other factors.

New shelters, if designed primarily to protect against fallout radiation, would automatically incorporate some small degree of protection against blast also. Or, the new shelters might be designed to provide a definite--and higher--degree of blast protection; in this case the shelters would have a very high fallout radiation protection factor inherently. Various studies have indicated that blast protection is the better choice for an urban environment on all important counts, including, ultimately, that of cost.

In either type of shelter, the occupants must be protected by massive materials. Using conventional techniques, construction that is strong enough to withstand high blast overpressures is automatically massive enough to afford a very high radiation protection factor. This is not true of shelters constructed primarily to protect from fallout radiation; they are not themselves strong enough to withstand great blast overpressures.

The selection of a shelter type or types also requires careful analyses of area and population need, available sites, and over-all costs, such as land acquisition, shelter construction, and shelter maintenance. Analyses of this sort constitute a separate study beyond the limitations of the present study. In this section, therefore, only rough and purely illustrative cost calculations and comparisons are presented, for the sake of showing what might be done.

This illustrative material reflects principles--governing the need for shelter in terms of degree and type, and the costs for given degrees and types of protection--that are drawn from other Institute research, and certain Government studies. Data for San Diego is related, where possible, to data on a range of possible nuclear attacks on the nation as a whole in the decade 1960-70, and to protection studies made for other cities, notably Norfolk, Virginia, which is a comparably vulnerable target in a nuclear war.

Shelter-Type Selection

For these illustrative purposes a criterion of 30 psi blast overpressure was chosen. The reasons have to do with both (1) the advantages for San Diego of blast shelter over fallout-only shelter, including, ultimately, an advantage in cost; and, (2) the particular values of 30 psi resistance construction, for general shelter building, over other possible overpressure resistances. The main reasons are discussed below.

1. Blast is a primary hazard to San Diego. The city contains military targets and is an attractive population-industrial target as well.

In targeting analyses and hypothetical attacks run by the Institute on the nation as a whole, and from the attacker's point of view, San Diego always receives direct nuclear bomb effects. It does not receive merely fallout, as certain other cities might under some attack strategies and weights.

In these analyses, the only times that San Diego does not receive direct attack effects are (a) when the weapon malfunctions or misfires, or (b) when the attacker mounts a "pure" military attack, of the city-avoidance type, and thus spares military targets associated with cities. For San Diego, such duds and avoidances cannot be counted on. While the attack data are classified, nonetheless it can be said that San Diego "inevitably" receives some direct--including blast--effects. These effects may be from a small weapon, of less than a megaton, or from one or more heavy weapons.

It is true that fallout-only shelters have some inherent blast resistance. Obviously they would be better than no shelter at all, and they would probably be better than most of the shelters that happen to exist in ordinary buildings.

But shelters designed to protect against fallout radiation only could not perform as well, in the conditions that affect San Diego, as shelters deliberately designed to protect against blast. Too many of the fallout-only shelters would collapse under the blast or overpressure and doom their occupants. Or they would be unavailable, when the fallout arrived, because of overcrowding, distance, rubble, etc. Thus a program of new fallout-only shelters would, to some extent, be self-defeating, since the number of survivors would be lower than for a blast shelter system of comparable costs.

2. Dollar-cost differences are not prohibitively large between fallout-only shelters and "moderate" (i.e., 30 psi) blast shelters.

To justify the cost of constructing a shelter, rather than merely to "find" one in an existing building, requires that the shelter's protection factor be at least in the 500 to 1,000 range that gives it a higher probability of "working" no matter what the radiation level may prove to be. But construction that is massive enough to afford such protection factors is already almost strong enough to afford resistance to 30 psi of blast overpressure. Given the same considerations of size, etc., the dollar costs are only a small to moderate fraction higher--for the bare protective shell of the shelter itself, but including blast protection--than they are for the fallout-only protection alone. The total dollar cost of the 30 psi blast shelter is higher primarily because of the necessary additional items, such as blast baffles or doors, special ventilation arrangements, anchoring, etc. The dollar cost of "shells" to achieve the improved (blast) protection by heavier construction could be as much as, but probably not much more than, the cost of building adequate fallout-only shelters.

The dollar costs of 30 psi blast shelters, when equipped, are admittedly higher than the costs of fallout-only shelters. But these dollar costs would be lower, per added survivor, than the fallout-only shelter costs.

This is simply because the 30 psi blast shelters would succeed in saving lives in environments where the fallout-only shelters failed. Given equal numbers of both kinds of shelter, in the same kind of direct effects environment, the people in the blast shelters would live, where their opposite numbers in the fallout-only shelters would die.

For any given investment, then, fewer 30 psi blast shelters could be built (than the cheaper fallout-only shelters) but they would deliver many more survivors. The per-survivor costs would be lower. Since shelter investments are aimed at buying lives, not shelters per se, this is the paramount consideration.

Costs per survivor or costs per added survivor cannot be evaluated on the basis of the dollar cost of merely a single shelter of each kind, that is, fallout-only versus 30 psi blast protection shelters. But, in terms of large numbers of shelters distributed throughout such a "direct-effects area" as San Diego, the comparisons above are valid.

Even in blast environments, people do survive; this was shown in Hiroshima. Some people who were close to ground zero survived because they happened to be in the right places within the right kinds of buildings.

In a similar situation, people who had not reached a shelter yet managed to survive a detonation's blast would need shelter for their continued protection--from fallout radiation. In a city limited to the relatively fragile fallout-only shelters, such survivors would find few or no protection-affording places. If, on the other hand, the city contained many blast shelters, most of these structures would still be either intact or essentially so. These blast shelters could then accommodate the latecomers.

The 30 psi shelters considered for illustrative purposes here are of the type that would survive well, when compared to ordinary structures, even within the so-called "radius of total destruction." For a large (megaton) weapon, the area swept by this radius would include many square miles of the city. In many of those square miles, the 30 psi blast shelters would protect most of the people who, otherwise, would have been lost--even with the fallout-only shelters.

3. Blast shelters as well as fallout-only shelters can be designed and equipped to withstand thermal effects and to resist chemical and biological warfare agents.

Of the two kinds of shelter, on the whole, the blast shelters could more easily cope with chemical and biological hazards than could the fallout-only shelters, given the same general precautions in construction and use, and given analogous equipment. Likewise, fire effects, including noxious gases, could more easily be countered with blast shelter construction.

4. For comparable investments of money and effort, many more people would be saved in blast shelters.

Even though, for a given investment the number of blast shelters would have to be lower, the total number of survivors would be higher.

5. For special purposes, as necessary, overpressure resistances of, say, 50, 100, or 250 psi could be achieved in constructing the blast shelters, and ought to be. But for most purposes, in a target city, the 30 psi resistance is probably the optimum required.

Past studies* have shown that, through the 12 hypothetical attacks on the United States, 30 psi resistance in shelter construction is about 60 to 90 percent as effective as 250 psi resistance. The 12 attacks covered a range of possible enemy strategies, intentions, and attack capabilities.

The effectiveness of the 30 psi blast shelter, relative to the effectiveness of the stronger 250 psi shelter, of course depends on the attack weight and intention. It can be said as a result of these attack studies, however, that 30 psi resistance "buys" most of the survivors that the 250 psi shelter does, and much less expensively.

This means that a blast shelter program need not be as expensive as is usually feared. The main reliance, in planning a shelter-building program, can be placed on 30 psi blast shelters. These can be obtained for gross (dollar) costs that are no more than twice the fallout-only shelter costs.

For San Diego conditions, the per added-survivor costs are much less than the costs for fallout-only shelters. Moreover, several times as many survivors can be expected, with use of the more protective blast shelters, than with use of the fallout-only type.

Comparative Effectiveness

In comparison with fallout-only shelters, the effectiveness (and cost-effectiveness) of 30 psi blast shelter in the hypothetical attacks, and its probable effectiveness in real attacks, is due to a number of elements. Most of these are connected with the fact that 30 psi blast shelters can be built, at the first floor level or basement level, as integral parts of ordinary structures.

This favorable factor has several immediate advantages:

1. Shelters that are integral parts of ordinary buildings can have dual use, and when an attack begins, may be already partly or even wholly occupied.

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* Richard I. Condit, Civil Defense Aspects of Urban Renewal Plans for Norfolk, Virginia, Final Report Volume I, for Norfolk Redevelopment and Housing Authority and U.S. Urban Renewal Agency: Stanford Research Institute, Menlo Park, California, November, 1962.

2. People in other parts of the building who must move into the shelter have at least some cover and protection from direct effects on their way there.

3. Because the building's integral shelter, whether at grade, or at one floor below grade, can be filled quickly, the requirements for warning time are reduced.

People already occupying the shelter at the time of an attack--because they work in it, or are shopping in it, or perhaps live in it--have a warning time requirement of zero. Also, since warning time cannot be exact, and might be very short (no more than half an hour, with missile delivery, and probably less) it is important that shelters--particularly blast area shelters--be occupied quickly.

4. Stronger shelters, say of 250 psi resistance, must be below ground if they are to be constructed without exorbitant costs.

Even if a design existed for a 250 psi blast shelter that did not need to be buried, such a shelter would probably not be suitable for incorporation into another, an "ordinary," structure. Nor would such a shelter be as accessible as a 30 psi shelter, built at or just below grade, that was part of an ordinary building. The 250 psi blast shelter, therefore, would not be filled as fast. It would require more warning time. It would also be more costly, needing more in the way of blast doors, etc., than the 30 psi blast shelter. These additional needs would complicate all problems--from warning-time and filling-time requirements to the accessity for having blast doors shut--and shut at the right time.

5. Shelters built to withstand overpressures greater than 30 to 35 psi become progressively more expensive as their blast resistance increases.

For general purposes shelters with greater resistance might be considered too expensive for any large-scale program aimed at protecting a whole city. Yet 30 psi blast shelters, which would do most of what 250 psi shelters are intended to do, would cost no more than about twice the amount of fallout-only shelters that have much lower survival rates in direct attacks.

Certain parts of San Diego or any city, or certain essential facilities within such a city, would undoubtedly need higher blast resistance than 30 psi. Nothing in the foregoing remarks should be interpreted as ruling out shelters with higher blast resistances, to be used for special purposes or in special cases. Rather the points

being made here are that moderate blast protection, such as 30 psi, is (a) adequate for the main part of the over-all task of saving people, (b) is consistent with the types of wall and roof sections needed for fallout-only protection, and (c) can be achieved more readily than can higher-resistance structures, which, to be effective, cost more, take more time to build, require more warning time, and need more expensive accessories.

Nor does a city's need for blast shelter in certain of its areas rule out the use, outside the city limits or on its fringes, of fallout-only shelters that have fire, biological, and chemical warfare resistance. Blast protection plainly would not be needed at some places because of (a) the low probability of direct bomb effects; and (b) the lower population density. Direct effects, in a city's outer areas, would kill comparatively few people. Fallout radiation, if these people lacked even fallout-only shelter, could ultimately kill or incapacitate them all.

Since San Diego is a probable target, at least 30 psi blast protection ought to be incorporated into any newly built shelters within the city's limits. For the remainder of San Diego County, since the probability of direct effects is extremely low--even considering circular error probability, gross aiming errors, etc.,--fallout-only shelters would probably suffice.

As was discussed in Section I of this report, to the extent that the classified attack studies could be drawn on for this purpose, ground bursts of large weapons were used in three hypothetical attacks on San Diego. Of course the 30 psi blast shelters would not withstand the cratering effects within the immediate blast area or the overpressure effects in the immediate surroundings of the crater. Such areas of the city are a special case and require special consideration.

But this is not to say that no shelters should be built in the "target" sections. It rather implies that the main emphasis, in the general shelter-building program, should be on the remainder of the city. Most of the people live in areas where a 30 psi blast shelter would be adequate.

Also, most of the city's future growth in building density can be expected to occur in such outer areas, since the heavily built up downtown sections may be regarded as essentially saturated. Transportation and traffic problems, in San Diego as in other cities, stimulate the growth of business activity in areas away from the city's core.

Thus a shelter-building program that concentrates on providing shelters away from the downtown areas of San Diego would serve another survival criterion. In an emergency, people would not have to move toward the expected target areas, the more dangerous points, to find shelter.

No matter where shelters were built, however, opportunities would repeatedly be present to add shelters while constructing ordinary buildings intended for other purposes, such as stores, garages, office buildings, etc. This would be as true within the expected aiming-point areas as elsewhere. If any building or installation must be placed (or replaced) at an expected aiming point, and without regard to cost and risk, the same considerations that justify such a building or installation also justify building a shelter within it, and as part of its initial design.

Numbers of Shelter Spaces Needed

Population distribution is different at various times of day or simply between day and night, so that to provide adequate protection at all times would require overprovision of individual shelter spaces. To estimate the overprovisions of spaces required for San Diego would need detailed study, but the Office of Civil Defense (OCD) has used a factor of 1.3 per person for such rule-of-thumb purposes.

Applying this factor to San Diego's population of 650,000 results in a requirement of about 850,000 shelter spaces. However, of the approximately 105,000 prime (protection factor 100 or better) shelter spaces found during the national Shelter Survey, perhaps as many as 40 percent (some 42,000 spaces) are already in deep basements and underground garages. The number of such shelter spaces, because they offer not only good shielding from fallout radiation but protection from all but extreme blast overpressures as well, could be subtracted from the number of shelters required. The original requirement of 850,000 shelter spaces is thus reduced by about 42,000 shelter spaces, and leaves a total requirement of some 810,000 shelter spaces.

Whether or not this number--of spaces that are both fallout radiation proof and blast resistant--should be deducted from the total requirement is a matter of engineering judgment. All of the 105,000 existing spaces would have to be investigated, to determine which of them have, or could be modified to provide, optimum blast protection.

The per occupant cost, that is, the cost for one space, of shelter affording 30 psi of blast protection has not been worked out for San Diego in particular. This also would require a special study. However, various national average costs have been tabulated by OCD and other agencies of the federal government. For illustrative purposes, a cost of $150 per occupant is assumed. This figure is derived from consideration of a number of OCD, SRI, and other documents.*

The $150 figure, which is roughly twice the $73 given for fallout-only spaces (by Devaney) in the reference just cited, is thought to be "conservative" in that it is probably high for the structural shell cost alone. The figure includes only materials and labor for the shell; it excludes supplies, equipment, or land costs. Food, medical, and sanitary supplies, as well as basic radiological measuring instruments, are provided by the federal government in the current civil defense program. Land costs are excluded because they would not be a factor, usually, in any shelters installed during the course of construction of new buildings erected for other purposes. Such land would already have been purchased, and the shelter would merely be included, in the building design, as part of the building.

Applying this unit shelter cost of $150 per occupant to the San Diego requirement for 810,000 blast shelter spaces results in a total cost of nearly $122 million. For this outlay the entire population of the City of San Diego would be protected from blast pressures of 30 psi as well as from the other effects associated with these overpressures.

Viewed as a total, $122 million seems a staggering sum. Viewed as the aggregate of individuals who survive because of it, however, the sum becomes quite realistic. No one would argue that a human being is not worth the $150 price of, say, a modest television set.

The important questions are:

> How many lives could be saved by spending this total sum to provide blast shelters for all?
>
> What is the cost <u>per</u> <u>survivor</u> that would be achieved for this sum?

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* For example, John F. Devaney, <u>Shelter</u>, OCDM-SA-61-12, Executive Office of the President, Office of Civil and Defense Mobilization, Washington, D.C., June 1961. Other relevant studies are listed at the end of this section.

Costs Per Added Survivor

For the purpose of answering these questions, the same three attacks cited in Part II of this report were re-calculated, assuming the entire San Diego population of 650,000 to be in the 30 psi blast shelters. The results are summarized in Table III.

Table III

ATTACK EFFECTS ASSUMING 30 PSI SHELTER*

Fatalities:	Light Attack	Medium Attack	Heavy Attack	Average
Blast	71,000	110,000	143,000	
Fallout	---	---	---	
Total	71,000	110,000	143,000	
Survivors:				
Injured	15,000	12,000	20,000	
Uninjured	564,000	528,000	487,000	
Total	579,000	540,000	507,000	
Survival (Percentage of 650,000 Population)	90%	83%	78%	83%

* This table should be compared with Table I on page 4 . Also, the same descriptions of the attacks are applicable.

The number of survivors added by providing 30 psi blast shelters for the entire population of the city rather than by relying on merely the small number of shelters identified in the national Fallout Shelter Survey, is shown in Table IV.

These hundreds of thousands of added survivors would have been purchased at a total cost of $122 million, exclusive of land and other costs, as discussed earlier. The average survivor cost, per resident of San Diego would be $188.

Table IV

SURVIVORS ADDED BY 30 PSI SHELTER SYSTEM

	Number of Survivors	Light Attack	Medium Attack	Heavy Attack	Average
(A)	Survey shelters only	153,000	45,000	39,000	79,000
(B)	Space for all 30-psi shelters	579,000	540,000	507,000	542,000
	Effectiveness Ratio (B) : (A)	3.8 : 1	12 : 1	13 : 1	9.6 : 1
	Added Survivors (B) - (A)	426,000	495,000	468,000	463,000

Compared with the Survey-identified shelters, the cost per added survivor would be:

Light Attack	Medium Attack	Heavy Attack	Average
$286.00	$246.00	$261.00	$266.00

Thus the cost per added survivor is higher than the per capita construction cost for blast shelter for the total population, since not all the people in San Diego would survive even with the 30 psi blast shelter program. Of the total population surviving the three attacks (assuming 30 psi shelter protection) the average percentage is 83 percent. This is certainly a worthwhile survival rate, and the cost per added survivor is still in the "television set" range.

The total 30 psi shelter program would cost no more, and in most instances less, than other services now provided for San Diego's residents, such as streets, sewers, schools, etc.

All these figures, of course, are merely estimates. They are not definitive, and should be used only for preliminary planning of a shelter program for San Diego. They do illustrate, however, that while the present system of Survey-identified shelters could save only 12 percent of the population, a shelter system of 30 psi resistance facilities

could save 83 percent. This difference of 71 percent of the total population that could be saved is a gain, over the system of Survey-identified shelters only, of nearly 600 percent.

Cost-Effectiveness and Cost per Added Survivor

The 30 psi blast shelters program discussed here for the sake of illustration seems justified on the basis of various OCD and SRI studies, notably Devaney (1961) and Condit (1962).* Actually, for San Diego, some other blast resistances might prove more appropriate, and a careful preparatory analysis would undoubtedly indicate that some kind of mix of shelter types is required. Shelters of 30 psi resistance might predominate and perhaps for certain fringes of the city, as well as for most of San Diego County, fallout-only shelters would be indicated.

Such a preparatory analysis would identify the installations and facilities that might be essential to the city's recovery, those that should be hardened regardless of cost, and those that should be hardened to some degree greater than 30 psi resistance.

The analysis would take into account the city's environmental constraints on building shelters. For example, some highly valued installation, seeming to call for 200 or 250 psi protection, might be located in a part of the city where the necessary excavation would be financially unfeasible, costing, perhaps, more than the installation itself. This example is only hypothetical, but is used to illustrate one point of the nettle that must be grasped in order to solve the nuclear war survival problems of such a triple-target city as San Diego.

Like any city in California, San Diego would also have to pay some attention to earthquake resistance and its effect on costs. Earthquake resistance on soft ground generally calls for rigid structures. This presents no problems in blast shelter construction, since the blast shelter itself must be rigid. Earthquake-proofing on a bedrock base, however, generally calls for resilient construction; this presents problems of insulating (with a layer of sand or other material) the rigid shelter from the base. The same problems confront the architect of office or apartment buildings, and are obviously not insurmountable, but they do affect costs.

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* Op. cit. See also the additional titles listed at the end of this section.

The cost-per-added-survivor factor is useful in deciding between options, since all will have some definite cost per survivor. An easy illustration is in the comparison, under the 12 hypothetical attacks cited earlier, of a program calling for all 30 psi shelters with a program of all 250 psi shelters. The 30 psi shelters were about 60 to 90 percent as effective as the 250 psi shelters, depending on the type of attack. The 250 psi shelter system, which would cost several times as much as the 30 psi system, would add, at most, about half as many survivors. For the 250 psi shelters, therefore, the cost per added survivor would be extremely high; this kind of comparison of added-survivor costs would give an index of the effectiveness of any two systems. Studies dealing with cost per added survivor would identify means for achieving the maximum number of survivors, at the lowest cost per added survivor, for any given total investment.

In designing any large shelter system, as for a whole city, it is well to remember that all costs would be spread over time. The entire plan could not be executed overnight; this obviously eases the financial problems since the total cost would not have to be raised at once.

Analysis might also show that certain installations now considered in need of protection would not be important post-attack in the recovery period. They therefore would not call for great investment, and this would simplify decisions on allocating resources over time.

The discussion and all calculations in this section only indicate the range of these problems; and their orders of magnitude. To come to grips with the actual problems requires a study of shelter programs resembling the one carried out in 1962 for the Norfolk (Virginia) Redevelopment and Housing Authority and the federal Urban Renewal Administration. San Diego, with its military, industrial, and population targets, probably presents a larger problem than Norfolk. Also, San Diego would be a different type of problem. Therefore little in the Norfolk study, beyond its general considerations, is directly applicable to San Diego's problems.

The purpose of this study in San Diego was only to analyze the problems of utilization of the shelters spaces identified in the national Fallout Shelter Survey; this final section, looking to other solutions to San Diego's survival problem, is only a by-product of the main study.

RELEVANT STUDIES

M. B. Bennedsen, Preliminary Engineering Procedures and Costs for Integrating 30-psi Fallout Shelter into Normal First Floor Plans During Original Construction for New Buildings in Downtown Norfolk, Virginia, Technical Report No. 2, for Norfolk Redevelopment and Housing Authority: Stanford Research Institute, Menlo Park, California, November, 1962.

OCD, Protective Structures Division, Dual Purpose School and Community Shelter for 350, 550, and 1,100 Persons, Shelter Design Series S55-1: Washington, D.C. Revised September, 1962.

OCD, Protective Structures Division, Parking Garage and Community Shelter for 5,000 Persons with Blast Resistance Capacity of 5, 25, & 50 psi, Shelter Design Series G35-2: Washington, D.C. April, 1963.

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