RESEARCH PAPER P-194

MAGNITUDE AND DISTRIBUTION OF WEAPON EFFECTS FOR THE DESIGN OF SHELTERS FOR PROTECTION AGAINST FALLOUT

H. A. Knapp

JULY 1965

INSTITUTE FOR DEFENSE ANALYSES
WEAPONS SYSTEMS EVALUATION DIVISION

FOREWORD

On November 3, 1961, the Advisory Committee on Civil Defense of the National Academy of Sciences included the following recommendation in a letter to the Assistant Secretary of Defense for Civil Defense:

> "With regard to the program as a whole, the Committee feels very strongly that it should be based on realistic and detailed planning assumptions for civil defense. We have, in our specific comments, urged the development of such assumptions. We believe that not only research, but all civil defense effort should be planned and carried out in conformance to the best possible premises concerning levels and types of enemy attack, and their effects on all parts of the nation. Planning assumptions would, furthermore, be simplified and made available to individuals and communities as guidance to assist them in planning their protective actions."

In the Department of Defense - Office of Civil Defense official publication FALLOUT PROTECTION, What to Know and Do About Nuclear Attack, it was subsequently stated:

> "Many of the spaces in the central areas of large population centers would be exposed to destruction by blast and fire in the event of a nuclear attack. But the pattern of attack cannot be predicted, and existing shelter is more widely distributed in relation to population than appears to the casual observer. Further, this space is immediately available, and the cost of identification, marking, and stocking is less than $4 per space."

After reviewing the Civil Defense program, the Military Operations Subcommittee of the House Committee on Government Operations issued a report on May 31, 1962, which reechoed the earlier recommendation made by the Advisory Committee on Civil Defense:

> "Analyses of hazard probabilities and damage should be carried forward, not only on the basis of varying attack

assumptions, but on assumptions of varying levels and kinds of shelter protection--including protection against blast and thermal as well as fallout effects--in order to determine an optimum shelter program for the United States."

In March, 1965, the Office of Civil Defense issued Technical Memorandum 61-3 (Revised) defining a fallout shelter as "a structure, room, or space that protects its occupants from fallout gamma radiation, with a protection factor of at least 40". The memorandum also states:

> "Detailed DoD studies of the lifesaving potential of fallout shelters indicate that for the current time frame and for the foreseeable future, shelters with a protection factor of 40 could save over 90% of these persons who would otherwise die if unprotected against potential lethal radiation levels. . . . Computations indicate that decreasing returns in added lives saved per added dollar invested are obtained as PF's are increased significantly above 40. On a nationwide basis, therefore, it would be better life-saving potential per dollar for the same dollar expenditure, to obtain more shelter space of lower PF than only a few shelter spaces with a very high PF."

Guidance of the type suggested by the Academy Committee is still not available, and there appears, at present, to be no plans for making it available.

CONTENTS

APPENDIXES

CONTENTS (Continued)

SUMMARY AND CONCLUSIONS

To design a shelter which offers its prospective occupants a reasonable prospect of survival in the event of nuclear attack, it is necessary to make a quantitative estimate of the levels of blast, thermal pulse, initial radiation, and fallout to which the shelter location could reasonably be subjected. To this end, it is necessary to make an estimate of the numbers and yields of weapons which would be detonated in the United States, and to indicate where it is likely that they would be detonated. Of particular importance to the urban population of the United States -- which constitutes 70 percent of the total population concentrated on 1 percent of the land area -- are the number and yields of the weapons which might be deliberately targeted to maximize population kill, and the criteria adopted by the attacker for determining how these weapons should be allocated to and within areas of population concentration.

It is argued that a targeting criteria which might be adopted by a potential enemy in assigning a portion of his nuclear delivery force for the purpose of maximizing population fatalities would be to aim weapons in such a way as to include the maximum number of persons within a blast level of at least 5 pounds per square inch (psi) overpressure. It is hypothesized that the total cost of delivering a nuclear weapon over intercontinental distances varies approximately as the 2/3 power of its yield. Since the area included within the 5 psi level for an airburst or surfaceburst also varies as the 2/3 power of the yield, the total area included within the 5 psi level for a given total cost for delivered weapons does not depend on the yield of the individual weapons delivered.

The area over which a single weapon exerts a blast level of at least 5 psi is taken as the "lethal" area of the weapon.[1]

It is assumed that the level of attack which might be delivered against population targets in the United States would lie between that characterized by 100 1-MT weapons and 1000 1-MT weapons. The lethal areas associated with these two attack levels are:

	Surfacebursts	Airbursts
100 1-MT weapons	2,380 sq. mi.	5,800 sq. mi.
1000 1-MT weapons	23,800 sq. mi.	58,000 sq. mi.

The total urbanized area of the United States covers approximately 25,000 square miles, or approximately the lethal area associated with the airburst of 430 1-MT weapons.

The lethal area associated with an airburst of a given yield is over twice that of a surfaceburst of the same yield. For attacks against urban population, it is an unsolved problem as to whether or not a larger number of fatalities would be incurred by airbursts, with more fatalities from the initial effects of blast, heat, and initial nuclear radiation, or from surfacebursts with a smaller number of fatalities from the immediate effects, but with an uncertain number of casualties

---

[1]The "lethal area" associated with a nuclear weapon burst is defined as the circular area, centered on the ground zero of the burst, of such radius that the total number of persons in a uniformly dense population which are killed from the blast, heat, and initial nuclear radiation of the burst is equal to the number of persons within the circle. If $P(r)$ is the probability that a person will be killed by the immediate weapon effects as a function of distance r from ground zero, then

$$\text{Lethal area} = \int_0^{\infty} 2\pi r\, P(r)\, dr \, .$$

It is a consequence of the definition that the total number of persons within the lethal area who are not killed just equals the total number outside who are killed.

due to fallout. Accordingly, the possibility of both airbursts and surfacebursts must be taken into account when considering shelter requirements in urban centers subject to direct attack.

Given an attack on the population of the United States, the maximum number of persons would be included within the lethal area of the weapons employed if the lethal area could be allocated to those places in the United States for which the population density is equal to or greater than some minimum population density D_{min}, and to no area for which population density is less than D_{min}. D_{min} can be determined from the total lethal area of the attack, and from a graph (Figure 9) which shows the area of the United States for which the population density is equal to or greater than any given density. The portion of any given urbanized area targeted to the 5 psi level may then be taken as the area within the local population density contour on which the population density is D_{min}. The number of weapons assigned to this area is then chosen so that their combined lethal areas are approximately those of the area within the population density contour determined by D_{min}.

For a given population concentration, there may be no reason to presume that weapons would be aimed at particular points within the area to be targeted (e.g., at specific military or industrial targets). In that case, the probability of survival in a shelter which protects to the X psi level and which is located at random within the targeted area is approximately the ratio of the area covered by X psi from any given weapons burst to the area covered by 5 psi from the same weapon burst. Under the targeting doctrine assumed, this probability is independent of weapon yield, or whether or not the weapon is airburst or surfaceburst. Under the assumptions of this targeting model, a 30 psi shelter will reduce the probability of being killed in a targeted area to about 10 percent.

For shelters subjected to blast levels greater than 30 psi ›out one and a half times the radius of the fireball), it is longer true that protection against blast and high levels of iidual radiation (fallout) automatically guarantees protection iinst initial nuclear radiation.

Fallout deposition patterns are highly unpredictable. The llout level at any point depends on the total, surfaceburst, ısion megatonage of all attacks against all targets which ıtribute to the fallout at that point. The highest levels of iidual radiation of concern to urban populations are likely be experienced in and immediately downwind of large urbanized ɜas subject to direct attack with multiple, high-yield rfacebursts. Based on one of several fallout models currently use, fallout contamination levels in the range of 5,000- ,000 roentgens/hour at 1 hour, corresponding to maximum bio- gical dose levels of 15,000 to 30,000 roentgens, might ısonably be anticipated in portions of an area attacked with surfaceburst 10-MT weapons, each deriving 50 percent of their ɜld from fission.

Data are presented to enable, for any given level of attack rected against populations, a rough allocation of weapons ɔng each of the 213 principal urbanized areas in the United ates. The model and data indicate that the Washington (D.C. - . - Md.) urbanized area, with 1.8 million persons and covering) square miles, would be allocated 3 1-MT weapons in an attack ainst the population of the United States consisting of 100 MT weapons airburst at optimum altitude. The model and data dicate this area would receive 12 1-MT weapons for an attack ainst the United States consisting of 1000 1-MT surfacebursts. each case the entire District of Columbia, consisting of 62 uare miles at an average density of 12,400 persons/square mile subjected to blast leve's of at least 5 psi. For an attack ainst the U.S. population with 300 1-MT airbursts, or 1000

1-MT surfacebursts, the model indicates that the entire Washington urbanized area, including Rockville, Maryland, could anticipate blast levels of at least 5 psi.

PART I - TARGETING ASSUMPTIONS FOR ATTACKS AGAINST POPULATIONS

A. THE PROBLEM

To design a shelter which offers its prospective occupants a reasonable prospect of survival against fallout in the event of thermonuclear war, it is necessary to make a quantitative estimate of the likely level of all weapon effects - blast, thermal, initial radiation, and fallout -- to which the shelter location would be subjected in a nuclear attack. The reason is simple enough: both the shelter and its occupants must withstand those weapon effects which precede the fallout. The problem is to anticipate for any proposed shelter location, both the right magnitude of effects, and the right combination of effects. More precisely, the basis for shelter design and operation must be a prudent and practical assessment of the probability that the proposed shelter will be subjected to various combinations and levels of weapon effects.

It is far from obvious that it is possible to develop useful guidance of this type for every -- or even for any -- location in the United States. There are many strategies and weapons available to the enemy. Our knowledge of them is incomplete, the problems change with time and with technological developments, and much that happens in war is not in accord with anybody's plan. Any place could be in the mile-across, 900-foot-deep hole created by the surfaceburst of a 30-MT warhead, in which case no shelter would be of any avail. And, any place could be largely untouched, even by fallout, in which case no shelter would be needed.

Neither of these latter assumptions would be a useful basis for civil defense planning. This follows from straightforward but not obvious computations on the areas of the fallout, blast, and thermal effects of nuclear weapons, the numbers of cities, towns, and military targets in the United States, and the plausible number of deliverable weapons possessed by any potential enemy. It has been recognized for some time that even remote, rural areas must concern themselves with the possibility of dangerous levels of fallout, and that some cities could be subjected to direct attack, either because they contain or are near to priority military targets, or simply because they are centers of population and industry. Two authoritative statements of targeting doctrine which offer an informed appraisal of the ultimate threat to civil populations have been given by Secretary McNamara and Marshal Sokolovskii:

Secretary McNamara testified before the Senate Armed Services Committee:[1]

> "The major mission of the strategic retaliatory forces is to deter war by their capability to destroy the enemy's war making potential, including not only his nuclear strike force and military installations, but also his urban society, if necessary."

Marshal Sokolovskii states in his book <u>Soviet Military Strategy</u>:[2]

> "What will be the characteristic features of a war of the future from the point of view of its military-strategic goals and the means of waging it?

[1]Hearings on the Department of Defense Appropriations for FY 1964, U.S. House of Representatives, Part I, Page 110 (Secretary McNamara's statement given on February 7, 1963).

[2]<u>Military Strategy</u>, edited by V. D. Sokolovskii (Voennaia Strategiia, V. D. Sokolovskii, Voennoe Izdatel'stvo Ministerstva Oborony, SSR, Moskva, 1962), translated by Foreign Technology Division, Wright-Patterson Air Force Base (quote from Chapter IV).

"On the basis of the above considered political and military goals of the two camps, it may be assumed that the belligerents will use the most decisive means of waging war with, above all, the mass use of nuclear weapons for the purpose of achieving the annihilation or capitulation of the enemy in the shortest possible time.

"The question arises of what, under these conditions, constitutes the main military-strategic goal of the war: the defeat of the enemy's armed forces as was the case in the past, or the annihilation and destruction of objectives in the enemy zone of the Interior and the disorganization of the latter?

"The theory of Soviet military strategy gives the following answer to this question: both of these goals should be achieved simultaneously. The annihilation of the enemy's armed forces, the destruction of objectives in the zone of the Interior, the disorganization of the zone of the Interior will be a single continuous process of the war. Two main factors are at the root of this solution of the problem: first, the need to decisively defeat the agressor in the shortest possible time, for which it will be necessary to deprive him simultaneously of his military, political, and economic capabilities of waging war; second, the real possibility of achieving these goals simultaneously with the aid of existing means of armed combat."

Assuming that some fraction of the nuclear striking force of a possible enemy might be employed for the unhappy purpose of killing people in the most efficient manner, what assumptions should be made as to just how it would be used? In particular, what criteria should the civil defense planner use as a guide for determining which cities could reasonably be candidates for direct attack? How far into the suburbs of such cities would it be prudent for the shelter designer to concern himself with blast and heat in addition to fallout, and with what levels of blast, heat, and fallout? Given crude guidance on how many bombs of what sizes might be expected to fall where, it then becomes possible to utilize the detailed and important technical information on the fallout, radiation, and blast effects of individual weapons given in such publications as The Effects of Nuclear Weapons for determining shelter requirements, and evaluating shelter proposals. Without such guidance, the 70 percent of the U.S. population which presently lives in urban areas has no basis for assessing the merits of alternative protective measures.

B. TARGETING FOR MAXIMUM POPULATION KILL

Determination of the burst locations of an attack designed to maximize population fatalities depends on a number of conditions and assumptions:

- The number and yields of nuclear weapons allocated to the destruction of urban targets,
- The definition of a fatality, or more correctly the combination of weapon effects assumed to give rise to fatalities over some defined period of time,
- The active and passive measures which have been taken to counter the effects of a population attack,
- The distribution of population over the targeted area.

It is assumed here that population preparedness is the same as currently exists in the United States, and that active defense measures are not of such a character as to influence the assumptions for passive defense planning. It is further assumed that the actual assignment of weapons is done in a way (described later) which maximizes blast fatalities. This is done without attempting to answer the question of whether or not more persons might in fact be killed during the first day or two by fire (as was the case in Hiroshima and Nagasaki),[1] or within 60 days by radiation, or within the first year by the combined effects of blast, fire, fallout, starvation, disease, exposure, and general chaos. The reason for the assumption is partly that the effects of fallout, fire, and general chaos are both uncertain and difficult to assess, and strongly dependent upon

[1] The Effects of Nuclear Weapons, paragraph 11.13-11.20, prepared by the United States Department of Defense, published by the United States Atomic Energy Commission, April 1962, Samuel Glasstone, editor, U.S. Government Printing Office (weapon effects-yield-distance relations, from Nuclear Bomb Effects Computer accompanying publications).

wind and weather. Also, blast is more dependable and decisive against industry and military targets in populated areas than are the other effects of airbursts or surfacebursts.

The question then arises as to what likelihood of a blast fatality should be assigned to a given level of blast overpressure. Here again simplifying assumptions are made which may be better justified as an assumption for optimal targeting than as a method of damage assessment. It is assumed that everyone subjected to an overpressure level of 5 psi (or greater) is killed, and that everyone subjected to less than 5 psi survives.

This assumption may be questioned on two counts: (1) the selection of a model with a single overpressure criterion for determining a fatality, and (2) the choice of 5 psi as the dividing line. Each of these assumptions is examined briefly.

The 1949 edition of The Effects of Atomic Weapons[1] gave a curve showing the percentage of survivors in Hiroshima as a function of radial distance from ground zero. This curve is reproduced as Figure 1, and redrawn in Figure 2 to show the same phenomenon as a function of peak blast overpressure. It is seen from Figure 2 that in this particular unwarned population, the airburst of a 14-KT bomb[2] caused casualties to begin at an overpressure level of 3 psi, that at 5 psi there were 30 percent fatalities, and that even at 16 psi, 15 percent evidently survived.

[1] The Effects of Atomic Weapons, prepared for and in cooperation with the U.S. Department of Defense and the U.S. Atomic Energy Commission under the direction of the Los Alamos Scientific Laboratory. Revised September 1950, Samuel Glasstone, Executive Editor, U.S. Government Printing Office.

[2] RM 4193 PR The Yield of the Hiroshima Bomb as Derived from Pressure Records, H. L. Brode, September 1964.

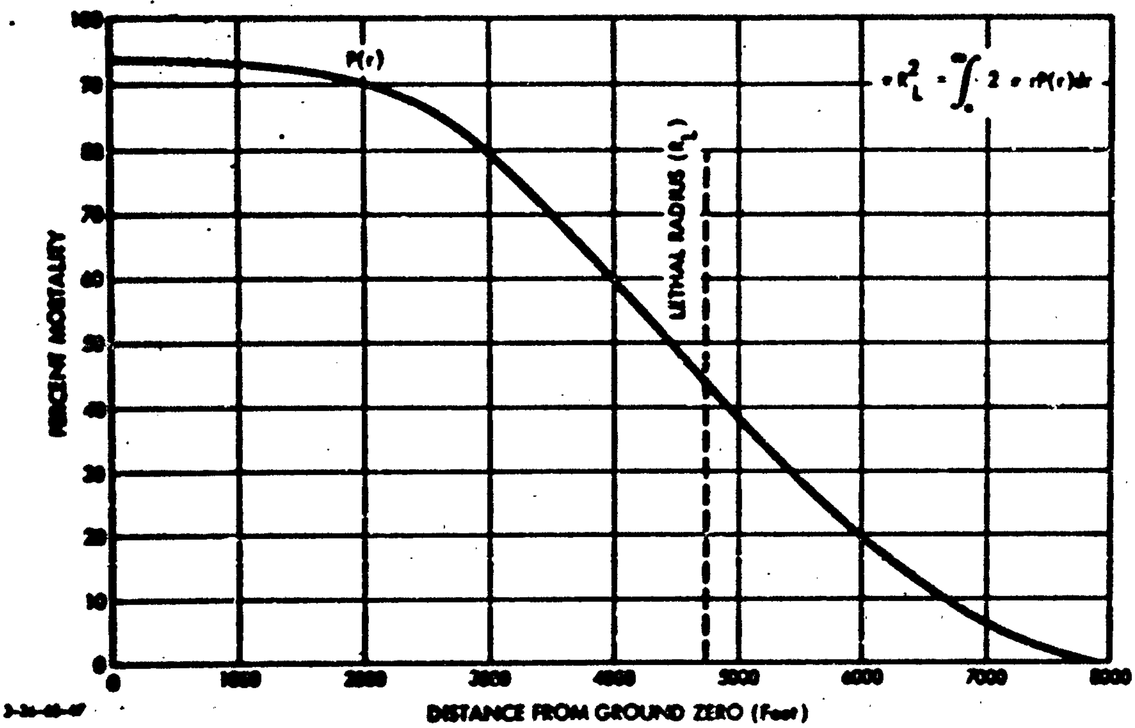


FIGURE 1. Percent Mortality as a Function of Distance from Ground Zero for the Atomic Bombings of Hiroshima and Nagasaki

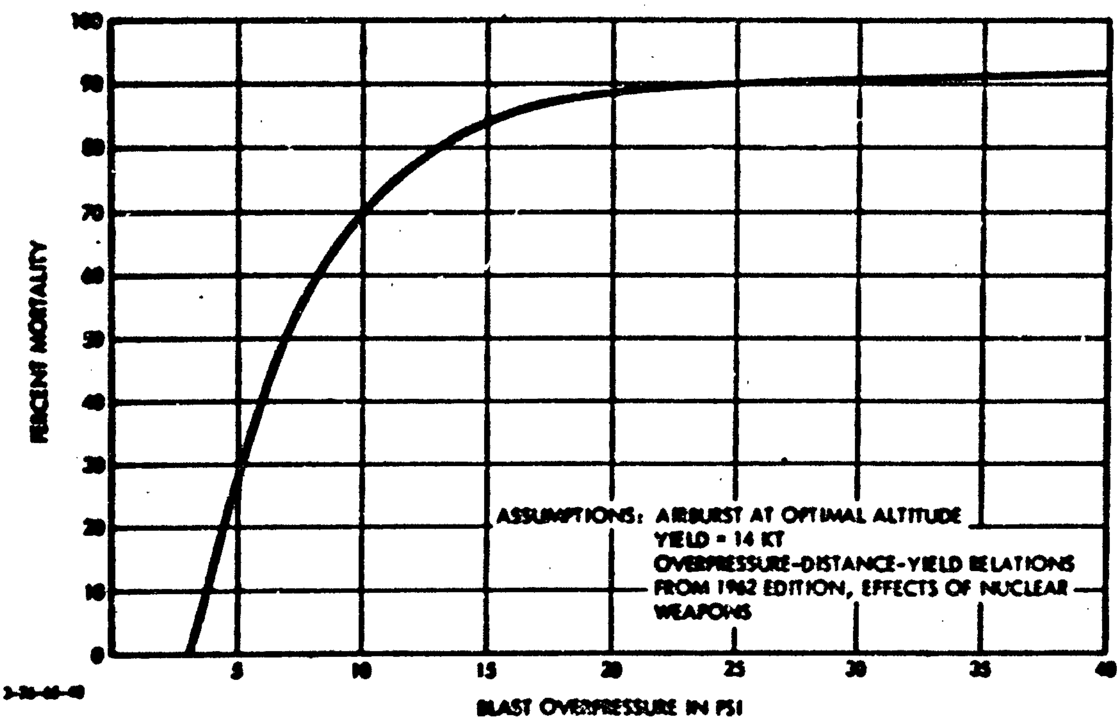


FIGURE 2. Percent Mortality as a Function of Peak Overpressure for the Atomic Bombings of Hiroshima and Nagasaki

the same 48 states will have increased in population to about 210 million persons (an increase of about 32 million persons, or almost 18 percent). Whereas in 1960 almost 70 percent of the population lived in urbanized areas,[1] by 1970 it is estimated that this figure will increase to about 80 percent.

In 1960, the urban population was concentrated in slightly more than 1 percent of the land area of the country (Table 4). The population of urbanized areas, something more than one-half of the total, occupied less than 1 percent of the total land area. Among urban places, the number of inhabitants per square mile decreased as size of place decreased. For places of 1,000,000 inhabitants or more, the average density was 13,865 persons per square mile; for places between 100,000 and 1,000,000, average densities ranged between 4,000 and 6,000 per square mile, and the average density for places of 2,500 to 5,000 was 1,446. In urban-fringe areas outside urban places, the average density was 1,781 per square mile, and in rural territory the density was 15. The average population density for the 48 conterminous states was about 60 persons/square mile.

[1] From 1960 Census, Vol. I, op. cit.:

"Urban and rural residence.--According to the definition adopted for use in the 1960 Census, the urban population comprises all persons living in (a) places of 2,500 inhabitants or more incorporated as cities, boroughs, villages, and towns (except towns in New England, New York, and Wisconsin); (b) the densely settled urban fringe, whether incorporated or unincorporated, of urbanized areas; (c) towns in New England and townships in New Jersey and Pennsylvania which contain no incorporated municipalities as subdivisions and have either 25,000 inhabitants or more or a population of 2,500 to 25,000 and a density of 1,500 persons or more per square mile; (d) counties in States other than the New England States, New Jersey, and Pennsylvania that have no incorporated municipalities within their boundaries and have a density of 1,500 persons per square mile; and (e) unincorporated places of 2,500 inhabitants or more. In other words, the urban population comprises all persons living in urbanized areas and in places of 2,500 inhabitants or more outside urbanized areas. The population not classified as urban constitutes the rural population."

Table 4. POPULATION AND DENSITY IN GROUPS OF PLACES CLASSIFIED ACCORDING TO SIZE: 1960

Area	Population	Land area in square miles	Population per square mile of land area
United States	179,323,175	3,548,974	51
1,000,000 or more	17,484,059	1,281	13,648
500,000 to 1,000,000	11,110,991	1,888	5,885
250,000 to 500,000	10,765,881	2,401	4,484
100,000 to 250,000	11,652,426	2,728	4,271
50,000 to 100,000	13,835,962	3,539	3,910
25,000 to 50,000	14,950,417	9,319	1,611
10,000 to 25,000	17,568,286	6,939	2,532
5,000 to 10,000	9,779,714	5,005	1,954
2,500 to 5,000	7,580,628	5,242	1,446
Other urban territory	10,540,851	5,917	1,781
Rural territory	54,054,425	3,506,736	15
Within urbanized areas	95,848,487	25,544	3,752
1,000,000 or more	17,484,059	1,281	13,645
500,000 to 1,000,000	11,110,991	1,888	5,885
250,000 to 500,000	10,765,881	2,431	4,404
100,000 to 250,000	11,652,426	2,728	4,271
50,000 to 100,000	13,835,962	3,539	3,910
25,000 to 50,000	6,015,421	2,504	2,398
10,000 to 25,000	8,330,638	2,873	2,900
5,000 to 10,000	2,862,099	1,480	1,933
2,500 to 5,000	1,250,219	866	1,441
Other urban territory	10,540,851	5,917	1,781
Outside urbanized areas	83,474,688	3,523,433	24
25,000 to 50,000	6,935,191	2,725	2,545
10,000 to 25,000	9,237,648	4,366	2,272
5,000 to 10,000	6,917,615	3,517	1,967
2,500 to 5,000	6,329,809	4,386	1,443
Rural territory	54,054,425	3,533,736	15

The distribution of the 1960 U.S. population is shown in Figure 11. A tabulation of U.S. urbanized areas, ranked according to population, is shown in Table 5. Detailed statistics on the land areas, population, and population densities of the central city and urban fringes of the 213 urbanized areas shown in Table 5 are presented in Appendix A. A summary of these statistics is presented in the graphs of Figures 9 and 12.

The U.S. population data summarized above are not very satisfactory inputs to the targeting model described in this paper. One is really interested in the population densities which will pertain in 1970, rather than those which existed in 1960. Further, the definition of urbanized areas, and the scale on which densities were computed, were not devised for the purpose for which they have been used here. A treatment of U.S. census statistics more directly oriented to the needs of civil defense is given in OCD-OEP National Location Code, but as yet without the presentation of land areas and population densities in the central city and the urban fringe.

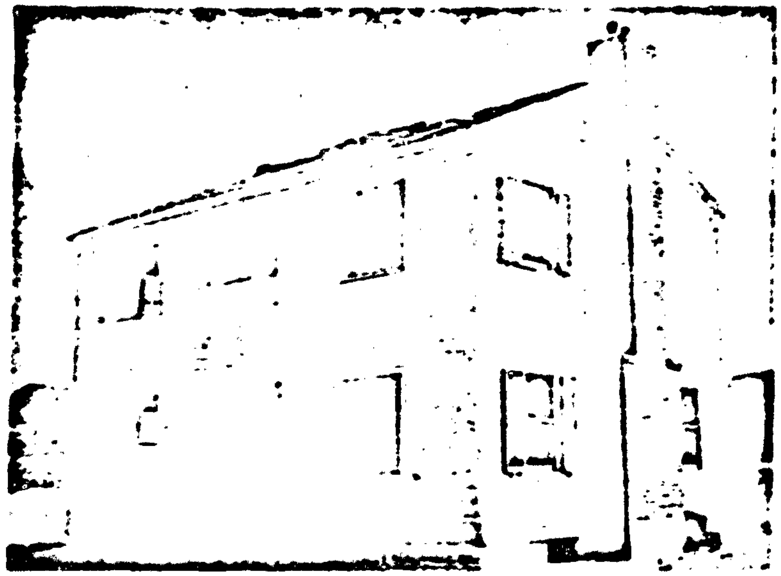


FIGURE 3. Wood-Frame House Exposed to 1.7 psi Overpressure and About 9 cal/cm^2 Thermal Energy (7,500 feet from 16-KT Burst on 300-ft Tower)

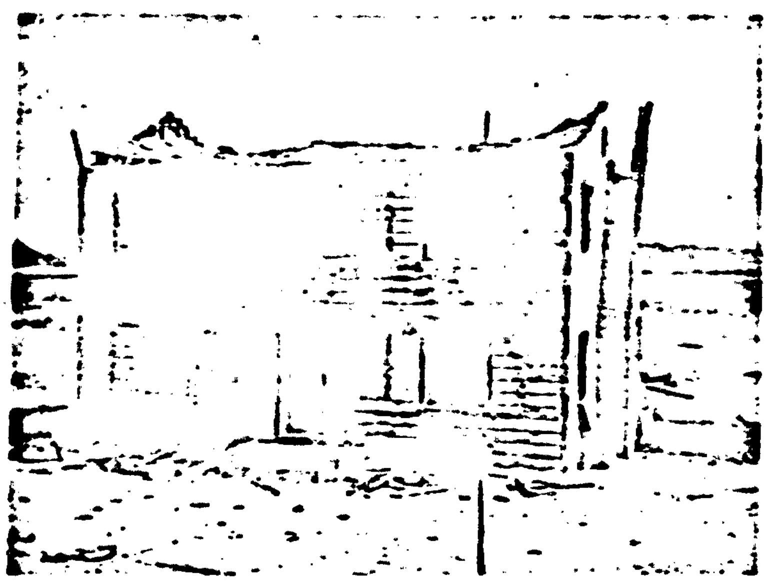


FIGURE 4. Strengthened Wood-Frame House Exposed to 4 psi Overpressure and About 25 cal/cm^2 Thermal Energy (5,500 feet from 29-KT Burst on a 500-ft Tower)

FIGURE 5. Unreinforced Brick House Exposed to 5 psi Overpressure (4,700 feet from 29-KT Burst on a 500-ft Tower)

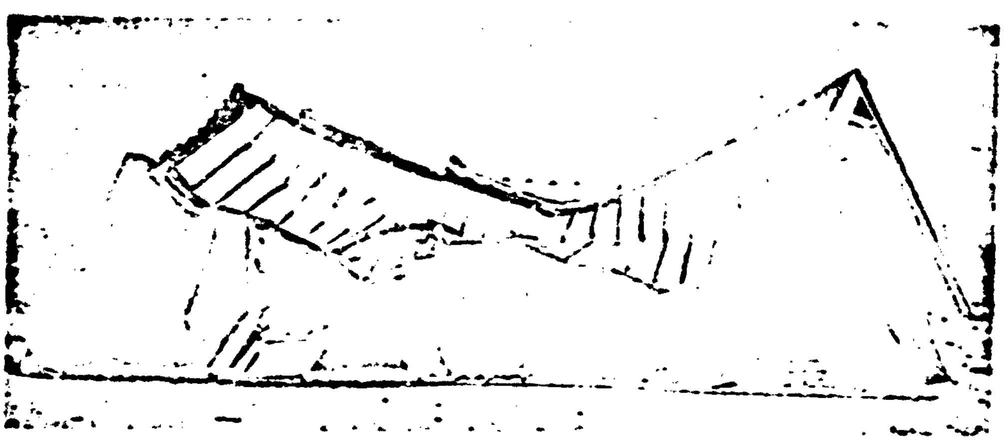


FIGURE 6. Steel-Framing, Steel Panel Building Exposed to 3.1 psi Overpressure

FIGURE 7. Thermal Effects on the Wood-Frame House Immediately After Burst, but Before Arrival of Blast Wave. Thermal Flux was 25 cal/cm^2. House Destroyed by Blast Wave Which Followed. (3,500 feet from 16-KT Burst on a 300-ft Tower)

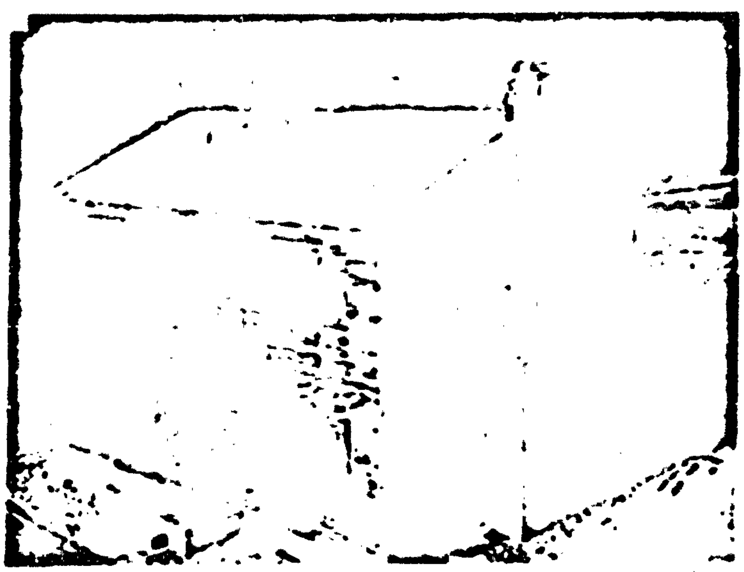


FIGURE 8. Thermal Effects on Wood-Frame House of Figure 7, Two Seconds Later

Table 1. LETHAL RADII AND AREAS FOR THE AIRBURSTS AND SURFACEBURSTS OF A 1-, 8- AND 64-MT WEAPON

Weapon Yield (MT)	Lethal Radius (statute miles)	Lethal Area (statute sq.mi.)
	Surfacebursts	
1	2.75	23.8
8	5.50	95.0
64	11.00	382.0
	Airbursts	
1	4.30	58.0
8	8.60	232.0
64	17.20	926.0

Assumption: Lethal radius corresponds to an overpressure of 5 psi.

$$R_L = R_{L1} Y^{1/3}$$

$$A_L = A_{L1} Y^{2/3}$$

where R_{L1} and A_{L1} are the lethal radius and area of a 1-MT burst.

No one can know what fraction of an enemy's total deliverable megatonage would be allotted to military and to urban targets. It could depend on how the war started, and the extent to which he believed the civil population of his own country had been deliberately attacked. One can, however, make some high and low estimates of the total weight of attack intended for the destruction of U.S. cities, and hypothesize some rough relations governing the total cost -- and presumably therefore the total military effort -- of delivering weapons of different yield to obtain some approximate tradeoffs between the number and yield of weapons which might be used against us if the U.S. were subjected to direct population attacks. The assumption made here, and one which cannot be justified except by general arguments relating to the economies of scale, is that the cost of a strategic weapon delivered over intercontinental distances varies approximately as the 2/3 power of the yield.

Suppose now one has three weights of attack target against a set of (urban) targets corresponding respectively, to the delivery of

100 1-MT bombs,
300 1-MT bombs,
1000 1-MT bombs.

How would these attack levels translate into numbers of weapons and total delivered megatonage if the same effort had been put into 8-MT bombs or 64-MT bombs, if the total cost is held constant?

Let $C(Y)$ = cost per strategic weapon delivered.

Then $C(Y) = C_1 Y^{2/3}$, where C_1 is the cost of delivery of a 1-MT weapon, and Y is the weapon yield in MT.

Let B = Strategic offensive budget for given level of population attack.

<u>Then</u> total number of weapons delivered $= \frac{B}{C(Y)} = \frac{B}{C_1} \frac{1}{Y^{2/3}}$,

total yield delivered $= Y \times \frac{B}{C(Y)} = (\frac{B}{C_1})\, Y^{1/3}$.

The equivalent numbers and yields of weapons for the three attack levels indicated above would then be shown in Table 2.

Table 2. SPECIFICATION OF NUMBER OF WEAPONS AND TOTAL YIELD FOR THREE LEVELS OF ATTACK

ATTACK LEVEL 1		
Attack No. 1	Attack No. 2	Attack No. 3
100 1-MT weapons 100 MT total yield	25 8-MT weapons 200 MT total yield	6 64-MT weapons 384 MT total yield
ATTACK LEVEL 2		
Attack No. 4	Attack No. 5	Attack No. 6
300 1-MT weapons 300 MT total yield	75 8-MT weapons 600 MT total yield	19 64-MT weapons 1216 MT total yield
ATTACK LEVEL 3		
Attack No. 7	Attack No. 8	Attack No. 9
1000 1-MT weapons 1000 MT total yield	250 8-MT weapons 2000 MT total yield	63 64-MT weapons 4032 MT total yield

TOTAL LETHAL AREA AT 5 PSI LEVEL	Attack Level 1	Attack Level 2	Attack Level 3
Surfaceburst	2,300 sq.mi.	7,140 sq.mi.	23,000 sq.mi.
Optimum Air-burst	5,000 sq.mi.	17,000 sq.mi.	56,000 sq.mi.

There is an interesting consequence of the assumptions concerning the cost of deliverable weapons as a function of individual weapon yield, and the manner in which the lethal area of a weapon increases with yield. Namely, for a given expenditure, the combined lethal area of the weapons does not depend on individual weapon yield. That is, the lethal area is the same for each attack level shown in Table 2.

It remains to determine how a given level of attack should be targeted -- that is to say, the location of the ground zeros -- for attacks against people designed to maximize blast fatalities. The basic criteria, discussed above, is that the maximum number of persons be included within the 5 psi overpressure level.

The key element is recognition that the essential factor governing the allocation of weapons is the density of population. It has been shown that for a given level of attack with airbursts or surfacebursts, a fixed amount of lethal area has to be distributed over the United States. Suppose now one has a curve, such as shown in Figure 9, showing the area of the United States for which the population density exceeds any given density D. It may be noted that the maximum number of persons could be covered with a given total lethal area if this area could be distributed in such a way as to cover all those areas in the United States for which the population density is greater than or equal to some minimum density D_{min}, and no areas at all for which the density of population is less than D_{min}. Further, the value of this D_{min} would then be determined from such a curve as that shown in Figure 9, together with the total lethal area available. If then one wished to know how much of the total lethal area should be allocated to any given metropolitan or urbanized area, it would suffice to determine the population density contour around a given city within which the population density is always greater than or equal to D_{min}, and to compute the area within this contour. The area so determined would be the optimum lethal area to allocate to any given city. This lethal area could then be converted back, from a knowledge of the lethal area of individual weapons, to provide a rule for calculating the optimum number of weapons to allocate to that particular city or urbanized area.

To be a strictly valid optimization procedure, this rule would require that the lethal area of a weapon be able to take

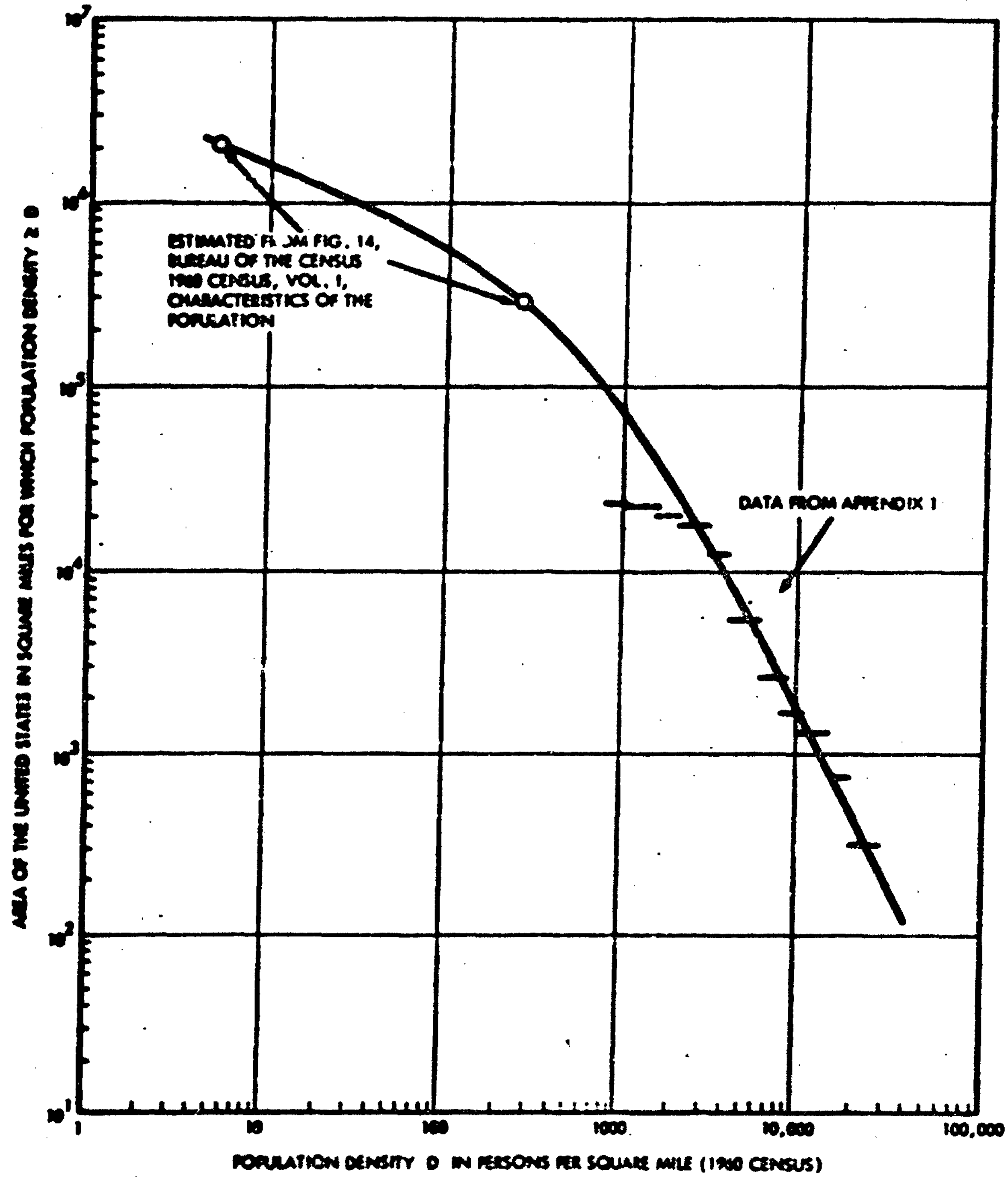


FIGURE 9. Area of the United States for Which the Population Density ≥ D Persons/mi^2 (1960 Census)

any shape to fit, without overlaps or gaps, within any population density contour for which the population density is equal to or greater than D_{min}. It would also be necessary to utilize only a fraction of a weapon in the event the area of a concentration of population for which the D is equal to or greater than D_{min} were less than a lethal area. For the concept of lethal area to be applicable, however, the population density should not vary significantly over linear distances comparable to the lethal radius. That this is the case for the weapon yields considered here (1, 8, 64 MT) can only be verified by a detailed examination of population densities in U.S. urban areas. It may also be noted, however, that since the cost per unit of delivered lethal (blast) area is assumed not to vary with the yield of the individual weapons, it is not unreasonable to assume that for a given level of attack against population, the yield of weapons for attack of a particular target would be selected to cover a given area as uniformly as possible. If one places weapons inside a contour where D is equal to or greater than D_{min} in such a way that the circular lethal areas of individual weapons are just tangent to each other, then one may argue that the gaps between the circular coverage are not too serious inasmuch as the locations not covered by 5 psi from any single weapon will be covered by an overpressure somewhat less than 5 psi from several weapons. But, whatever the approximations involved, the important and essential result is that a simple and direct criterion exists of deducing an optimum, or near optimum, allocation of weapons to any particular target among all the competing targets in the country from (1) one curve showing the area of the U.S. for which the population density exceeds any given amount, (2) a map of the particular target of interest on which contours of constant population density are indicated, and (3) a second curve showing the area within the target area for which the population density exceeds any given amount.

It should be emphasized, of course, that some cities, by virtue of thin colocation with important military targets or important governmental control or industrial centers have a strategic targeting importance for reasons other than population *per se*. Such cities might be attacked much more -- or less -- heavily than indicated by the model. It is also possible that arguments can be made that the best way to disrupt a country and kill its population is to spread the attack much more widely than indicated by the method proposed here on the grounds that the longer range effects of starvation, disease, and economic chaos would take a larger toll if no urban areas were left physically intact. Further the model tells nothing about whether or not an enemy might decide to seek to avoid population fatalities or maximize them, or how much of his total military effort would be allocated to the task of killing people if that were one of his targeting objectives. But it does provide crude but important quantitative guidance to urban and suburban populations *per se* as to magnitude of the various weapon effects to which they could reasonably be subjected in the event the enemy targets in the simplest way to assure maximum prompt population kill.

C. ADDITIONAL CONSEQUENCES OF THE TARGETING MODEL

The model, as presented, leads to a number of interesting side conclusions. First, the selection of ground zeros within the minimum density contour is not directly important. All that matters is that the weapons be laid down in such a way that the entire area is covered with a minimum of gaps or overlaps. There may, of course, be local reasons why particular points within an area would be a more profitable aim point. For example, some might coincide with a higher concentration of industry, or an important governmental seat, or a target of direct military interest. Unless one assumes that a given metropolitan area would be attacked with a single weapon whose circular lethal area coincided approximately with the density contour to be targeted, or unless there are local reasons for assuming the selection of specific aim points, one might assume for the purpose of designing and locating shelters that any point within the contour indicating the density of population to be targeted is as likely to be a ground zero as any other point. Under this assumption the model gives an indication of the potential value of constructing a shelter which will withstand a given overpressure level, provided the enemy targets for maximum population kill on the assumption of an unsheltered population. The value of the potential shelter protection so afforded is, in fact, independent of the yield of the individual weapons employed, or whether or not targeting (for blast kill) is done on the basis of an airburst or surfaceburst. For suppose the lethal radius of a single weapon corresponds to X psi, and that a shelter is built to withstand Z psi. Then if R_{L1} is the lethal radius of a 1-MT weapon, the lethal area of a Y-MT weapon will be $\pi(R_{L1}Y^{1/3})^2$. If R_{Z1} is the distance to which an overpressure of Z psi is experienced from a 1-MT weapon, then $\pi(R_{Z1}Y^{1/3})^2$ will be the area over which this overpressure is experienced from a Y-MT bomb. Thus the protection offered by the shelter capable of withstanding Z psi, and located at random within the targeted area will be given by the ratio

$$\frac{\pi\left(R_{Z1}Y^{1/3}\right)^2}{\pi\left(R_{L1}Y^{1/3}\right)^2} = \left(\frac{R_{Z1}}{R_{L1}}\right)^2$$

and this holds for both airbursts or surfacebursts. Assuming, as before, that R_{L1} corresponds to 5 psi, one can then plot potential survival probability in a Z psi shelter provided that targeting is done to achieve maximum population kill against an unsheltered population. Such a curve is shown in Figure 10. The value of achieving shelter protection in the range of 20-30 psi is immediately apparent.

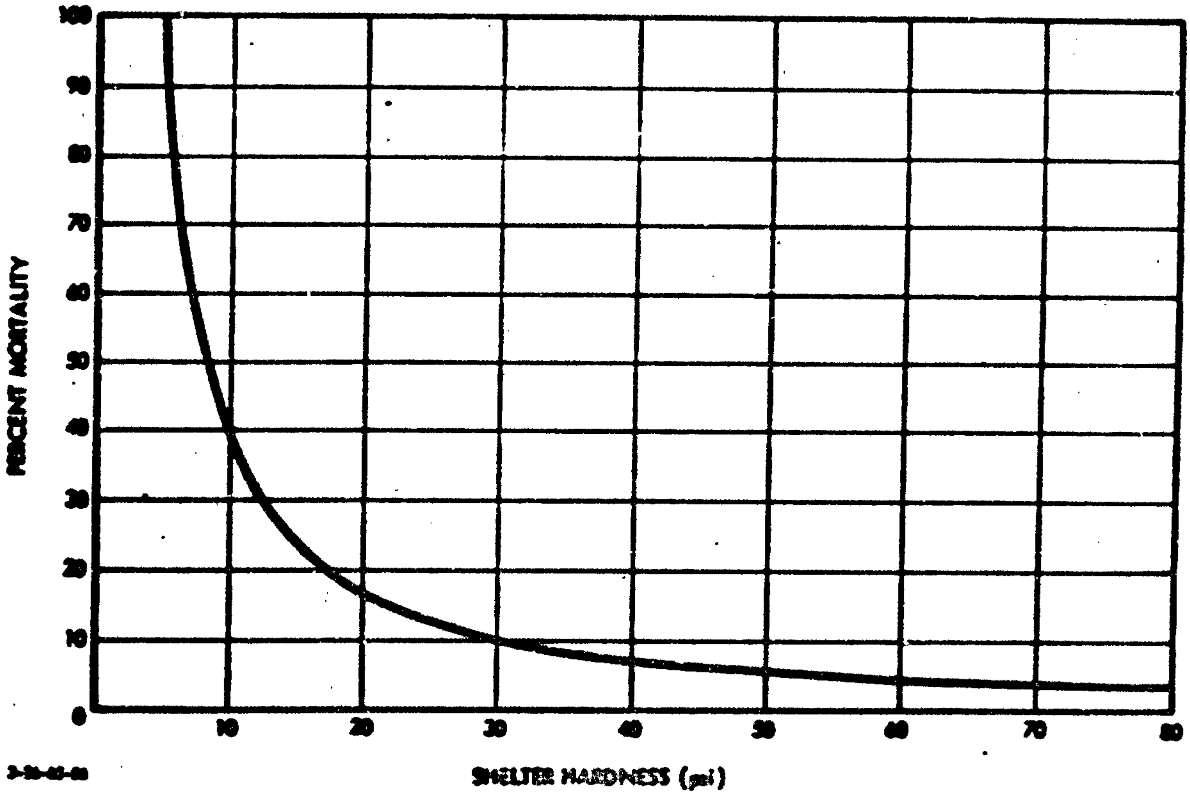


FIGURE 10. Percent Mortality in a Targeted Area, Assuming Targeting Optimized to Cover the Maximum Number of Persons with an Overpressure of 5 psi

Finally, it may be noted that the targeting model herein proposed can still be applied if the population of certain densely settled areas is sheltered to any specified level of blast protection provided the density of population in the sheltered areas is first assumed to be reduced by the same ratio as plotted in Figure 10. This means, for example, that the effect of a 30 psi shelter, from the point of view of an enemy targeteer trying to optimize fatalities in an unsheltered population, is to reduce the density of population in a specific area by a factor of 10. This would suggest that for a given level of attack, some persons who would not be targeted in an unsheltered population would then become logical targets for direct attack. The total national casualties would decrease, however, depending (in a complex way) on how many persons in what areas were sheltered, and to what level of protection.

Table 3. POPULATION OF THE UNITED STATES AND OUTLYING AREAS: 1960 and 1950

	1960	1950	Increase, 1950 to 1960	
			Number	Percent
Total	183,285,009	154,233,234	29,051,775	18.8
United States	179,323,175	151,325,798	27,997,377	18.5
Conterminous United States	178,464,236	150,697,361	27,766,875	18.4
Alaska	226,167	128,643	97,524	75.8
Hawaii	632,772	499,794	132,978	26.6
Commonwealth of Puerto Rico	2,349,544	2,210,703	138,841	6.3
Outlying areas of sovereignty or jurisdiction	237,869	215,188	22,681	10.5
United States population abroad	1,374,421	481,545	892,876	185.4

D. THE POPULATION OF THE UNITED STATES

The utility of the targeting model described -- or that of any other model -- depends in part on the distribution of the population of the United States over the land area of the United States. The principal characteristics of this population distribution, as abstracted from references,[1] are here summarized. The data and conclusions given are all based on the 1960 census. The principal factor to keep in mind when projecting these figures into the future are that the U.S. population is not only growing, but, as described below, is becoming relatively more concentrated.

On April 1, 1960, the population of the 48 conterminous states, with total land area of about 3 million square miles, was 178, 464, 236 (see Table 3). By 1970 it is estimated that

[1] U.S. Department of Commerce, Bureau of the Census, 1960 Census, Vol. I, Characteristics of the ulation, U.S. Government Printing Office, Washington, D. C., 1961.
OCD-OEP National Location Code, prepared by the Bureau of the Census for the Office of Civil Defense, Department of Defense, and the National Resource Evaluation Center, Office of Emergency Planning, 1962 (in 8 volumes), Unclassified.
Bureau of the Budget, Executive Office of the President, Standard Metropolitan Statistical Areas, 1964.

the same 48 states will have increased in population to about 210 million persons (an increase of about 32 million persons, or almost 18 percent). Whereas in 1960 almost 70 percent of the population lived in urbanized areas,[1] by 1970 it is estimated that this figure will increase to about 80 percent.

In 1960, the urban population was concentrated in slightly more than 1 percent of the land area of the country (Table 4). The population of urbanized areas, something more than one-half of the total, occupied less than 1 percent of the total land area. Among urban places, the number of inhabitants per square mile decreased as size of place decreased. For places of 1,000,000 inhabitants or more, the average density was 13,865 persons per square mile; for places between 100,000 and 1,000,000, average densities ranged between 4,000 and 6,000 per square mile, and the average density for places of 2,500 to 5,000 was 1,446. In urban-fringe areas outside urban places, the average density was 1,781 per square mile, and in rural territory the density was 15. The average population density for the 48 conterminous states was about 60 persons/square mile.

---

[1] From 1960 Census, Vol. I, op. cit.:

"Urban and rural residence.--According to the definition adopted for use in the 1960 Census, the urban population comprises all persons living in (a) places of 2,500 inhabitants or more incorporated as cities, boroughs, villages, and towns (except towns in New England, New York, and Wisconsin); (b) the densely settled urban fringe, whether incorporated or unincorporated, of urbanized areas; (c) towns in New England and townships in New Jersey and Pennsylvania which contain no incorporated municipalities as subdivisions and have either 25,000 inhabitants or more or a population of 2,500 to 25,000 and a density of 1,500 persons or more per square mile; (d) counties in States other than the New England States, New Jersey, and Pennsylvania that have no incorporated municipalities within their boundaries and have a density of 1,500 persons per square mile; and (e) unincorporated places of 2,500 inhabitants or more. In other words, the urban population comprises all persons living in urbanized areas and in places of 2,500 inhabitants or more outside urbanized areas. The population not classified as urban constitutes the rural population."

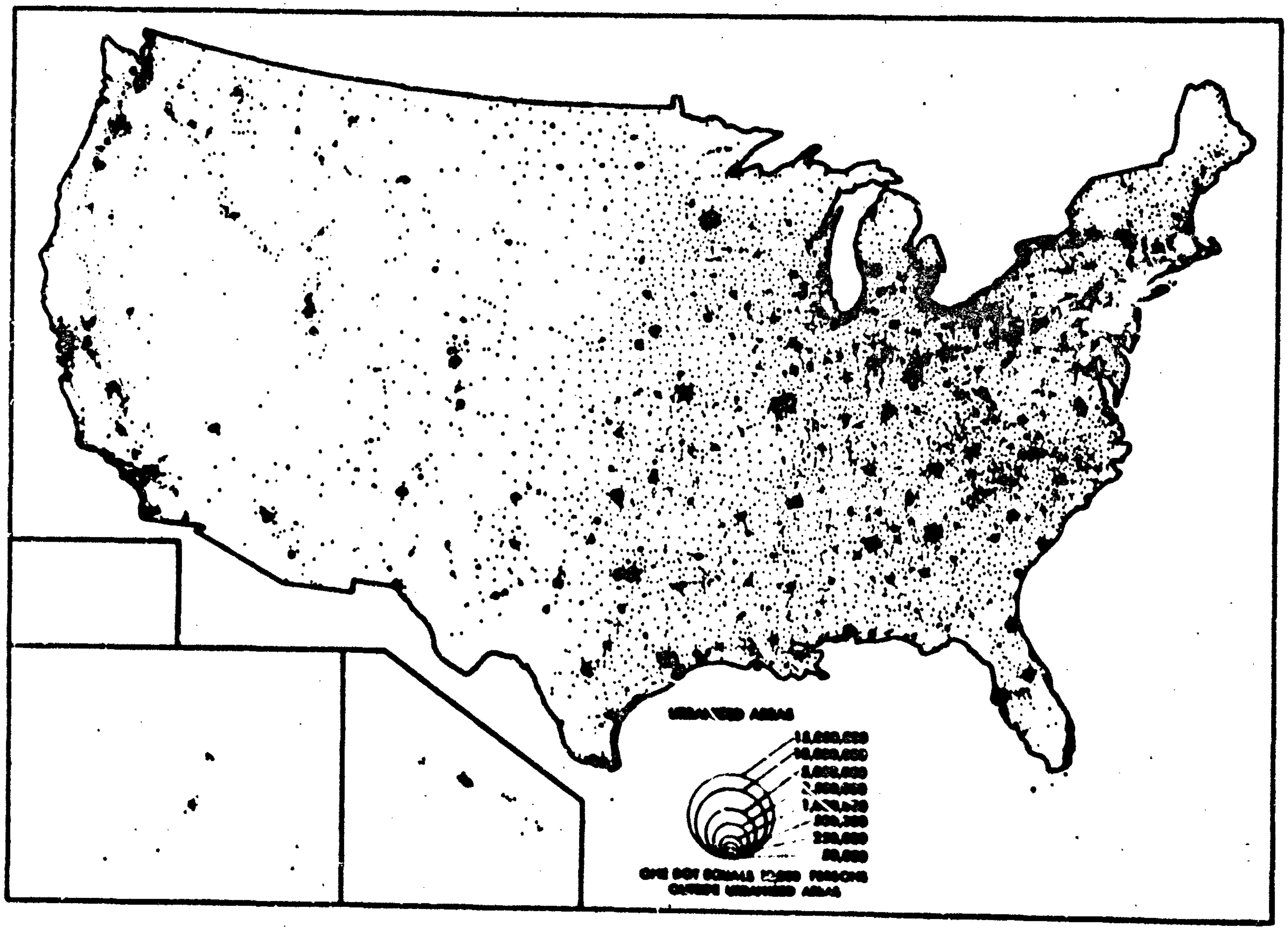


FIGURE II. Distribution of U.S. Population, 1960 ble 4. POPULATION AND DENSITY GROUPS OF PLACES CLASSIFIED ACCORDING TO SIZE: 1960

Area	Population	Land area in square miles	Population per square mile of land area
United States	179,323,175	3,540,974	51
000,000 or more	17,484,059	1,281	13,646
0,000 to 1,000,000	11,110,991	1,888	5,885
0,000 to 500,000	10,765,881	2,401	4,484
0,000 to 250,000	11,652,425	2,728	4,271
,000 to 100,000	13,836,902	3,539	3,910
,000 to 50,000	14,950,612	5,319	2,811
,000 to 25,000	17,468,306	6,929	2,532
00 to 10,000	9,779,714	5,005	1,954
00 to 5,000	7,580,028	5,242	1,446
her urban territory	10,840,851	5,917	1,781
ral territory	54,054,425	3,500,736	15
thin urbanized areas	95,848,487	25,544	3,752
000,000 or more	17,484,059	1,281	13,645
0,000 to 1,000,000	11,110,991	1,888	5,885
0,000 to 500,000	10,765,881	2,401	4,484
0,000 to 250,000	11,652,425	2,728	4,271
,000 to 100,000	13,836,902	3,539	3,910
,000 to 50,000	6,015,421	2,594	2,090
,000 to 25,000	6,230,630	2,073	2,906
00 to 10,000	2,882,090	1,488	1,923
00 to 5,000	1,290,719	884	1,461
her urban territory	10,840,851	5,917	1,781
tside urbanized areas	83,474,686	3,523,436	24
,000 to 50,000	6,936,191	2,725	2,545
,000 to 25,000	9,237,640	4,066	2,272
00 to 10,000	6,917,615	3,517	1,967
00 to 5,000	6,329,809	4,388	1,443
ral territory	54,054,425	3,500,736	15

The distribution of the 1960 U.S. population is shown in Figure 11. A tabulation of U.S. urbanized areas, ranked according to population, is shown in Table 5. Detailed statistics on the land areas, population, and population densities of the central city and urban fringes of the 213 urbanized areas shown in Table 5 are presented in Appendix A. A summary of these statistics is presented in the graphs of Figures 9 and 12.

The U.S. population data summarized above are not very satisfactory inputs to the targeting model described in this paper. One is really interested in the population densities which will pertain in 1970, rather than those which existed in 1960. Further, the definition of urbanized areas, and the scale on which densities were computed, were not devised for the purpose for which they have been used here. A treatment of U.S. census statistics more directly oriented to the needs of civil defense is given in OCD-OEP National Loca-
on Code, but as yet without the presentation of land areas and
pulation densities in the central city and the urban fringe.

Table 5. RANK OF U.S. URBANIZED AREAS ACCORDING TO THE 1960 CENSUS

Rank	Urbanized Area	Population	Rank	Urbanized Area	Population	Rank	Urbanized Area	Population
1	New York-Northeastern New Jersey	14,114,927	71	Des Moines, Iowa	241,115	141	Kalamazoo, Mich.	115,659
2	Los Angeles-Long Beach, Calif.	6,488,791	72	Wilkes-Barre, Pa.	233,932	142	Ann Arbor, Mich.	115,282
3	Chicago-Northwestern Indiana	5,959,213	73	Tucson, Ariz.	227,433	143	Macon, Ga.	114,161
4	Philadelphia, Pa.-N.J.	3,635,228	74	Davenport-Rock Island-Moline, Iowa-Ill.	227,176	144	Lexington, Ky.	111,940
5	Detroit, Mich.	3,537,709	75	Spokane, Wash.	226,938	145	Portland, Maine	111,701
6	San Francisco-Oakland, Calif.	2,430,663	76	Worcester, Mass.	225,446	146	Springfield, Ill.	111,403
7	Boston, Mass.	2,413,236	77	South Bend, Ind.-Mich.	218,933	147	Brockton, Mass.	111,315
8	Washington, D.C.-Md.-Va.	1,808,423	78	Tacoma, Wash.	214,930	148	Cedar Rapids, Iowa	105,118
9	Pittsburgh, Pa.	1,804,400	79	Canton, Ohio	213,574	149	Pueblo, Colo.	103,336
10	Cleveland, Ohio	1,784,991	80	Fresno, Calif.	213,444	150	Waterloo, Iowa	102,827
11	St. Louis, Mo.-Ill.	1,667,693	81	Scranton, Pa.	210,676	151	Wichita Falls, Texas	102,104
12	Baltimore, Md.	1,418,948	82	Charlotte, N.C.	209,551	152	York, Pa.	100,872
13	Minneapolis-St. Paul, Minn.	1,377,143	83	Harrisburg, Pa.	209,501	153	Colorado Springs, Colo.	100,220
14	Milwaukee, Wis.	1,149,997	84	Newport News-Hampton, Va.	208,874	154	New Britain, Conn.	99,894
15	Houston, Texas	1,139,678	85	Shreveport, La.	208,583	155	Wheeling, W.Va.-Ohio	98,951
16	Buffalo, N.Y.	1,054,370	86	Chattanooga, Tenn.-Ga.	205,143	156	Sioux City, Iowa-Nebr.-S. Dak.	97,926
17	Cincinnati, Ohio-Ky.	993,568	87	Orlando, Fla.	200,955	157	Springfield, Mo.	97,224
18	Dallas, Texas	932,349	88	Baton Rouge, La.	193,485	158	Green Bay, Wis.	97,162
19	Kansas City, Mo.-Kans.	921,121	89	Utica-Rome, N.Y.	187,779	159	Johnstown, Pa.	96,474
20	Seattle, Wash.	864,109	90	Austin, Texas	187,187	160	Racine, Wis.	95,862
21	Miami, Fla.	852,705	91	Pomona-Ontario, Calif.	186,547	161	Eugene, Oreg.	95,600
22	New Orleans, La.	845,237	92	Little Rock-North Little Rock, Ark.	185,017	162	Muskegon-Muskegon Heights, Mich.	95,390
23	San Diego, Calif.	836,175	93	Peoria, Ill.	181,432	163	Raleigh, N.C.	93,931
24	Denver, Colo.	803,624	94	Fort Wayne, Ind.	179,571	164	Lancaster, Pa.	93,855
25	Atlanta, Ga.	768,125	95	Erie, Pa.	177,433	165	Manchester, N.H.	91,696
26	Providence-Pawtucket, R.I.-Mass.	659,542	96	Corpus Christi, Texas	177,380	166	Abilene, Texas	91,566
27	Portland, Oreg.-Wash.	651,685	97	West Palm Beach, Fla.	172,835	167	Springfield, Ohio	90,157
28	San Antonio, Texas	641,965	98	Knoxville, Tenn.	172,734	168	Hamilton, Ohio	89,778
29	Indianapolis, Ind.	639,340	99	Rockford, Ill.	171,681	169	Decatur, Ill.	89,516
30	Columbus, Ohio	616,743	100	Savannah, Ga.	169,887	170	Las Vegas, Nev.	89,427
31	Louisville, Ky.-Ind.	606,659	101	Charleston, W.Va.	169,530	171	Lake Charles, La.	89,115
32	San Jose, Calif.	602,805	102	Lansing, Mich.	169,325	172	Aurora, Ill.	85,522
33	Phoenix, Ariz.	552,043	103	Stamford, Conn.	166,997	173	Durham, N.C.	84,642
34	Memphis, Tenn.	544,505	104	Lawrence-Haverhill, Mass.-N.H.	166,125	174	Odessa, Texas	84,285
35	Birmingham, Ala.	521,330	105	Huntington-Ashland, W.Va.-Ky.-Ohio	165,732	175	Altoona, Pa.	34,058
36	Norfolk-Portsmouth, Va.	507,825	106	Columbia, S.C.	162,62[illegible]	176	Norwalk, Conn.	82,270
37	Fort Worth, Texas	502,682	107	Reading, Pa.	160,297	177	Steubenville-Weirton, Ohio-W. Va.	81,613
38	Dayton, Ohio	501,664	108	Charleston, S.C.	160,113	178	Terre Haute, Ind.	81,415
39	Rochester, N.Y.	493,402	109	Columbus, Ga.-Ala.	158,382	179	St. Joseph, Mo.-Kans.	81,187
40	Akron, Ohio	458,253	110	Binghamton, N.Y.	158,141	180	Monroe, La.	80,546
41	Albany-Schenectady-Troy, N.Y.	455,447	111	Madison, Wis.	157,814	181	Champaign-Urbana, Ill.	78,014
42	Sacramento, Calif.	451,920	112	Jackson, Miss.	147,480	182	Muncie, Ind.	77,504
43	Springfield-Chicopee-Holyoke, Mass.-Conn.	449,777	113	Duluth-Superior, Minn.-Wis.	144,763	183	Tuscaloosa, Ala.	76,815
44	Toledo, Ohio	430,283	114	Evansville, Ind.	143,663	184	Huntsville, Ala.	74,970
45	Oklahoma City, Okla.	429,188	115	Montgomery, Ala.	142,893	185	Kenosha, Wis.	72,852
46	Omaha, Nebr.-Iowa	389,881	116	Lorain-Elyria, Ohio	142,063	186	Bay City, Mich.	72,763
47	Hartford, Conn.	381,619	117	Bakersfield, Calif.	141,763	187	Santa Barbara, Calif.	72,740
48	San Bernardino-Riverside, Calif.	377,531	118	Waterbury, Conn.	141,626	188	Fargo-Moorhead, N. Dak.-Minn.	72,730
49	Youngstown-Warren, Ohio-Pa.	372,748	119	Stockton, Calif.	141,624	189	Fitchburg-Leominster, Mass.	72,347
50	Jacksonville, Fla.	372,569	120	Amarillo, Texas	137,969	190	Jackson, Mich.	71,412
51	Bridgeport, Conn.	366,654	121	Lincoln, Nebr.	136,220	191	Reno, Nev.	70,189
52	Honolulu, Hawaii	351,336	122	Lubbock, Texas	129,283	192	Gadsden, Ala.	68,944
53	Salt Lake City, Utah	348,661	123	Saginaw, Mich.	129,215	193	Asheville, N.C.	68,592
54	Nashville, Tenn.	346,729	124	Winston-Salem, N.C.	128,176	194	Sioux Falls, S. Dak.	66,582
55	Richmond, Va.	333,438	125	Pensacola, Fla.	128,043	195	High Point, N.C.	66,543
56	Syracuse, N.Y.	333,286	126	Greenville, S.C.	126,887	196	Lewiston-Auburn, Maine	65,253
57	St. Petersburg, Fla.	324,842	127	New Bedford, Mass.	126,657	197	Midland, Texas	63,274
58	Fort Lauderdale-Hollywood, Fla.	319,951	128	Atlantic City, N.J.	124,902	198	Lima, Ohio	62,963
59	Tampa, Fla.	301,790	129	Roanoke, Va.	124,752	199	Pittsfield, Mass.	62,396
60	Tulsa, Okla.	298,922	130	Fall River, Mass.-R.I.	123,951	200	Lawton, Okla.	61,941
61	Grand Rapids, Mich.	294,230	131	Augusta, Ga.-S.C.	123,698	201	Harlingen-San Benito, Texas	61,658
62	Wichita, Kans.	292,130	132	Greensboro, N.C.	123,334	202	Fort Smith, Ark.-Okla.	61,640
63	Wilmington, Del.-N.J.	283,667	133	Ogden, Utah	121,927	203	Provo-Orem, Utah	60,795
64	New Haven, Conn.	278,794	134	Topeka, Kans.	119,503	204	Billings, Mont.	60,712
65	Flint, Mich.	277,786	135	Beaumont, Texas	119,178	205	Laredo, Texas	60,678
66	El Paso, Texas	277,128	136	Lowell, Mass.	118,547	206	Dubuque, Iowa-Ill.	59,447
67	Mobile, Ala.	260,130	137	Galveston-Texas City, Texas	118,482	207	Lynchburg, Va.	59,319
68	Allentown-Bethlehem, Pa.	256,016	138	Joliet, Ill.	116,585	208	San Angelo, Texas	58,815
69	Trenton, N.J.-Pa.	242,46[illegible]	139	Port Arthur, Texas	116,365	209	Albany, Ga.	58,353
70	Albuquerque, N. Mex.	241,216	140	Waco, Texas	116,163	210	Great Falls, Mont.	57,629
						211	Texarkana, Texas-Ark.	53,420
						212	Meriden, Conn.	51,850
						213	Tyler, Texas	51,739

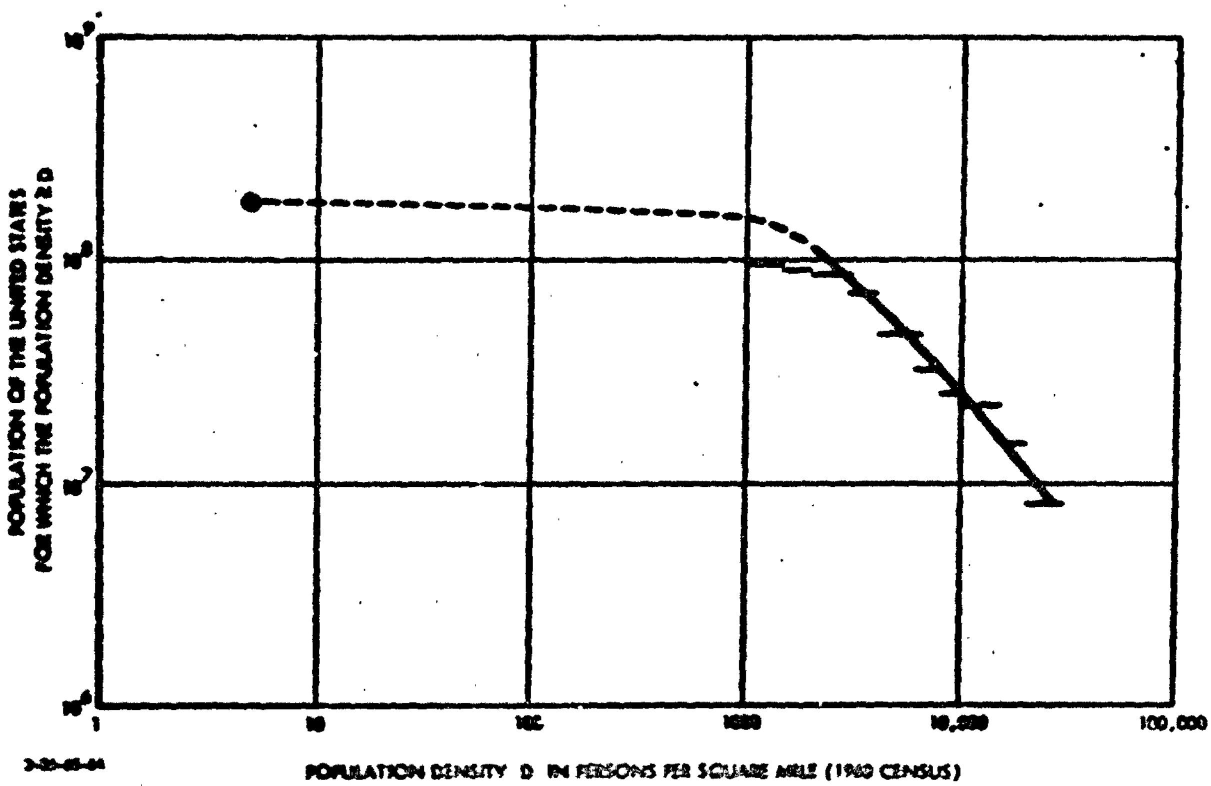


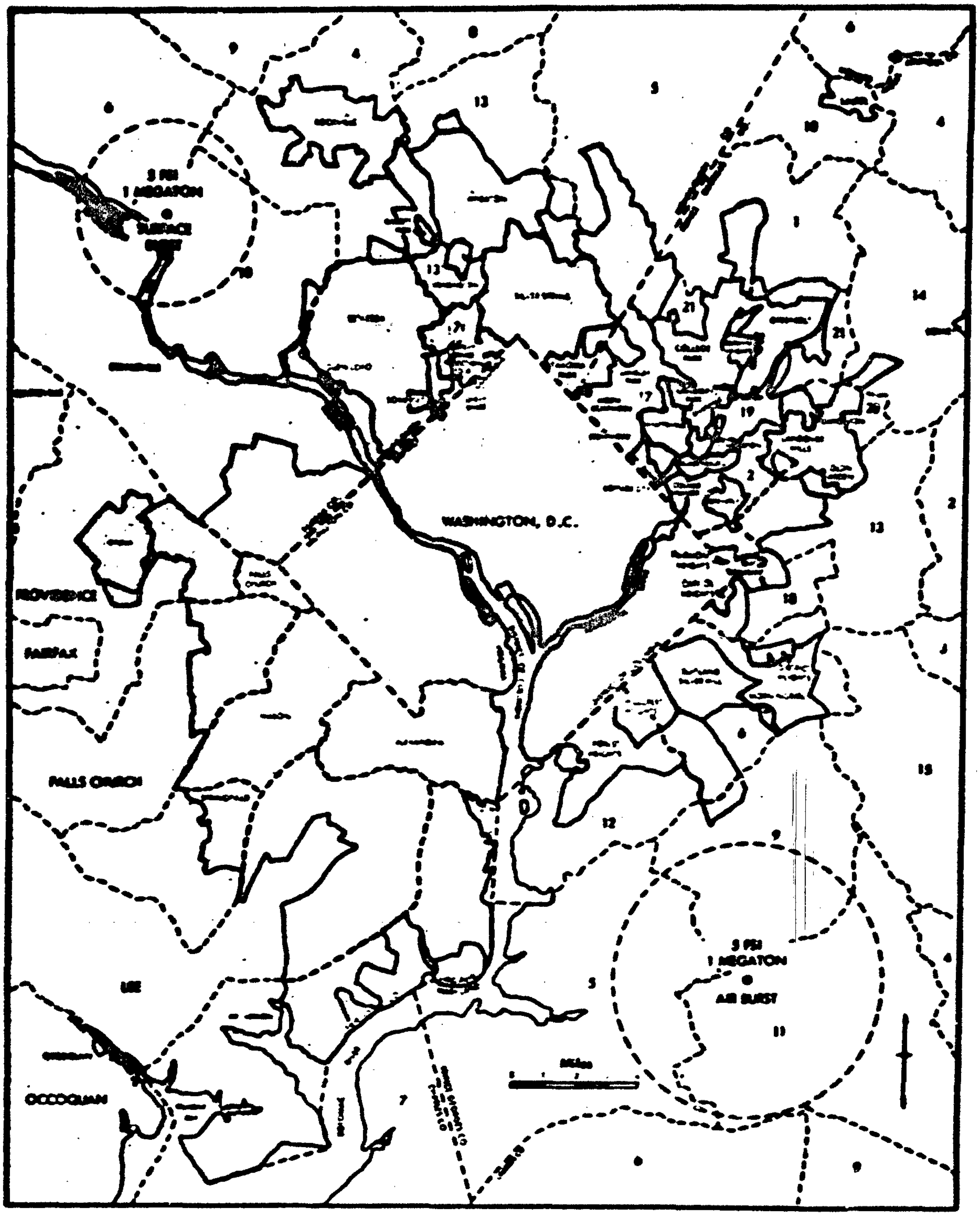
FIGURE 12. Estimate of the Population of the United States for Which the Population Density is ≥ D Persons/mi^2 (1960 Census)

E. THE TARGETING MODEL APPLIED TO A SPECIFIC URBAN AREA

The 1960 population, land area, and population density of the Washington (D.C., Md., Va.) urbanized area are listed in Appendix A as follows:

Urbanized Area	Population	Land Area (Mi.^{2})	Density of Population (Persons/mi.^{2})
Washington (D.C., Md., Va.)	1,808,423	340.0	5,308
Washington	763,956	61.4	12,442
Urban fringe	1,044,467	279.3	3,740

Further details on the character of this area as a population target are provided by the map of Figure 13, the population data of Table 6, and by an estimate of the amount of this urbanized area for which the population density exceeds any given amount (Figure 14).



NOTE: Refer to Table VI for population of indicated subdivisions of Washington, D.C.

URBANIZED AREA

FIGURE 13. Washington (D.C., Md., Va.) Urbanized Area, 1960 Census

3-20-65-59

Table 6. POPULATION STATISTICS FOR THE WASHINGTON (D.C., MD., VA.) URBANIZED AREA, 1960 CENSUS

Area	1960	1950
WASHINGTON (D.C.-MD.-VA.) URBANIZED AREA		
The area.	1,808,423	1,287,333
Washington, D.C.	763,956	802,178
Outside central city	1,044,467	485,155
The area includes the following minor civil divisions and parts of minor civil divisions:		
In the District of Columbia .	763,956	802,178
Washington, D.C.	763,956	802,178
In Maryland	[illegible]	253,623
Montgomery County (part)	300,540	117,637
Dist. 4, Rockville (part). . . .	34,208	671
Garrett Park town	968	696
Rockville city (part)	26,090	(1)
Dist. 5, Colesville (part) . . .	11,961	(1)
Dist. 7, Bethesda.	83,197	42,867
Bethesda (U).	56,527	(1)
Chevy Chase village	2,405	1,971
Chevy Chase Section Four village	2,243	(2)
Glen Echo town.	310	306
Somerset town	1,444	420
Dist. 10, Potomac (part)	538	190
Dist. 13, Wheaton (part)	170,637	74,241
Kensington town	2,175	1,611
Rockville city (part)	---	(1)
Silver Spring (U)	66,348	(1)
Takoma Park city (part) . . .	11,540	9,[illegible]
Wheaton (U)	54,635	(1)
Prince Georges County (part) . . .	289,440	135,[illegible]
Dist. 1, Vansville (part). . . .	5,223	579
College Park city (part). . .	1,318	---
Dist. 2, Bladensburg.	31,033	17,894
Bladensburg town.	3,103	2,899
Cheverly town (part).	4,911	3,117
Colmar Manor town	1,772	1,732
Cottage City town	1,099	1,349
Edmonston town (part)	---	---
Landover Hills town	1,850	1,661
Dist. 6, Spauldings (part) . . .	58,934	16,733
District Heights town	7,524	1,735
Hillcrest Heights (U) (part).	13,086	(1)
Morningside town.	1,708	1,[illegible]
Suitland-Silver Hill (U). . .	10,300	(1)
Dist. 9, Surratts (part)	1,296	(1)
Dist. 12, Oxon Hill (part) . . .	19,446	2,404
Forest Heights town	3,524	1,125
Hillcrest Heights (U) (part).	1,410	(1)
In Maryland--Con.		
Prince Georges County (part)--Con.		
Dist. 13, Kent (part)	12,868	2,464
Glenarden town (part).	881	(1)
Dist. 14, Bowie (part).	1,252	(1)
Dist. 16, Hyattsville	16,082	13,748
Edmonston town (part).	1,197	1,193
Hyattsville city (part). . . .	14,546	12,258
Dist. 17, Chillum	68,547	35,481
Brentwood town	3,693	3,523
Hyattsville city (part). . . .	622	---
Langley Park (U)	11,510	(1)
Mount Rainier city	9,855	10,989
North Brentwood town	864	833
Takoma Park city (part). . . .	5,284	3,950
Dist. 18, Seat Pleasant (part). .	55,181	15,592
Capitol Heights town	3,138	2,729
Cheverly town (part)	312	201
Fairmount Heights town.	2,308	2,097
Seat Pleasant town	5,365	2,255
Dist. 19, Riverdale	18,886	12,148
Carrollton city (part)	---	(3)
College Park city (part) . . .	---	---
Edmonston town (part).	---	(1)
Riverdale town	4,389	5,530
University Park town (part). .	3,091	2,235
Dist. 20, Lanham (part)	11,701	1,829
Carrollton city (part)	3,385	(3)
Glenarden town (part).	665	---
Dist. 21, Berwyn (part)	38,363	18,941
Berwyn Heights town.	2,376	674
College Park city (part). . . .	17,264	11,170
Greenbelt city	7,479	7,074
University Park town (part). .	7	---
In Virginia.	608,887	231,732
Arlington County.	163,401	135,449
Fairfax County (part)	300,071	26,961
Dranesville Dist. (part). . . .	35,837	(1)
Falls Church Dist..	36,039	14,511
Lee Dist. (part).	31,082	(1)
Mason Dist. (part).	60,031	(1)
Springfield (U).	10,783	---
Mount Vernon Dist. (part)	60,576	11,489
Providence Dist. (part)	19,506	961
Vienna town.	11,440	(1)
Alexandria city	91,023	61,787
Falls Church city	10,192	7,535

[1]Not in area in 1950.
[2]Not reported separately in 1950.
[3]Incorporated since 1950.

Standard metropolitan statistical area, central city, and other component areas	1960	1950	Increase	
			Number	Percent
WASHINGTON, D.C.-MD.-VA.				
Total.	2,001,897	1,464,089	537,808	36.7
Washington, D.C. . . .	763,956	802,178	-38,222	-4.8
Outside central city .	1,237,941	661,911	576,030	87.0

Standard metropolitan statistical area, central city, and other component areas	1960	1950	Increase	
			Number	Percent
Washington, D.C. . . .	763,956	802,178	-38,222	-4.8
Alexandria city, Va. .	91,023	61,787	29,236	47.3
Falls Church city, Va.	10,192	7,535	2,657	35.3
Arlington County, Va..	163,401	135,449	27,952	20.6
Fairfax County, Va. .	275,002	98,557	176,445	179.0
Montgomery County, Md.	340,928	164,401	176,527	107.4
Prince Georges County, Md..	357,395	194,182	163,213	84.1

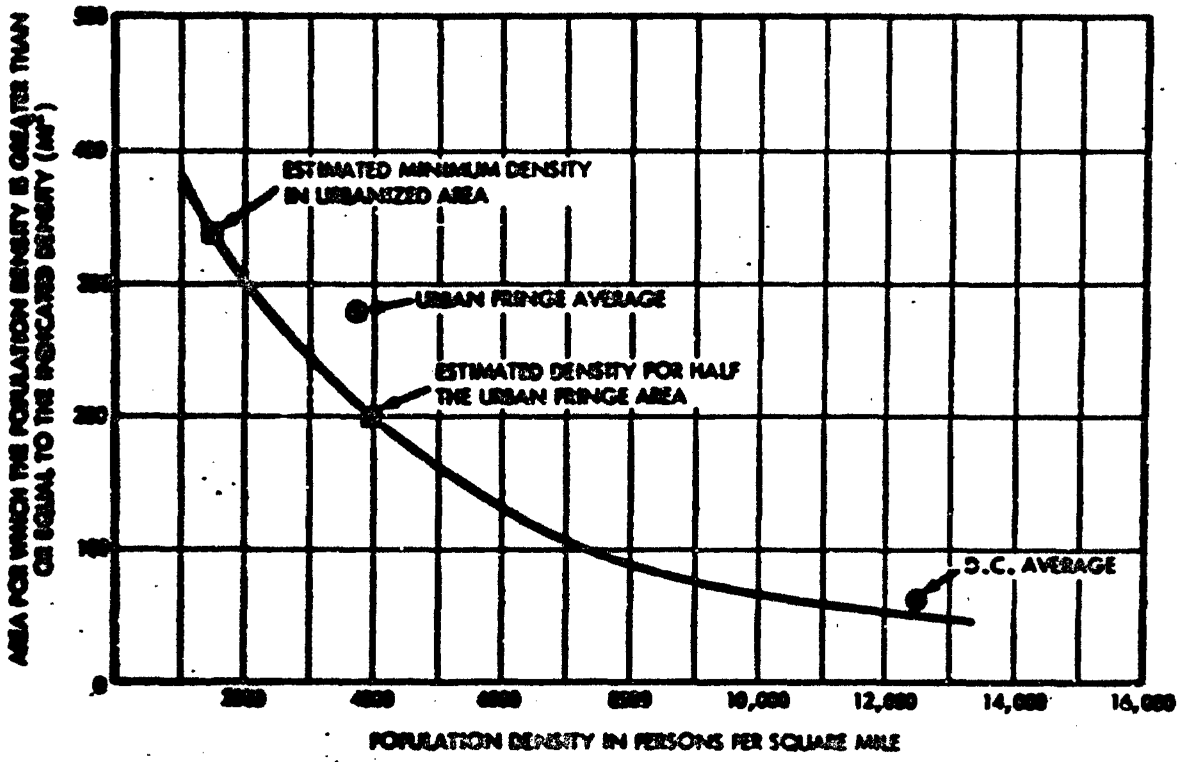


FIGURE 14. Estimated Area of the Washington (DC, Md., Va.) Urbanized Area for Which the Population Density Exceeds any Given Density

The total lethal areas(at the 5 psi level) of illustrative Attack Levels 1, 2 and 3 were summarized in Table 2. These areas may be translated into the minimum population density to be targeted throughout the whole United States through the curve of Figure 9, and thence into the area within the Washington, D. C. urbanized area to be targeted through the curve of Figure 14. The results, together with the number of 1-MT airbursts or surfacebursts allocated to the Washington area for each attack level, assuming all weapons had a yield of 1 MT, and all were either airburst or surfaceburst, are presented in Table 7.

Table 7 shows that for the three illustrative attack levels of Table 2, a minimum of one-fourth, and a maximum of all the Washington urbanized area -- always including all of the District

Table 7. WEAPONS ALLOCATION TO THE WASHINGTON URBANIZED AREA FOR ATTACKS WITH 1-MT WEAPONS

	Attack Level 1 ([illegible] 1-MT bombs)	Attack Level 2 ([illegible] 1-MT bombs)	Attack Level 3 ([illegible] 1-MT bombs)
Surfacebursts			
Density to target in U.S. (persons/mi²)	[illegible]	[illegible]	[illegible]
Estimated area to target in Washington, D.C. area (square miles)	[illegible]	163	[illegible]
Lethal area/weapon for 1-MT weapon (square miles)	23.8	23.8	23.8
Number 1-MT weapons assigned to Washington, D.C. area	3 or 4	7 or 8	12
Airbursts			
Density to target in U.S. (persons/mi²)	[illegible]	2700	1300
Estimated area to target in Washington, D.C. urbanized area (square miles)	162	[illegible]	[illegible]
Lethal area/weapon for 1-MT weapon (square miles)	[illegible]	[illegible]	[illegible]
Number 1-MT weapons assigned to Washington, D.C. area	3	4 or 5	6

of Columbia -- might reasonably be considered subjected to a blast overpressure of at least 5 psi (and therefore to a thermal pulse of 50 cal/cm^2). The total number of 1-MT weapons allocated to this area is seen to lie between 3 and 12, depending on the level of the attack and whether or not targeting was done on the basis of airbursts or surfacebursts. The actual ground zero, for any given type and level of attack, could be selected in a variety of ways and still subject approximately the same number of persons to 5 psi.

It would be possible to be more precise as to the most desirable ground zeros provided there were population density contour maps of the Washington urbanized area in which the density at any given point is defined as the number of persons included within a weapon's lethal area centered on that point. Use of the lethal area as the unit of area for density computational purposes would smooth out the substantial density variations between nearby communities when a square mile is the unit area. This means that there would be different population density contours for weapons of different yield, and for weapons of the same yield, depending on whether or not they were airburst or surfaceburst.

From the estimate of area to be targeted shown in Table 7 and the lethal areas of the 8- and 64-MT weapons shown in Table 1, it could be concluded that from 1 to 3 8-MT weapons, or (for Attack Level 3) even a single (surfaceburst) 64-MT weapon would not be an unreasonable assignment of megatonage to the Washington urbanized area. It also follows that a combination of 1- and 8-MT weapons (with combined lethal area equal to the area of the density of population to be targeted) or a combination of airbursts and surfacebursts could reasonably be included in a potential enemy's targeting for this area. Needless to say, under the assumption of an attack on populations, these weapons could be scheduled to arrive in many different ways, from many different sources, and at varied intervals after the commencement of hostilities. Under the conditions of war, all, or none, or some fraction of those scheduled to be delivered might in fact be delivered, and those that arrived might or might not arrive with sufficient warning for the immediate population affected to take shelter.

The most important result of the analysis from the point of view of shelter design considerations is that an attack on population does not necessarily result in a single bomb being targeted at the center of each metropolitan area with total population exceeding some given number of persons. Some cities may receive no bombs at all, and others may receive a great many. For example, for a surfaceburst attack on populations with 300 1-MT bombs, approximately half the 213 urbanized areas listed in Table 5 would be allocated no weapons at all, whereas Los Angeles would be targeted with about 21. These assignments would change as the attack level and weapon yield are varied. But the threat to urban populations -- which by 1970 will include 80 percent of the U.S. population -- is much greater than that to rural population, and for some urban concentrations -- notably the larger ones -- it is much greater than others. For the Washington (D.C., Md., Va.) urbanized area, viewed as a population target, the effectiveness of fallout shelters is an attack designed to maximize population fatalities would likely depend on their ability -- and that of the people in them -- to withstand blast in the range of 5 to 30 psi (see Figure 10) and the associated thermal effects as well as subsequent fallout. This does not necessarily mean, all things considered, that it is not worthwhile to locate and provision fallout shelters in large urban areas. A full and excellent discussion of the benefits and limitations of such a program has been recently given by Secretary McNamara,[1] and is reproduced in its entirety in Appendix B. The present treatment illustrates some of the implications of the Secretary's remarks when considered from the differing point of view of persons in the 213 largest urbanized areas of the United States listed in Table 5.

[1] Hearings on the Department of Defense Appropriations for FY 1964, U.S. House of Representatives, Part I, Page 110 (Secretary McNamara's statement given on February 7, 1963).

PART II. THE INTENSITY AND DISTRIBUTION OF INITIAL AND RESIDUAL RADIATION

A. GENERAL CONSIDERATIONS

In contrast to the blast and thermal effects of nuclear weapons, the initial gamma rays and neutrons from a nuclear burst, and the delayed gamma and beta rays from fallout are a threat to biological systems, but not to structures. The hazard is complex and subtle in that the potentially harmful radiations are not sensed by the body and the many different biological effects are delayed in time from an hour or so to many years following exposure. The individual fallout particles, which contain the radioactive byproducts of the fission and fusion processes imbedded in or on a mass of inert materials, cover a wide range in size. Some are as big as grains of sand, others as small as particles of dust. In highly contaminated areas, the total bulk of fallout material deposited from a surfaceburst would be clearly visible in daylight as long as meteorological conditions permit the particles to settle and be retained on foliage or on smooth surfaces. It is very difficult to predict when the fallout will come to earth, but it is known that potentially lethal concentrations of radioactivity can be deposited hundreds of miles from the point of detonation, and that it can cover an area an order of magnitude greater than the area where fatalities are produced by blast. The hazard persists in time. Although the immediate and greatest danger is from gamma (X-ray like) radiations from the fallout particles, these particles also emit beta rays (electrons) which can cause burns if fresh fallout comes in contact with the skin and is not promptly washed off. There are several short- and long-lived radionuclides among the fission products -- notably I-131 (half-life 8 days), Sr 90 (half-life 28 years), and Cs-137 (half-life 30 years) -- which can produce an internal hazard via the food chain.

The type and amount of radioactive material which may be deposited in an area where shelters are to be constructed affects shelter design directly by indicating the amount of shielding necessary to hold radiation exposure of the shelter occupants to within specified limits, and indirectly by influencing the length of time the shelter must be occupied, continuously or partially, to hold dose levels within specified limits. Shelter stay times are also affected by fallout levels in other than the immediate area of the shelter, and by the level of radiation exposure which is to be permitted over various intervals of time. In fact, almost every way in which fallout affects civil defense activities outside the shelter has an influence on shelter stay times, and thus on the space requirements within the shelter for food, supplies, and equipment.

In developing estimates as to the levels of blast, thermal pulse, and initial nuclear radiation that might reasonably be anticipated at specific locations in the United States in the event some fraction of a nuclear attack on this country were targeted in such a way as to maximize population fatalities, the principal variables are the numbers and yields of the weapons employed, whether they are assumed to be burst in the air or on the surface, and the targeting criteria.

Comparable estimates of the external gamma doses and dose rates from the fallout involve additional important uncertainties:

- The speed and direction of the wind at all altitudes up to the top of the mushroom cloud, and at all locations throughout the United States,
- Precipitation patterns throughout the United States,
- The level and distribution of attack on military targets,

- The fraction of the total yield of each weapon due to fission,
- A method of estimating the distribution and deposition times of the radioactivities from a single surfaceburst, when all the factors listed above are specified precisely.

Large uncertainties and variations in estimates of fallout doses and dose rates at specific locations are introduced by each of these factors, in addition to the uncertainties present in estimates of the distribution and intensity of the immediate effects.

B. RADIATION DOSE UNITS[1]

The effect of nuclear radiations on a biological system is expressed in terms of an "absorbed dose". The rad is defined as the absorbed dose of any nuclear radiation which is accompanied by the liberation of 100 ergs of energy per gram of absorbing material. Although all ionizing radiation (gamma rays, X rays, beta rays, neutrons, protons, alpha particles, etc.) are capable of producing similar biological effects, the absorbed dose measured in rads which will produce a certain biological effect may vary appreciably from one type of radiation to another. This difference in behavior is expressed by means of the "relative biological effectiveness" (RBE) of a particular nuclear radiation. The RBE is defined as the ratio of the absorbed dose in rads of gamma radiation to the absorbed dose in rads of the given radiation having the same biological effect.

The value of the RBE for a particular type of nuclear radiation depends on several factors, including the energy of the radiation, the kind and degree of biological damage, and the nature of the organism or tissue under consideration.

[1] The Effects of Nuclear Weapons, op cit., Paragraph 11.80 et seq; and RAND R-425-PR A Review of Nuclear Explosion Phenomenon Pertinent to Protective Construction, H. L. Brode, May 1964.

The rem is defined as (dose in rads) x (RBE).

The roentgen is a measure of radiation exposure dose from ma or X rays (as opposed to absorbed dose), and is defined the quantity of X or gamma radiation such that the associated puscular emission per 0.001293 grams of air produces, in air, s carrying one electrostatic unit of electricity. (The mass one cm^3 of dry atmospheric air is 0.001293 grams at $0^{\circ}C$ and mm of mercury pressure.)

The RBE for gamma rays is approximately unity, by defini- n, although it varies somewhat with the energy of the iation. Because one roentgen exposure dose gives rise to it one rad absorbed dose in tissue for photons of inter- iate energy (0.3 to 3 mev), the absorbed dose for gamma (or rays is often stated, somewhat loosely, in roentgens.

The RBE for beta particles is close to unity. The RBE for ha particles from radioactive sources has been variously re- ted to be from 10 to 20, but this may be too large. For lear weapon neutrons, the RBE for acute radiation injury is taken as one, but it is appreciably larger where the bio- ical effect considered is the formation of opacities of the s of the eye (cataracts).

EQUIVALENT RESIDUAL DOSE (BIOLOGICALLY EFFECTIVE DOSE)

Human exposure to fallout radiations can lead to different es of biological damage;

a. Sickness or death within 2 hours to 6 months, depending on the total dose delivered and the dose rate and time interval over which it is delivered,

b. Shortening of life and the development of various kinds of malignant neoplasms from 1 to 20 years following exposure,

c. Changes in the genetic material of the individual exposed which may result in the genetic death of a future descendant -- perhaps many generations later -- and/or in some degree of physical disability to several descendants.

Damages of Types b and c are probably also dependent on the dose rate and the time interval over which the dose is delivered, but to a lesser extent than the type of injury listed under a.

The notion of biological dose or equivalent residual dose (ERD) is an attempt to equate the clinical manifestations of radiation injury of Type a resulting from a protracted dose (i.e., a dose delivered over a period greater than about four days) with a brief dose (a dose delivered over a period less than four days). The assumptions made for computing the equivalent residual dose may be described as follows. Any radiation dose may be considered as consisting of two parts, a reparable dose, D_R, and an irreparable (permanent) dose, D_P. The irreparable dose, D_P, consists of 10 percent of the total dose. The reparable dose, D_R, is constantly being repaired by the body at a rate of about 2-1/2 percent per day. Thus if $r(t)$ is the dose rate in roentgens/hour,

$$\frac{d\,D_P}{dt} = 0.1\ r(t)$$

$$\frac{d\,D_R}{dt} = 0.9\ r(t) - 0.00104\ D_R$$

At any time after irradiation stops, the dosage which has been accumulated over a period of time is assumed to correspond, in its clinical manifestations, to a brief dose $= D_P + D_R$.

The implications of this concept is that one-tenth of any dose accumulated is permanent as regards damage of Type a above, and that the effect of the remaining nine-tenths of the accumulated dose is constantly being repaired in such a way that any time irradiation stops, only one-half of the reparable dose D_R will remain after 30 days.

The decay rate from a given amount of fallout deposited on the ground is such that the equivalent residual dose accumulated at a point three feet above the ground from one hour following

etonation reaches a maximum at about four days following de-
onation and this maximum is approximately equal to the four-day otal dose. If the equivalent residual dose is computed tarting six hours after detonation, it reaches a maximum at bout one week following detonation, and this maximum is approx-mately equal to the total dose accumulated from six hours to ne week. Since the total dose from six hours to four days is bout 90 percent of the total dose from six hours to one week, nd an even larger fraction of the one-week dose is accumulated rom one hour to four days the maximum biological dose from any allout deposited between one and six hours (or thereabouts) ill be approximately equal to the total dose accumulated during he first week.

The clinical features of radiation injury of Type a esulting from various levels of brief or equivalent residual oses are described in Appendix C.

. INITIAL NUCLEAR RADIATION

The initial nuclear radiation from a weapon burst is de-ined as that emitted by a weapon burst and its radioactive by-roducts within one minute from the instant of detonation. As civil defense hazard, it consists of high-energy gamma photons nd neutrons. For a 20-KT device, about 80 percent of the total amma dose received is delivered within three seconds. For a -MT device, 80 percent is delivered in about eight seconds. he neutrons are released essentially instantaneously.

Table 8. INITIAL DOSE VERSUS DISTANCE - 1 MT[a]

Distance (mi)	Gamma-Ray Dose (roentgens)	Neutron Dose (rads)	Overpressure (psi)
2.0	~[illegible]	~0.10	~10
1.5	~700	~11.00	~20
1.0	~14,000	~1,[illegible].00	~40
0.5	~[illegible]	~173,000.00	~200

[a]The numerical values given above were received from Dr. Brode on 19 Apr 61. They differ from the values given on p. 15 of RAND R-425-PR, but are consistent with the formulas presented on p. 14 of that document.

An estimate of the relative contribution to the total dose (in rads or rems) from the initial gamma photons and neutrons is shown in Table 8.

An important feature of the initial gamma radiation as opposed to the residual gamma radiation is the greater penetrability of the initial nuclear radiation. The tenth-value thickness of earth for initial gamma radiation is about 26 inches, whereas it is cnly 12 inches for the residual gamma radiation. The overall radiation reduction (protection) factor for a given thickness of earth for each of these two types of radiation is shown in Figure 15.

Figure 16 shows the initial nuclear radiation and overpressure as a function of range and yield for a surfaceburst.[1] According to Figure 16, the initial nuclear radiation from a 1-MT surfaceburst is less than one rem whenever the overpressure is less than 5 psi. However an overpressure of 30 psi (the approximate radius of the fireball) corresponds to an initial dose of 10^4 rem, and an overpressure of 100 psi to an initial dose of about 2.6×10^5 rem, for a 1-MT burst.

These estimates are qualified in the Effects of Nuclear Weapons as follows (par. 8.27):

> "The data are based on the assumption that the average density of the air in the transmission path, between the burst point and the target, is 0.9 of the normal sea level density. Because of variations in weapons design and the different characteristics of the gamma rays associated with fission and fusion, as well as for other reasons (par. 8.85) the gamma ray doses calculated from Figs. 8.27 a and b cannot be exact. For yields from about 1 to 100 kilotons TNT equivalent, they are reliable within a factor of two or so; from 100 kilotons to 1 megaton, within a factor of 5; and above 1 megaton, within a factor of about 10."

The data of Figures 15 and 16 illustrate an important consideration for the design of blast shelters in the 30 to 100 psi range; namely, that protection against blast and residual radiation does not automatically guarantee protection against initial radiation. Suppose, for example, a 30 psi shelter has a PF of 1000 against residual radiation -- i.e., the protection equivalent to about 36 inches of earth. The same thickness of earth

---

[1] From Fig. 2.16, discussion p. 46, USAEC CEX-62.2 Nuclear Bomb Effects Computer, Fletcher et al, February 1963.

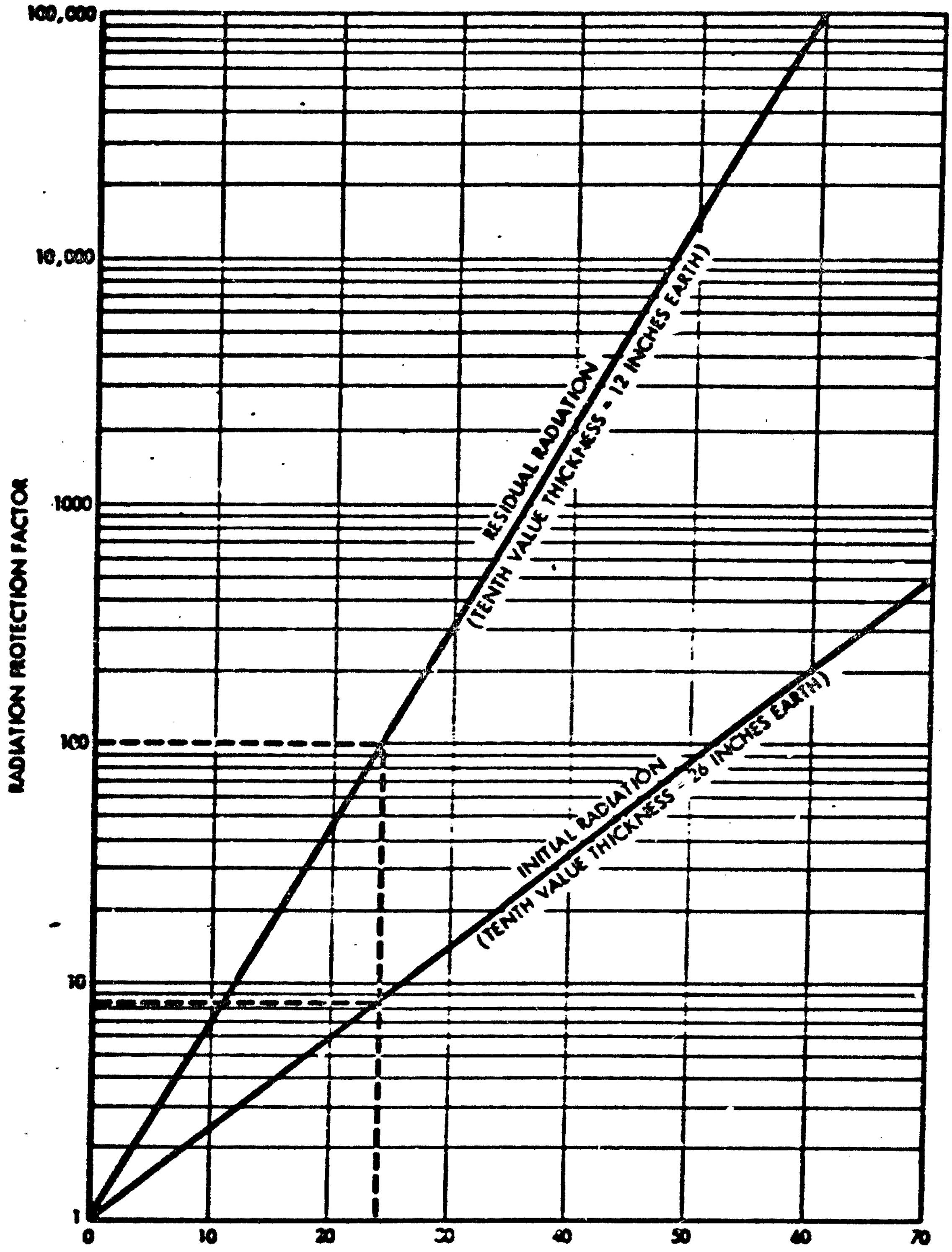


FIGURE 15. Radiation Protection Factor Vs. Earth Thickness for Initial and Residual Gamma Radiation

4-16-65-4

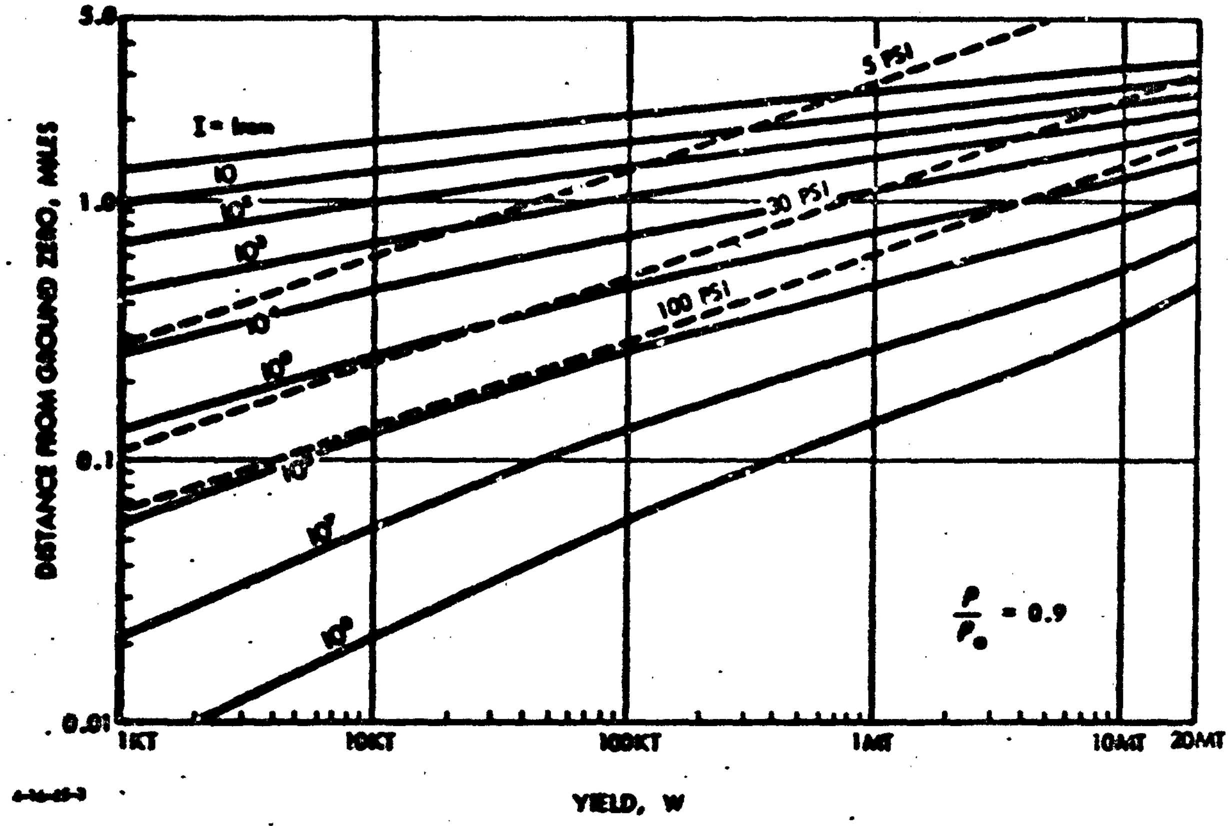


FIGURE 16. Initial Nuclear Radiation and Overpressure as A Function of Range and Yeild for Surface Bursts

would give a protection factor of about 25 from the initial radiation. A protection factor of 25, applied against a dose of 10^4 rem at the 30 psi blast level, would result in a total in-shelter dose of 400 rem. Similarly a 100 psi blast shelter with a PF of 10,000 (48" earth) against residual radiation gammas might offer a PF of only 70 against the initial gammas. Since 100 psi corresponds to 2.6×10^5 rem for a 1-MT surfaceburst (Figure 16), there is a possibility at the 100 psi level of an in-shelter dose of about 3700 rem. These estimates are <u>very</u> rough because no consideration has been given to the different geometrical relationships between the radiation source and the shielding material in the two cases, and because of the large uncertainties in the initial radiation dose level noted above. 'urther, they are based on a 1-MT surfaceburst. They do illus- ;rate, however, the necessity to take initial radiation into ıccount when designing blast shelters in the 30 to 100 psi 'ange, and the very large amount of shielding that may be re- ıuired to protect against initial nuclear radiation at these .evels of blast.

:. RESIDUAL NUCLEAR RADIATION

Residual nuclear radiation is defined as that radiation :mitted from the radioactive byproducts of a nuclear explosion .ater than one minute from the instant of the explosion. The ;ources and characteristics of this radiation vary with the per- :entage contribution of fission and fusion to the energy release ıf the weapon. Those radioactivities induced by neutron capture .n earth and bomb materials are of immediate interest only in 'eapons whose fission fraction is less than about 10 percent.[1] 'therwise, as shown later, the gamma radiation they emit is ıominated by that from the fission products.

When uranium (or plutonium) undergoes fission, about one- enth of 1 percent of the mass of the fissioning atoms is con- 'erted to energy. The rest is accounted for by over 200 ıifferent isotopes of 36 different elements. Each fissioning ıranium atom gives rise to a pair of fission products whose mass s almost that of the unsplit atom. For each kiloton of energy

For some weapons, neptunium 239 (half-life 2.3 days, average gamma photon energy = 0.27 mev) may be created in such quantity as to constitute a significant hazard in addition to the fission products. See Table 10.

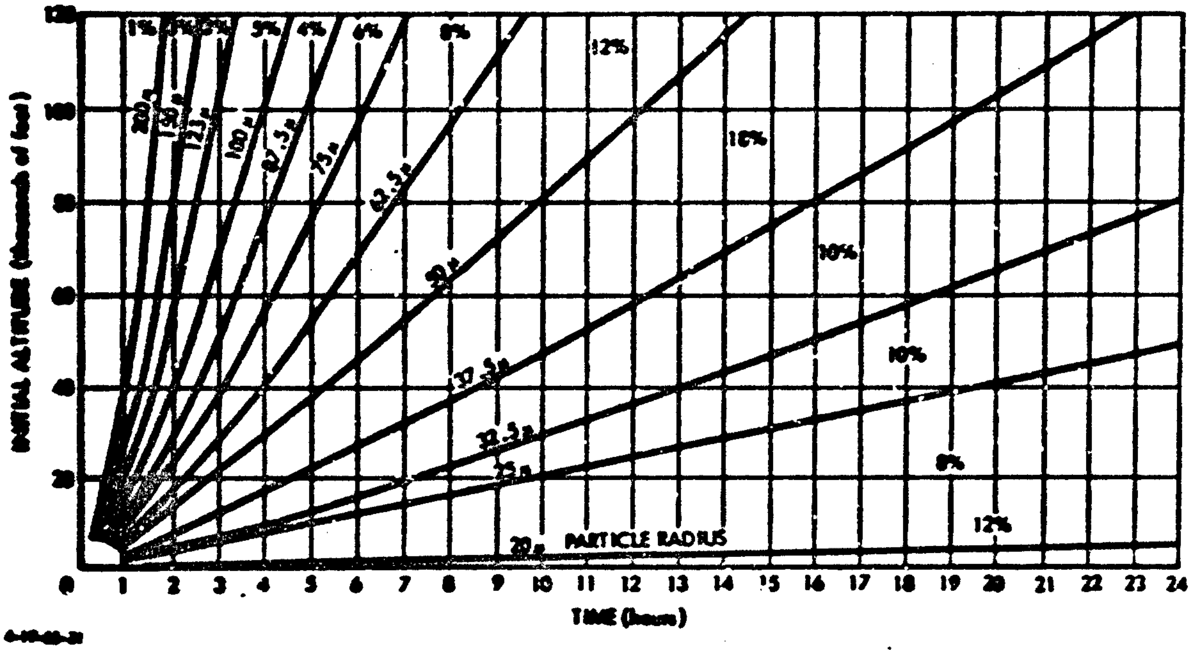


FIGURE 17. Times of Fall of Particles of Different Sizes from Various Altitudes and Percentages of Total Activity Carried (Reproduced from "The Effects of Nuclear Weapons")

released,[1] 56 grams of uranium = 1.45×10^{23} uranium atoms are fissioned.

When a nuclear weapon is burst in the air, the mass of the fallout particles consists of the weapon casing and the fission fragments. The particle diameters lie largely in the range of 2 to 12 microns, and most of the particles take weeks or months to reach the earth. Under these circumstances most of the radioactivities which give rise to an external gamma radiation hazard decay harmlessly in the air. However, long-lived internal

---

[1] By definitions, 1 kiloton is 10^{12} calories $= 4.2 \times 10^{19}$ ergs

$= 1.15 \times 10^{6}$ kilowatt hours

$= 2.64 \times 10^{25}$ mev

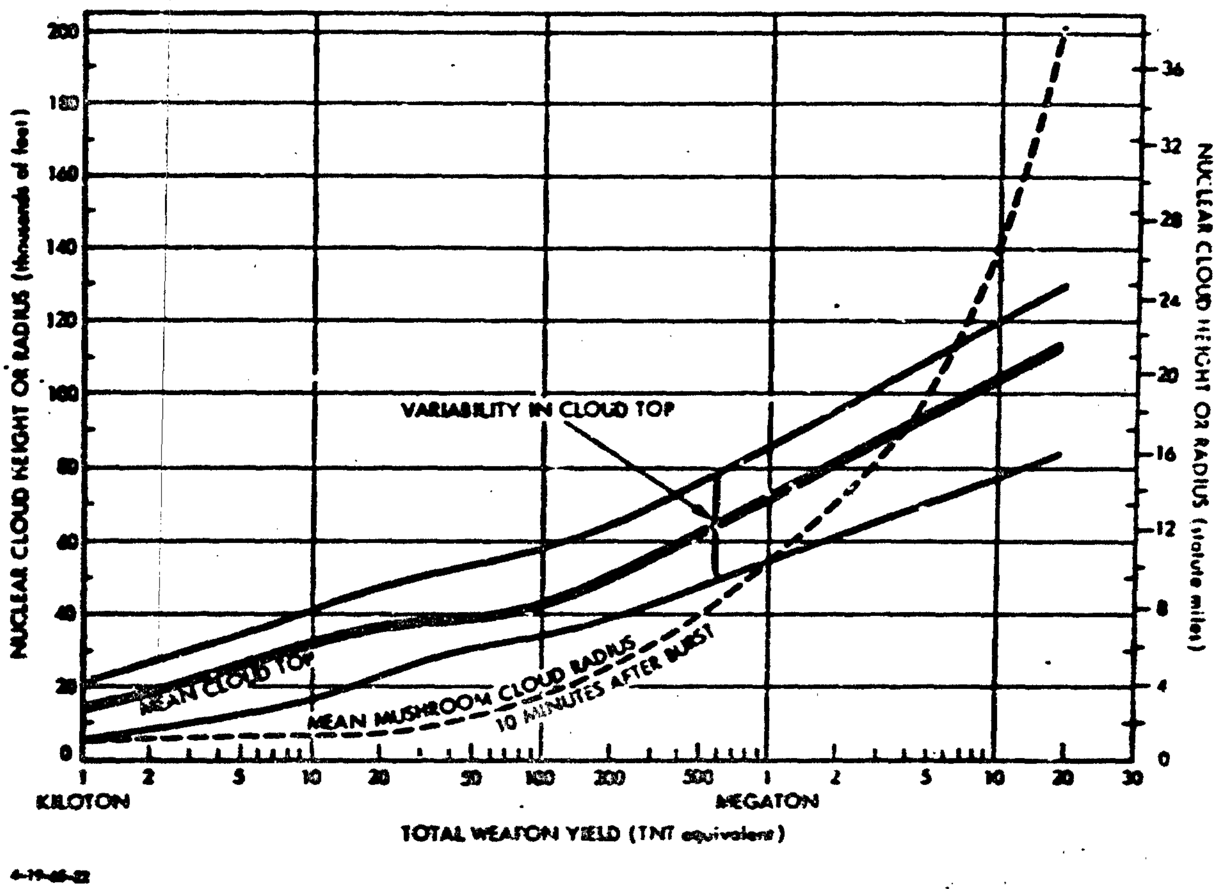


FIGURE 18. Approximate Nuclear Cloud Dimensions

emitters (strontium 90, half-life 28 years; cesium 137, half-life 30 years), if deposited in sufficient concentrations, can still present an internal hazard via the food chain.

The approximate distribution of the radioactive material from a surfaceburst on particles of different sizes and the time required for these particles to fall from different altitudes are shown on Figure 17. The approximate height and radius of the top of the mushroom cloud into which the fallout particles are lifted by rising air currents before being scattered by the winds are shown in Figure 18.

Many different mathematical models of varying degrees of complexity have been developed to predict when and where the particles of different sizes will be redeposited on the earth. It is evident that the answer must depend on the speed and direction of the winds, or more exactly, on the speeds and directions of the wind at different altitudes and different locations of the fallout pattern. The results of the various models differ widely,[1] and no one is sure which model is more correct or whether or not any of them are sufficiently accurate to give a reliable estimate of what doses and dose rates will actually be experienced at various locations on the ground at various times following a nuclear detonation.

An illustration of the difference between a predicted and an actual fallout pattern is shown in Figure 19.

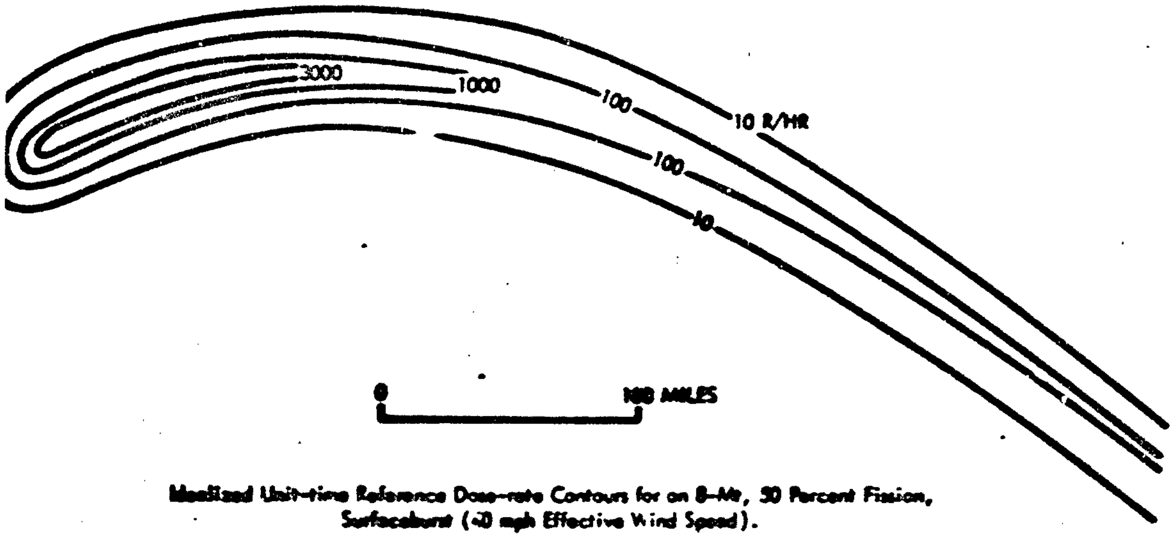
In spite of the great difference possible between predicted and actual fallout patterns, it is assumed that idealized patterns are useful as an indication of the shapes and levels of fallout deposition patterns which could reasonably be anticipated as a result of surfacebursts of different yields, under different conditions of wind. It should be noted that currently available fallout models assume that no precipitation or irregular wind conditions occur in the area where the fallout particles are deposited.

F. DOSES AND DOSE RATES FROM A UNIFORM DISTRIBUTION OF FISSION PRODUCTS ON THE GROUND

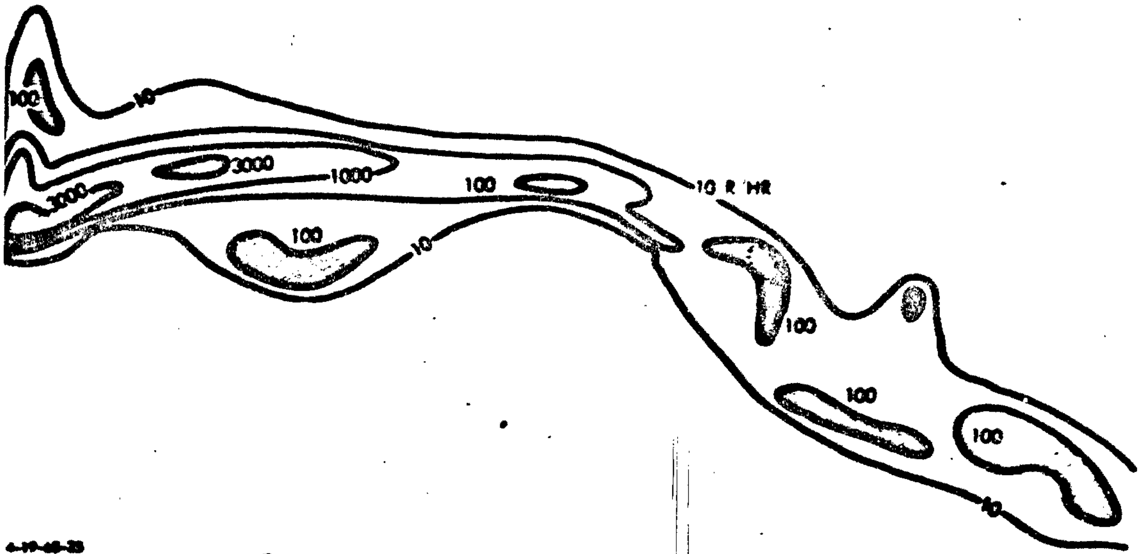
It is a common assumption of most fallout models that only the fission product radioactivity will be directly considered in the computations, and that the fission products will be considered unfractionated -- that is, the relative concentrations of the many different radionuclides present in any sample of fallout are the same as for the radioactive debris taken as a whole.

---

[1] TID-7632 Radioactive Fallout from Nuclear Weapons Tests, proceedings of a conference held in Germantown, Maryland, November 15-17, 1961 USAEC.



Idealized Unit-time Reference Dose-rate Contours for an 8-Mt, 50 Percent Fission, Surfaceburst (40 mph Effective Wind Speed).



4-19-68-35

Corresponding Actual Dose-rate Contours (Hypothetical).

FIGURE 19. Predicted and Actual Fallout Dose-rate Contours

With this assumption, there exists a simple, time-invariant scription of the fallout contamination level at a given loca-on, namely the number of kilotons-equivalent of fission oducts deposited per unit area. External gamma dose rates d accumulated doses three feet above a smooth, infinite plane ntaminated to a level of 1 KT per square mile are shown in ble 9.

Table 9. GAMMA DOSE RATE AND ACCUMULATED DOSE 3 FEET ABOVE A SMOOTH, INFINITE PLANE[a]

Beta Activity Curies/Mi.² (NRDL TR-187 P. 7 Et Seq. From Graphs)	Time After Fission	Dose Rate r/hr. (NRDL TR-247 P. 13 Et Seq. From Graphs)	Accumulated Dose From 1 Hr. in r (NRDL TR-247 P. 31 Et Seq. From Tables)	Interval Dose in r	Dose from Time Indicated to: 1 Day	1 Week	1 Month	1 Year
	1/2 hrs.	8600	-2603					
4.40×10^9	1 hr.	3720	0	2302	7507	9667	10,723	11,820
1.95×10^9	2 hrs.	1620	2302	1119	5215	7155	8,361	9,438
1.22×10^9	3 hrs.	883	3421	700	4076	6046	7,302	8,299
8.02×10^7	4 hrs.	577	4221	495	3376	5346	6,602	7,599
6.74×10^7	5 hrs.	432	4716	292	2881	4851	6,087	7,104
3.09×10^7	6 hrs.	300	5008	1367	2499	4460	5,825	6,722
2.05×10^7	12 hrs.	192	6448	706	1192	3182	4,278	5,375
1.89×10^7	18 hrs.	91.0	7151	446	446	2413	3,572	4,669
1.30×10^7	1 day	60.4	7507	886	0	1970	3,128	4,223
4.80×10^6	2 days	21.8	8463	392		1114	2,278	3,367
2.74×10^6	3 days	12.5	8845	250		722	1,878	2,975
2.02×10^6	4 days	8.90	9095	189		472	1,628	2,725
1.60×10^6	5 days	7.02	9284	155		283	1,439	2,536
1.30×10^6	6 days	5.02	9439	128		128	1,284	2,381
1.16×10^6	7 days	4.90	9567	296		0	1,156	2,253
8.00×10^5	10 days	3.43	9863	274			860	1,957
5.88×10^5	2 weeks	2.36	10,137	321			586	1,683
3.80×10^5	3 weeks	1.93	10,458	265			265	1,362
2.95×10^5	1 month	.886	10,723	432			0	1,097
1.16×10^5	2 months	.388	11,155	190				665
7.35×10^4	3 months	.213	11,345	148				465
5.17×10^4	4 months	.140	11,482	93				338
3.88×10^4	5 months	.111	11,575	70				245
2.90×10^4	6 months	.0832	11,645	121				175
1.47×10^4	9 months	.0384	11,766	54				54
8.70×10^3	1 year	.0248	11,820	59				0
1.88×10^3	3 years	1.11×10^{-3}	11,879	119				
2.40×10^2	30 years	3.96×10^{-5}	11,998					

[a] Uniformly contaminated with unfractionated fission products from the thermal fission of U-235 at a density of 1 kiloton-equivalent of fission products per square mile.

An alternate, time-independent method of describing a fallout contamination level is in terms of the roentgens/hour infinite plane dose rate, normalized to one hour -- that is assuming that all the fallout which is eventually deposited at a given location has in fact been deposited at one hour following the detonation. The relation between those two descriptions is indicated in Table 9; i.e., 1 KT/mi^2 = 3720 r/hr at 1 hr.

Table 10. APPROXIMATE CONTRIBUTIONS OF INDUCED ACTIVITIES AND FISSION PRODUCTS TO FALLOUT INFINITY DOSE

Activity	Half-Life	Average Mev/ Disintegration	Infinity Dose in Roentgens: Normal Weapon Surfaceburst			Normal Weapon Airburst			Clean Weapon Surfaceburst
			Low	Typical	High	Low	Typical	High	Typical
U-240.	14.2 hrs.	0.34	10	60	.	10	60	300	
Na-24	15 hrs.	4.19	50	250	60	1	5	10	
Np-239	2.33 days	0.27	40	250	900	40	250	900	
U-237	6.75 days	0.16	35	150	350	35	150	350	
Fe-59	45.1 days	1.10	0	1	2	0	1	2	
Co-58	72 days	0.97	1	2	20	1	2	20	
Co-57	270 days	0.13	0	1	10	0	[illegible]	10	
Mn-54	300 days	0.84	1	3	30	1	3	30	
Co-60	5.3 yrs.	2.50	3	20	30	3	10	30	
Mn-56	2.6 hrs.	1.80	15	100	600	0	0	0	
Total Induced				837			482		500
Fission Products				6000			6600		600

NOTE: Normal weapon assumed 50 percent fission yield. Clean weapon assumed 5 percent fission yield. Fission products assumed unfractionated. Infinity dose = dose from 1 hour to ∞ hours.

SOURCE: USAEC External Gamma Doses and Dose Rates from the Fallout from Nuclear Explosions, H. A. Knapp. Fallout Studies Branch, Div. Biology and Medicine, May 16, 1960, reprinted P. 527 et seq. Hearings on Civil Defense before a Subcommittee of the Committee on Government Operations, 86th Congress, March 1960.

It is clear from Table 9 that the doses and dose rates experienced at a given location at various times following a nuclear burst will depend very much on how long it takes for all the fallout which is going to be deposited at a particular location to be deposited. Fallout deposition times, as with other features of the fallout models, are subject to large uncertainties. At areas close to the point of detonation (say in areas of 30 psi overpressure or more) some fallout (or throwout) will begin within minutes. At greater distances -- it is estimated[1] that the time of fallout arrival is about 24 minutes. One hundred miles from the point of detonation the fallout may not begin for 4 to 6 hours and it may last for several hours.

An estimate of the approximate contribution of induced activities to the infinity (approximate 1 year) dose from clean and normal weapons is shown in Table 10.

[1] The Effects of Nuclear Weapons, op cit., par. 9.84.

G. CONTAMINATION LEVELS AND ACCUMULATED DOSES IN AN IDEALIZED FALLOUT PATTERN: SCALING WITH YIELD AND WIND

Fallout particles of a size large enough to be visible against a white sheet or paper -- say those with diameters in excess of 50 microns[1] -- are for the most part deposited within 24 hours from the time of detonation. They contribute the most immediate and most predictable threat from the fallout of a single-weapon burst. That portion of the fallout which occurs within 24 hours is (somewhat arbitrarily) called early fallout, as opposed to delayed fallout which occurs after 24 hours. It is the doses and dose rates from early fallout which one attempts to define with an idealized fallout pattern. For land surfacebursts in the megaton range, it is estimated that from 50 percent to 70 percent of the radioactivity created by the nuclear explosion will be deposited as early fallout.

Sample fallout patterns from the fallout model described in The Effect of Nuclear Weapons are shown in Figures 20 and 21. Figure 20 illustrates how the total dose may accumulate during the first 18 hours following detonation. Figure 21 shows the time-invariant level of contamination, and may be used in conjunction with Table 9 to obtain accumulated doses and dose rates once all the fallout at a given location has been deposited.

The dose rates and doses shown in Figures 20 and 21 are for a 1-MT surfaceburst of 100 percent fission yield. They must be scaled down by a factor equal to the fraction of the total yield due to fission. This fraction is normally taken as 1/2 for illustrative purposes, although fractions as low as 1/3, and as high as 2/3 indicate the general range of uncertainty introduced by this factor.

[1] 1 micron = 10^{-6}; meter = 10^{-3} millimeter.

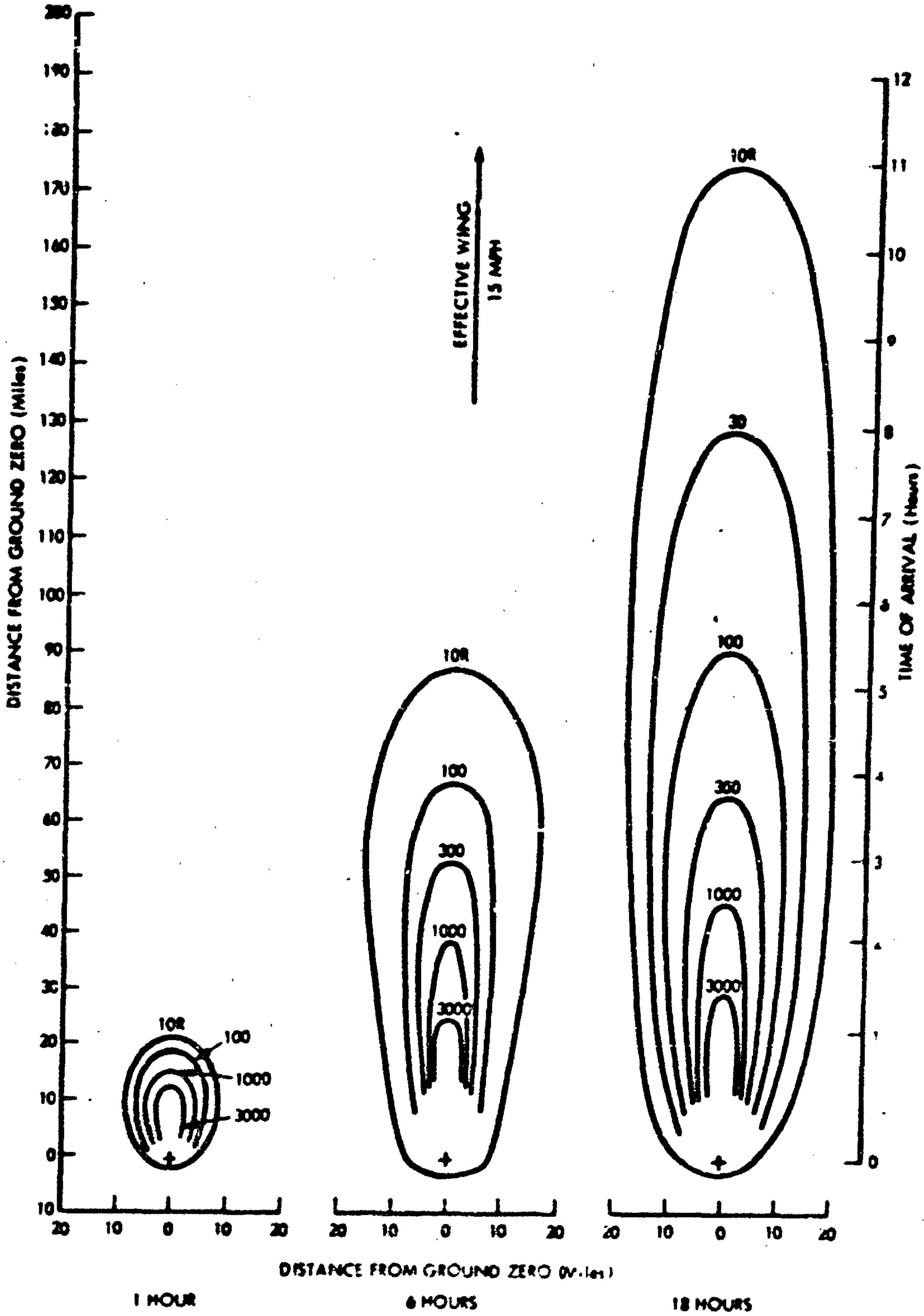
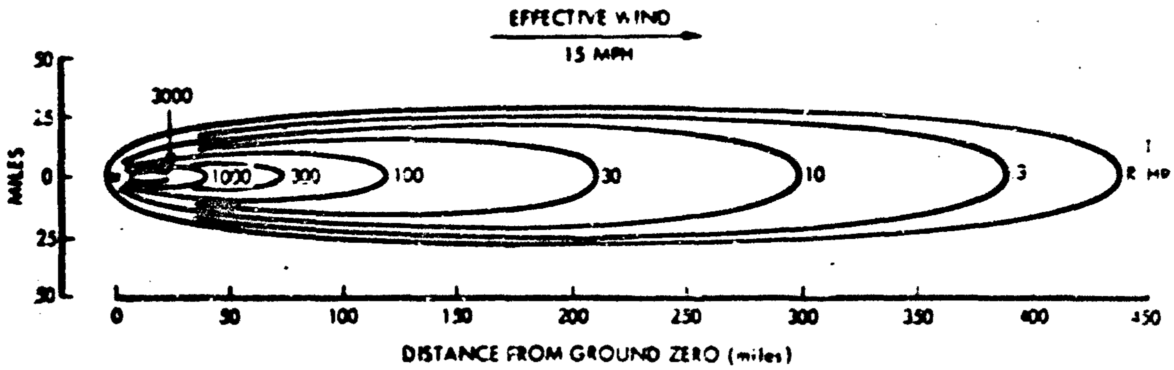


FIGURE 20. Total Dose Contours from Early Fallout at 1, 6, and 18 Hours After Surfaceburst with 1 MT Fission Yield (15 mph Effective Wind Speed).

6-19-68-36



6-19-65-27

FIGURE 21. Idealized Unit-time Reference Dose-rate Pattern for Early Fallout from a 1 MT Fission Yield Surfaceburst (15 mph Effective Wind Speed).

An important factor to consider in connection with the fallout contours given in Figure 21 is how they scale with yield and wind. This is described in The Effect of Nuclear Weapons as follows:

> "In order to obtain the idealized fallout pattern for a fission yield of F megatons, the values of the various contour lines in Fig. 9.73 may be multiplied by F. Thus, for a weapon having a total yield of M megatons with 50 percent of the energy derived from fission, the factor would be 0.5M. This scaling procedure, although highly simplified, gives reasonably good results for surface bursts from about 100 kilotons to 10 megatons fission yield. However, the higher values of dose rate (and dose) are probably overestimated for fission yields in excess of 1 megaton. Except for isolated points in the immediate vicinity of ground zero, observations indicate that unit-time reference dose rates greater than about 10,000 roentgens per hour are unlikely. A possible reason is that as the weapon yield increases so also does the initial volume of the radioactive cloud; hence, the maximum concentration of activity in the cloud does not change very much with the yield. The fallout contamination moderately near ground zero, where the dose rate is high, will thus not increase in proportion to the yield, as the sample scaling law given here implies. At greater distances downwind the law is much more reliable because as a result of spreading by the wind, the initial cloud volume has relatively little influence on the concentration of fallout on the ground.

"9.76 It should be noted that the proportional scaling procedure makes no allowance for the effect of the total i.e., fission plus fusion, yield; thus it predicts the same fallout pattern for a 1-megaton all-fission detonation as for a 2-megaton 50-percent fission explosion. Actually, the unit-time reference dose rate near ground zero might be somewhat smaller in the latter case because the same amount of radioactivity would be spread through a larger volume of the initial cloud. At greater distances downwind from the burst point the effect of the initial cloud concentration is small, as indicated above. Furthermore, at such locations the dilution effect may be compensated by the fact that the cloud from the 2-megaton explosion will probably rise higher, thus increasing the distances at which particles from the same relative position in the cloud will reach the ground.

"9.77 As stated in 9.65, the effective wind speed and direction are the mean values from the ground up to a certain level in the radioactive cloud, depending on the total yield of the explosion. As a very rough approximation, the atmospheric layers over which the wind is to be averaged as a function of the weapon yield, are as follows:

Total yield	Layer
Less than 1 MT	Surface to 40,000 feet
1 MT to 5 MT	Surface to 60,000 feet
More than 5 MT	Surface to 80,000 feet

These values should be adequate for the rough evaluation of hypothetical fallout situations based on the idealized patterns. More elaborate prediction schemes take into consideration the winds at different levels instead of a single average effective wind.

"9.78 If there is no directional wind shear, then doubling the wind speed would cause the particles of a given size to reach the ground at twice the distance from ground zero, so that they are spread over roughly twice the area. Based on this conclusion the following scaling laws may be used in connection with the idealized fallout pattern: (a) the unit-time reference dose-rate value for each contour in the 15-mile-per-hour wind velocity pattern in Fig. 9.73 is multiplied by 15/v where v is the actual effective wind velocity in miles per hour and (b) the downwind distances in Fig. 9.73 are multiplied by v/15. For a 30-mile-per-hour wind, for example, the contour values would be halved and the distances doubled.

"9.79 It will be apparent that in scaling for either yield or wind speed the values of the dose-rate contours are changed. The scaled downwind extent for any given contour value may readily be obtained by plotting the scaled dose rates versus the scaled downwind distances on logarithmic graph paper and reading downwind distances corresponding to the desired contour value from the resulting smooth curve.

"Both the idealized 15-mile-per-hour pattern in Fig. 9.73 and the wind scaling procedure tend to maximize the downwind extent of the dose-rate contours since they involve the postulate that there is very little (or no) wind shear. This is not an unreasonable assumption for the continental United States, since the wind shear is generally small at altitudes of interest from the standpoint of fallout. If there is considerable wind shear, e.g., 20° or more in the lower half of the mushroom head, the fallout pattern would be wider and shorter than that based on Fig. 9.73. The actual unit-time reference dose rate at a specified downwind distance from ground zero for a given effective wind speed would then be smaller than predicted. The crosswind values at certain distances might, however, be increased.

"It may be noted that the method for wind scaling described in 9.78 may be approximated by another procedure; the reference dose-rate contour values are left unchanged but the distances in Fig. 9.73 are multiplied by $(v/15)^{1/2}$. If considerable wind shear exists, a better approximation may be obtained by using the factor $(v/15)^{1/3}$. The results of this approximation are not reliable for dose rates greater than about 1,000 roentgens per hour for reasons similar to those given in 9.75."

The ENW model described above differs in a number of ways with a more comprehensive and detailed model developed by Pugh and Galiano[1] and subsequently modified by Pugh in 1961 in conjunction with a Fallout Subcommittee of the Advisory Committee on Civil Defense, National Academy of Sciences, for use by the National Resources Evaluation Center.[2] A tabulation of the WSEG-NAS model results for a number of yields and winds of interest is presented in Appendix D.

---

[1]WSEG Research Memorandum No. 10, An Analytic Model of Close in Deposition of Fallout for Use in Operational-Type Studies, George E. Pugh, Robert J. Galiano, October 1959.

[2]Ferber, Gilbert J. and Heffter, J. L., A Comparison of Fallout Model Predictions with a Consideration of Wind Effects, p. 122, et seq., AEC TID-7632.

One difference between the ENW and WSEG-NAS models is that the maximum H+1-hour dose rate in the WSEG-NAS model is not limited to 10,000 r/hr at 1 hr. For example, the WSEG-NAS model indicates an H+1-hour contour of 30,000 r/hr at 1 hr. over a 742 square mile area for a 100-MT 100 percent fission surfaceburst, a 10-knot wind, and an effective fallout shear of 0.1 knot per 1000-foot altitude.

H. METEOROLOGICAL DATA FOR USE WITH FALLOUT PREDICTION MODELS

The principal information needed to apply the models described above to determine the fallout at any designated point is:

- The yield, fission yield, and burst points of the weapons contributing fallout to that point,
- The effective wind speed and direction (and for the WSEG-NAS model, the effective fallout shear) at the points of detonation of the weapons contributing fallout to that point.

The wind speed and direction could, of course, be almost anything. There are, however, seasonal regularities in wind conditions at given places throughout the country. These are described in some detail in Chapter 5 of DOD-OCD Federal Civil Defense Guide.[1] The most important data and discussion are reproduced in Table 11 and in the following paragraph:

> "Daily Variability
>
> It should be noted that the data in Table XI, this report, and Figures 9 through 13 represent mean or averaged data, based upon five years of upper air observations. On any one day, the actual direction and speed may vary considerably from the seasonal or annual mean. Table II shows the ratios of the vector standard deviations to the average wind speeds for winter and summer and the range of the mean seasonal direction in degrees for each of the 52 rawin locations. The former tabulations indicate the ratio of the scatter to the scaler magnitude of the vector and thus,

[1] DOD-OCD, Federal Civil Defense Guide, Part E, Chapter 5, Appendix 6, Application of Meteorological Data to RADEF, December 15, 1963.

Table 11. CLIMATOLOGICAL MEAN WIND DIRECTION (D) AND AVERAGE SPEED (S) IN KNOTS IN THE LAYER FROM 80,000 FT. ALTITUDE TO SURFACE OF THE EARTH AND VECTOR STANDARD DEVIATION (V)

Location	Spring			Summer			Fall			Winter			Annual	
	D	S	V	D	S	V	D	S	V	D	S	V	D	S
Albrook	276	02.5	08.3	277	18.7	07.3	275	08.8	07.6	044	02.2	09.3	279	5
Albuquerque	082	24.9	19.4	335	03.6	13.2	095	17.1	19.5	092	28.9	22.3	087	[illegible]
Anchorage	056	05.8	19.4	049	03.7	17.0	053	14.3	20.4	080	17.7	[illegible]	064	[illegible]
Annette	077	12.9	22.4	098	05.0	18.9	076	22.0	21.7	090	24.0	23.5	084	[illegible]
Big Spring	078	30.7	18.7	284	05.3	13.8	093	15.5	29.0	084	35.6	21.2	094	[illegible]
Bismark	097	17.1	20.8	085	16.8	15.1	087	23.9	20.5	109	27.8	25.5	095	[illegible]
Boise	096	16.6	20.0	062	15.7	14.8	097	19.4	20.7	102	25.9	22.3	092	19
Brownsville	078	24.4	15.4	275	12.8	10.7	088	08.2	17.7	077	29.5	16.5	075	[illegible]
Buffalo	096	26.3	23.1	107	16.6	16.5	083	28.8	22.6	089	37.4	[illegible]	092	27
Burrwood	087	28.1	18.7	261	09.5	11.8	088	14.0	19.4	083	37.0	17.8	086	19
Caribou	089	19.8	22.7	093	16.4	18.7	080	29.9	23.3	081	29.7	[illegible]	084	[illegible]
Charleston	092	29.9	22.3	229	03.6	13.6	079	19.0	21.6	088	42.4	13.4	099	[illegible]
Columbia	087	28.2	22.6	093	08.4	13.4	096	23.8	21.3	091	38.5	25.3	092	[illegible]
Dayton	092	28.7	23.5	115	11.5	14.9	089	24.9	20.9	090	41.5	[illegible]	092	26
Denver	099	20.7	20.2	273	10.0	13.5	103	18.6	19.7	104	26.0	[illegible]	097	[illegible]
Dodge City	083	25.7	20.4	072	06.7	13.1	096	20.8	20.7	093	32.2	23.2	090	[illegible]
Edmonton	099	12.8	17.8	076	09.5	15.3	102	23.0	18.5	109	27.1	18.2	103	[illegible]
Ely	095	17.7	20.8	052	12.9	13.0	092	16.9	19.8	102	24.0	[illegible]	089	[illegible]
Fairbanks	067	06.8	18.2	060	04.6	14.8	061	15.3	18.4	085	19.7	25.5	072	[illegible]
Fort Worth	082	31.5	20.4	282	03.7	13.2	095	16.5	20.7	065	37.8	22.3	[illegible]	[illegible]
Great Falls	[illegible]	[illegible]	[illegible]	[illegible]	16.2	[illegible]	[illegible]	28.1	[illegible]	106	30.0	[illegible]	[illegible]	[illegible]
Green Bay	096	21.7	21.5	105	17.3	16.1	097	26.2	22.1	090	32.4	[illegible]	[illegible]	[illegible]
Greensboro	082	30.2	22.8	137	05.8	14.5	081	22.3	21.5	097	43.4	[illegible]	[illegible]	[illegible]
Hempstead	094	29.0	24.4	104	13.6	16.7	081	29.0	24.2	089	42.7	25.3	[illegible]	[illegible]
International Falls	099	16.3	23.2	038	17.8	16.5	106	24.0	21.4	107	27.9	21.2	[illegible]	[illegible]
Jacksonville	094	27.7	20.8	253	06.5	12.0	083	16.5	20.7	088	39.0	18.2	[illegible]	[illegible]
Lake Charles	083	29.6	19.0	263	08.2	12.1	094	15.3	19.8	082	38.8	19.3	085	[illegible]
Lihue	093	15.8	15.0	289	04.5	09.8	123	01.0	12.0	106	15.1	16.9	[illegible]	[illegible]
Little Rock	085	21.1	21.8	212	01.9	13.2	090	19.7	20.8	085	43.5	22.2	[illegible]	[illegible]
Long Beach	093	20.7	20.4	029	07.6	13.2	082	12.7	17.1	101	22.2	23.3	098	[illegible]
Maniwaki	097	20.5	22.7	108	16.2	17.8	085	27.3	23.0	089	30.8	22.2	092	23
Medford	100	18.9	21.2	064	12.8	16.0	032	17.0	22.2	099	26.3	24.3	[illegible]	[illegible]
Miami	097	21.8	17.2	267	12.4	10.7	080	06.5	18.4	088	29.5	17.2	[illegible]	[illegible]
Montgomery	092	30.7	22.5	246	05.4	13.4	087	18.5	21.5	086	42.2	21.4	[illegible]	[illegible]
Mt. Clemens	089	26.2	24.0	109	16.2	16.4	088	26.9	22.3	092	37.0	[illegible]	[illegible]	[illegible]
Nantucket	090	29.3	24.3	097	14.6	17.7	077	30.3	23.6	[illegible]	42.6	[illegible]	[illegible]	[illegible]
Nashville	088	31.2	22.7	146	03.7	13.3	089	22.0	21.2	096	47.7	[illegible]	[illegible]	[illegible]
Nome	042	05.7	18.8	343	03.2	17.3	036	11.1	19.5	081	17.8	[illegible]	[illegible]	[illegible]
Norfolk	095	31.3	23.0	128	06.8	15.7	079	23.9	22.9	089	44.9	[illegible]	[illegible]	[illegible]
Oakland	100	19.5	21.5	083	11.2	15.1	093	14.0	20.7	105	25.1	[illegible]	[illegible]	[illegible]
Omaha	089	24.2	22.0	089	11.8	13.9	100	24.2	21.2	090	32.3	[illegible]	[illegible]	[illegible]
Pittsburgh	093	29.5	23.7	110	13.1	15.8	083	27.3	22.2	089	43.0	[illegible]	092	[illegible]
Rantoul	092	28.2	23.5	110	11.9	14.8	095	25.3	21.4	091	39.0	[illegible]	[illegible]	[illegible]
Rome	094	26.8	24.2	104	17.0	16.1	081	29.2	23.7	089	37.5	24.4	[illegible]	[illegible]
San Juan	103	10.5	12.7	276	13.4	09.0	250	05.7	13.1	[illegible]	11.8	[illegible]	[illegible]	[illegible]
Seattle	093	16.8	21.8	076	11.0	18.0	091	21.4	21.8	[illegible]	25.7	[illegible]	[illegible]	[illegible]
Sault Ste. Marie	090	19.9	22.0	113	17.7	17.8	095	25.3	22.9	098	30.4	[illegible]	[illegible]	[illegible]
St. Cloud	095	18.9	21.3	095	17.7	16.8	103	25.2	21.3	103	29.1	[illegible]	[illegible]	[illegible]
Tucson	081	26.7	20.3	349	05.1	14.6	085	14.6	18.6	088	27.4	[illegible]	[illegible]	[illegible]
Washington	094	30.5	24.1	112	19.5	16.5	090	28.7	22.9	089	44.7	[illegible]	[illegible]	[illegible]
Whitehorse	068	08.7	19.7	[illegible]	32.9	19.1	066	17.8	19.5	087	21.3	[illegible]	[illegible]	[illegible]

are a measure of the reliability of the mean as a prediction. The mean data in Table I are more representative of the winds on any particular day where the ratio of V/S has a low value. For example, the mean data for Washington in winter (089 degrees, 45 knots) has a V/S value of .55 whereas the summer mean data (112 degrees, 10 knots) has a V/S value of 1.57. Therefore, the mean winter data for Washington are more representative of the winds on any one day during the winter than the mean summer data are representative of the winds on any one summer day. Further, at Ft. Worth in summer when V/S equals 3.56 the mean summer data (282 degrees, 4 knots) would not be a very reliable prediction for the winds on any one summer day."

I. DOSES AND DOSE RATES IN OVERLAPPING FALLOUT PATTERNS

Since no attempt has been made to estimate the possible level of attack on military targets, or the distribution of such an attack throughout the United States, it is not possible to give an example of the integrated fallout pattern throughout this country for even one set of wind conditions. What will be considered instead is an estimate of the maximum level of fallout which might reasonably be anticipated in and around a reasonably large populated area subjected to a direct attack. Specifically, it will be assumed that 3 10-MT, 50 percent fission yield weapons have been surfaceburst in such a way that the 5 psi circles are just tangent to each other. The wind speed selected is 10 knots -- the average for the Washington, D.C. area in the summer (see Table 11). The model used will be the WSEG-NAS model, the effective wind shear 0.1 kt/1000-foot altitude. One wishes to examine how the H+1-hour contour levels, and the first week dose (maximum biological dose) contour levels can overlap under these conditions. The individual patterns, with overlap indicated, are plotted in Figures 22 and 23.

It may be seen from Figure 22 that most of the area covered by the 5 psi blast level has a contamination level of at least 1500 r/hr at 1 hr. About half the total 5 psi area and somewhat more of the downwind area outside the 5 psi circles are contaminated to a level of at least 5000 r/hr at 1 hr. Significant areas within the 5 psi blast level and dow ind of it are contaminated to levels in the range of 5000 to 10,000 r/hr at 1 hr. The highest levels indicated by the patterns are about 13,000 r/hr at 1 hr. Very extensive areas downwind are overlapped by all 3 patterns, for a total contamination level of at least 4500 r/hr at 1 hr.

From Figure 23, it is seen that a maximum biological dose (approximately equal to the total dose during the first week) through most of the 5 psi area is at least 5000 r, that it is about 15,000 r over significant positions of the blast area and beyond, and that it reaches about 26,000 r is the area of greatest intensity.

These results are for a fission yield of 50 percent. They should be increased by 1/3 if the fission yield is increased from 1/2 to 2/3. They would increase if the effective wind were less than 10 knots, or if there were heavy fallout from other targets. They would decrease if the effective wind were greater than 10 knots, or if the fission yield were less than 50 percent. They would disappear altogether if the weapons were airburst.

One cannot draw reliable general conclusions as to the level of fallout contamination against which protection should be sought in and around all urban areas by a single illustrative example using one of several fallout models, and considering only an area subject to heavy attack. For fallout, as with blast and heat, each area requires special study, and each area must be considered in light of many postulated attacks on the country as a whole. The data and methods described in this paper show one way of making such a study, provided additional assumptions are made as to the weight and distribution of attacks on military targets.

There is, perhaps, one tentative conclusion of some importance which follows from the WSEG-NAS model. Namely, that in areas in and around a target subjected to multiple attack with high-yield surfaceburst weapons, contamination levels in the range of 5000 to 10,000 r/hr at 1 hr, and first-week doses in the range of 15,000 r to 30,000 r are not unreasonable fallout levels to consider -- along with other factors such as cost -- in the design of shelters and in planning recovery operations.

Appendix A

DISTRIBUTION OF LAND AREA BY DENSITY OF POPULATION

Table 1. POPULATION, LAND AREAS, AND DENSITIES OF U.S. URBANIZED AREAS (1960 CENSUS)

(213 Urbanized Areas, See Table 5 for Rank According to Population)

URBANIZED AREA	POPULATION (Persons)	AREA (mi^2)	DENSITY (persons/mi^2)	DISTRIBUTION OF LAND AREA BY DENSITY OF POPULATION: 1000	1000-1500	1500-2000	2000-3000	3000-4000	4000-6000	6000-8000	8000-10,000	10,000-15,000	15,000-20,000	20,000-30,000
Abilene, Tex.	91,566	63.8	1,435	1.3	62.5									
Abilene	90,368	62.5	1,446											
In Urban Fringe	1,198	1.3	922											
Akron, Ohio	458,253	141.3	3,243			87.6			53.9					
Akron	290,351	53.9	5,387											
In Urban Fringe	167,902	87.4	1,921											
Albany, Ga.	58,353	24.4	2,392			1.4	23.0							
Albany	55,890	23.0	2,430											
In Urban Fringe	2,463	1.4	1,759											
Albany-Schenectady-Troy, N.Y.	455,447	106.4	4,281				67.8			38.6				
In Central Cities	278,900	38.6	7,225											
Albany	129,726	19.0	6,828											
Schenectady	81,682	10.3	7,930											
Troy	67,492	9.3	7,257											
In Urban Fringe	176,547	67.8	2,604											
Albuquerque, N.M.	241,216	76.0	3,174				19.8	56.2						
Albuquerque	201,189	56.2	3,580											
In Urban Fringe	40,027	19.8	2,022											
Allentown-Bethlehem, Pa.	256,016	60.1	4,260					42.5		17.6				
In Central Cities	183,755	36.6	5,021											
Allentown	108,347	17.6	6,155											
Bethlehem	75,408	19.0	3,969											
In Urban Fringe	72,261	23.5	3,075											
Altoona, Pa.	83,358	18.0	4,618			9.0				9.0				
Altoona	69,407	9.0	7,712											
In Urban Fringe	13,951	9.0	1,517											
Amarillo, Tex.	137,969	54.8	2,518				54.8							
Amarillo	137,969	54.8	2,518											
In Urban Fringe	---	---	---											
Ann Arbor, Mich.	115,282	27.9	4,132				14.2	13.7						
Ann Arbor	67,340	13.7	4,915											
In Urban Fringe	47,942	14.2	3,376											
Asheville, N.C.	68,592	32.3	2,124		8.3		24.0							
Asheville	60,192	24.0	2,508											
In Urban Fringe	8,400	8.3	1,012											
Atlanta, Ga.	768,125	245.8	3,125				117.6	128.2						
Atlanta	487,455	128.2	3,802											
In Urban Fringe	280,670	117.6	2,387											
Atlantic City, N.J.	124,902	60.0	2,082		48.5				11.9					
Atlantic City	59,544	11.5	5,178											
In Urban Fringe	65,358	48.5	1,348											
Augusta, Ga.-S.C.	123,698	43.1	2,870			28.1			15.0					
Augusta	70,626	15.0	4,708											
In Urban Fringe	53,072	28.1	1,889											
Aurora, Ill.	85,922	23.8	4,152				9.8		10.0					
Aurora	63,715	10.8	5,900											
In Urban Fringe	21,907	9.8	2,225											
Austin, Tex.	187,197	50.7	3,691	1.3				49.4						
Austin	186,545	49.4	3,776											
In Urban Fringe	612	1.3	471											
Bakersfield, Cal.	141,763	38.3	3,701						38.3					
Bakersfield	56,848	16.0	3,553											
In Urban Fringe	84,915	22.3	3,808											
Baltimore, Md.	1,418,948	220.3	6,441						141.3			79.0		
Baltimore	939,024	79.0	11,886											
In Urban Fringe	479,924	141.3	3,396											
Baton Rouge, La.	193,485	56.9	3,400				25.9			31.0				
Baton Rouge	152,419	31.0	4,917											
In Urban Fringe	41,066	25.9	1,587											

Table 1. (Continued)

URBANIZED AREA	POPULATION (Persons)	AREA (mi^2)	DENSITY (persons/mi^2)	DISTRIBUTION OF LAND AREA BY DENSITY OF POPULATION: <1000	1000-1500	1500-2000	2000-3000	3000-4000	4000-6000	6000-8000	8,000-10,000	10,000-15,000	15,000-20,000	20,000-30,000
Bay City, Mich.	72,763	23.0	3,164		13.4				9.6					
Bay City	53,604	9.6	5,584											
In Urban Fringe	19,159	13.4	1,430											
Beaumont, Tex.	119,178	73.3	1,626	2.5		70.8								
Beaumont	119,175	70.8	1,683											
In Urban Fringe	3	2.5	1											
Billings, Mont.	60,712	15.5	3,917		6.2				9.3					
Billings	52,851	9.3	5,683											
In Urban Fringe	7,861	6.2	1,268											
Binghamton, N.Y.	158,141	31.0	5,101						20.1	10.9				
Binghamton	75,941	10.9	6,967											
In Urban Fringe	82,200	20.1	4,090											
Birmingham, Ala.	521,330	156.8	3,325				82.3		74.5					
Birmingham	340,887	74.5	4,576											
In Urban Fringe	180,443	82.3	2,193											
Boston, Mass.	2,413,236	515.8	4,679					468.0				47.8		
Boston	697,197	47.8	14,586											
In Urban Fringe	1,716,039	468.0	3,667											
Bridgeport, Conn.	366,654	171.3	2,140		153.4						17.9			
Bridgeport	156,748	17.9	8,757											
In Urban Fringe	209,906	153.4	1,368											
Brockton, Mass.	111,315	40.8	2,728			19.3		21.5						
Brockton	72,813	21.5	3,387											
In Urban Fringe	38,502	19.3	1,995											
Buffalo, N.Y.	1,054,370	160.2	6,582						120.8			39.4		
In Central Cities	532,759	39.4	13,522											
Buffalo	532,759	39.4	13,522											
Niagara Falls	(5)	-	---											
In Urban Fringe	521,611	120.8	4,318											
Canton, Ohio	213,574	50.7	4,213				36.4			14.3				
Canton	113,631	14.3	7,946											
In Urban Fringe	99,943	36.4	2,746											
Cedar Rapids, Iowa	105,118	40.4	2,602			7.4	33.0							
Cedar Rapids	92,035	33.0	2,789											
In Urban Fringe	13,083	7.4	1,768											
Champaign-Urbana, Ill.	78,014	12.4	6,291		1.0				5.8	6.4				
In Central Cities	76,877	11.4	6,744											
Champaign	49,583	6.4	7,747											
Urbana	27,294	5.0	5,459											
In Urban Fringe	1,137	1.0	1,137											
Charleston, S.C.	160,113	30.8	5,198					25.7				5.1		
Charleston	65,925	5.1	12,926											
In Urban Fringe	94,188	25.7	3,665											
Charleston, W.Va.	169,590	55.9	3,032					55.9						
Charleston	85,796	28.4	3,021											
In Urban Fringe	83,794	27.5	3,044											
Charlotte, N.C.	209,551	73.9	2,836	9.1				64.8						
Charlotte	201,564	64.8	3,111											
In Urban Fringe	7,987	9.1	878											
Chattanooga, Tenn.	205,143	89.[illegible]	2,302		52.4			36.7						
Chattanooga	130,009	36.[illegible]	3,542											
In Urban Fringe	75,134	52.4	1,434											
Chicago, Ill./Northwestern, Ind.	5,959,213	959.8	6,209					659.0	76.8				228.2	
In Central Cities	3,899,091	300.8	12,959											
Chicago	3,550,404	224.2	15,836											
Gary	178,320	41.6	4,287											
Hammond	111,698	23.5	4,753											
East Chicago	57,669	11.5	5,015											
In Urban Fringe	2,061,122	659.0	3,128											
Cincinnati, Ohio/Ky.	993,568	242.3	4,101				165.0			77.3				
Cincinnati	502,550	77.3	6,501											
In Urban Fringe	491,018	165.0	2,976											

Table 1. (Continued)

URBANIZED AREA	POPULATION (Persons)	AREA (mi²)	DENSITY (persons/mi²)	DISTRIBUTION OF LAND AREA BY DENSITY OF POPULATION <1000	1000-1500	1500-2000	2000-3000	3000-4000	4000-6000	6000-8000	8,000-10,000	10,000-15,000	15,000-20,000	20,000-30,000
Cleveland, Ohio	1,784,991	586.7	3,042			505.5						81.2		
Cleveland	876,050	81.2	10,789											
In Urban Fringe	908,941	505.5	1,798											
Colorado Springs, Col.	108,220	29.3	3,420				12.6		16.7					
Colorado Springs	70,194	16.7	4,203											
In Urban Fringe	30,026	12.6	2,383											
Columbia, S.C.	162,601	52.3	3,109			33.9			18.4					
Columbia	97,433	18.4	5,295											
In Urban Fringe	65,168	33.9	1,922											
Columbus, Ga./Ala.	158,382	53.8	2,944			27.4			26.4					
Columbus	116,779	26.4	4,423											
In Urban Fringe	41,603	27.4	1,518											
Columbus, Ohio	616,743	104.8	4,259				55.8		49.0					
Columbus	471,316	49.0	5,296											
In Urban Fringe	145,427	55.8	2,606											
Corpus Christi, Tex.	177,380	53.1	3,340	15.3					37.8					
Corpus Christi	167,690	37.8	4,436											
In Urban Fringe	9,690	15.3	633											
Dallas, Tex.	932,349	647.0	1,441	367.1			279.9							
Dallas	679,684	279.9	2,428											
In Urban Fringe	252,665	367.1	688											
Davenport, Iowa/Rock Island, Moline, Ill.	227,176	95.9	2,369		29.1	46.7			20.1					
In Central Cities	183,549	66.8	2,748											
Davenport	88,981	46.7	1,905											
Rock Island	51,863	10.9	4,758											
Moline	42,705	9.2	4,642											
In Urban Fringe	43,627	29.1	1,499											
Dayton, Ohio	501,664	120.5	4,029				[illegible]			33.6				
Dayton	262,332	33.6	7,838											
In Urban Fringe	239,332	90.9	2,633											
Decatur, Ill.	89,516	27.6	3,243		7.9			19.7						
Decatur	78,004	19.7	3,950											
In Urban Fringe	11,512	7.9	1,457											
Denver, Col.	803,624	166.6	4,824					95.6		71.0				
Denver	493,887	71.0	6,956											
In Urban Fringe	309,737	95.6	3,240											
Des Moines, Iowa	241,115	97.0	2,486	32.5				64.5						
Des Moines	208,982	64.5	3,240											
In Urban Fringe	32,133	32.5	9 989											
Detroit, Mich.	3,537,709	731.9	4,834					592.3				139.6		
In Central Cities	1,670,144	139 6	11,964											
Detroit	1,670,144	139.6	11,964											
Pontiac	(9)	-	---											
In Urban Fringe	1,867,565	592.3	3,153											
Dubuque, Iowa./Ill.	59,447	15.8	3,762		2.2				13.6					
Dubuque	56,606	13.6	4,162											
In Urban Fringe	2,841	2.2	1,291											
Duluth, Minn./Superior, Wis.	144,763	104.4	1,387	41.8		62.6								
In Central Cities	140,447	99.9	1,406											
Duluth	106,884	62.6	1,707											
Superior	33,563	37.3	900											
In Urban Fringe	4,316	4.5	959											
Durham, N.C.	84,642	27.0	3,135		5.0			22.0						
Durham	78,302	22.0	3,559											
In Urban Fringe	6,340	5.0	1,268											
El Paso, Tex.	277,128	115.0	2,410		0.4		114.6							
El Paso	276,687	114.6	2,416											
In Urban Fringe	441	0.4	1,103											
Erie, Pa.	177,433	54.7	3,129		37.9					16.8				
Erie	138,443	16.8	7,364											
In Urban Fringe	38,990	37.9	1,029											

Table 1. (Continued)

URBANIZED AREA	POPULATION (Persons)	AREA (mi^2)	DENSITY (persons/ mi^2)	DISTRIBUTION OF LAND AREA BY DENSITY OF POPULATION: 1000	1000-1500	1500-2000	2000-3000	3000-4000	4000-6000	6000-8000	8,000-10,000	10,000-15,000	15,000-20,000	20,000-30,000
Eugene, Ore.	95,686	38.2	2,505			23.7		14.5						
Eugene	50,977	14.5	3,516											
In Urban Fringe	44,709	23.7	1,886											
Evansville, Ind.	143,660	34.1	4,213		2.1				32.0					
Evansville	141,543	32.0	4,423											
In Urban Fringe	2,117	2.1	1,008											
Fall River, Mass./R.I.	123,951	47.6	2,604			13.7	33.9							
Fall River	99,942	33.9	2,948											
In Urban Fringe	24,009	13.7	1,752											
Fargo, N.D./Moorhead, Minn.	72,730	20.2	3,600	5.1				6.1	9.0					
In Central Cities	69,596	15.1	4,609											
Fargo	46,662	9.0	5,185											
Moorhead	22,934	6.1	3,760											
In Urban Fringe	3,134	5.1	615											
Fitchburg, Leominster, Mass.	72,307	57.7	1,254	29.5		28.2								
In Central Cities	70,956	56.9	1,247											
Fitchburg	43,021	27.4	1,570											
Leominster	27,929	29.5	947											
In Urban Fringe	1,397	0.8	1,746											
Flint, Mich.	277,786	75.2	3,694			45.3				29.9				
Flint	196,940	29.9	6,587											
In Urban Fringe	80,846	45.3	1,785											
Ft. Lauderdale, Hollywood, Fla.	319,951	123.9	2,582			17.9	84.5	21.5						
In Central Cities	118,885	39.4	3,017											
Ft. Lauderdale	83,648	21.5	3,891											
Hollywood	35,237	17.9	1,949											
In Urban Fringe	201,066	84.5	2,379											
Ft. Smith, Ark./Okla.	61,640	29.3	2,104			4.6	24.7							
Ft. Smith	52,991	24.7	2,145											
In Urban Fringe	8,649	4.6	1,880											
Ft. Wayne, Ind.	179,571	48.6	3,695			11.8			36.8					
Ft. Wayne	161,776	36.8	4,396											
In Urban Fringe	17,795	11.8	1,508											
Ft. Worth, Tex.	502,682	272.6	1,844		132.1		140.5							
Ft. Worth	356,268	140.5	2,536											
In Urban Fringe	146,414	132.1	1,108											
Fresno, Cal.	213,444	60.6	3,522				32.0		28.6					
Fresno	133,929	28.6	4,683											
In Urban Fringe	79,515	32.0	2,485											
Gadsden, Ala.	68,944	47.0	1,467	16.3		30.7								
Gadsden	58,088	30.7	1,892											
In Urban Fringe	10,856	16.3	666											
Galveston, Texas City, Tex.	118,482	153.3	773	153.3										
In Central Cities	99,240	129.2	768											
Galveston	67,175	84.2	798											
Texas City	32,065	45.0	713											
In Urban Fringe	19,242	24.1	798											
Grand Rapids, Mich.	294,230	91.2	3,226			66.8				24.4				
Grand Rapids	177,313	24.4	7,267											
In Urban Fringe	116,917	66.8	1,750											
Great Falls, Mont.	57,629	12.9	4,467			1.5			11.4					
Great Falls	55,357	11.4	4,856											
In Urban Fringe	2,272	1.5	1,515											
Green Bay, Wis.	97,162	46.6	2,085		29.8			16.8						
Green Bay	62,888	16.8	3,743											
In Urban Fringe	34,274	29.8	1,150											
Greensboro, N.C.	123,336	50.8	2,428			2.2	48.6							
Greensboro	119,574	48.6	2,460											
In Urban Fringe	3,762	2.2	[illegible]											

Table 1. (Continued)

URBANIZED AREA	POPULATION (Persons)	Area (mi^2)	DENSITY (persons/ mi)	DISTRIBUTION OF LAND AREA BY DENSITY OF POPULATION: 1000	1000-1500	1500-2000	2000-3000	3000-4000	4000-6000	6000-8000	8,000-10,000	10,000-15,000	15,000-20,000	20,000-30,000
Greenville, S.C.	126,837	52.6	2,412				32.6							
Greenville	66,188	26.3	2,724											
In Urban Fringe	60,649	28.3	2,145											
Hamilton, Ohio	89,778	34.1	2,633	21.9					12.2					
Hamilton	72,354	12.2	5,931											
In Urban Fringe	17,424	21.9	796											
Harlingen-San Benito, Tex.	61,656	51.1	1,207	16.4	31.0		5.7							
In Central Cities	57,629	36.7	1,570											
Harlingen	41,207	31.0	1,329											
San Benito	16,422	5.7	2,881											
In Urban Fringe	4,029	14.4	280											
Harrisburg, Pa.	209,501	48.2	4,346					40.6				7.6		
Harrisburg	79,697	7.6	10,486											
In Urban Fringe	129,804	40.6	3,197											
Hartford, Conn.	381,619	131.2	2,909			113.8					17.4			
Hartford	162,178	17.4	9,321											
In Urban Fringe	219,441	113.8	1,928											
High Point, N.C.	66,543	33.7	1,975		3.4		29.3							
High Point	62,063	30.3	2,048											
In Urban Fringe	4,480	3.4	1,318											
Honolulu, Haw.	351,336	99.8	3,520					99.8						
Honolulu	294,194	83.9	3,526											
In Urban Fringe	57,142	15.9	3,594											
Houston, Tex.	1,139,678	430.5	2,647			102.6	328.1							
Houston	938,219	328.1	2,860											
In Urban Fringe	201,459	102.6	1,967											
Huntington-Ashland, W.Va./Ky.	163,732	42.2	3,927				34.2					6.0		
In Central Cities	116,910	22.0	5,221											
Huntington	83,627	8.0	10,452											
Ashland	31,283	14.0	2,235											
In Urban Fringe	50,822	20.2	2,516											
Huntsville, Ala.	74,970	53.2	1,484		53.2									
Huntsville	72,365	50.7	1,427											
In Urban Fringe	2,605	2.5	1,042											
Indianapolis, Ind.	639,340	144.9	4,412				73.7			71.2				
Indianapolis	476,258	71.2	6,689											
In Urban Fringe	163,082	73.7	2,213											
Jackson, Mich.	71,412	22.1	3,231			11.6			10.5					
Jackson	50,720	10.5	4,830											
In Urban Fringe	20,692	11.6	1,784											
Jackson, Miss.	147,480	49.7	2,957	3.2				46.6						
Jackson	144,422	46.5	3,105											
In Urban Fringe	3,058	3.2	956											
Jacksonville, Fla.	372,569	111.4	3,344				81.2							
Jacksonville	201,030	30.2	6,657											
In Urban Fringe	171,539	81.2	2,113											
Johnstown, Pa.	96,474	21.0	4,534				15.0				5.6			
Johnstown	53,949	5.6	9,634											
In Urban Fringe	42,525	15.4	2,761											
Joliet, Ill.	116,593	36.9	3,159				22.7		14.2					
Joliet	66,780	14.2	4,703											
In Urban Fringe	49,893	22.7	2,194											
Kalamazoo, Mich.	115 [illegible]	42.1	2,747			18.0		20.1						
Kalamazoo	82,089	24.1	3,406											
In Urban Fringe	33,370	18.0	1,855											
Kansas City, Mo./Kan.	921,121	282.4	3,262				132.8	129.6						
Kansas City	475,939	129.6	3,664											
In Urban Fringe	445,182	152.6	2,920											
Kenosha, Wis.	72,662	13.2	5,512			3.1				10.1				
Kenosha	67,899	10.1	6,723											
In Urban Fringe	4,763	3.1	1,553											

Table 1. (Continued)

URBANIZED AREA	POPULATION (Persons)	AREA (mi²)	DENSITY (persons/mi²)	DISTRIBUTION OF LAND AREA BY DENSITY OF POPULATION: 1000	1000-1500	1500-2000	2000-3000	3000-4000	4000-6000	6000-8000	8,000-10,000	10,000-15,000	15,000-20,000	20,000-30,000
Knoxville, Tenn.	175,734	59.7	2,943			34.3			25.4					
Knoxville	111,827	25.4	4,403											
In Urban Fringe	63,907	34.3	1,776											
Lake Charles, La.	89,115	24.8	3,593					24.8						
Lake Charles	63,392	16.3	3,889											
In Urban Fringe	25,723	8.5	3,026											
Lancaster, Pa.	93,855	29.2	3,214		21.9						7.3			
Lancaster	61,055	7.3	8,364											
In Urban Fringe	32,800	21.9	1,498											
Lansing, Mich.	169,325	47.2	3,587				26.0		21.2					
Lansing	107,807	21.2	5,085											
In Urban Fringe	61,518	26.0	2,366											
Laredo, Tex.	60,678	13.5	4,495						13.5					
Laredo	60,678	13.5	4,495											
Las Vegas, Nev.	89,427	34.3	2,607				34.3							
Las Vegas	64,405	24.7	2,607											
In Urban Fringe	25,022	9.6	2,606											
Lawrence, Mass./Haverhill, N.H.	166,125	70.5	2,356		32.0	31.3					7.2			
In Central Cities	117,279	39.2	2,992											
Lawrence	70,933	7.2	9,852											
Haverhill	46,346	32.0	1,448											
In Urban Fringe	48,846	31.3	1,561											
Lawton, Okla.	61,941	13.2	4,693	1.2					12.0					
Lawton	61,697	12.0	5,141											
In Urban Fringe	244	1.2	203											
Lewiston-Auburn, Me.	65,233	95.9	680	60.9	35.0									
In Central Cities	65,233	95.9	680											
Lewiston	40,804	35.0	1,166											
Auburn	24,429	60.9	401											
Lexington, Ky.	111,940	27.2	4,115					14.2	13.0					
Lexington	62,810	13.0	4,832											
In Urban Fringe	49,130	14.2	3,460											
Lima, Ohio	62,963	13.1	4,806				4.8		8.3					
Lima	51,037	8.3	6,149											
In Urban Fringe	11,926	4.8	2,485											
Lincoln, Neb.	136,220	35.0	3,892	9.6					25.4					
Lincoln	128,521	25.4	5,060											
In Urban Fringe	7,699	9.6	802											
Little Rock-North Little Rock, Ark.	185,017	62.2	2,975		14.0		19.9	28.3						
In Central Cities	165,845	48.2	3,441											
Little Rock	107,813	28.3	3,810											
North Little Rock	58,032	19.9	2,916											
In Urban Fringe	19,172	14.0	1,369											
Lorain/Elyria, Ohio	142,880	81.4	1,755	49.1				32.3						
In Central Cities	112,716	32.3	3,490											
Lorain	68,932	18.0	3,830											
Elyria	43,782	14.3	3,062											
In Urban Fringe	30,164	49.1	614											
Los Angeles-Long Beach, Cal.	6,488,791	1,370.0	4,736						1326.1	43.9				
In Central Cities	2,823,183	530.7	5,320											
Los Angeles	2,479,015	484.8	5,113											
Long Beach	344,168	45.9	7,498											
In Urban Fringe	3,665,608	839.3	4,367											
Louisville, Ky./Ind.	606,659	135.6	4,474				78.5			57.1				
Louisville	390,639	57.1	6,841											
In Urban Fringe	216,020	78.5	2,752											
Lowell, Mass.	118,547	30.0	3,952			16.9				13.1				
Lowell	92,107	13.1	7,031											
In Urban Fringe	26,440	16.9	1,564											

Table 1. (Continued)

Urbanized Area	Population (Persons)	Area (mi.²)	Density (persons/mi.²)	Distribution of Land Area by Density of Population: Under 1000	1000-1500	1500-2000	2000-3000	3000-4000	4000-6000	6000-8000	8000-10,000	10,000-15,000	15,000-20,000	20,000 and over
Lubbock, Tex.	129,289	76.2	1,697	1.2		75.0								
Lubbock	128,691	75.0	1,716											
In Urban Fringe	598	1.2	498											
Lynchburg, Va.	59,319	27.6	2,149	4.6			23.0							
Lynchburg	54,790	23.0	2,382											
In Urban Fringe	4,529	4.6	985											
Macon, Ga.	114,161	33.2	3,439				18.2		15.0					
Macon	69,764	15.0	4,651											
In Urban Fringe	44,397	18.2	2,439											
Madison, Wis.	157,814	54.3	2,906			18.6		35.7						
Madison	126,706	35.7	3,549											
In Urban Fringe	31,108	18.6	1,672											
Manchester, N.H.	91,698	34.6	2,650		2.6		32.0							
Manchester	88,282	32.0	2,759											
In Urban Fringe	3,416	2.6	1,314											
Memphis, Tenn.	544,505	155.7	3,497			27.5		128.2						
Memphis	497,524	128.2	3,881											
In Urban Fringe	46,981	27.5	1,708											
Meriden, Conn.	51,850	23.5	2,206				23.5							
Meriden	51,850	23.5	2,206											
Miami, Fla.	852,705	183.1	4,657					148.9			34.2			
Miami	291,688	34.2	8,529											
In Urban Fringe	561,017	148.9	3,768											
Midland, Tex.	63,274	23.5	2,693		0.6		22.9							
Midland	62,625	22.9	2,735											
In Urban Fringe	649	0.6	1,082											
Milwaukee, Wis.	1,149,997	392.0	2,934		300.9						91.1			
Milwaukee	741,324	91.1	8,137											
In Urban Fringe	408,673	300.9	1,358											
Minneapolis, St. Paul, Minn.	1,377,143	657.3	2,095		548.6					52.2	56.5			
In Central Cities	796,283	108.7	7,326											
Minneapolis	482,872	56.5	8,546											
St. Paul	313,411	52.2	6,004											
In Urban Fringe	580,860	548.6	1,059											
Mobile, Ala.	268,139	171.5	1,563		152.9			18.6						
Mobile	202,779	152.9	1,326											
In Urban Fringe	65,360	18.6	3,514											
Monroe, La.	80,546	40.4	1,994		22.3		18.1							
Monroe	52,219	18.1	2,885											
In Urban Fringe	28,327	22.3	1,270											
Montgomery, Ala.	142,893	39.2	3,645		7.8				31.4					
Montgomery	134,393	31.4	4,280											
In Urban Fringe	8,500	7.8	1,090											
Muncie, Ind.	77,504	17.6	4,404			5.3			12.3					
Muncie	68,603	12.3	5,577											
In Urban Fringe	8,901	5.3	1,679											
Muskegon, Muskegon Heights, Mich.	95,849	24.1	3,958				11.2		9.2	3.7				
In Central Cities	66,537	12.9	5,158											
Muskegon	46,485	9.2	5,053											
Muskegon Heights	17,552	3.7	[illegible]											
In Urban Fringe	29,312	11.2	2,617											
Nashville, Tenn.	346,729	179.3	1,934		150.3				29.0					
Nashville	170,874	29.0	5,892											
In Urban Fringe	175,855	150.3	1,170											
New Bedford, Mass.	126,857	29.7	4,265				10.5	19.1						
New Bedford	102,477	19.1	5,365											
In Urban Fringe	24,380	10.6	2,281											

Table 1. (Continued)

URBANIZED AREA	POPULATION (Persons)	AREA (mi²)	DENSITY (persons/mi²)	< 1000	1000-1500	1500-2000	2000-3000	3000-4000	4000-6000	6000-8000	8,000-10,000	10,000-15,000	15,000-20,000	20,000-30,000
				DISTRIBUTION OF LAND AREA BY DENSITY OF POPULATION										
New Britain, Conn.	99,894	22.6	4,420			8.9				13.7				
In Central Cities	82,201	13.7	6,000											
New Britain	82,201	13.7	6,000											
Bristol	(9)	-	---											
In Urban Fringe	17,693	8.9	1,988											
New Haven, Conn.	278,794	83.8	3,327			65.9					17.9			
New Haven	152,048	17.9	8,494											
In Urban Fringe	126,726	65.9	1,923											
New Orleans, La.	845,237	266.5	3,172					266.5						
New Orleans	627,525	198.8	3,157											
In Urban Fringe	[illegible]	67.7	3,216											
Newport News, Hampton, Va.	208,874	149.1	1,401	17.1		132.0								
In Central Cities	202,920	132.0	1,537											
Newport News	113,662	75.0	1,515											
Hampton	89,258	57.0	1,566											
In Urban Fringe	5,958	17.1	348											
New York/Northeastern N.J.	14,114,927	1,891.5	7,462					1516.6		11.7			35.1	328.1
In Central Cities	8,743,015	374.9	23,321											
New York City	7,781,984	315.1	24,697											
Newark	405,220	23.6	17,170											
Jersey City	276,101	13.0	21,239											
Paterson	143,663	8.4	17,103											
Clifton	82,084	11.7	7,016											
Passaic	53,963	3.1	17,407											
In Urban Fringe	5,371,912	1,516.6	3,542											
Norfolk, Portsmouth, Va.	507,825	108.6	4,676				40.6			68.0				
In Central Cities	420,725	68.0	6,188											
Norfolk	305,872	50.0	6,117											
Portsmouth	114,773	18.0	6,376											
In Urban Fringe	87,100	40.6	2,147											
Norwalk, Conn.	82,270	38.8	2,120		14.1		24.7							
Norwalk	67,775	24.7	2,744											
In Urban Fringe	14,495	14.1	1,028											
Odessa, Tex.	84,285	19.4	4,345		3.7				15.7					
Odessa	80,338	15.7	5,117											
In Urban Fringe	3,947	3.7	1,067											
Ogden, Utah	121,927	66.7	1,828		47.8			18.9						
Ogden	70,197	18.9	3,714											
In Urban Fringe	51,730	47.8	1,082											
Oklahoma City, Okla.	429,188	385.2	1,114		321.5	63.7								
Oklahoma	328,253	321.5	1,009											
In Urban Fringe	100,935	63.7	1,637											
Omaha, Nebr./Iowa	389,881	89.0	4,381				37.8		51.2					
Omaha	301,598	51.2	5,891											
In Urban Fringe	88,283	37.8	2,336											
Orlando, Fla.	200,995	76.8	2,617				55.7		21.1					
Orlando	88,135	21.1	4,177											
In Urban Fringe	112,860	55.7	2,026											
Pensacola, Fla.	128,049	45.8	2,796				45.8							
Pensacola	56,752	20.1	2,823											
In Urban Fringe	71,297	25.7	2,774											
Peoria, Ill.	181,432	50.4	3,630				35.2			15.2				
Peoria	103,162	15.2	6,787											
In Urban Fringe	78,270	35.2	2,224											

Table 1. (Continued)

URBANIZED AREA	POPULATION (persons)	AREA (mi^2)	DENSITY (persons/mi^2)	DISTRIBUTION OF LAND AREA BY DENSITY OF POPULATION										
				<1000	1000-1500	1500-2000	2000-3000	3000-4000	4000-6000	6000-8000	8,000-10,000	10,000-15,000	15,000-20,000	20,000-30,000
Philadelphia, Pa./N.J.	3,635,228	596.7	6,092					469.5					127.2	
Philadelphia	2,002,512	127.2	15,743											
In Urban Fringe	1,632,716	469.5	3,478											
Phoenix, Ariz.	552,043	248.4	2,222			61.0	187.4							
Phoenix	439,170	187.4	2,343											
In Urban Fringe	112,873	61.0	1,850											
Pittsburgh, Pa.	1,804,400	525.0	3,437				470.9					54.1		
Pittsburgh	604,332	54.1	11,171											
In Urban Fringe	1,200,068	470.9	2,548											
Pittsfield, Mass.	62,306	*43.2	1,442		40.9	2.3								
Pittsfield	57,879	40.9	1,415											
In Urban Fringe	4,427	2.3	1,925											
Pomona-Ontario, Cal.	185,947	71.3	2,616				52.9	18.4						
In Central Cities	113,778	36.2	3,143											
Pomona	67,157	18.4	3,650											
Ontario	46,617	17.8	2,619											
In Urban Fringe	72,773	35.1	2,073											
Port Arthur, Tex.	116,165	79.5	1,464		79.5									
Port Arthur	66,676	45.7	1,459											
In Urban Fringe	49,489	33.8	1,470											
Portland, Me.	111,701	51.2	2,182		29.6			21.6						
Portland	72,566	21.6	3,360											
In Urban Fringe	39,135	29.6	1,322											
Portland, Ore./Wash.	651,685	192.4	3,387				125.2		67.2					
Portland	372,676	67.2	5,546											
In Urban Fringe	279,009	125.2	2,229											
Providence-Pawtucket, R.I./Mass.	659,542	180.0	3,558				97.5				8.0	17.9		
In Central Cities	288,499	26.5	10,887											
Providence	207,498	17.9	11,592											
Pawtucket	81,001	8.6	9,419											
In Urban Fringe	371,043	151.5	2,297											
Provo-Orem, Utah	60,795	42.4	1,434	7.6	15.6	19.2								
In Central Cities	54,441	34.8	1,564											
Provo	36,047	19.2	1,877											
Orem	18,394	15.6	1,179											
In Urban Fringe	6,354	7.6	836											
Pueblo, Col.	103,336	25.5	4,052		8.4				17.1					
Pueblo	91,181	17.1	5,332											
In Urban Fringe	12,155	8.4	1,447											
Racine, Wis.	95,862	14.6	6,566			3.4				11.2				
Racine	89,144	11.2	7,959											
In Urban Fringe	6,718	3.4	1,976											
Raleigh, N.C.	93,931	33.5	2,804				33.5							
Raleigh	93,931	33.5	2,804											
In Urban Fringe	---	-	---											
Reading, Pa.	160,297	33.1	4,843				23.5					9.6		
Reading	98,177	9.6	10,227											
In Urban Fringe	62,120	23.5	2,643											
Reno, Nev.	70,189	16.3	4,306						16.3					
Reno	51,470	11.8	4,362											
In Urban Fringe	18,719	4.5	4,160											
Richmond, Va.	333,438	88.5	3,768				51.5		37.0					
Richmond	219,958	37.0	5,945											
In Urban Fringe	113,480	51.5	2,203											
Roanoke, Va.	124,752	40.4	3,088			18.6		26.0						
Roanoke	97,110	26.0	3,735											
In Urban Fringe	27,642	14.4	1,920											
Rochester, N.Y.	493,402	113.3	4,355				76.9				33.4			
Rochester	318,611	36.8	8,753											
In Urban Fringe	174,791	76.9	2,273											
Rockford, Ill.	171,881	43.2	3,974				17.2		26.0					
Rockford	126,706	26.0	4,873											
In Urban Fringe	44,975	17.2	2,615											

Table 1. (Continued)

URBANIZED AREA	POPULATION (Persons)	AREA (mi²)	DENSITY (persons/mi²)	DISTRIBUTION OF LAND AREA BY DENSITY OF POPULATION: 1000	1000-1500	1500-2000	2000-3000	3000-4000	4000-6000	6000-8000	8,000-10,000	10,000-15,000	15,000-20,000	20,000-30,000
Sacramento, Cal.	451,920	134.0	3,373				88.9		45.1					
Sacramento	191,667	45.1	4,250											
In Urban Fringe	260,253	88.9	2,927											
Saginaw, Mich.	129,215	31.1	4,155				14.5		16.6					
Saginaw	98,265	16.6	5,920											
In Urban Fringe	30,950	14.5	2,134											
St. Joseph, Mo./Kan.	81,187	28.8	2,819		1.1		27.7							
St. Joseph	79,673	27.7	2,876											
In Urban Fringe	1,514	1.1	1,376											
St. Louis, Mo./Ill.	1,667,693	323.2	5,160					262.2				61.0		
St. Louis	750,026	61.0	12,296											
In Urban Fringe	917,667	262.2	3,500											
St. Petersburg, Fla.	324,842	115.2	2,820				61.2	54.0						
St. Petersburg	181,298	54.0	3,357											
In Urban Fringe	143,544	61.2	2,345											
Salt Lake City, Utah	348,661	131.7	2,647				75.6	56.1						
Salt Lake City	189,454	56.1	3,377											
In Urban Fringe	159,207	75.6	2,106											
San Angelo, Tex.	58,815	29.7	1,980			29.7								
San Angelo	58,815	29.7	1,980											
San Antonio, Tex.	641,965	192.4	3,337			31.9		160.5						
San Antonio	587,718	160.5	3,662											
In Urban Fringe	54,247	31.9	1,701											
San Bernardino, Riverside, Cal.	377,531	169.4	2,229			103.5	40.6	25.3						
In Central Cities	176,254	65.9	2,675											
San Bernardino	91,922	25.3	3,633											
Riverside	84,332	40.6	2,077											
In Urban Fringe	201,277	103.5	1,945											
San Diego, Cal.	836,175	275.7	3,033				192.4	83.3						
San Diego	573,224	192.4	2,979											
In Urban Fringe	262,951	83.3	3,157											
San Francisco-Oakland, Cal.	2,430,663	571.5	4,253				470.9			53.0			47.6	
In Central Cities	1,107,864	100.6	11,013											
San Francisco	740,316	47.6	15,553											
Oakland	367,548	53.0	6,935											
In Urban Fringe	1,322,799	470.9	2,809											
San Jose, Cal.	602,805	223.1	2,702				168.6	54.5						
San Jose	204,196	54.5	3,747											
In Urban Fringe	398,609	168.6	2,364											
Santa Barbara, Cal.	72,740	29.7	2,449		10.0		19.7							
Santa Barbara	58,768	19.7	2,983											
In Urban Fringe	13,972	10.0	1,397											
Savannah, Ga.	169,887	61.1	2,780		13.6			41.5						
Savannah	149,245	41.5	3,596											
In Urban Fringe	20,642	19.6	1,053											
Scranton, Pa.	210,676	104.8	2,010		79.5				25.3					
Scranton	111,443	25.3	4,405											
In Urban Fringe	99,233	79.5	1,248											
Seattle, Wash.	864,109	238.3	3,626				149.8			88.5				
Seattle	557,087	88.5	6,295											
In Urban Fringe	307,022	149.8	2,050											
Shreveport, La.	208,583	52.4	3,981				16.4		36.0					
Shreveport	164,372	36.0	4,566											
In Urban Fringe	44,211	16.4	2,696											
Sioux City, Iowa/Nebr./S. Dak.	97,926	54.3	1,803			54.3								
Sioux City	89,159	49.4	1,805											
In Urban Fringe	8,767	4.9	1,789											

Table 1. (Continued)

URBANIZED AREA	POPULATION (Persons)	AREA (sq. mi.)	DENSITY (persons/sq. mi.)	Under 1000	1000-1500	1500-2000	2000-3000	3000-4000	4000-6000	6000-8000	8000-10,000	10,000-15,000	15,000-20,000	20,000-30,000
				DISTRIBUTION OF LAND AREA BY DENSITY OF POPULATION										
Sioux Falls, S.D.	68,542	17.4	3,927				0.4	17.0						
Sioux Falls	65,466	[illegible]	3,897											
In Urban Fringe	[illegible]	[illegible]	2,790											
South Bend, Ind./Mich.	218,933	64.0	3,421				40.2		23.8					
South Bend	132,445	23.8	5,565											
In Urban Fringe	86,488	40.2	2,151											
Spokane, Wash.	226,938	64.1	3,540				21.1		43.0					
Spokane	181,608	43.0	4,223											
In Urban Fringe	45,330	21.1	2,148											
Springfield, Ill.	111,403	32.6	3,417				11.2	21.4						
Springfield	83,271	21.4	3,891											
In Urban Fringe	28,132	11.2	2,512											
Springfield, Mo.	97,224	35.6	2,731			0.9	34.7							
Springfield	95,865	34.7	2,763											
In Urban Fringe	1,359	0.9	1,510											
Springfield, Ohio	90,157	22.6	4,377			6.9			15.7					
Springfield	82,723	15.7	5,269											
In Urban Fringe	7,434	6.9	1,077											
Springfield, Chicopee, Holyoke, Mass./Conn.	449,777	239.3	1,883	164.5			22.8	18.4	33.[illegible]					
In Central Cities	288,705	74.3	3,886											
Springfield	174,463	32.[illegible]	5,277											
Chicopee	61,553	19.8	3,145											
Holyoke	52,689	22.8	2,311											
In Urban Fringe	161,072	164.5	979											
Stamford, Conn.	168,990	98.1	1,722		59.7		38.6							
Stamford	92,713	38.4	2,414											
In Urban Fringe	76,277	59.7	1,284											
Steubenville, Weirton, Ohio-W. Va.	81,613	36.8	2,218			31.0			5.8					
In Central Cities	57,696	10.4	[illegible]											
Steubenville	32,495	[illegible]	[illegible]											
Weirton	28,201	[illegible]	[illegible]											
In Urban Fringe	23,917	[illegible]	[illegible]											
Stockton, Cal.	141,604	38.4	3,688					38.4						
Stockton	86,321	22.9	3,769											
In Urban Fringe	55,283	15.5	3,567											
Syracuse, N.Y.	333,286	[illegible]	4,923				42.7				29.0			
Syracuse	216,038	25.[illegible]	8,492											
In Urban Fringe	117,248	42.[illegible]	2,746											
Tacoma, Wash.	214,930	82.8	2,596			35.3		47.5						
Tacoma	147,979	47.5	3,115											
In Urban Fringe	66,951	35.3	1,897											
Tampa, Fla.	301,790	103.4	2,919		18.4			85.0						
Tampa	274,970	85.0	3,235											
In Urban Fringe	26,820	18.4	1,458											
Terre Haute, Ind.	81,415	31.7	2,568		7.0		24.7							
Terre Haute	72,500	24.7	2,935											
In Urban Fringe	8,915	7.0	1,274											
Texarkana, Tex./Ark.	53,422	26.7	2,001	4.8		15.9		6.0						
In Central Cities	50,006	21.9	2,283											
Texarkana, Tex.	30,218	15.9	1,901											
Texarkana, Ark.	19,788	6.0	3,298											
In Urban Fringe	3,416	4.8	711											
Toledo, Ohio	439,283	138.9	3,163		88.7					48.2				
Toledo	318,003	48.2	6,598											
In Urban Fringe	121,280	90.7	1,337											
Topeka, Kan.	119,500	36.2	3,301	0.1				36.1						
Topeka	119,484	36.1	3,310											
In Urban Fringe	16	0.1	160											
Trenton, N.J./Pa.	262,471	75.3	3,219			67.9							7.4	
Trenton	114,167	7.4	15,428											
In Urban Fringe	148,304	67.9	2,184											
Tucson, Ariz.	227,433	86.4	2,632	15.5				70.9						
Tucson	212,892	70.9	3,003											
In Urban Fringe	14,541	15.5	938											

Table 1. (Continued)

URBANIZED AREA	POPULATION (Persons)	AREA (mi^2)	DENSITY (persons/mi^2)	DISTRIBUTION OF LAND AREA BY DENSITY OF POPULATION: 1000	1000-1500	1500-2000	2000-3000	3000-4000	4000-6000	6000-8000	8,000-10,000	10,000-15,000	15,000-20,000	20,000-30,000
Tulsa, Okla.	298,922	70.2	4,258			22.4			47.8					
Tulsa	261,685	47.8	5,475											
In Urban Fringe	37,237	22.4	1,662											
Tuscaloosa, Ala.	76,815	30.5	2,519		9.5			21.0						
Tuscaloosa	63,370	21.0	3,018											
In Urban Fringe	13,445	9.5	1,415											
Tyler, Tex.	51,739	18.6	2,782			0.3	18.3							
Tyler	51,230	18.3	2,799											
In Urban Fringe	509	0.3	1,697											
Utica, Rome, N.Y.	187,779	112.4	1,671	77.1		18.3			17.0					
In Central Cities	152,056	94.1	1,616											
Utica	100,410	17.0	5,906											
Rome	51,646	77.1	670											
In Urban Fringe	35,723	18.3	1,950											
Waco, Tex.	116,163	64.9	1,798	27.6		37.3								
Waco	97,808	37.3	2,622											
In Urban Fringe	18,355	27.6	665											
Washington, D.C./Md./Va.	1,808,423	340.7	5,308					279.3				61.4		
Washington	763,956	61.4	12,442											
In Urban Fringe	1,044,467	279.3	3,740											
Waterbury, Conn.	141,626	50.4	2,810			22.8		27.6						
Waterbury	107,130	27.6	3,882											
In Urban Fringe	34,496	22.8	1,513											
Waterloo, Iowa	102,827	49.5	2,077			15.7	33.8							
Waterloo	71,755	33.8	2,123											
In Urban Fringe	31,072	15.7	1,979											
West Palm Beach, Fla.	172,835	98.6	1,753		79.9			18.7						
West Palm Beach	56,208	18.7	3,006											
In Urban Fringe	116,627	79.9	1,460											
Wheeling, W.Va./Ohio	98,951	27.3	3,625				6.5		10.8					
Wheeling	53,400	10.8	4,944											
In Urban Fringe	45,551	16.5	2,761											
Wichita, Kan.	292,138	79.7	3,665		27.9				51.9					
Wichita	254,698	51.9	4,907											
In Urban Fringe	37,440	27.8	1,347											
Wichita Falls, Tex.	102,104	37.4	2,730				37.3	0.1						
Wichita Falls	101,724	37.3	2,727											
In Urban Fringe	380	0.1	3,800											
Wilkes-Barre, Pa.	233,932	74.1	3,157				67.2				6.9			
Wilkes-Barre	63,551	6.9	9,210											
In Urban Fringe	170,381	67.2	2,535											
Wilmington, Del./N.J.	283,667	90.0	3,152				74.2			15.8				
Wilmington	95,827	15.8	6,065											
In Urban Fringe	187,840	74.2	2,532											
Winston-Salem, N.C.	128,176	43.0	2,981		11.9			31.1						
Winston-Salem	111,135	31.1	3,573											
In Urban Fringe	17,041	11.9	1,432											
Worcester, Mass.	225,446	61.3	3,678			24.3			37.0					
Worcester	186,587	37.0	5,043											
In Urban Fringe	38,859	24.3	1,599											
York, Pa.	100,872	10.4	9,699								5.7	4.7		
York	54,504	4.7	11,597											
In Urban Fringe	46,368	5.7	8,135											
Youngstown, Warren, Ohio/Pa.	372,748	108.0	3,451				63.9		44.1					
In Central Cities	226,337	44.1	5,1[illegible]											
Youngstown	166,689	33.2	5,021											
Warren	59,648	10.9	5,472											
In Urban Fringe	146,411	63.9	2,291											
				1,198	2,090	2,817	5,985	7,239	3,133	960	328	406	462	328

Total Land Area for which Density Greater than or Equal to that in Density Class

	POPULATION (Persons)	AREA (mi^2)	DENSITY (persons/mi^2)	1000	1000-1500	1500-2000	2000-3000	3000-4000	4000-6000	6000-8000	8,000-10,000	10,000-15,000	15,000-20,000	20,000-30,000
Total U.S. Urban Areas (1950)	95,843,607	23,886.3	3,752	25,860	24,287	21,898	19,088	13,028	5,776	2,687	1,714	1,348	778	328
In Central Cities	57,9[illegible]5,122	10,837.7	5,[illegible]9											
In Urban Fringe	37,873,355	14,706.6	2,575											

Table 2. POPULATION, LAND AREAS, AND DENSITY OF U.S. URBANIZED AREAS (1960 CENSUS)

Urbanized Area	Population (Persons)	Area (mi²)	Density (Persons/mi²)	Distribution of Population by Density of Population: 1000	1000-1500	1500-2000	2000-3000	3000-4000	4000-6000	6000-8000	8,000-10,000	10,000-15,000	15,000-20,000	20,000-30,000
Abilene, Tex.	91,666	63.9	1,430	1193	90,388									
Akron, Ohio	458,253	141.3	3,243			167,902			290,351					
Albany, Ga.	60,333	26.6	2,362			2,433	57,900							
Albany-Schenectady-Troy, N.Y.	455,447	108.4	4,201				176,547			278,900				
Albuquerque, N.M.	241,216	76.0	3,174				40,036			201,180				
Allentown-Bethlehem, Pa.	256,016	60.1	6,230					187,669		168,347				
Altoona, Pa.	83,093	18.0	4,616			15,631				69,037				
Amarillo, Tex.	137,969	54.8	2,518				137,969							
Ann Arbor, Mich.	115,282	27.9	4,132					47,942	67,340					
Asheville, N.C.	68,592	32.3	2,124		8,400		60,192							
Atlanta, Ga.	768,125	243.0	3,163				280,670	487,455						
Atlantic City, N.J.	124,962	60.0	2,082		65,318				59,644					
Augusta, Ga./S.C.	123,698	43.1	2,870			53,072			70,626					
Aurora, Ill.	83,022	20.6	4,032				21,307		61,715					
Austin, Tex.	187,157	58.7	3,191	612				186,545						
Bakersfield, Cal.	141,763	38.3	3,701					141,763						
Baltimore, Md.	1,418,948	222.3	6,381					479,924				939,024		
Baton Rouge, La.	193,485	56.0	3,455			41,066			152,419					
Bay City, Mich.	72,763	23.0	3,164		19,129				53,634					
Beaumont, Tex.	119,175	73.3	1,626	3		119,172								
Billings, Mont.	63,712	16.6	3,817		7,881				55,831					
Binghamton, N.Y.	158,141	31.0	5,101						82,180	75,961				
Birmingham, Ala.	521,330	156.8	3,326				180,483		340,847					
Boston, Mass.	2,413,236	518.0	4,659					1,716,039				697,197		
Bridgeport, Conn.	365,844	171.3	2,136		259,084						106,760			
Brockton, Mass.	111,315	40.9	2,728			38,497		72,818						
Buffalo, N.Y.	1,054,370	165.2	6,382						321,611			732,759		
Canton, Ohio	213,574	50.7	4,213				99,943			113,631				
Cedar Rapids, Iowa	105,118	40.4	2,602			13,053	92,065							
Champaign-Urbana, Ill.	78,816	12.4	6,356		1,137				37,296	40,383				
Charleston, S.C.	160,113	29.8	5,373					94,188				65,925		
Charleston, W.Va.	169,500	55.9	3,032					169,500						
Charlotte, N.C.	209,551	73.9	2,836	7067				202,484						
Chattanooga, Tenn.	205,143	89.1	2,302		75,134			130,009						
Chicago, Ill./N.W. Ind.	5,959,213	946.5	6,296					2,281,122	307,607			3,370,484		
Cincinnati, Ohio/Ky.	993,568	242.3	4,101				491,219			502,349				
Cleveland, Ohio	1,784,991	506.7	3,523			908,941						876,050		
Colorado Springs, Col.	160,220	29.3	3,620				89,026		71,194					
Columbia, S.C.	162,601	53.3	3,100			65,168			97,433					
Columbus, Ga./Ala.	159,382	53.8	2,948			41,003			118,379					
Columbus, Ohio	616,743	144.8	4,259				143,427		473,316					
Corpus Christi, Tex.	177,380	53.1	3,340	9690					167,690					
Dallas, Tex.	932,349	647.0	1,441	352,485			579,864							
Davenport, Iowa/Rock Island-Moline, Ill.	227,176	93.9	2,419		43,627	83,591			99,958					
Dayton, Ohio	501,664	124.6	4,026				237,392			[illegible]				
Decatur, Ill.	89,516	27.6	3,243		11,512			78,004						
Denver, Col.	803,624	168.6	4,766					290,737		512,887				
Des Moines, Iowa	241,115	97.0	2,495	22,133				218,982						
Detroit, Mich.	3,537,709	731.9	4,834					1,657,569				1,880,140		
Dubuque, Iowa/Ill.	60,647	16.0	3,782		2,061				58,586					
Duluth, Minn./Superior, Wis.	166,733	106.0	1,337	37,079		129,654								
Durham, N.C.	84,642	27.0	3,135		6,302			78,340						
El Paso, Tex.	277,128	118.0	2,348		481		276,647							
Erie, Pa.	177,433	55.7	3,185		53,803					123,630				
Eugene, Oregon	95,826	38.2	2,508			46,789		49,037						
Evansville, Ind.	162,569	34.1	4,767		2,117				160,452					

Table 2. (Continued)

URBANIZED AREA	POPULATION (Persons)	AREA (mi²)	DENSITY (Persons/mi.)	DISTRIBUTION OF POPULATION BY DENSITY OF POPULATION: 1000	1000-1500	1500-2000	2000-3000	3000-4000	4000-6000	6000-8000	8,000-10,000	10,000-15,000	15,000-20,000	20,000-30,000
Fall River, Mass./R.I.	123,951	47.6	2,604			24,099	99,842							
Fargo, N.D./Moorhead, Minn.	72,728	20.2	3,600	3,134				22,934	46,632					
Fitchburg-Leominster, Mass.	72,347	57.7	1,254	27,929		44,418								
Flint, Mich.	277,786	76.2	3,634			80,046				196,940				
Ft. Lauderdale-Hollywood, Fla.	319,951	123.0	2,602			36,237	181,808	83,848						
Ft. Smith, Ark./Okla	61,640	29.3	2,104			8,849	52,891							
Ft. Wayne, Ind.	179,571	48.6	3,693			17,798			161,774					
Ft. Worth, Tex.	502,682	272.6	1,844		148,416		356,260							
Fresno, Cal.	213,444	60.6	3,522				79,818		133,929					
Gadsden, Ala.	68,944	47.0	1,467	10,856		58,088								
Galveston-Texas City, Tex.	118,482	153.2	773	118,482										
Grand Rapids, Mich.	294,230	91.2	3,228			116,917				177,313				
Great Falls, Mont.	57,629	12.9	4,467			2,272			55,357					
Green Bay, Wis.	97,162	46.6	2,085		34,273			62,889						
Greensboro, N.C.	123,334	50.8	2,428			3,760	119,574							
Greenville, S.C.	126,887	52.6	2,412				126,887							
Hamilton, Ohio	89,778	34.1	2,633	17,426					72,354					
Harlingen-San Benito, Tex.	81,839	51.1	1,287	4,829		16,422								
Harrisburg, Pa.	209,501	48.2	4,346					129,804				79,697		
Hartford, Conn.	381,619	131.2	2,909			219,041					147,178			
High Point, N.C.	66,543	33.7	1,973		4,460		62,083							
Honolulu, Haw.	351,336	99.8	3,520					351,336						
Houston, Tex.	1,139,678	430.6	2,667			201,459	933,219							
Huntington, W.Va./Ashland, Ky./Ohio	165,732	42.2	3,927				82,105					83,627		
Huntsville, Ala.	74,970	53.2	1,409		74,970									
Indianapolis, Ind.	639,340	144.9	4,412				163,082			476,258				
Jackson, Mich.	71,412	22.1	3,231			20,692			50,720					
Jackson, Miss.	167,480	49.7	2,987	3,058				164,422						
Jacksonville, Fla	372,569	111.8	3,344				191,539			181,030				
Johnstown, Pa.	96,474	21.8	4,594				42,526				53,900			
Joliet, Ill.	116,585	35.9	3,195				49,806		66,780					
Kalamazoo, Mich.	115,659	42.1	2,747			33,570		82,089						
Kansas City, Mo./Kan.	921,121	282.4	3,262				445,562	475,579						
Kenosha, Wis.	72,852	13.2	5,519			4,953				67,899				
Knoxville, Tenn.	172,734	59.7	2,893			60,587			111,887					
Lake Charles, La.	89,115	24.6	3,593					89,115						
Lancaster, Pa.	93,059	29.2	3,216		32,006						61,053			
Lansing, Mich.	169,325	47.2	3,587				61,518		107,807					
Laredo, Tex.	60,678	12.9	4,695						60,678					
Las Vegas, Nev.	89,427	30.3	2,947				89,427							
Lawrence-Haverhill, Mass./N.H.	158,125	70.5	2,356		46,346	40,846					70,933			
Lawton, Okla.	61,841	13.2	4,693	244					61,597					
Lewiston-Auburn, Me.	65,263	93.9	650	24,449	40,854									
Lexington, Ky.	111,949	27.2	4,118					49,130	62,819					
Lima, Ohio	62,963	13.1	4,806				11,036			51,937				
Lincoln, Neb.	136,220	35.0	3,892	7,699					128,531					
Little Rock-N. Little Rock, Ark.	183,817	62.2	2,975		19,173		56,633	107,011						
Lorain-Elyria, Ohio	142,088	81.4	1,739	23,146				118,711						
Los Angeles-Long Beach, Cal.	8,403,791	[illegible]75.0	4,733						8,146,623	264,168				
Louisville, Ky./Ind.	595,069	155.6	3,474				216,229			378,839				
Lowell, Mass.	110,547	29.0	3,802			68,460				52,187				
Lubbock, Tex.	129,289	73.2	1,697	593		128,691								

Table 2. (Continued)

URBANIZED AREA	POPULATION (Persons)	AREA (mi^2)	DENSITY (Persons/mi.)	DISTRIBUTION OF POPULATION BY DENSITY OF POPULATION: 1000	1000-1500	1500-2000	2000-3000	3000-4000	4000-6000	6000-8000	8,000-10,000	10,000-15,000	15,000-20,000	25,000-35,000
Lynchburg, Va.	89,119	27.6	2,164	4,329			84,790							
Macon, Ga.	114,161	33.2	3,450				44,397		69,764					
Madison, Wis.	157,814	54.3	2,986			31,190		126,706						
Manchester, N.H.	91,698	34.6	2,650		3,416		88,282							
Memphis, Tenn.	544,905	155.7	3,497			46,981		497,924						
Meriden, Conn.	81,929	23.6	2,296				81,929							
Miami, Fla.	852,705	183.1	4,657					561,017			291,688			
Midland, Tex.	63,274	29.5	2,693		649		62,625							
Milwaukee, Wis.	1,149,997	322.0	2,934		450,873						741,320			
Minneapolis-St. Paul, Minn.	1,377,143	667.3	2,065		130,658					313,611	682,872			
Mobile, Ala.	265,139	171.5	1,563		202,770			63,300						
Monroe, La.	68,543	40.4	1,994		16,327		52,219							
Montgomery, Ala.	142,003	39.2	3,645		6,900				130,303					
Muncie, Ind.	77,908	17.6	4,436			8,981			69,603					
Muskegon-Muskegon Hgts., Mich.	94,370	24.1	3,916				29,313		46,628	19,363				
Nashville, Tenn.	346,729	159.3	2,632			173,659			170,674					
New Bedford, Mass.	159,987	29.7	6,265				24,180		162,477					
New Britain, Conn.	99,834	22.6	4,420			17,089				82,291				
New Haven, Conn.	278,794	83.0	3,337			120,746					162,009			
New Orleans, La.	868,237	208.5	3,172					868,237						
Newport News-Hampton, Va.	208,874	149.1	1,401	5,954		202,920								
New York, N.Y./Northeastern N.J.	14,114,927	691.5	7,462					3,371,912		62,089			482,846	8,030,083
Norfolk-Portsmouth, Va.	507,825	109.6	4,675				87,167			329,828				
Norwalk, Conn.	81,272	38.0	2,120		14,993		67,775							
Odessa, Tex.	80,337	19.0	4,363		3,937				83,329					
Ogden, Utah	121,927	65.7	1,828		51,783			70,197						
Oklahoma City, Okla.	429,188	385.2	1,114		324,283	104,939								
Omaha, Neb.	389,881	69.8	4,381				60,263		301,590					
Orlando, Fla.	200,995	73.0	2,817				112,839		88,139					
Pensacola, Fla.	123,049	43.3	2,796				123,049							
Peoria, Ill.	181,432	59.0	3,063				78,279			103,163				
Philadelphia, Pa./N.J.	3,635,228	596.7	6,092					1,022,716					2,092,612	
Phoenix, Ariz.	552,043	248.4	2,222			112,873	439,170							
Pittsfield, Mass.	62,353	43.2	1,442		57,879	4,477								
Pittsburgh, Pa.	1,804,400	523.0	3,437				1,220,146					600,322		
Pomona-Ontario, Cal.	186,547	71.3	2,616				119,350	67,197						
Port Arthur, Tex.	116,365	79.5	1,464		116,365									
Portland, Me.	111,701	51.2	2,162		39,133			72,568						
Portland, Ore./Wash.	651,683	192.0	3,387				279,009		372,676					
Providence-Pawtucket, R.I./Mass.	659,542	188.0	3,538				371,063				91,091	337,698		
Provo-Orem, Utah	56,794	63.4	1,026	6334	13,394	36,047								
Pueblo, Col.	103,335	25.9	4,052		12,153				91,181					
Racine, Wis.	95,862	14.6	6,566			6,718				89,144				
Raleigh, N.C.	93,931	33.5	2,804				93,931							
Reading, Pa.	160,297	33.1	6,043				62,120					98,177		
Reno, Nev.	70,189	15.3	4,586						70,189					
Richmond, Va.	333,418	89.9	3,710				113,420		219,998					
Roanoke, Va.	124,752	40.4	3,089			27,642		97,110						
Rochester, N.Y.	493,402	113.3	4,335				174,791				318,611			
Rockford, Ill.	171,651	43.2	3,976				66,973		105,789					
Sacramento, Cal.	451,920	134.0	3,373				260,483		191,437					
Saginaw, Mich.	119,215	91.1	4,183				30,989		88,226					
St. Joseph, Mo./Kansas	80,167	28.0	2,819		1,314		79,073							
St. Louis, Mo./Ill.	1,667,693	329.2	5,160					917,081				750,000		
St. Petersburg, Fla.	324,842	115.2	2,820				143,444	181,252						
Salt Lake City, Utah	349,351	131.7	2,647				189,257	159,094						

Table 2. (Continued)

Urbanized Area	Population (Persons)	Area (mi²)	Density (Persons/mi²)	Distribution of Population by Density of Population: 1000	1000-1500	1500-2000	2000-3000	3000-4000	4000-6000	6000-8000	8,000-10,000	10,000-15,000	15,000-20,000	20,000-30,000
San Angelo, Tex.	58,815	29.7	1,980			58,815								
San Antonio, Tex.	641,965	193.6	3,327			54,247		587,718						
San Bernardino-Riverside, Cal.	377,531	169.6	2,229			201,277	84,332	91,922						
San Diego, Cal.	836,175	273.7	3,633				573,284	262,891						
San Francisco-Oakland, Cal.	2,430,663	521.3	4,853				1,383,799			287,548			759,316	
San Jose, Cal.	602,805	213.1	2,790				398,659	204,196						
Santa Barbara, Cal.	72,740	29.7	2,449		13,972		58,768							
Savannah, Ga.	169,887	61.1	2,780		29,642			140,245						
Scranton, Pa.	210,676	104.0	2,019		99,233				111,443					
Seattle, Wash.	864,109	222.3	3,623				327,022			537,087				
Shreveport, La.	263,523	82.6	3,031				40,211		223,272					
Sioux City, Iowa/Neb./S.D.	97,928	50.3	1,933			97,928								
Sioux Falls, S.D.	66,842	17.6	3,827				1,118	65,408						
South Bend, Ind.	218,933	64.0	3,421				86,488		132,446					
Spokane, Wash.	226,910	66.1	3,549				45,229		181,688					
Springfield, Ill.	111,403	32.6	3,417				28,132	83,271						
Springfield, Mo.	97,224	35.6	2,731			1,339	95,885							
Springfield, Ohio	90,187	20.6	4,377			7,464			82,723					
Springfield, Chicopee, Holyoke, Mass./Conn.	449,777	233.8	1,922	161,872			62,689	61,543	174,683					
Stamford, Conn.	166,948	95.1	1,762		74,277		92,713							
Steubenville, Ohio/Weirton, W.Va.	81,813	36.0	2,218			49,115			32,698					
Stockton, Cal.	141,604	38.6	3,668					141,604						
Syracuse, N.Y.	333,286	67.7	4,923				117,303				215,983			
Tacoma, Wash.	214,930	82.8	2,593			46,951		167,979						
Tampa, Fla.	301,790	103.4	2,919		26,820			274,970						
Terre Haute, Ind.	81,415	31.7	2,566		8,916		72,500							
Texarkana, Tex./Ark.	53,408	26.7	2,001	3,414		30,210		19,780						
Toledo, Ohio	438,283	134.9	3,249		120,280					318,003				
Topeka, Kan.	119,500	36.2	3,301	16				119,484						
Trenton, N.J./Pa.	242,601	75.3	3,219			128,234							116,187	
Tucson, Ariz.	227,433	80.4	2,822	14,541				212,892						
Tulsa, Okla.	298,922	70.2	4,259			37,237			261,686					
Tuscaloosa, Ala.	76,815	30.5	2,519		13,443			63,372						
Tyler, Tex.	51,739	19.0	2,722			259	51,480							
Utica-Rome, N.Y.	187,779	112.4	1,671	51,645		35,723			100,410					
Waco, Tex.	115,163	64.9	1,790	18,335			97,828							
Washington, D.C./Md./Va.	1,808,423	343.7	5,308					1,844,487				763,936		
Waterbury, Conn.	141,625	50.6	2,818			34,496		107,129						
Waterloo, Iowa	102,227	49.5	2,077			31,072	71,155							
[?] Palm Beach, Fla.	172,823	99.6	1,719		116,637			56,236						
Wheeling, W.Va./Ohio	93,851	27.3	2,623				40,331		53,400					
Wichita, Kan.	292,129	79.7	3,665		37,640				254,829					
Wichita Falls, Tex.	102,104	[illegible]	2,739				101,794	309						
Wilkes-Barre, Pa.	233,952	74.1	3,157				170,361				63,551			
Wilmington, Del./N.J.	283,987	90.0	3,152				187,050			96,937				
Winston-Salem, N.C.	128,176	43.0	2,981		17,041			111,135						
Worcester, Mass.	225,460	61.2	3,679			39,639			185,987					
York, Pa.	100,872	19.0	5,699								46,343	54,530		
Youngstown, Ohio/Warren, Pa.	372,749	159.0	3,431				163,411		209,337					

APPENDIX B

EXCERPT FROM STATEMENT OF SECRETARY OF DEFENSE, ROBERT S. McNAMARA BEFORE THE HOUSE ARMED SERVICES COMMITTEE ON THE FISCAL YEAR 1966-70 DEFENSE PROGRAM AND 1966 DEFENSE BUDGET, FEBRUARY 18, 1965

Excerpt from Statement of Secretary of Defense Robert S. McNamara before the House Armed Services Committee on the Fiscal Year 1966-70 Defense Program and 1966 Defense Budget, February 18, 1965.

CAPABILITIES OF THE PROGRAMED FORCES FOR DAMAGE LIMITATION

The ultimate deterrent to a deliberate nuclear attack on the United States and its Allies is our clear and unmistakable ability to destroy an aggressor as a viable society, even after our forces have been attacked. But if deterrence fails, whether by accident or miscalculation, it is essential that forces be available to limit the damage of such an attack to ourselves and our Allies.

The utility of the Strategic Offensive Forces in the Damage Limiting role is critically dependent on the timing of the enemy attack on U.S. urban targets. For example, if an enemy missile attack on U.S. cities were to be sufficiently delayed after an attack on U.S. military targets (an unlikely contingency) our strategic missiles (which can reach their targets in less than one hour) could significantly reduce the weight of that attack by destroying, prior to launch, a large part of the enemy's forces withheld for use against our cities.

If the urban attack were delayed still longer, our bomber force could also contribute to the Damage Limiting objective. However, if the enemy were to launch his attack against our urban areas at the beginning of a general nuclear war, our Strategic Offensive Forces -- both missiles and bombers -- would have a greatly reduced value in the Damage Limiting role. Their contribution in that case would be limited to the destruction of enemy residual forces -- unlaunched strategic missiles and bombers, re-fire missiles, and any other strategic forces the enemy might withhold for subsequent strikes.

Since we have no way of knowing how the enemy would execute a nuclear attack upon the United States, we must also intensively explore alternative "defensive" systems as means of limiting damage to ourselves. The problem here is to achieve an optimum balance among all the elements of the general nuclear war forces, particularly in their Damage Limiting role. This is what we mean by "balanced" defense.

Although a deliberate nuclear attack upon the United States may seem a highly unlikely contingency in view of our unmistakable Assured Destruction capability, it must receive our urgent attention because of the enormous consequences it would have. In this regard, I should make two points clear. First, in order to preclude any possibility of miscalculation by others, I want to reiterate that although the U.S. would itself suffer severely in the event of a general nuclear war, we are fully committed to the defense of our Allies. Second, we do not view Damage Limitation as a question of concern only to the U.S. Our offensive forces cover strategic enemy capabilities to inflict damage on our Allies in Europe just as they cover enemy threats to the continental U.S.

To appreciate fully the implications of an attack on our cities, it is useful to examine the Assured Destruction objective from the attacker's point of view, since our Damage Limiting problem is, in effect, his Assured Destruction problem.

Several points are evident from our analysis of this problem. First, it is clear that with limited fallout protection, an enemy attack on our urban areas would cause great loss of life, chiefly because of the heavy concentration of population in our large cities, which I noted earlier. Second, the analysis clearly demonstrates the distinct utility of a nation-wide fallout shelter program in reducing fatalities, at all levels of attack. Third, the analysis shows that the attack would destroy a large percentage of our industrial capacity. Each successive doubling of the number of delivered warheads would increase the destruction of our population and industrial capacity by proportionately smaller amounts, since smaller and smaller cities would have to be attacked.

In order to assess the potentials of various Damage Limiting programs we have examined a number of "balanced" defense postures at different budget levels. These postures are designed to defend against the assumed threat in the early 1970s. To illustrate the critical nature of the timing of the attack, we used two limiting cases. First, we assumed that the enemy would initiate nuclear war with a simultaneous attack against our cities and military targets. Second, we assumed that the attack against our cities would be delayed long enough for us to retaliate against the aggressor's military targets with our missiles. In both cases, we assumed that all new systems will perform essentially as estimated since our main purpose here was to gain an insight into the overall problem of limiting damage. The results of this analysis are summarized in the table below.

Estimated Effect on U.S. Fatalities of Additions to the Approved Damage Limiting Program
(Based on 1970 population of 210 million)

Additional Investment	Millions of U.S. Fatalities	
	Early Urban Attack	Delayed Urban Attack
$ 0 billion	149	122
5 billion	120	90
15 billion	96	59
25 billion	78	41

The $5 billion of additional investment (of which about $2 billion would come from non-Federal sources) would provide a full fallout shelter program for the entire population. The $15 billion level would add about $8-1/2 billion for a limited deployment of a low cost configuration of a missile defense system, plus about $1-1/2 billion for new manned bomber defenses. The $25 billion level would provide an additional $8-1/2 billion for anti-missile defenses (for a total of about $17 billion) and another $1-1/2 billion for improved manned bomber defenses (for a total of $3 billion).

The number of strategic missiles required to take full advantage of the possibility that the aggressor might delay his attack on our cities is already included in the forces programed through 1970.

The high utility of a full nation-wide fallout shelter program in the Damage Limiting role is apparent from the foregoing table -- it would reduce fatalities by about 30 million compared with the present level of fallout protection. The following table shows that a transfer of resources from fallout shelters to other defensive systems would result in substantially less effective defense postures for any given budget level.

Estimated Effect of Fallout Protection on U.S. Fatality Levels for Several Damage Limiting Programs
(Based on 1970 total population of 210 million)

Additional Investment	Millions of U.S. Fatalities			
	Early Urban Attack		Delayed Urban Attack	
	Partial Protection	Full Protection	Partial Protection	Full Protection
$ 0 billion	149	149	122	122
5 billion	145	120	107	90
15 billion	121	96	79	59
25 billion	107	78	59	41

The figures indicate that in the case of an early attack on our urban centers, for the same level of survivors, any Damage Limiting program which excludes a complete fallout shelter system would cost at least twice as much as a program which includes such a system -- even under the favorable assumption that the enemy would not exploit our lack of fallout protection by surface bursting his weapons upwind of the fallout areas. In addition, fallout shelters should have the highest priority of any defensive system because they decrease the vulnerability of the population to nuclear contamination under all types of attack. Since at the $15 and $25 billion budget levels, the bulk of the additional funds would go to missile defense, a high confidence in the potential effectiveness of the system would have to be assured before commitment to such large expenditures would be justified. Furthermore, at these budget levels, missile defenses would also have to be interlocked with either local or area bomber defenses in order to avoid having one type of threat undercut a defense against the other.

Although missiles clearly have a better chance than bombers of destroying residual enemy offensive forces because they can reach them much sooner, we also examined the effectiveness of bombers in the Damage Limiting role. In one such analysis we compared a strategic aircraft -- the AMSA -- and two strategic missiles -- MINUTEMAN II and an improved missile for the 1970s. (This improved missile could be developed and deployed within the same time frame as the AMSA). Although there are many uncertainties with regard to both the assumptions and the planning factors used in this comparison, it did demonstrate clearly one important point, namely, that there are less costly ways of destroying residual enemy missiles and aircraft than by developing and deploying a new AMSA -- even ignoring the fact that enemy missile silos and bomber fields are far more likely to be empty by the time the bombers pass over than when the missiles arrive.

There is also the possibility in the 1970s of a small nuclear attack on the United States by a nation possessing only a primitive nuclear force. Accordingly, we have undertaken a number of studies in this area. Our preliminary conclusion is that a small, balanced defense program could, indeed, significantly reduce fatalities from such an attack. However, the lead time for additional nations to develop and deploy an effective ballistic missile system capable of reaching the United States is greater than we require to deploy the defense.

In summary, several tentative conclusions may be drawn from our examination of the Damage Limiting problem:

(1) With no new U.S. defenses against nuclear attack in the early 1970s, the strategic offensive forces likely to confront us could inflict a very high level of fatalities on the United States.

(2) A nation-wide civil defense program costing about $5 billion could reduce fatalities by about 30 million.

(3) If active defense systems operate as estimated, a large, balanced Damage Limiting program for an additional $20 billion could reduce fatalities associated with an early urban attack by another 40 million.

(4) There is no defense program within this general range or expenditures which would reduce fatalities to a level much below 80 million unless the enemy delayed his attack on our cities long enough for our missile forces to play a major Damage Limiting role.

Moreover, we have thus far not taken into account a factor which I touched on at the beginning of this discussion, and that is possible reactions of potential aggressors which could serve to offset our Damage Limiting initiatives. Let me illustrate this point with the following example. Suppose we had already spent an additional $15 billion for a balanced, Damage Limiting posture of the type I described earlier, expecting that it would limit fatalities to, say, 95 million in the event of a first strike against our cities. We then decide to spend another $10 billion to reduce the fatalities to about 75 million. If the enemy chooses to offset this increase in survivors, he should be able in the 1970s to do so by spending about $6 billion more on his offensive forces, or 60 percent of our cost.

At each successively higher level of U.S. expenditures, the ratio of our costs for Damage Limitation to the potential aggressor's costs for Assured Destruction becomes less and less favorable for us. Indeed, at the level of spending required to limit fatalities to about 40 million in a large first strike against our cities, we would have to spend on Damage Limiting programs about four times what the potential aggressor would have to spend on damage creating forces, i.e., his Assured Destruction forces.

This argument is not conclusive against our undertaking a major new Damage Limiting program. The resources available to the Soviets are more limited than our own and they may not actually react to our initiatives as we have assumed. But it does underscore

ıe fact that beyond a certain level of defense, the cost
lvantage lies increasingly with the offense, and this fact
ıst be taken into account in any decision to commit ourselves
: large outlays for additional defensive measures.

Appendix C

CLINICAL FEATURES OF RADIATION INJURY

CLINICAL FEATURES OF RADIATION INJURY

A. GENERAL

All that is known about the quantitative immediate effects of various radiations on normal humans comes from analysis of experience with radiation therapy (sick humans), from studies of accidental exposure, from the study of the Japanese who survived the atomic bombing, and from controlled experiments with animals. Even though much of the information is indirect, more is known about radiation than about any other agent capable of causing mass casualties. In an emergency due to radioactive fallout, the casualty rate for any group of people can be predicted with considerable confidence, on the basis either of radiological exposure data or of medical evaluation of a representative sample of the group.[2] A system of prediction consists of a classification of the varieties of radiation injuries, the clinical manifestations and prognosis of each

---

[1] National Committee on Radiation Protection and Measurements Report No. 29, Exposure to Radiation in an Emergency, January 1962, p. 59 et seq.

[2] The Defense Atomic Support Agency made the following comment on this sentence during review of this paper:

"The statement that in an emergency the casualty rate can be predicted with considerable confidence can be rather misleading. Enough is known, if a certain dose is given, to predict what would happen to an individual. However, in an emergency situation, the dosages or conditions of exposure will not be well enough known. Even 20 years after the Japanese explosions these are not well known. A medical evaluation will not completely separate the groups because there is too much overlapping between the groups."

variety, and the dose, or range of dose, or conditions of exposure, responsible for each variety.

B. CLASSIFICATION OF RADIATION INJURY

Asymptomatic, or inapparent, or undetectable radiation injury occurs when the brief exposure dose, or the ERD, or the dose of internal (β-γ) radiation is less than 50 r. The effects of a single, brief dose between about 15 and 50 r can be detected when statistical methods are applied to blood-count data from a sufficiently large group of people. Presumably, the same is true for the effects of an ERD less than about 50 r. Except for the statistical change in blood count, no one will be aware of exposure in this range.

Acute radiation sickness[1] (also called the "acute radiation syndrome," "whole-body radiation injury," etc.) is caused by external or internal γ or X radiation. Clinical manifestations include general "toxic" symptoms,[2] such as weakness, nausea, easy fatigue, etc., and specific symptoms and signs caused by damage to the gastrointestinal tract, the blood-forming organs, the central nervous system, etc. The signs of radiation sickness include alterations of the blood count, excretion of abnormal substances in the urine, loss of hair (epilation), a tendency to bleed easily, etc. Radiation sickness may consist of nothing more than a decrease in the white cell count and slight fatigue, or it may be so severe that death occurs within hours of the onset of exposure. Five clinical groups can be distinguished on the basis of severity which can be correlated with the size of the dose.

---

[1] Radiation sickness is described as acute when clinical manifestations occur early and do not last longer than 6 months.

[2] Symptoms are what the patient complains about, e.g., headache, weakness, etc. Signs of radiation injury are observed by an examiner, e.g., hemorrhage, loss of hair, etc., or detected by a laboratory test, e.g., low white cell count, etc.

Group I: Less than half this group vomit within 24 hours after the onset of exposure. There are either no subsequent symptoms or, at most, weakness and easy fatigue. There is a decrease in the white blood cell count (which is most marked in the case of the lymphocytes) and in the platelet count. Less than 5 percent (1 out of 20) require medical care. All others can perform their customary tasks. Any deaths that occur are caused by complications. Sickness of this type has been seen after brief, whole-body doses of γ and X radiation in the range of 50 to 200 r. An ERD of external γ radiation of 50 to 200 r may have a similar effect.

Group II: More than half this group vomit soon after the onset of exposure and are sick for a few days. This is followed by a period of 1 to 3 weeks when there are few or no symptoms. During the latent period, typical changes occur in the blood count and can be used for diagnosis. At the end of the latent period, epilation (loss of hair) is seen in more than half, and this is followed by a moderately severe illness due primarily to the damage to the blood-forming organs. Most of the people in this group require medical care. More than half will survive, with the chances of survival being better for those who received the smaller doses. Sickness of this type has been seen after brief, whole-body doses of γ or X radiation on the order of 200 to 450 r. An ERD of external γ radiation of the same size will probably cause a similar illness.

Group III: This is a more serious version of the sickness described as Group II. The initial period of illness is longer, the latent period is shorter, and the main episode of illness is characterized by extensive hemorrhages and complicating infections. People in this group need medical care and hospitalization. Less than half will survive, with the chances of survival being poorest for those who received the largest doses. Sickness of this type has been seen after brief whole-body γ radiation with doses in excess of 450 r. It is possible that an ERD of external γ radiation of the same size will have a similar effect.

Group IV: This is an accelerated version of the sickness described as Group III. All in this group begin to vomit soon after the onset of exposure, and this continues for several days or until death. Damage to the gastro-intestinal tract predominates, manifested by intractable diarrhea, which soon becomes bloody. Changes in the blood count occur early, and within a few days the total white cell count may be less than 500 per mm.[1] Death occurs

[1] Values cited are for brief, whole-body exposure to 250 kvp X rays.

before the end of the second week, and usually before the appearance of hemorrhages or epilation. All in this group need care, and it is unlikely that many will survive. Sickness of this type has been seen after brief, whole-body exposure to γ radiation in excess of 600 r. During protracted exposure to external γ radiation, it is not probable that an illness of this type would be the first evidence of injury.

Group V: This is an extremely severe illness in which damage to the brain and nervous system predominates. Symptoms, signs, and rapid prostration come on almost as soon as the dose has been received. Death occurs within a few hours or a few days. Sickness of this type has been seen after a brief whole-body exposure to γ rays in excess of several thousand r and to equivalent doses from neutrons.

Chronic radiation sickness.[1] There is almost no information about the effects of protracted external exposure of man. Some radium chemists and radiologists who worked with radiation before the hazards were recognized frequently developed a progressive refractory anemia and died either from the anemia or from complicating infections. Animal experiments provide little additional information concerning the patterns of chronic radiation sickness that may occur in man. At present, we cannot tell the size of the ERD that will be lethal, when exposure is protracted over a period of years.

[1] The sickness is described as chronic when the symptoms and signs persist beyond 6 months.

Appendix D

PATTERN DIMENSIONS AND AREAS FOR H+1 HOUR DOSE RATE CONTOURS AND MAXIMUM BIOLOGICAL DOSE (≈ 1 WEEK DOSE)

CALCULATED FALLOUT CONTOURS
MAXIMUM BIOLOGICAL DOSE

1.000 MEGATON YIELD 0. KNOT WIND

EFFECTIVE FALLOUT SHEAR .10 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-15.53	15.48	34.51	34.51	1669.53	1680.90	.00
3.00	-14.68	14.64	32.62	32.62	1497.72	1502.83	.00
10.00	-13.69	13.57	30.42	30.42	1300.50	1302.86	.00
30.00	-12.72	12.59	28.26	28.26	1121.40	1123.90	.00
100.00	-11.56	11.52	25.69	25.69	921.85	931.64	.00
300.00	-10.40	10.29	23.09	23.09	748.30	750.36	.00
1000.00	-8.94	8.83	19.86	19.86	552.19	554.40	.00
3000.00	-7.37	7.27	16.37	16.37	374.69	376.23	.00
10000.00	-5.11	5.08	11.36	11.36	180.08	181.93	.00
30000.00	.70	.40	1.56	1.56	2.55	2.70	.00
MAXIMUM DOSE RATE	30642.64						

EFFECTIVE FALLOUT SHEAR .20 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-15.68	15.07	60.90	60.90	2842.05	2883.89	.00
3.00	-14.29	14.11	57.36	57.36	2544.79	2551.03	.00
10.00	-13.17	13.04	53.21	53.21	2187.39	2191.08	.00
30.00	-12.16	12.06	49.12	49.12	1860.97	1859.02	.00
100.00	-10.94	10.90	44.20	44.20	1509.99	1516.49	.00
300.00	-9.70	9.56	39.18	39.18	1183.41	1185.68	.00
1000.00	-8.12	8.10	32.81	32.81	820.41	836.20	.00
3000.00	-6.35	6.21	25.65	25.65	504.62	506.87	.00
10000.00	-3.49	3.39	14.10	14.10	150.83	152.39	.00
MAXIMUM DOSE RATE	16832.83						

EFFECTIVE FALLOUT SHEAR .40 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-14.55	14.50	114.43	114.43	5203.31	5221.58	.00
3.00	-13.64	13.52	107.28	107.28	4568.78	4576.88	.00
10.00	-12.57	12.45	98.86	98.86	3873.89	3884.00	.00
30.00	-11.50	11.47	90.46	90.46	3225.92	3264.20	.00
100.00	-10.21	10.09	80.27	80.27	2553.15	2559.16	.00
300.00	-8.86	8.76	69.69	69.69	1919.81	1928.55	.00
1000.00	-7.10	6.97	55.83	55.83	1230.67	1234.47	.00
3000.00	-4.98	4.91	39.12	39.12	602.16	607.48	.00
MAXIMUM DOSE RATE	8636.65						

CALCULATED FALLOUT CONTOURS
MAXIMUM BIOLOGICAL DOSE

1,000 MEGATON YIELD 10. KNOT WIND

EFFECTIVE FALLOUT SHEAR .10 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-5.53	471.25	8.87	53.65	37174.91	40176.57	305.25
3.00	-5.13	395.98	8.31	42.47	25071.83	26736.55	255.00
10.00	-4.65	316.97	7.66	31.69	15301.58	16007.62	195.00
30.00	-4.18	248.91	7.00	23.36	9089.31	9286.93	155.25
100.00	-3.60	180.11	6.20	15.88	4656.36	4582.22	109.25
300.00	-3.01	124.15	5.37	10.66	2247.41	2128.91	63.00
1000.00	-2.22	71.77	4.28	6.66	826.71	799.16	29.25
3000.00	-1.29	32.38	2.95	4.17	227.22	220.77	8.00
10000.00	.65	6.72	.00	1.56	13.39	17.77	3.00
MAXIMUM DOSE RATE	11126.37						

EFFECTIVE FALLOUT SHEAR .20 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-5.52	423.77	9.19	92.09	56133.74	62095.48	271.25
3.00	-5.11	350.44	8.61	71.30	36271.45	39822.11	224.00
10.00	-4.64	274.16	7.93	51.53	20781.87	22566.95	181.25
30.00	-4.16	209.46	7.24	36.58	11413.28	12273.24	131.25
100.00	-3.59	145.74	6.41	23.49	5282.61	5509.57	89.25
300.00	-2.98	96.02	5.54	14.65	2265.99	2278.17	55.25
1000.00	-2.19	52.72	4.60	8.18	728.78	705.12	29.25
3000.00	-1.26	2-.03	3.01	-.49	183.47	178.49	8.00
10000.00	.80	5.12	.00	1.33	7.93	12.33	3.00
MAXIMUM DOSE RATE	10566.95						

EFFECTIVE FALLOUT SHEAR .40 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-5.47	377.22	10.36	156.86	86668.26	94292.58	239.25
3.00	-5.07	306.06	9.70	118.65	53085.87	57980.80	195.00
10.00	-4.59	232.95	8.91	82.91	28135.48	30935.30	143.00
30.00	-4.11	172.10	8.13	56.63	14360.15	15673.47	109.25
100.00	-3.52	113.99	7.17	34.42	5930.13	6353.35	71.25
300.00	-2.91	70.81	6.17	20.16	2236.96	2333.83	41.25
1000.00	-2.10	36.09	4.86	10.25	610.89	614.68	19.25
3000.00	-1.12	15.79	3.18	5.10	139.16	133.56	5.25
MAXIMUM DOSE RATE	8933.95						

CALCULATED FALLOUT CONTOURS
MAXIMUM BIOLOGICAL DOSE

1.000 MEGATON YIELD 20. KNOT WIND

EFFECTIVE FALLOUT SHEAR .10 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-4.30	847.53	7.62	46.25	57071.51	61839.49	551.25
3.00	-4.04	703.71	7.10	33.89	37758.61	39734.00	440.00
10.00	-3.63	547.92	6.49	26.13	21015.77	22636.36	341.25
30.00	-3.22	410.03	5.88	18.71	12610.82	12379.77	255.00
100.00	-2.72	289.31	5.13	12.31	5691.97	5648.49	168.00
300.00	-2.18	187.35	4.33	8.19	2595.07	2437.83	80.00
1000.00	-1.46	94.33	3.26	4.98	790.72	748.71	35.00
3000.00	-.53	34.08	1.70	2.98	160.96	161.81	5.25
MAXIMUM DOSE RATE	6582.93						

EFFECTIVE FALLOUT SHEAR .20 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-4.39	734.95	7.79	78.30	85184.56	93397.58	483.00
3.00	-4.04	612.70	7.18	59.23	52780.08	57378.24	399.00
10.00	-3.63	466.50	6.56	41.46	25584.48	30636.01	305.25
30.00	-3.22	364.79	5.94	28.35	14755.43	15499.24	209.25
100.00	-2.71	228.31	5.18	17.39	6213.10	6311.62	143.00
300.00	-2.18	141.23	4.37	10.44	2601.98	2352.82	80.00
1000.00	-1.45	69.12	3.26	5.55	656.45	615.15	35.00
3000.00	-.52	27.20	1.79	3.03	136.99	131.80	5.25
MAXIMUM DOSE RATE	6476.81						

EFFECTIVE FALLOUT SHEAR .40 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-4.37	664.39	8.01	131.41	124810.57	138088.06	440.00
3.00	-4.02	527.46	7.47	95.75	73388.06	80766.72	341.25
10.00	-3.61	368.02	6.82	65.16	38835.39	40166.38	255.00
30.00	-3.20	276.30	6.18	42.55	17363.09	18682.38	168.00
100.00	-2.69	173.05	5.39	26.51	6429.69	6785.30	109.25
300.00	-2.15	103.86	4.53	13.61	2158.12	2202.28	55.25
1000.00	-1.42	47.17	3.33	5.56	519.62	500.88	24.00
3000.00	-.47	18.36	1.68	3.16	97.11	96.07	5.25
MAXIMUM DOSE RATE	6098.63						

CALCULATED FALLOUT CONTOURS
MAXIMUM BIOLOGICAL DOSE

1,000 MEGATON YIELD 40. KNOT WIND

EFFECTIVE FALLOUT SHEAR .10 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-3.10	1509.15	6.42	39.47	88658.34	93762.87	960.00
3.00	-2.83	1224.04	5.95	29.99	55556.07	57794.55	783.00
10.00	-2.52	930.60	5.39	21.21	30789.24	31083.35	575.00
30.00	-2.19	685.30	4.82	14.74	16370.85	15917.47	399.00
100.00	-1.79	447.09	4.10	9.46	7138.60	6683.47	224.00
300.00	-1.35	264.92	3.32	6.26	2760.17	2617.79	120.00
1000.00	-.71	105.74	2.16	3.60	636.64	602.43	24.00
3000.00	.34	25.63	.00	1.76	65.06	71.68	5.25
XIMUM DOSE TE	3553.28						

EFFECTIVE FALLOUT SHEAR .20 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-3.10	1329.50	6.44	65.78	126445.48	137694.30	869.25
3.00	-2.83	1035.19	5.97	48.47	74786.27	83547.33	675.00
10.00	-2.52	777.68	5.40	32.75	37932.67	40138.33	483.00
30.00	-2.19	552.08	4.83	21.54	18163.77	18752.64	341.25
100.00	-1.79	364.03	4.11	12.62	6915.80	6853.77	195.00
300.00	-1.35	196.01	3.33	7.30	2360.72	2262.22	99.00
1000.00	-.71	83.39	2.16	3.76	537.73	496.93	29.25
3000.00	.35	22.19	.00	1.75	56.89	61.98	5.25
XIMUM DOSE TE	3537.09						

EFFECTIVE FALLOUT SHEAR .40 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-3.10	1155.01	6.51	108.59	178981.58	197537.34	755.25
3.00	-2.83	892.99	6.03	77.48	99726.57	109022.71	573.00
10.00	-2.51	633.48	5.46	50.05	44272.91	50004.10	399.00
30.00	-2.19	429.76	4.88	31.21	19933.80	21173.96	271.25
100.00	-1.78	252.07	4.16	16.99	6567.47	6776.35	155.25
300.00	-1.36	136.13	3.36	8.98	1960.78	1939.02	80.00
1000.00	-.71	57.75	2.17	4.14	409.27	380.27	29.25
3000.00	.37	15.96	.00	1.72	40.10	44.06	5.25
XIMUM DOSE TE	3474.49						

CALCULATED FALLOUT CONTOURS
MAXIMUM BIOLOGICAL DOSE

10.000 MEGATON YIELD 0. KNOT WIND

EFFECTIVE FALLOUT SHEAR .10 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-28.96	28.93	62.77	62.77	5696.39	5708.39	.00
3.00	-27.54	27.43	59.71	59.71	5149.27	5153.80	.00
10.00	-25.90	25.78	56.15	56.15	4550.67	4559.06	.00
30.00	-24.31	24.28	52.70	52.70	3992.09	4022.61	.00
100.00	-22.44	22.32	48.64	48.64	3414.54	3419.26	.00
300.00	-20.58	20.67	44.60	[illegible]	2868.16	2876.19	.00
1000.00	-18.32	18.23	39.72	39.72	2276.53	2281.10	.00
3000.00	-15.99	15.90	34.67	34.67	1730.20	1736.95	.00
10000.00	-12.97	12.86	28.11	28.11	1137.29	1139.38	.00
30000.00	-9.39	9.26	20.36	20.36	595.02	596.35	.00
MAXIMUM DOSE RATE	100769.93						

EFFECTIVE FALLOUT SHEAR .20 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-28.39	28.23	102.86	102.86	9117.05	9131.76	.00
3.00	-26.83	26.72	97.57	97.57	8201.37	8211.51	.00
10.00	-25.17	25.08	91.45	91.45	7194.87	7217.86	.00
30.00	-23.53	23.48	85.40	85.40	6297.45	6311.49	.00
100.00	-21.58	21.45	78.42	78.42	5293.67	5301.25	.00
300.00	-19.66	19.60	71.37	71.37	4367.44	4399.95	.00
1000.00	-17.27	17.14	62.75	62.75	3385.93	3390.98	.00
3000.00	-14.77	14.74	53.68	53.68	2479.45	2483.41	.00
10000.00	-11.43	11.40	41.52	41.52	1488.61	1488.96	.00
30000.00	-7.11	6.99	25.85	25.85	570.73	572.52	.00
MAXIMUM DOSE RATE	60114.90						

EFFECTIVE FALLOUT SHEAR .40 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-27.47	27.35	188.77	188.77	16236.95	16257.25	.00
3.00	-25.97	25.85	178.49	178.49	14505.53	14531.10	.00
10.00	-24.23	24.21	166.49	166.49	12562.80	12667.44	.00
30.00	-22.52	22.41	154.74	154.74	10903.64	10919.38	.00
100.00	-20.48	20.38	140.73	140.73	9004.86	9032.41	.00
300.00	-18.42	18.34	126.61	126.61	7296.14	7311.63	.00
1000.00	-15.87	15.78	109.04	109.04	5396.98	5421.30	.00
3000.00	-13.11	12.97	90.08	90.08	3684.20	3690.55	.00
10000.00	-9.18	9.05	63.05	63.05	1799.76	1806.99	.00
30000.00	-2.05	1.87	14.10	14.10	86.36	86.96	.00
MAXIMUM DOSE RATE	31787.33						

CALCULATED FALLOUT CONTOURS
MAXIMUM BIOLOGICAL DOSE

10,000 MEGATON YIELD 10. KNOT WIND

EFFECTIVE FALLOUT SHEAR .10 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-14.71	714.93	23.76	111.63	119215.10	127944.15	461.25
3.00	-13.77	618.82	22.41	91.87	86147.96	91290.55	399.00
10.00	-12.66	516.44	20.85	72.33	57766.93	60116.38	323.00
30.00	-11.58	426.35	19.32	56.55	38221.06	38901.50	271.25
100.00	-10.27	332.31	17.49	41.67	22764.72	22423.16	195.00
300.00	-8.95	251.93	15.63	30.47	13131.11	12684.60	143.00
1000.00	-7.29	171.41	13.29	21.02	6377.23	5900.06	80.00
3000.00	-5.47	106.07	10.73	15.48	2766.45	2713.18	29.25
10000.00	-2.86	43.62	6.91	9.41	673.95	687.13	11.25
30000.00	2.54	7.53	.00	1.80	11.29	28.49	5.25
MAXIMUM DOSE RATE	26924.86						

EFFECTIVE FALLOUT SHEAR .20 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-14.67	654.57	24.83	195.53	185545.27	205551.31	419.25
3.00	-13.73	560.18	23.63	158.18	129619.45	142600.60	360.00
10.00	-12.62	460.16	21.79	121.47	82947.36	90211.57	288.00
30.00	-11.53	372.96	20.18	92.32	51937.23	55754.94	239.25
100.00	-10.22	283.15	18.25	65.10	28593.36	30001.09	181.25
300.00	-8.89	208.07	16.29	44.93	15049.92	15311.90	131.25
1000.00	-7.22	135.70	13.83	28.14	6476.21	6318.00	71.25
3000.00	-5.39	80.63	11.12	17.79	2484.77	2403.31	35.00
10000.00	-2.73	33.14	7.06	9.90	566.35	537.77	11.25
MAXIMUM DOSE RATE	25516.72						

EFFECTIVE FALLOUT SHEAR .40 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-14.54	594.86	28.76	361.76	292075.50	327145.42	379.25
3.00	-13.59	502.32	27.10	271.76	197326.45	220211.03	323.00
10.00	-12.47	404.95	25.17	203.73	120610.51	133504.66	255.00
30.00	-11.37	320.86	23.26	150.37	71619.15	78672.05	209.25
100.00	-10.06	235.67	20.99	101.85	36321.50	39311.44	143.00
300.00	-8.64	166.28	18.66	67.03	17384.00	18622.60	99.00
1000.00	-6.98	102.20	15.73	39.01	6547.75	6689.27	35.25
3000.00	-5.09	56.76	12.47	22.32	2185.06	2168.49	29.25
10000.00	-2.30	22.18	7.39	10.99	426.59	422.77	8.00
MAXIMUM DOSE RATE	21508.42						

CALCULATED FALLOUT CONTOURS
MAXIMUM BIOLOGICAL DOSE

10.000 MEGATON YIELD 20. KNOT WIND

EFFECTIVE FALLOUT SHEAR .10 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-12.64	1329.06	20.23	98.62	192787.37	204923.26	860.00
3.00	-11.79	1120.03	19.03	79.81	135548.18	162000.38	728.00
10.00	-10.79	919.70	17.64	61.68	88266.84	90159.74	575.00
30.00	-9.79	744.71	16.26	47.27	56236.33	58018.85	461.25
100.00	-8.60	563.94	14.99	33.96	31853.63	30540.10	341.25
300.00	-7.37	411.70	12.80	24.33	17294.64	16916.84	209.25
1000.00	-5.99	251.92	10.72	17.38	7607.31	7359.62	71.25
3000.00	-4.05	142.14	8.25	11.59	2742.65	2661.39	41.25
10000.00	-1.33	42.78	4.10	6.70	449.62	464.47	8.00
MAXIMUM DOSE RATE	17614.49						

EFFECTIVE FALLOUT SHEAR .20 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-12.63	1190.47	20.33	170.48	293428.40	322169.15	783.00
3.00	-11.78	1005.48	19.31	135.54	199184.71	215907.10	649.25
10.00	-10.77	810.81	17.89	101.72	122201.21	131286.14	528.00
30.00	-9.78	642.76	16.49	75.22	73077.88	77898.17	399.00
100.00	-8.58	472.36	14.80	51.24	37711.52	38710.42	288.00
300.00	-7.28	333.25	13.07	34.12	18432.52	18233.53	193.00
1000.00	-5.78	203.57	10.85	20.70	7137.07	6808.08	99.00
3000.00	-4.02	108.69	8.34	12.54	2351.69	2220.84	48.00
10000.00	-1.29	36.44	4.60	6.79	397.06	422.26	8.00
MAXIMUM DOSE RATE	17298.53						

EFFECTIVE FALLOUT SHEAR .40 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-12.59	1073.62	21.68	294.72	452412.97	502768.68	701.25
3.00	-11.73	892.78	20.39	229.58	296936.03	326194.49	575.00
10.00	-10.72	704.37	18.88	167.44	171259.03	188083.56	461.25
30.00	-9.73	543.09	17.38	119.78	95943.60	104166.58	361.25
100.00	-8.52	384.66	15.58	77.76	44994.73	43015.31	239.25
300.00	-7.28	259.24	13.76	48.89	19551.62	20631.96	155.25
1000.00	-5.70	149.09	11.37	27.03	5974.68	6573.32	80.00
3000.00	-3.91	75.77	8.67	16.63	1915.43	1831.83	35.00
10000.00	-1.11	26.02	3.98	7.03	299.79	299.62	8.00
MAXIMUM DOSE RATE	14185.92						

CALCULATED FALLOUT CONTOURS
MAXIMUM BIOLOGICAL DOSE

19.000 MEGATON YIELD 40. KNOT WIND

EFFECTIVE FALLOUT SHEAR .10 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-9.91	2379.68	17.47	86.18	308771.83	323486.76	1520.00
3.00	-9.19	2008.96	16.38	68.02	211985.85	218156.60	1295.00
10.00	-8.35	1618.40	15.08	52.10	132751.03	133128.32	1023.00
30.00	-7.58	1280.24	13.79	39.08	81306.25	79042.41	783.00
100.00	-6.47	935.23	12.23	27.44	43416.11	40380.97	528.00
300.00	-5.40	649.46	10.60	19.58	21841.25	20144.86	253.00
1000.00	-4.01	373.02	8.47	13.61	8331.82	8030.53	143.00
3000.00	-2.36	156.62	5.88	8.61	2195.68	2120.79	29.25
10000.00	.74	31.92	.00	3.98	179.35	204.07	0.00
MAXIMUM DOSE RATE	10114.17						

EFFECTIVE FALLOUT SHEAR .20 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-9.91	2167.49	17.55	147.43	499218.77	499323.73	1403.25
3.00	-9.19	1786.16	16.44	114.99	391050.91	324274.69	1155.00
10.00	-8.36	1409.17	15.14	84.09	176536.34	187265.87	899.00
30.00	-7.50	1087.74	13.85	60.40	100216.59	103966.28	675.00
100.00	-6.47	768.16	12.28	39.61	48120.06	48202.10	461.25
300.00	-5.40	516.73	10.64	25.50	23623.56	20829.86	288.00
1000.00	-4.00	287.15	8.59	15.17	7327.96	6939.90	143.00
3000.00	-2.35	128.89	5.89	8.85	1952.08	1824.97	41.25
10000.00	.75	29.16	.00	3.96	163.74	186.02	0.00
MAXIMUM DOSE RATE	10060.40						

EFFECTIVE FALLOUT SHEAR .40 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-9.90	1918.78	17.86	251.63	690270.33	762331.51	1259.25
3.00	-9.18	1567.72	16.72	191.68	432350.93	474781.88	1023.00
10.00	-8.33	1205.64	15.39	135.58	237814.57	238343.49	783.00
30.00	-7.49	902.60	14.07	93.62	124635.62	133306.66	575.00
100.00	-6.45	609.71	12.47	57.96	53538.54	54101.83	379.25
300.00	-5.38	383.72	10.60	34.70	21183.81	21451.50	226.00
1000.00	-3.98	205.53	8.61	18.29	6250.24	6020.61	109.25
3000.00	-2.32	94.53	5.96	9.63	1576.61	1464.56	41.25
10000.00	.87	22.83	.00	3.86	127.01	143.08	0.00
MAXIMUM DOSE RATE	9853.59						

CALCULATED FALLOUT CONTOURS
MAXIMUM BIOLOGICAL DOSE

100.000 MEGATON YIELD [illegible] . KNOT WIND

EFFECTIVE FALLOUT SHEAR .10 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALF-WIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALF-WIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-53.99	53.92	112.93	112.93	19121.92	19142.21	.00
3.00	-51.61	51.48	107.94	107.94	17460.84	17478.05	.00
10.00	-48.86	48.80	102.19	102.19	15624.24	15676.80	.00
30.00	-46.21	46.11	96.65	96.65	14000.38	14014.68	.00
100.00	-43.12	43.01	90.18	90.18	12177.62	12201.02	.00
300.00	-40.09	40.01	83.85	83.85	10536.45	10549.75	.00
1000.00	-36.48	36.39	76.31	76.31	8713.29	8734.56	.00
3000.00	-32.85	32.73	68.71	68.71	7069.23	7077.11	.00
10000.00	-28.36	29.26	59.27	59.27	5260.29	5268.68	.00
30000.00	-23.47	23.42	49.09	49.09	3608.47	3616.31	.00
MAXIMUM DOSE RATE	331497.11						.00

EFFECTIVE FALLOUT SHEAR . 20 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALF-WIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALF-WIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-53.23	53.13	159.11	159.11	26556.66	26581.51	.00
3.00	-50.81	50.69	151.87	151.87	24181.92	24212.23	.00
10.00	-48.01	48.01	143.52	143.52	21670.53	21647.88	.00
30.00	-45.31	45.19	135.45	135.45	19237.62	19255.99	.00
100.00	-42.16	42.10	126.01	126.01	16620.14	16677.31	.00
300.00	-39.05	38.94	116.74	116.74	14286.80	14301.59	.00
1000.00	-35.36	35.32	105.65	105.65	11656.64	11725.63	.00
3000.00	-31.58	31.45	94.39	94.39	9331.71	9345.60	.00
10000.00	-26.85	26.72	80.27	80.27	6746.48	6756.82	.00
30000.00	-21.66	21.53	64.74	64.74	4385.56	4391.70	.00
MAXIMUM DOSE RATE	231949.15						.00

EFFECTIVE FALLOUT SHEAR .40 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALF-WIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALF-WIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-52.02	51.89	271.18	271.18	44220.44	44251.06	.00
3.00	-49.54	49.45	258.25	258.25	40063.46	40153.68	.00
10.00	-46.67	46.58	243.28	243.28	35595.10	35634.97	.00
30.00	-43.88	43.76	228.78	228.78	31453.82	31495.79	.00
100.00	-40.61	40.57	211.74	211.74	26961.83	27001.64	.00
300.00	-37.38	37.26	194.90	194.90	22820.10	22853.70	.00
1000.00	-33.49	33.39	174.59	174.59	18318.47	18341.13	.00
3000.00	-29.49	29.47	153.73	153.73	14132.08	14237.05	.00
10000.00	-26.36	24.33	127.00	127.00	9645.64	9713.14	.00
30000.00	-18.48	18.40	96.34	96.34	5569.23	5581.42	.00
MAXIMUM DOSE RATE	132995.46						.00

CALCULATED FALLOUT CONTOURS
MAXIMUM BIOLOGICAL DOSE

100.000 MEGATON YIELD 10. KNOT WIND

EFFECTIVE FALLOUT SHEAR .10 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-36.57	990.69	64.34	198.49	305428.68	[illegible]	624.00
3.00	-34.47	878.99	61.08	169.32	234930.45	242943.75	551.25
10.00	-32.02	758.81	57.28	139.79	171190.23	173649.82	483.00
30.00	-29.64	651.54	53.58	115.39	124325.45	123464.90	399.00
100.00	-26.81	537.22	49.21	91.43	84073.18	81008.13	323.00
300.00	-23.99	436.49	44.86	72.45	56030.86	52400.29	239.25
1000.00	-20.53	331.03	39.53	55.21	33438.44	30687.77	155.25
3000.00	-16.91	240.11	33.95	45.59	18940.55	18403.07	29.25
10000.00	-12.12	147.13	26.53	35.00	8417.38	8754.25	24.00
30000.00	-6.31	68.67	17.14	22.64	2535.16	2666.81	15.00
MAXIMUM DOSE RATE	60567.94						

EFFECTIVE FALLOUT SHEAR .20 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-36.48	921.12	67.23	351.79	479705.83	529171.93	599.25
3.00	-34.38	810.92	63.80	295.60	354690.88	392489.59	528.00
10.00	-31.93	692.73	59.82	239.19	251658.46	272262.18	460.00
30.00	-29.53	587.77	55.96	192.53	175072.06	186686.12	379.25
100.00	-26.70	476.73	51.36	147.15	111542.78	116369.84	305.25
300.00	-23.86	381.10	46.76	111.36	69374.97	70661.75	224.00
1000.00	-20.39	280.88	41.16	78.60	36032.27	37196.07	168.00
3000.00	-16.74	198.06	35.29	53.11	19671.77	18595.15	99.00
10000.00	-11.91	117.79	27.63	37.71	7891.55	7683.65	29.25
30000.00	-6.02	56.87	17.42	23.40	2203.66	2238.01	15.00
MAXIMUM DOSE RATE	66208.74						

EFFECTIVE FALLOUT SHEAR .40 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-36.20	851.70	77.82	627.67	776649.37	875416.16	551.25
3.00	-34.08	742.94	73.60	520.60	565271.21	639613.15	483.00
10.00	-31.61	626.70	68.93	413.76	383351.63	427851.30	399.00
30.00	-29.19	524.06	64.38	326.25	256677.22	283312.92	341.25
100.00	-26.32	416.32	58.99	242.23	156621.09	188622.94	255.00
300.00	-23.45	323.70	53.59	176.96	89953.98	96648.68	195.00
1000.00	-19.92	230.51	46.97	118.36	44909.68	46539.15	163.00
3000.00	-16.20	153.23	39.99	77.31	20863.84	20821.61	89.25
10000.00	-11.22	86.46	30.56	45.86	7229.64	7035.21	35.00
30000.00	-5.60	37.30	18.07	25.08	1660.38	1666.44	15.00
MAXIMUM DOSE RATE	56671.41						

CALCULATED FALLOUT CONTOURS
MAXIMUM BIOLOGICAL DOSE

100.00 MEGATON YIELD 20. KNOT WIND

EFFECTIVE FALLOUT SHEAR .10 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-33.20	1841.32	53.00	178.95	510283.13	500263.76	1189.25
3.00	-31.31	1620.27	50.30	151.06	385596.00	391897.72	1023.00
10.00	-29.01	1383.02	47.06	123.10	274631.38	273027.06	869.25
30.00	-26.75	1172.12	43.90	100.18	194696.07	188652.37	701.25
100.00	-24.07	940.53	40.15	78.14	126980.66	119375.02	551.25
300.00	-21.37	732.96	36.39	61.11	81328.32	74320.56	399.00
1000.00	-19.65	549.95	31.77	48.17	45767.85	42976.56	72.25
3000.00	-16.54	376.63	26.87	39.31	23869.47	24156.76	71.25
10000.00	-9.79	200.56	20.17	26.92	8712.60	8894.91	48.00
30000.00	-3.72	62.26	10.92	16.10	1641.50	1676.91	15.00
MAXIMUM DOSE RATE	50733.03						

EFFECTIVE FALLOUT SHEAR .20 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-33.86	1786.02	53.84	312.95	785296.41	858740.13	1121.25
3.00	-31.38	1485.32	51.11	260.50	575139.26	620292.65	960.00
10.00	-28.97	1233.77	47.81	207.17	392150.23	417429.35	811.25
30.00	-26.71	1048.43	44.59	163.63	264100.68	278427.06	675.00
100.00	-24.03	833.00	40.78	122.07	161021.76	164327.85	528.00
300.00	-21.33	647.63	36.93	89.94	95568.16	96512.09	399.00
1000.00	-18.95	460.63	32.26	61.61	48736.23	46298.27	255.00
3000.00	-14.48	307.80	27.24	42.64	23131.84	21587.90	120.00
10000.00	-9.71	163.33	20.40	28.11	7860.03	7639.59	55.25
30000.00	-3.61	56.66	10.93	16.26	1516.96	1538.76	15.00
MAXIMUM DOSE RATE	49313.43						

EFFECTIVE FALLOUT SHEAR .40 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-33.15	1566.89	57.23	555.26	1252282.81	1395319.10	1023.00
3.00	-31.17	1332.60	54.21	453.66	889654.83	986089.96	869.25
10.00	-28.85	1124.74	50.69	353.44	581590.17	640649.32	728.00
30.00	-26.58	926.96	47.25	272.52	373961.61	407333.35	599.25
100.00	-23.88	717.61	43.17	196.20	213143.96	228520.11	461.25
300.00	-21.17	542.23	39.08	138.62	116772.17	122509.96	341.25
1000.00	-17.82	370.08	34.03	88.56	53286.20	52950.30	224.00
3000.00	-14.26	236.32	28.66	55.45	22426.46	21826.81	131.25
10000.00	-9.42	119.60	21.27	31.58	6675.79	6606.52	48.00
30000.00	-3.16	43.90	10.73	16.67	1231.31	1232.03	15.00
MAXIMUM DOSE RATE	66456.77						

CALCULATED FALLOUT CONTOURS
MAXIMUM BIOLOGICAL DOSE

100.000 MEGATON YIELD 40. KNOT WIND

EFFECTIVE FALLOUT SHEAR .10 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT GROUND	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-28.56	3404.79	45.64	160.38	849210.75	856966.76	2161.25
3.00	-26.76	2968.10	43.14	133.91	630102.24	629976.46	1848.00
10.00	-24.68	2500.98	40.22	107.69	437807.36	427226.45	1520.00
30.00	-22.63	2087.53	37.36	86.47	302005.87	286634.36	1259.25
100.00	-20.19	1651.74	33.95	66.49	189974.27	174619.06	899.00
300.00	-17.72	1273.39	30.50	51.74	116311.29	104933.12	575.00
1000.00	-14.64	883.88	26.21	42.33	60763.32	59740.77	168.00
3000.00	-11.31	553.51	21.56	32.09	27910.97	28672.05	153.25
10000.00	-6.65	222.98	14.89	20.23	7174.13	7290.46	35.00
30000.00	.02	53.09	.08	10.32	815.99	860.68	15.00

MAXIMUM DOSE RATE 32599.16

EFFECTIVE FALLOUT SHEAR .20 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT GROUND	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-28.53	3134.35	45.87	270.32	1282999.06	1312744.96	2024.00
3.00	-26.75	2705.52	43.35	227.73	916245.15	977392.43	1763.00
10.00	-24.67	2249.50	40.42	177.92	603868.51	635568.38	1443.00
30.00	-22.62	1849.39	37.56	137.81	393830.68	405238.46	1155.00
100.00	-20.18	1433.53	34.11	100.15	229345.00	228406.96	869.25
300.00	-17.70	1089.56	30.65	71.89	128916.59	126017.81	626.00
1000.00	-14.62	730.81	26.33	48.16	60713.51	56373.57	360.00
3000.00	-11.29	452.19	21.65	34.10	25755.66	24022.53	155.25
10000.00	-6.62	191.93	14.93	20.52	6551.41	6401.28	41.25
30000.00	.08	50.20	.09	10.29	771.57	812.68	15.00

MAXIMUM DOSE RATE 32413.28

EFFECTIVE FALLOUT SHEAR .40 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT GROUND	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-28.50	2844.36	46.78	487.29	2003422.81	2214316.87	1848.00
3.00	-26.72	2443.43	44.21	391.91	1394845.97	1520635.66	1599.00
10.00	-24.63	1998.52	41.21	298.81	872562.51	969518.03	1295.00
30.00	-22.58	1611.70	38.27	224.86	538810.08	577250.86	1023.00
100.00	-20.13	1213.39	34.78	156.58	288383.21	292808.98	755.25
300.00	-17.64	886.84	31.22	106.49	147528.19	151304.96	551.25
1000.00	-14.55	576.06	25.80	65.19	61280.33	60271.78	323.00
3000.00	-11.22	341.23	22.01	39.91	23039.77	22094.23	160.00
10000.00	-6.53	147.64	15.10	21.65	5573.31	5241.05	40.00
30000.00	.32	42.25	.80	10.15	642.48	678.87	15.00

MAXIMUM DOSE RATE 31700.36

CALCULATED FALLOUT CONTOURS
H+1 DOSE RATE CONTOURS

1.000 MEGATON YIELD [illegible] . KNOT WIND

EFFECTIVE FALLOUT SHEAR .10 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND [illegible]	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-14.97	14.97	33.65	33.26	1537.97	1564.36	.00
3.00	-14.09	13.99	31.30	31.30	1377.48	1388.62	.00
10.00	-13.03	12.92	29.00	29.00	1181.02	1183.10	.00
30.00	-12.00	11.94	26.73	26.73	1001.20	1036.38	.00
100.00	-10.80	10.73	23.99	23.99	808.26	811.36	.00
300.00	-9.94	9.40	21.19	21.19	628.90	630.17	.00
1000.00	-7.93	7.91	17.61	17.61	434.95	438.03	.00
3000.00	-6.10	5.97	13.54	13.54	255.63	256.76	.00
10000.00	-3.01	3.00	6.68	6.68	58.86	63.05	.00
MAXIMUM DOSE RATE	14723.86						

EFFECTIVE FALLOUT SHEAR .20 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND [illegible]	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-14.50	14.44	58.56	58.56	2553.83	2561.83	.00
3.00	-13.99	13.46	54.87	54.87	2327.00	2331.05	.00
10.00	-12.51	12.39	50.52	50.52	1970.03	1975.54	.00
30.00	-11.46	11.41	46.19	46.19	1635.32	1657.55	.00
100.00	-10.13	10.01	40.93	40.93	1291.66	1296.54	.00
300.00	-8.77	8.67	35.64	35.64	956.22	971.31	.00
1000.00	-6.99	6.86	28.23	28.23	612.40	616.10	.00
3000.00	-4.83	4.72	19.45	19.45	289.30	291.42	.00
MAXIMUM DOSE RATE	6997.03						

EFFECTIVE FALLOUT SHEAR .40 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND [illegible]	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-13.65	13.64	109.71	109.71	4780.18	4790.17	.00
3.00	-13.00	12.87	102.22	102.22	4145.88	4153.38	.00
10.00	-11.87	11.79	93.33	93.33	3446.69	3449.20	.00
30.00	-10.73	10.66	84.40	84.40	2826.06	2836.33	.00
100.00	-9.33	9.30	73.38	73.38	2130.94	2133.99	.00
300.00	-7.84	7.81	61.63	61.63	1504.38	1516.24	.00
1000.00	-5.77	5.68	45.37	45.37	809.12	816.31	.00
3000.00	-2.76	2.68	21.73	21.73	182.48	185.70	.00
MAXIMUM DOSE RATE	4139.94						

CALCULATED FALLOUT CONTOURS
H+1 DOSE RATE CONTOURS

1.000 MEGATON YIELD 10. KNOT WIND

EFFECTIVE FALLOUT SHEAR .10 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT GROUND	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-5.11	490.00	8.29	54.96	39335.52	42746.09	323.00
3.00	-4.68	410.17	7.69	43.04	26133.80	28045.37	271.25
10.00	-4.16	325.58	6.97	31.57	15489.56	16354.13	209.25
30.00	-3.64	251.96	6.26	22.61	8834.07	9077.99	155.25
100.00	-2.93	176.67	5.33	14.61	4173.45	4121.72	109.25
300.00	-2.26	114.63	4.36	9.09	1758.36	1668.10	63.00
1000.00	-1.25	55.43	2.88	6.09	453.07	435.42	26.00
3000.00	.42	12.95	.00	2.00	38.39	41.96	3.00
MAXIMUM DOSE RATE	3666.26						

EFFECTIVE FALLOUT SHEAR .20 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT GROUND	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-5.10	439.67	8.39	93.99	59133.09	65559.67	288.00
3.00	-4.66	361.47	7.96	71.67	37339.32	41223.89	239.25
10.00	-4.14	279.37	7.21	50.63	20086.70	22548.25	181.25
30.00	-3.62	208.91	6.45	36.50	10770.37	11544.34	131.25
100.00	-2.96	139.86	5.51	20.70	4433.25	4611.09	89.25
300.00	-2.24	86.08	4.47	11.44	1579.69	1577.73	48.00
1000.00	-1.21	36.07	2.93	5.32	318.29	318.06	19.25
3000.00	.33	8.92	.00	1.91	24.12	28.43	3.00
MAXIMUM DOSE RATE	3431.93						

EFFECTIVE FALLOUT SHEAR .40 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT GROUND	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-5.05	390.13	9.67	150.79	83177.99	98365.81	255.00
3.00	-4.61	313.81	8.95	117.78	52981.19	58901.99	209.25
10.00	-4.09	236.56	8.09	79.79	27183.73	29634.56	153.25
30.00	-3.35	167.88	7.22	51.78	12763.83	13922.82	109.25
100.00	-2.88	103.92	6.13	28.62	4989.58	4889.83	63.00
300.00	-2.34	57.15	4.92	14.53	1313.46	1333.52	35.00
1000.00	-1.07	22.60	1.99	5.67	218.46	228.60	11.25
3000.00	1.29	3.92	.00	1.03	4.15	8.69	3.00
MAXIMUM DOSE RATE	2931.60						

CALCULATED FALLOUT CONTOURS
[illegible] DOSE RATE CONTOURS

1,000 KILOTON YIELD 20. KNOT WIND

EFFECTIVE FALLOUT SHEAR .10 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT GROUND	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-4.68	879.23	7.06	47.19	59729.26	63349.16	575.00
3.00	-3.64	722.64	6.31	36.06	38891.61	41136.53	461.25
10.00	-3.19	583.06	5.83	25.38	21768.06	22551.36	360.00
30.00	-2.73	416.51	5.16	17.64	11572.22	11813.36	255.00
100.00	-2.14	274.53	4.26	10.82	4997.12	4782.36	153.25
300.00	-1.47	168.47	3.26	6.49	1739.37	1658.05	63.00
1000.00	-.43	52.62	1.53	3.01	264.44	258.67	15.00
MAXIMUM DOSE RATE	3007.37						

EFFECTIVE FALLOUT SHEAR .20 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT GROUND	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-4.58	709.58	7.16	79.10	86507.11	97597.10	505.25
3.00	-3.44	607.00	6.57	50.77	53597.03	53011.92	399.00
10.00	-3.19	469.59	5.80	30.83	27579.10	29504.78	293.25
30.00	-2.72	338.69	5.19	23.59	13082.99	13974.29	209.25
100.00	-2.13	207.57	4.39	14.61	4695.23	6767.67	131.25
300.00	-1.46	113.29	3.38	7.51	1320.96	1342.49	63.00
1000.00	-.43	37.60	1.51	3.07	135.91	103.08	11.25
MAXIMUM DOSE RATE	2804.58						

EFFECTIVE FALLOUT SHEAR .40 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT GROUND	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-4.00	633.09	7.42	131.97	127321.49	142147.79	440.00
3.00	-3.63	535.09	6.83	94.42	72615.40	68501.67	341.25
10.00	-3.17	384.49	6.12	60.75	33561.39	37809.08	239.25
30.00	-2.70	260.63	5.39	37.03	14221.95	15929.93	168.00
100.00	-2.11	147.46	4.45	18.79	4218.08	4411.34	89.25
300.00	-1.43	71.62	3.38	8.67	994.60	997.65	41.25
1000.00	-.37	22.39	1.47	3.18	119.95	116.33	8.00
MAXIMUM DOSE RATE	1827.49						

CALCULATED FALLOUT CONTOURS
H+1 DOSE RATE CONTOURS

1.000 MEGATON YIELD 40. KNOT WIND

EFFECTIVE FALLOUT SHEAR .10 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT GROUND ZERO	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-2.81	1260.21	5.91	30.87	91780.93	97831.99	1023.00
3.00	-2.52	1254.30	5.39	29.72	56113.23	58682.32	811.25
10.00	-2.16	936.10	4.76	20.30	29467.10	29924.00	599.25
30.00	-1.79	666.73	4.11	13.40	14404.63	14076.30	399.00
100.00	-1.30	402.86	3.34	7.82	5277.94	4961.85	209.25
300.00	-.72	193.78	2.17	4.26	1382.33	1302.18	80.00
1000.00	.49	30.74	.89	1.57	68.34	76.78	5.25
MAXIMUM DOSE RATE	1877.68						

EFFECTIVE FALLOUT SHEAR .20 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT GROUND ZERO	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-2.81	1367.74	5.92	65.80	129462.13	141082.82	899.00
3.00	-2.52	1071.65	5.41	47.27	73584.13	79716.40	701.25
10.00	-2.16	768.69	4.78	30.32	34015.76	35937.71	483.00
30.00	-1.79	529.20	4.12	18.70	16873.08	15709.24	323.00
100.00	-1.30	291.29	3.25	9.66	4494.40	4437.79	168.00
300.00	-.72	130.62	2.17	4.56	1085.34	937.07	63.00
1000.00	.40	24.36	.60	1.55	53.98	60.61	5.25
MAXIMUM DOSE RATE	1972.77						

EFFECTIVE FALLOUT SHEAR .40 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT GROUND ZERO	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-2.81	1179.73	5.99	107.09	179983.99	198934.76	735.25
3.00	-2.51	894.97	5.47	73.87	94082.67	104161.22	575.00
10.00	-2.16	610.12	4.83	44.79	39797.71	43079.00	399.00
30.00	-1.79	385.99	4.16	23.37	14572.09	13499.21	239.25
100.00	-1.30	195.22	3.20	12.64	3312.47	2594.23	120.00
300.00	-.71	81.73	2.10	4.85	648.68	633.66	41.23
1000.00	.52	15.48	.00	1.49	32.46	37.95	5.25
MAXIMUM DOSE RATE	1883.78						

CALCULATED FALLOUT CONTOURS
H+1 DOSE RATE CONTOURS

10,000 MEGATON YIELD 0 KNOT WIND

EFFECTIVE FALLOUT SHEAR .10 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-28.02	27.93	60.76	60.76	5331.16	5338.89	.00
3.00	-26.56	26.43	57.57	57.57	4785.07	4791.43	.00
10.00	-24.83	24.78	53.87	53.87	4182.71	4200.32	.00
30.00	-23.19	23.11	50.26	50.26	3648.91	3655.86	[illegible]
100.00	-21.21	21.09	45.99	45.99	3050.46	3055.69	.00
300.00	-19.24	19.24	41.70	41.70	2511.74	2520.12	.00
1000.00	-16.81	16.68	36.43	36.43	1912.53	1916.00	.00
3000.00	-14.23	14.16	30.84	30.84	1371.09	1374.53	.00
10000.00	-10.72	10.64	23.23	23.23	776.40	779.17	.00
30000.00	-5.90	5.80	12.80	12.80	233.70	235.24	.00
MAXIMUM DOSE RATE	40620.18						

EFFECTIVE FALLOUT SHEAR .20 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-27.36	27.22	99.36	99.36	8505.96	8516.40	.00
3.00	-25.86	25.72	93.89	93.89	7590.19	7604.77	.00
10.00	-24.08	24.08	87.51	87.51	6550.36	6620.55	.00
30.00	-22.36	22.24	81.26	81.26	5685.83	5693.71	.00
100.00	-20.31	20.22	73.79	73.79	4680.96	4697.79	.00
300.00	-18.23	18.14	66.26	66.26	3778.13	3785.36	.00
1000.00	-15.65	15.58	56.86	56.86	2772.46	2780.79	.00
3000.00	-12.84	12.71	46.65	46.65	1868.59	1872.35	.00
10000.00	-8.79	8.69	31.93	31.93	871.92	875.41	.00
MAXIMUM DOSE RATE	29825.35						

EFFECTIVE FALLOUT SHEAR .40 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-26.48	26.35	181.98	181.98	15082.36	15102.96	.00
3.00	-24.93	24.83	171.29	171.29	13340.57	13393.11	.00
10.00	-23.10	23.02	158.75	158.75	11480.40	11501.33	.00
30.00	-21.30	21.17	146.37	146.37	9749.44	9765.37	.00
100.00	-19.13	19.12	131.48	131.48	7874.98	7899.81	.00
300.00	-16.91	16.78	116.23	116.23	6141.97	6152.41	.00
1000.00	-14.09	13.99	96.80	96.80	4259.47	4269.18	.00
3000.00	-10.88	10.83	74.80	74.80	2540.82	2551.25	.00
10000.00	-5.55	5.50	38.16	38.16	652.52	662.28	.00
MAXIMUM DOSE RATE	19273.88						

CALCULATED FALLOUT CONTOURS
H+1 DOSE RATE CONTOURS

20,000 [illegible] YIELD 10. KNOT WIND

EFFECTIVE FALLOUT SHEAR .10 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-13.84	751.34	22.51	116.66	129872.92	140228.74	483.00
3.00	-12.86	639.30	21.10	95.83	93119.35	96400.69	419.25
10.00	-11.66	641.92	19.44	75.60	61858.35	64949.43	341.25
30.00	-10.49	443.71	17.70	57.68	40237.84	41336.06	288.00
100.00	-9.05	346.20	15.77	41.60	23166.39	23081.43	209.25
300.00	-7.57	256.26	13.68	29.33	12556.80	12133.99	143.00
1000.00	-5.62	166.71	10.95	18.92	5398.83	5121.84	83.00
3000.00	-3.34	91.83	7.63	12.21	1860.68	1825.93	29.25
10000.00	1.06	18.41	.06	4.51	116.23	137.74	0.00
MAXIMUM DOSE RATE	10069.63						

EFFECTIVE FALLOUT SHEAR .20 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-13.80	687.91	23.50	206.08	202493.41	224862.39	440.00
3.00	-12.80	588.27	22.06	164.25	147483.42	153038.36	379.25
10.00	-11.61	481.85	20.31	124.92	88588.93	96827.85	303.25
30.00	-10.43	380.34	18.57	93.39	54311.92	55567.73	235.00
100.00	-8.99	290.47	16.45	64.07	29513.13	30137.25	181.25
300.00	-7.58	207.73	14.25	42.26	15989.61	16222.96	131.25
1000.00	-5.34	127.02	11.33	26.30	5191.11	5029.40	71.25
3000.00	-3.22	65.86	7.82	13.27	1477.96	1423.26	29.25
10000.00	1.57	13.99	.00	3.93	72.73	92.97	0.00
MAXIMUM DOSE RATE	9943.02						

EFFECTIVE FALLOUT SHEAR .40 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-13.66	626.93	27.22	359.77	317163.08	356979.19	399.00
3.00	-12.65	526.79	25.40	280.99	212709.95	[illegible]	341.25
10.00	-11.43	422.60	23.41	207.65	127259.91	141718.43	271.25
30.00	-10.26	331.64	21.26	150.23	73192.40	[illegible]	209.25
100.00	-8.80	239.23	18.83	97.73	35910.50	37943.37	139.25
300.00	-7.27	161.34	16.22	60.50	15133.02	[illegible]	99.00
1000.00	-5.33	90.06	12.76	31.29	4613.60	[illegible]	48.00
3000.00	-2.02	40.98	8.32	14.95	1042.59	1210.90	19.25
MAXIMUM DOSE RATE	8943.95						

CALCULATED FALLOUT CONTOURS
H+1 DOSE RATE CONTOURS

10.000 KILOTON YIELD 20. KNOT WIND

EFFECTIVE FALLOUT SHEAR .10 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-11.76	1373.51	19.00	102.60	209316.22	223509.64	899.00
3.00	-10.85	1175.96	17.72	82.75	146467.08	156270.42	755.25
10.00	-9.76	952.71	16.21	63.22	93523.63	96371.10	624.00
30.00	-8.67	774.61	14.79	47.65	58295.20	58627.90	483.00
100.00	-7.33	577.87	12.86	33.18	31657.39	30502.69	341.25
300.00	-5.91	409.66	10.86	22.61	15818.43	14761.28	224.00
1000.00	-3.99	240.44	8.16	14.48	5797.81	5540.31	71.25
3000.00	-1.54	93.27	4.66	7.79	1199.30	1184.84	24.00
MAXIMUM DOSE RATE	5777.00						

EFFECTIVE FALLOUT SHEAR .20 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-11.75	1250.36	19.28	177.64	319299.47	351777.42	811.25
3.00	-10.84	1056.03	17.90	139.96	216190.21	234126.81	675.00
10.00	-9.75	845.71	16.46	103.62	128817.33	139239.73	551.25
30.00	-8.66	663.73	14.90	75.00	74573.29	79216.36	419.25
100.00	-7.31	476.99	13.01	49.01	36131.37	37277.21	305.25
300.00	-5.88	322.32	11.00	30.60	15099.34	15777.85	195.00
1000.00	-3.96	176.91	8.25	16.45	4898.40	4673.23	89.25
3000.00	-1.50	68.08	4.45	7.99	923.92	873.46	24.00
MAXIMUM DOSE RATE	5676.16						

EFFECTIVE FALLOUT SHEAR .40 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-11.70	1126.31	20.23	305.50	489455.66	546119.86	728.00
3.00	-10.73	933.67	18.97	235.56	314633.18	349165.50	599.25
10.00	-9.69	730.66	17.34	168.59	177835.02	196036.80	483.00
30.00	-8.40	555.61	15.70	117.16	95170.74	103913.05	360.00
100.00	-7.26	379.70	13.60	71.88	40769.23	43587.10	239.25
300.00	-5.08	240.11	11.53	41.30	15361.39	15933.46	143.00
1000.00	-3.63	118.91	8.98	19.46	3897.97	3738.44	63.00
3000.00	-1.33	43.78	4.40	8.35	619.12	591.65	15.00
MAXIMUM DOSE RATE	5389.21						

CALCULATED FALLOUT CONTOURS
H+1 DOSE RATE CONTOURS

10.000 MEGATON YIELD 40. KNOT WIND

EFFECTIVE FALLOUT SHEAR .10 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-9.16	2499.19	16.29	89.53	333475.99	352774.45	1599.00
3.00	-8.36	2105.91	15.11	70.92	226642.15	235537.25	1368.00
10.00	-7.44	1687.76	13.69	52.89	138846.61	140830.69	1055.25
30.00	-6.30	1331.57	12.26	38.75	82221.33	88843.14	811.25
100.00	-5.32	942.72	10.47	26.02	41087.50	38753.68	528.00
300.00	-4.04	623.13	8.51	17.27	18485.38	17015.28	271.25
1000.00	-2.21	301.44	5.64	9.98	4967.14	4738.82	109.25
3000.00	.62	62.36	.00	4.42	489.03	436.83	11.25
MAXIMUM DOSE RATE	3123.14						

EFFECTIVE FALLOUT SHEAR .20 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-9.16	2252.93	16.36	152.76	496112.68	542794.23	1481.25
3.00	-8.38	1857.35	15.17	117.89	324680.70	[illegible]	1224.00
10.00	-7.43	1461.27	13.79	84.36	182773.20	190073.02	939.25
30.00	-6.49	1119.58	12.31	58.94	99819.54	103381.77	701.25
100.00	-5.31	757.15	10.51	36.49	43281.63	43708.80	461.25
300.00	-4.03	473.62	8.56	21.45	16789.70	18191.36	271.25
1000.00	-2.20	216.35	5.63	10.32	3841.05	3510.38	99.00
3000.00	.64	51.89	.00	4.40	342.26	383.12	11.25
MAXIMUM DOSE RATE	3108.53						

EFFECTIVE FALLOUT SHEAR .40 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-9.12	2089.31	16.63	259.29	741336.71	882092.21	1395.00
3.00	-8.35	1632.61	15.42	194.79	453279.49	582983.92	1035.25
10.00	-7.42	1239.57	13.97	136.19	240634.43	252855.76	811.25
30.00	-6.48	906.18	12.30	88.90	118390.69	127447.97	573.00
100.00	-5.29	580.96	10.67	50.87	44632.46	46083.78	360.00
300.00	-4.01	335.89	8.46	26.99	14359.75	14612.69	195.00
1000.00	-2.17	139.28	5.69	11.42	2899.72	2537.77	71.25
3000.00	.72	34.96	.00	4.32	225.92	241.04	11.25
MAXIMUM DOSE RATE	3044.63						

CALCULATED FALLOUT CONTOURS
H+1 DOSE RATE CONTOURS

100,000 MEGATON YIELD 0 . KNOT WIND

EFFECTIVE FALLOUT SHEAR .10 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT GROUND	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-52.41	52.29	109.42	109.42	18813.78	18829.02	.00
3.00	-49.95	49.83	104.48	104.48	16349.09	16370.73	.00
10.00	-47.11	47.05	98.53	98.53	14533.58	14571.78	.00
30.00	-44.39	44.22	92.75	92.75	12898.32	12936.65	.00
100.00	-41.12	41.11	85.01	85.01	11090.38	11109.63	.00
300.00	-37.93	37.81	79.36	79.36	9633.42	9639.59	.00
1000.00	-34.10	34.03	71.33	71.33	7632.21	7633.58	.00
3000.00	-30.18	30.11	63.13	63.13	5956.43	5978.73	.00
10000.00	-25.20	25.10	52.70	52.70	4150.86	4163.82	.00
30000.00	-19.57	19.53	40.93	40.93	2493.19	2513.73	.00
MAXIMUM DOSE RATE	133285.13						

EFFECTIVE FALLOUT SHEAR .20 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT GROUND	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-51.63	51.50	156.32	156.32	24973.25	24997.77	.00
3.00	-49.12	49.06	146.85	146.85	22592.94	22647.10	.00
10.00	-46.23	46.13	138.19	138.19	20327.63	20368.15	.00
30.00	-43.42	43.31	129.79	129.79	17651.80	17680.85	.00
100.00	-40.11	40.06	119.91	119.91	15077.06	15096.21	.00
300.00	-36.86	36.73	110.12	110.12	12701.18	12726.12	.00
1000.00	-32.83	32.76	98.28	98.28	10121.75	10133.06	.00
3000.00	-28.79	28.75	86.07	86.08	7764.66	7779.96	.00
10000.00	-23.31	23.47	70.29	70.92	5173.77	5187.25	.00
30000.00	-17.35	17.22	51.86	51.86	2811.71	2815.86	.00
MAXIMUM DOSE RATE	113457.11						

EFFECTIVE FALLOUT SHEAR .40 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT GROUND	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-59.37	59.26	262.62	262.62	61453.52	61515.46	.00
3.00	-47.81	47.79	249.26	249.26	37373.81	37429.72	.00
10.00	-44.80	44.70	233.70	233.70	32333.39	32466.31	.00
30.00	-41.92	41.88	218.56	218.56	28594.02	28770.75	.00
100.00	-38.49	38.36	200.66	200.66	24198.09	24226.65	.00
300.00	-35.05	35.06	182.81	182.81	19851.12	19136.27	.00
1000.00	-30.88	30.77	160.98	160.98	15336.26	15509.16	.00
3000.00	-26.49	26.36	138.08	138.08	11445.46	11461.07	.00
10000.00	-20.62	20.52	107.52	107.52	6939.09	6948.71	.00
30000.00	-13.17	13.06	68.65	68.43	2621.13	2635.90	.00
MAXIMUM DOSE	63906.63						

CALCULATED FALLOUT CONTOURS
H+1 DOSE RATE CONTOURS

100.00 MEGATON YIELD 10. KNOT WIND

EFFECTIVE FALLOUT SHEAR .10 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-35.03	1043.88	61.96	208.91	334891.47	354047.37	675.00
3.00	-32.85	927.59	58.56	177.09	257292.47	260390.07	599.25
10.00	-30.28	801.79	54.99	146.49	186844.32	191463.07	503.25
30.00	-27.77	688.80	50.69	120.21	134867.75	133331.96	419.25
100.00	-24.76	567.45	46.05	94.36	89937.72	87701.70	341.25
300.00	-21.72	459.53	41.36	73.57	58758.65	55612.21	271.25
1000.00	-17.92	345.11	35.52	54.36	33726.65	30996.00	160.00
3000.00	-13.82	244.79	29.18	41.45	17915.73	16838.63	29.25
10000.00	- 8.06	138.83	20.06	29.32	6619.20	6754.63	29.25
30000.00	.32	39.70	.00	12.09	741.97	611.68	15.00
MAXIMUM DOSE RATE	31649.90						

EFFECTIVE FALLOUT SHEAR .20 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-36.95	971.44	66.73	378.73	529023.77	524923.91	626.00
3.00	-32.73	856.29	61.16	311.12	393037.11	426673.39	551.25
10.00	-30.10	732.06	56.99	250.75	275796.21	300887.76	461.25
30.00	-27.46	603.97	52.90	200.37	190610.65	206659.06	399.00
100.00	-24.64	502.45	48.02	151.86	119548.67	128728.90	323.00
300.00	-21.58	390.13	43.09	112.94	72673.91	76466.69	239.25
1000.00	-17.77	289.90	36.93	77.15	37696.11	37257.78	168.00
3000.00	-13.63	197.56	30.25	51.18	17894.60	16977.16	99.00
10000.00	-7.00	106.30	20.55	31.20	5738.95	5592.69	29.25
30000.00	1.07	29.61	.00	11.99	567.15	566.58	15.00
MAXIMUM DOSE RATE	30198.03						

EFFECTIVE FALLOUT SHEAR .40 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-34.63	898.91	74.69	661.18	859032.57	969379.93	575.00
3.00	-32.44	784.88	79.31	567.44	623989.25	762829.21	503.25
10.00	-29.85	662.23	65.62	432.98	421228.39	478699.59	419.25
30.00	-27.30	553.01	60.81	339.12	278363.26	369121.96	360.00
100.00	-24.26	437.27	55.07	248.39	166561.38	179920.06	271.25
300.00	-21.16	336.55	49.25	177.31	92888.25	99624.39	209.25
1000.00	-17.24	233.72	41.95	113.56	43875.56	44759.91	143.00
3000.00	-13.00	149.61	29.96	68.99	17713.69	15723.05	80.00
10000.00	-6.90	71.99	22.09	39.77	4509.56	4432.38	29.25
30000.00	5.67	14.64	.00	5.46	74.81	174.23	11.25
MAXIMUM DOSE RATE	25782.63						

CALCULATED FALLOUT CONTOURS
H+1 DOSE RATE CONTOURS

100.000 MEGATON YIELD 20. KNOT WIND

EFFECTIVE FALLOUT SHEAR .10 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-31.50	1941.96	50.57	180.23	570333.90	592496.34	1259.25
3.00	-29.43	1710.87	47.64	150.51	421923.74	433215.50	1080.00
10.00	-26.97	1401.45	44.21	128.56	290771.08	300224.49	929.25
30.00	-24.55	1233.14	40.03	103.86	200373.69	201991.29	755.25
100.00	-21.44	999.30	35.76	70.63	136335.22	128049.19	599.25
300.00	-18.66	783.04	32.62	61.00	83823.63	77337.31	440.00
1000.00	-14.09	565.38	27.37	46.45	44470.60	40916.03	224.00
3000.00	-10.71	370.59	21.40	34.31	28739.20	20932.16	71.25
10000.00	-6.63	159.46	12.10	19.70	4961.12	5070.63	35.00
MAXIMUM DOSE RATE	19930.28						

EFFECTIVE FALLOUT SHEAR .20 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-31.47	1798.20	51.38	330.70	868496.95	950109.46	1189.25
3.00	-29.33	1569.90	48.40	273.73	633171.98	697648.11	1023.00
10.00	-26.93	1324.32	44.91	216.56	438749.07	459610.06	840.00
30.00	-24.52	1108.72	41.46	169.75	282436.73	301372.63	701.25
100.00	-21.60	874.01	37.33	124.63	169799.56	173333.60	551.25
300.00	-18.61	672.16	33.11	89.53	97264.86	97161.57	419.25
1000.00	-14.86	465.19	27.73	58.37	45992.14	44810.02	271.25
3000.00	-10.66	293.22	21.76	37.27	19029.14	17787.10	120.00
10000.00	-4.31	123.36	12.12	20.10	4079.06	4030.25	35.00
MAXIMUM DOSE RATE	18719.59						

EFFECTIVE FALLOUT SHEAR .40 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-31.36	1654.50	54.50	584.56	1385080.58	1547997.49	1088.00
3.00	-29.26	1428.80	51.32	476.08	980115.22	1030390.69	939.25
10.00	-26.88	1187.03	47.59	368.26	635801.97	782147.55	783.00
30.00	-24.37	973.67	43.91	281.03	482181.65	449318.53	624.00
100.00	-21.46	768.62	39.48	190.17	222393.59	238639.52	483.00
300.00	-18.63	553.81	34.96	135.30	115467.20	121931.31	341.25
1000.00	-14.62	364.87	29.21	81.08	47560.30	48228.13	226.00
3000.00	-10.37	213.65	22.72	45.86	16531.12	16133.86	109.25
10000.00	-3.89	81.20	12.13	21.13	2887.06	2884.50	29.25
MAXIMUM DOSE RATE	17535.53						

CALCULATED FALLOUT CONTOURS
H+1 DOSE RATE CONTOURS

100,000 KILOTON YIELD 40. KNOT WIND

EFFECTIVE FALLOUT SHEAR .10 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-26.72	3393.16	43.09	168.48	939710.63	937974.38	2303.00
3.00	-24.83	3133.04	40.43	140.78	686970.97	698861.60	1979.25
10.00	-22.59	2641.79	37.39	111.99	474234.60	468694.94	1639.25
30.00	-20.37	2301.63	34.19	88.98	322661.57	310866.84	1331.25
100.00	-17.66	1732.91	30.43	67.04	197684.24	184138.46	991.25
300.00	-14.87	1320.44	26.53	50.40	116349.17	105710.71	649.25
1000.00	-11.26	887.31	21.46	37.83	53639.57	53393.37	168.00
3000.00	-7.02	504.33	15.46	25.73	20699.58	20691.76	155.25
10000.00	.24	184.52	.00	11.61	1846.46	1989.70	24.00
MAXIMUM DOSE RATE	10720.24						

EFFECTIVE FALLOUT SHEAR .20 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-26.71	3389.12	43.30	292.79	1412506.47	1324140.90	2161.25
3.00	-24.62	2857.40	40.63	230.79	1066156.62	[illegible]	1848.00
10.00	-22.50	2373.61	37.48	185.18	658815.12	[illegible]	1520.00
30.00	-20.35	1956.77	34.36	141.69	421167.18	437393.67	1224.00
100.00	-17.45	1494.03	30.57	100.71	237136.18	229128.92	929.25
300.00	-14.83	1105.90	26.65	69.71	126319.02	122739.31	649.25
1000.00	-11.22	716.94	21.53	43.48	53161.72	49390.20	360.00
3000.00	-7.90	394.85	15.49	26.86	17782.09	16952.68	155.25
10000.00	.30	93.61	.00	11.59	1663.92	1720.10	26.00
MAXIMUM DOSE RATE	10559.12						

EFFECTIVE FALLOUT SHEAR .40 KNOTS PER 1000 FT ALTITUDE

1 DOSE RATE (ROENTGENS/HR)	2 MAXIMUM UPWIND POSITION	3 MAXIMUM DOWNWIND DISTANCE	4 CROSSWIND HALFWIDTH AT ORIGIN	5 MAXIMUM CROSSWIND HALFWIDTH	6 ACTUAL AREA	7 ESTIMATED AREA ELLIPSE	8 RANGE TO MAXIMUM WIDTH
1.00	-26.68	3024.86	44.16	512.13	2210701.10	2434821.59	1979.25
3.00	-24.78	2379.49	41.43	409.83	1519326.48	1674344.79	1640.00
10.00	-22.54	2104.65	38.21	309.45	945017.41	[illegible]	1368.00
30.00	-20.31	1697.41	35.01	229.32	568434.22	619159.44	1039.00
100.00	-17.60	1234.39	31.14	156.99	282093.76	309682.01	811.25
300.00	-14.79	890.24	27.13	100.32	130571.20	142903.01	351.25
1000.00	-11.15	539.43	21.90	56.12	49538.92	48939.02	305.25
3000.00	-6.91	276.96	15.67	29.43	13770.91	13223.71	131.25
10000.00	.52	70.46	.00	11.53	1249.60	1285.06	19.25
MAXIMUM DOSE RATE	10424.67						