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DEPARTMENT OF DEFENSE
DEFENSE ATOMIC SUPPORT AGENCY
WASHINGTON 25, D.C.

ADDRESS REPLY TO:
THE CHIEF, DEFENSE ATOMIC
SUPPORT AGENCY
DASARZ 930.1

3 1 JUL 1962

MEMORANDUM FOR: ASSISTANT TO THE SECRETARY OF DEFENSE (ATOMIC ENERGY)

SUBJECT: AEC/DOD Study

1. Reference is made to my memorandum of 27 April 1962 discussing the participation of the Defense Atomic Support Agency in a joint Atomic Energy Commission/Department of Defense (AEC/DOD) study on the short and long-term biological environmental consequences of nuclear warfare.

2. The Defense Atomic Support Agency (DASA) has completed the basic portion of its contribution to the study to include (a) the targeting against the USSR for a series of hypothetical attacks (1000MT, 3000 MT, and 10,000MT against each of two target systems, each for surface and for air burst weapons), (b) the analysis of fatal and non-fatal casualties from blast, and (c) an analysis of fatal and non-fatal casualties from radioactive fallout. All analyses differentiate between the application of clean and normal weapons. The study presented at Inclosure 1 constitutes a basic, or first, iteration. A second iteration will be forwarded on or about 10 August 1962 and will present considerable refinements to the basic iteration in light of more accurate data and deeper analysis. The latter presentation will explore in considerable detail the distribution of selected radionuclides in relationship to categories of ecological interest. 100MT

3. The basic study submitted herewith is in keeping with the original guidance received for the conduct of the study. Subsequent to initiating work on the study, however, important parameters were better defined, and on numerous occasions the parameters were changed. The latest change is an on-going effort to incorporate into the study modified weapon design data furnished by Dr. Carl F. Miller, Office of Civil Defense (arranged by Dr. Miller on 30 July 1962). Copies of this study and follow-on material will be forwarded under separate cover to Mr. Hal Hollister, Atomic Energy Commission, for use in connection with the final study presentation.

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1 Incl
AEC/DOD Study(S,RD)

Robert H. Booth
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Major General, USA
Chief

AUG 1 '62

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THE EFFECTS OF CLEAN NUCLEAR WEAPONS

1. Objective

The purpose of this study is to describe briefly the methodology, techniques, and data employed in calculating the immediate and short-term fatalities and casualties among people and livestock as well as to provide quantitative information for further study of the long-term radiation burden among survivors, farm animals and agricultural resources as a consequence of nuclear war involving clean and normal nuclear weapon types in a variety of weapon applications.

A range of hypothetical weapon bursts totaling one, three, and ten thousand megatons in the USSR is considered, investigating for each total the relative influence of weapon burst height, degree of weapon cleanliness, and to some extent the system of targets. For each case, the number of early fatalities and casualties are tabulated and graphed (and mapped in the cases of surface-burst weapons). The life-time accumulated external radiation dose sustained by survivors is tabulated and graphed as a spectrum of population, and mapped to identify the areas in which the doses would occur. Further, maps are provided to show the extent of fallout radiation; areas within which farm animals become fatalities from external radiation; and areas of agricultural contamination by gross fallout products as well as by radioactive elements of biological importance. Approximate estimates of resulting world-wide radio-active fallout are developed. Finally, a brief analysis is given with the results.

In the course of this study, assumptions are stated at points where they are introduced; pertinent implications are noted; and important source material is identified.

2. Approach

In considering the relative effects of clean and normal weapons it is first necessary to establish some meaningful measuring indices with which to compare effects of the two types. Since a given yield of either weapon type has the same blast and thermal energy, structural damage caused by each will be the same and cannot be used as a comparative index.

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Clean and normal weapons do differ substantially, however, in the production of radioactive elements and this difference permits fatalities, casualties, land contamination, and world-wide fallout to be significant measures of the relative effects of each type.

A simple approach would be to calculate the area of lethal contamination produced by a surface burst of each weapon type, compare the relative areas, and conclude that the clean weapon is so many percent as fatality-productive as the normal. Such a conclusion might be quite misleading, however, since it applies only to an area of uniform population density and does not reflect the possibility of overlapping patterns from other target areas. It is evident that reliable evaluations require a real-world framework and, to achieve this, two comprehensive target systems based upon a recent Target Data Inventory (TDI) were developed, appropriate weapon assignments of three different total megatonnages were hypothesized, and the fallout processes of the several types of radiation sources were investigated and converted into mathematical models for simulation in a high-speed computer. Each of the twelve hypothetical attacks (two target systems, three magnitudes of attack, and two burst heights) were in turn run off in a computer for both the clean and normal weapon types.

A brief summary of results and conclusions are given in sections 3 and 4 below, followed by pertinent tabulations in Annex A. Discussions of the parameters and methodology used are given in Annexes B and C; information on radioactive fission product, weapon material, and soil fallout is provided in Annexes D, E, and F. Discussions of population shelters; fatality and casualty criteria; agricultural contamination; and world-wide fallout are given in Annexes G through J. Detailed results are tabulated and mapped for each parametric combination in Annex K.

3. Results

Fatalities for all the combinations of weapon cleanliness, target strategy, and height of burst are plotted in Figure 1.

The first and most striking feature of the results shown is the very considerable divergence in total casualties. There is a constant factor of 7 or 8 between the most lethal combination of normal surface bursts and the more sparing air burst attack against military targets. Another noteworthy feature is that for an attack of about 1000 MT total weight, there are very few additional casualties beyond the air burst cases from the surface bursting of clean weapons, regardless of whether the targeting is against military targets only or against the combined array of military and non-military targets. Clean surface bursts do tend, however, to become more lethal as the weight of attack increases owing to the small but accumulating contributions of radio activity. .

Another interesting point is that, at about 1000 MT weight, fatalities are about the same from an air burst-combined targets combination, a clean-surface burst-combined targets combination, or a normal weapon-surface burst attack against military targets only. This equivalence disappears rapidly, of course, as the weight of attack increases.

Clean weapons burst on the surface against the broad target array cause about one-half as many fatalities as normal weapons for all weights of attack up to 10 - 12,000 MT. In the more discriminating application against military targets only, the clean weapons cause only 30% of the normal weapon fatalities for all attack weights. Perhaps a more meaningful way of evaluating the relative merits of clean and normal weapons is as follows: A clean weapon lay-down of 8 to 10 times the total yield of normal weapons will cause the same number of fatalities as the smaller attack with normal weapons, for either a broad mixed or specific military target strategy in the attack range from 500 MT to more than 10,000 MT. The most population-sparing employment of weapons is with air burst; the most lethal by far is the combination of normal weapons burst on the surface which can devastate a population with as little as 1000 MT.

4. Conclusions

There are two or three conclusions which are pointed up by this investigation.

a. It is quite feasible, in attempting almost any military strategy, to inflict simultaneously almost any desired level of population destruction ranging from a few percent to almost complete obliteration. The upper bound would be slightly higher than the normal weapon surface burst results shown, with slightly greater concentration on population centers.

The lower bound would be a percent or two per 1000 MT with air bursts concentrating on important military targets. This lower bound could be reached by not targeting the several dozen military headquarters located in cities.

b. In minimizing fatalities clean weapons could be employed against hardened targets which require surface bursts.

c. With a more varied stockpile which includes clean weapons and the greater employment flexibility which accompanies their inclusion, considerable planning versatility could be undertaken with a minimum of constraints.

Annexes:
- A - Effects Upon Total Population in the USSR(S)
- B - Parameters Employed(S-RD)
- C - Methodology(S)
- D - Radioactive Fission Products(C)
- E - Induced Weapon Material Radioactivity(S-RD)
- F - Induced Soil Activity(C)
- G - Population Shelters(C)
- H - Fatality Criteria(C)
- I - Agricultural Contamination(U)
- J - Worldwide Fallout(U)
- K - Map (typical)(S)

FOIA(b)(3) - 42 USC 2162(a) - RD DOE EO13526 6.2(a)

EFFECTS UPON TOTAL POPULATION
IN THE USSR

	NORMAL WEAPONS								CLEAN WEAPONS							
	AIR BURST				SURFACE BURST				AIR BURST				SURFACE BURST			
	Combined		Military		Combined		Military		Combined		Military		Combined		Military	
	mill	%			mill	%			mill	%			mill	%		
LOW ATTACK																
WEIGHT MT	971		586		971		586		971		586		971		586	
DEAD	41	20	9	4	79	38	33	16	41	20	9	4	43	21	10	5
INJURED	11	5	4	2	22	11	17	8	11	5	4	2	16	8	8	4
WELL	158	75	197	94	108	51	157	76	158	75	197	94	150	71	188	91
MEDIUM ATTACK																
WEIGHT MT	3014		1869		3014		1869		3014		1869		3014		1869	
DEAD	50	24	12	6	111	53	56	27	50	24	12	6	55	26	17	8
INJURED	6	3	3	1	23	11	22	11	6	3	3	1	16	8	11	6
WELL	154	73	195	93	75	36	129	62	154	73	195	93	138	66	179	86
HIGH ATTACK																
WEIGHT MT	10000		6037		10000		6037		10000		6037		10000		6037	
DEAD	62	30	19	9	166	79	106	51	62	30	19	9	85	40	36	18
INJURED	4	2	6	3	13	6	22	11	4	2	6	3	29	14	24	12
WELL	144	68	185	88	31	15	79	38	144	68	185	88	96	46	147	71

ANNEX B

Parameters Employed

An endless list of parameters have varying degrees of influence upon the resultant effects of nuclear weapons including such factors as the military and non-military postures in the target areas, amount of warning time, general morale and psychological reactions of the population, etc. There are important reasons for not introducing a wide variety of parameters, an obvious reason being that many such parameters cannot be specified numerically, another being that some factors are almost completely dependent upon subjective judgment and, further, that a long list of parameters tend to become interdependent upon each other. A most important reason, though, is that the introduction of additional parameters with more than one set of assigned values increases the volume of computational effort geometrically.

The first four parameters listed below are of prime interest in this study and are assigned specific values, generating 24 combinations for investigation with each combination being applied in turn. These establish the general framework of target-weapon application. In addition, there are three others which are not permitted to vary (and in this sense are not parameters) but which require identification and description because of their importance to the development of results. These three relate to population, shelter, meteorology, and soil.

1. Weapons

Two weapon types are considered; clean and normal. [redacted]

FOIA(b)(3) - 42 USC 2162(a) - RD DOE EO13526 6.2(a)

Three yields of each type are considered in the study, one, five, and twenty total megatons. [redacted] All normal or all clean weapons are used in each attack; the weapon types are not mixed in any event. Weapon details relating to induced radioactivity are given in Annexes E and F.

2. Target Systems

Two targeting philosophies are investigated. A combined attack of broad scope was developed against important military targets such as long and medium-range airfields, missile facilities, weapon storage sites, submarine bases, command centers, army, air, and naval bases, supply depots, military communications, and other military facilities; important war-support industries such as missile factories, weapon production plants, atomic energy installations, aircraft plants, large power plants; and other major industrial centers as well as population centers. Co-located targets were identified within radii of moderate damage expectancy from a one MT weapon with the aim point generally near the center of the complex unless a very important or hardened target was in the group in which case the aim point was shifted accordingly. Once the target areas were identified, weapon assignments were made (within the constraints of the three weapon sizes considered in the study) according to the techniques of the Joint Atomic Weapon Planning Manual and Air Force Manual 200-8. In the smallest weight of attack, the targeting criterion was a reasonably high probability (50 - 90%) of at least significant or moderate damage to the targets. The locations and structural vulnerability of the targets was generated by the DASA Damage Assessment Center data base which in turn is largely developed from the Target Data Inventory (TDI).

The second targeting philosophy included military targets only. This was achieved by simply eliminating all non-military targets from the list. Although this procedure reduced the number of aim points (and consequently the weight of attack), it provides a valid basis for comparison since the military target attack is then a sub-set of the combined attack, and no additional aim points are introduced which would tend to confuse the results.

3. Size of Attack

Three weights of attack were analyzed in order to achieve a reasonably broad spectrum and more clearly show the direction (on summary graphs) in which the results are leading. For the combined targets attacks the total weights are about one, three, and ten thousand megatons. The 1000 MT attack was developed first, mostly with 1 MT weapons which generally achieved at least 50% probability of moderate damage to the targets under consideration. The same targets and desired ground zeros were considered in the 3000 MT attack and the individual weapon weight was raised as necessary to establish a high probability of severe damage. The number of aim points and weapons were not changed, reflecting an approach which would simplify the comparative analysis of effects upon populations, animals, and cropland. A similar approach was followed in developing the 10,000 MT attack, in this case seeking a very high probability of severe damage to targets. A brief analysis showed that the probabilities of severe structural damage were usually well above 90%. Even so, there were a number of weapons left unassigned and in this case the target list was expanded to include 180 additional (and less important) targets. These were added to the list in the proper military:non-military proportions so as to preserve targeting symmetry.

It is to be noted that in some cases, especially in the 10,000 MT attack, the probability of damage was perhaps higher than warranted and in this sense the large attack would tend to be wasteful; on the other hand, since only one weapon was assigned to a given aim point (implying excellent delivery reliability) the sum total attack would tend to be very efficient. Combat attritional and other operational factors are omitted since it is not the purpose of the study to attempt war-gaming.

Weapon distribution and number of aim points are given in Table B-1.

4. Height of Burst

Two heights of burst are employed in this study, zero and 640 feet scaled according to the cubed root of weapon yield. The surface burst tends to minimize blast effects upon soft targets but is optimum for very hard targets. On the other hand, the 640-foot burst is more far-reaching in damaging soft targets but cannot destroy very hard targets even if located directly under the burst point. In this study, all weapons in each run are either surface or air burst, hence are not completely efficient in certain target situations.

5. Population Shelters

Shelters for population are invariant for all attacks. The shelter situation employed in the study assumes that there are no blast shelters for the population nor are there any fallout shelters specifically constructed for the purpose. However, a reasonable measure of fallout protection is available for a substantial number of the urban dwellers in basements and the central portions of multi-story masonry buildings. Shelter for the rural inhabitants is not as effective. It is further assumed that those not killed by direct effects are able to reach their shelters, implying a reasonable amount of knowledge and training on the part of the population.

Shelter effectiveness is handled mathematically by use of a residual number which simply expresses the proportion of the exterior radiation which penetrates to the occupants within. The behavior of the personnel with respect to the continued use of the available shelters is handled by an adjustment to the residual number. Shelter protection for urban and rural population is handled separately. Additional details are given in Annex G.

6. Meteorology

The same meteorological situation is used in all attacks, namely the mean winds for the spring season. By choosing this season a medium-type of meteorological situation is reflected, avoiding the more erratic or extreme winter and summer meteorology. An effective wind vector, giving direction and velocity at each burst point, is developed by weighting the wind characteristics at appropriate altitude intervals from cloud height down to surface according to the proportional length of stay of the "average" particle in each altitude interval. At city burst points, wind velocity and direction deviation is introduced in order to combine CEP and wind deviation so as to produce, by a series of random number runs, the significant median dose level for effects computation. Downwind from the urban target area the effective wind vector is used without deviation.

Basic meteorological data are provided by the Air Weather Service.

TABLE B-1

Yield Distribution of Weapons

Size of attack	Low		Medium		High	
Type of attack	Combined Targets	Military Only	Combined Targets	Military Only	Combined Targets	Military Only
Total wt. of attack (MT)	971	586	3014	1869	10000	6037
Number of aim points	607	354	607	354	787	456
Number of weapons	607	354	607	354	787	456
Weapon distribution:						
1 MT	516	296	369	204	220	152
5 MT	91	58	141	89	104	13
20 MT	0	0	97	61	463	291

7. Soil

A fixed composition of soil elements is used for all burst points in all attacks. The composition reflects, in general, a cross between Podzolic and Chernozem, two soil types prevalent in the target areas of the USSR. The specific chemical percent by weight of the top foot or so of soil was derived from a large group of soil analyses compiled by the Military Geology Branch of USGS, Corps of Engineers, in Engineer Intelligence Note No. 32. Under the assumption that the analyses were performed with the application of heat which would permit the escape of unbound water and organic matter, the chemical compositions given were adjusted to reflect the presence of 17½% water and 10% cellulosic matter (in units of CH_3O).

It must be noted that soil compositions vary radically, even within local regions, and variations in specific elements by a factor of ten are not uncommon. Further, it is likely that a number of bursts may occur on or near paved areas which could influence the induced activities markedly. There is little information for guidance in this respect, however. Additional details and a discussion of soil radioactivity is given in Annex F.

ANNEX C

Methodology

In order to calculate the number and distribution of casualties and fatalities by electronic computer (or by any other method) it is first necessary to identify on a geographical basis the number and location of all urban and rural dwellers in the USSR to serve as a data base upon which to perform the assessment. This information is provided in the Target Data Inventory which regularly furnishes up-to-date information on the population of Soviet cities; the exact location of the population center of each, and the radius within which are located 95% of the inhabitants of a city of at least 50,000 population. For smaller cities the radius reflects the built-up area of the city, which is quite adequate for casualty assessment since there is good correlation between building and population densities in cities of this size. For rural dwellers, the nation is divided into some 7500 cells, the size of each being one-half degree of longitude by one-third degree latitude. Each cell is identified by its geographic center and urban and rural populations.

In addition to the population data base, other input must be provided to the computer such as tables of fatality and casualty probabilities in terms of effective radiobiological dose, vulnerability number, and certain other relationships which are required for machine computation.

Using the urban population information of the data base, the computer generates concentric rings about the city center, each annulus being broken up into tracts of less than a half-mile on side. The incremental population is identified with the center of each of these small areas.

Attack parameters are also input to the computer and include such details as aim point, yield, CEP, and height of burst. The casualty computation is then essentially a calculation of distance between burst point (or aim point with CEP) and the locations of the individual population centers. The distance is related to a probability of casualty which is then applied to the population group and summarized or printed out.

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For radioactive fallout computations, a model described in WSEG Memo No. 10 is employed in the computer to determine intensities, doses, and probability of casualty from each weapon that affects the population point.

Additional details of the blast casualty model and the nation-wide fallout program are given in Part A of the Joint Atomic Weapon Planning Model.

ANNEX D

Radioactive Fission Products

The fallout model employed in computing population casualties is the model developed in WSEG Memo No. 10 as modified by information submitted recently by Dr. Carl F. Miller of OCD. The basic model is a mathematical representation of the spatial distribution of the stabilized cloud's radioactivity which is then deposited downwind as a function of particle fall velocity, wind speed and wind shear. The resulting surface contamination is based upon Pacif test information and a radioactive material balance of 2500 $r/_{hr}$-sq. miles per KT fission provided by Dolan of DASA. Miller's information, based upon a comprehensive treatment of the thermodynamics of particle formation during the early minutes after burst, provides a method for reflecting the fractionation processes which govern the chemical and physical characteristics of the radioactive fallout material. Further information on the subject is provided in Miller's recent publications. To the extent that the WSEG model is based upon test data it reflects to greater or lesser extent the fractionation phenomenon as it occurred in the Pacific. However, as Miller's work shows there is a difference in radioactive decay rate between the fractionated and unfractionated activity. Accordingly, for this study, decay rates for fractionated material are used for fallout activity located within about 15 miles from burst point and unfractionated decay rates are used farther downwind. These decay rates are given in Table D-1.

ANNEX E

Induced Weapon Material Radioactivity

Induced weapon material radioactivity contributes to the overall fallout activity. Such activity depends largely upon weapon design and composition. The normal weapon as used in the tests between 1954 and 1958 is the basis for weapon radioactivity in this study.

FOIA(b)(3) - 42 USC 2162(a) - RD DOE EO13526 6.2(a)

Test data from two or three tests indicates that about 1½ moles are produced per MT total yield.

Los Alamos has recently provided some data on this subject and Miller has developed an analytical method for determining these activities.

FOIA(b)(3) - 42 USC 2162(a) - RD DOE EO13526 6.2(a)

ANNEX F

Induced Soil Activity

About half of the neutrons escaping from the case of the weapon are available for inducing activity in the soil elements at burst point. These radionuclides are carried up in the fireball and eventually deposited downwind with the other fallout materials. As indicated in Annex B, Russian soil composition is used in this study. Table F-1 lists these elements and their abundance by weight. Also shown for each element is the thermal cross-section which is divided by its atomic weight and multiplied by its abundance in order to obtain a weighted average so as to determine the proportion of incident neutrons captured by each. The lower part of the table identifies the gamma-emitting radionuclides which have been included in the fallout model used in this project. Miller furnished the dose rates and Knapp of the AEC provided fundamental information on the subject.

Soil Activity
(Table F-1)

Element	% by wt.	Thermal σ_a (barns)	$\frac{\sigma_a}{A}$	% by wt. x $\frac{\sigma_a}{A}$ x 100	Neutrons Captured per Incident Neutron $\left(\frac{N_i}{N_r}\right)$
Oxygen	57.10	0.0002	0.0000125	0.0714	5.36×10^{-4}
Silicon	27.61	0.13	0.00463	12.80	9.61×10^{-2}
Aluminum	3.90	0.21	0.0078	3.04	2.28×10^{-2}
Carbon	3.22	0.003	0.00025	0.0805	6.05×10^{-4}
Iron	1.71	2.50	0.0448	7.65	5.75×10^{-2}
Magnesium	0.30	0.063	0.00259	0.0776	5.83×10^{-4}
Potassium	1.15	1.97	0.0504	5.79	4.35×10^{-2}
Calcium	0.76	0.44	0.0108	0.87	6.53×10^{-3}
Sodium	0.59	0.56	0.0244	1.408	1.06×10^{-2}
Titanium	0.31	5.60	0.117	3.624	2.72×10^{-2}
Phosphorous	0.04	0.20	0.0065	0.026	1.95×10^{-4}
Manganese	0.04	13.40	0.244	0.976	7.34×10^{-3}
Nitrogen	0.48	1.88	0.134	6.43	4.83×10^{-2}
Sulphur	0.06	0.52	0.0162	0.097	7.29×10^{-4}
Hydrogen	2.75	0.33	0.327	90.00	6.76×10^{-1}

Element	$\frac{N_i}{N_r}$	r/hr per Neutron Captured per sq. ft. at Zero Time
Na - 24	0.0106	2.62×10^{-14}
Mg - 27	6.0×10^{-5}	3.86×10^{-16}
Al - 28	0.023	1.03×10^{-12}
Si - 31	5.4×10^{-4}	1.94×10^{-19}
K - 40	0.04	5.4×10^{-28}
K - 42	0.016	4.55×10^{-17}
Ca - 49	3.0×10^{-5}	5.28×10^{-16}
Mn - 56	0.007	4.97×10^{-15}
Fe - 55	0.0036	1.07×10^{-21}
Fe - 59	1.94×10^{-4}	2.41×10^{-19}

ANNEX G

Population Shelters

A description of the population shelters in the USSR and their availability to urban and rural inhabitants have been furnished by Mr. Charles B. Walker of AFCIN. Also given is the fallout protection factor (expressed reciprocally as a residual number) provided by each type. These are shown in Figure G-1. It is assumed that there are no blast shelters and that the population are in their basements and buildings at the time of fallout arrival.

An important factor in considering shelter effectiveness is the behavior of the occupants, that is, the continued use of the shelter. It is believed that the Soviet population is aware of and has had training in fallout protection. However, a certain proportion of the occupants for one reason or another emerge for several hours daily beginning on the first day; others come out on the second day, and so on. This less-than-complete use of shelters can be reflected by an adjusted residual number ($R\bar{N}$) which is determined by dividing the time integral of the decay rate for the first 2 weeks into the summation of the product of the individual incremental time integrals and residual numbers used during each interval. The $R\bar{N}$'s for a variety of shelter types and behavior patterns are given in Table G-2. The proportions of urban and rural inhabitants in each shelter-behavior situation are given in Tables G-3 and G-4. The combination of $R\bar{N}$'s of Table G-2 and populations of G-3 and G-4 are combined so as to produce the cumulative distribution of protection for inhabitants as shown in G-5. This distribution of $R\bar{N}$'s is used to develop the probabilities of fatality and casualty to urban and rural populations as a function of exterior dose which are given in Tables G-6 and G-7.

In any contaminated area, it is assumed that the fallout fatalities are those with the least shelter. In order to determine the life-time doses accumulated by survivors it is necessary to determine their shelter protection and this is provided as a function of exterior dose in G-8 and G-9. The resultant information is then put into the computer in tabular form.

Shelter Effectiveness and Availability
(Table G-1)

Category	Description	Residual Number	Percent of Population Urban	Percent of Population Rural
I	Multi-story masonry bldgs. with basements	0.005	31	0
II	Brick/stone, two story with basements	0.10	22	10
III	Brick/stone or insulated log, wood roof, no basement	0.40	17	50
IV	Simple frame or log, no basement	0.50	20	30
V	Open	0.70	10	10

Residual Numbers (RN) by Shelter Type

Shelter Type	I	II	III	IV	V
Residual Number	0.005	0.10	0.40	0.50	0.70

Adjusted Residual Numbers ($\overline{RN}$) for Shelter and Behavior Situations
(Table G-2)

Behavior	Shelter Type I	II	III	IV	V
A. Out 2 hrs. each day from first day	.0575	.146	.423	.515	.70
B. " " " " " " second "	.0289	.121	.411	.507	.70
C. " " " " " " third "	.0178	.111	.406	.504	.70
D. " " " " " " fourth "	.0098	.104	.404	.502	.70
E. " " " " " " seventh "	.0066	.102	.401	.501	.70
F. Out 4 hrs. each day from first day	.1090	.190	.445	.530	.70
G. " " " " " " second "	.0465	.136	.419	.514	.70
H. " " " " " " third "	.0289	.121	.411	.507	.70
J. " " " " " " fourth "	.0187	.112	.406	.504	.70
K. " " " " " " seventh "	.0082	.103	.402	.502	.70
L. Out 6 hrs each day from first day	.1630	.236	.470	.547	.70
M. " " " " " " second "	.0671	.154	.429	.520	.70
N. " " " " " " third "	.0432	.133	.417	.513	.70
P. " " " " " " fourth "	.0299	.121	.411	.510	.70
Q. " " " " " " seventh "	.0097	.104	.403	.504	.70

Percent of Population in Various Shelter and Behavior Situations
(Table G-3)
URBAN

Behavior Pattern	Shelter Type I	II	III	IV	V
A	3	3	2	2	
B	3	2	1	1	
C	3	2	1	1	
D	3	2	1	1	
E	2	1	1	1	
F	3	2	2	2	
G	2	1	1	2	
H	2	1	1	1	
J	2	1	1	1	
K	2	1	1	1	
L	2	2	2	2	
M	1	1	1	2	
N	1	1	1	1	
P	1	1	0.5	1	
Q	1	1	0.5	1	
TOTAL	31%	22%	17%	20%	10%

Percent of Population in Various Shelter and Behavior Situations
(Table G-4)
RURAL

Behavior Pattern	Shelter Type I	II	III	IV	V
A		2	4	2	
B		1	2	1	
C		1	2	1	
D		0	2	1	
E		0	1	0	
F		1	8	5	
G		1	6	4	
H		1	4	3	
J		0	2	1	
K		0	1	0	
L		1	8	5	
M		1	6	4	
N		1	3	2	
P		0	1	1	
Q		0	0	0	
TOTAL	0%	10%	50%	30%	10%

G-4

CONFIDENTIAL

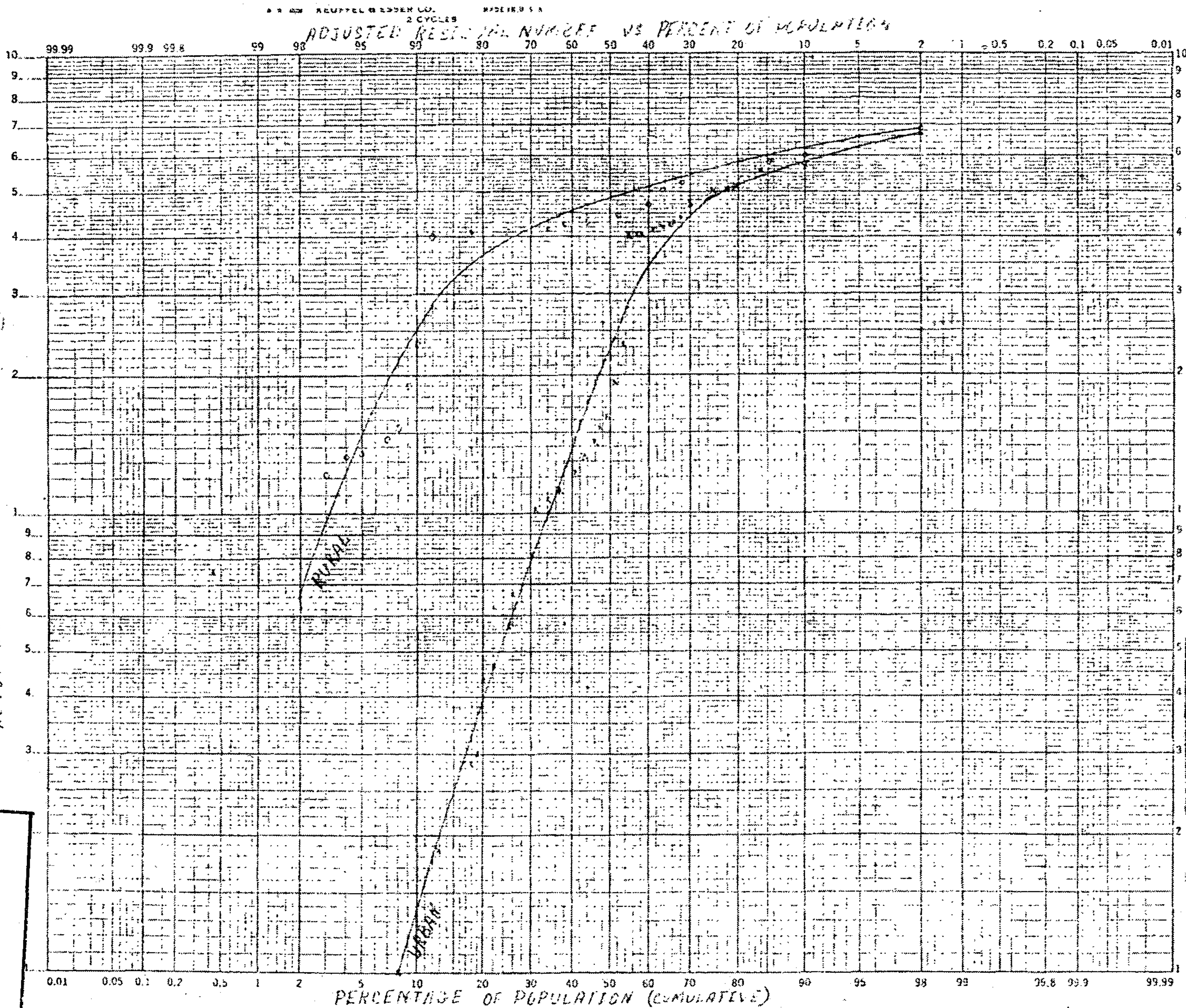


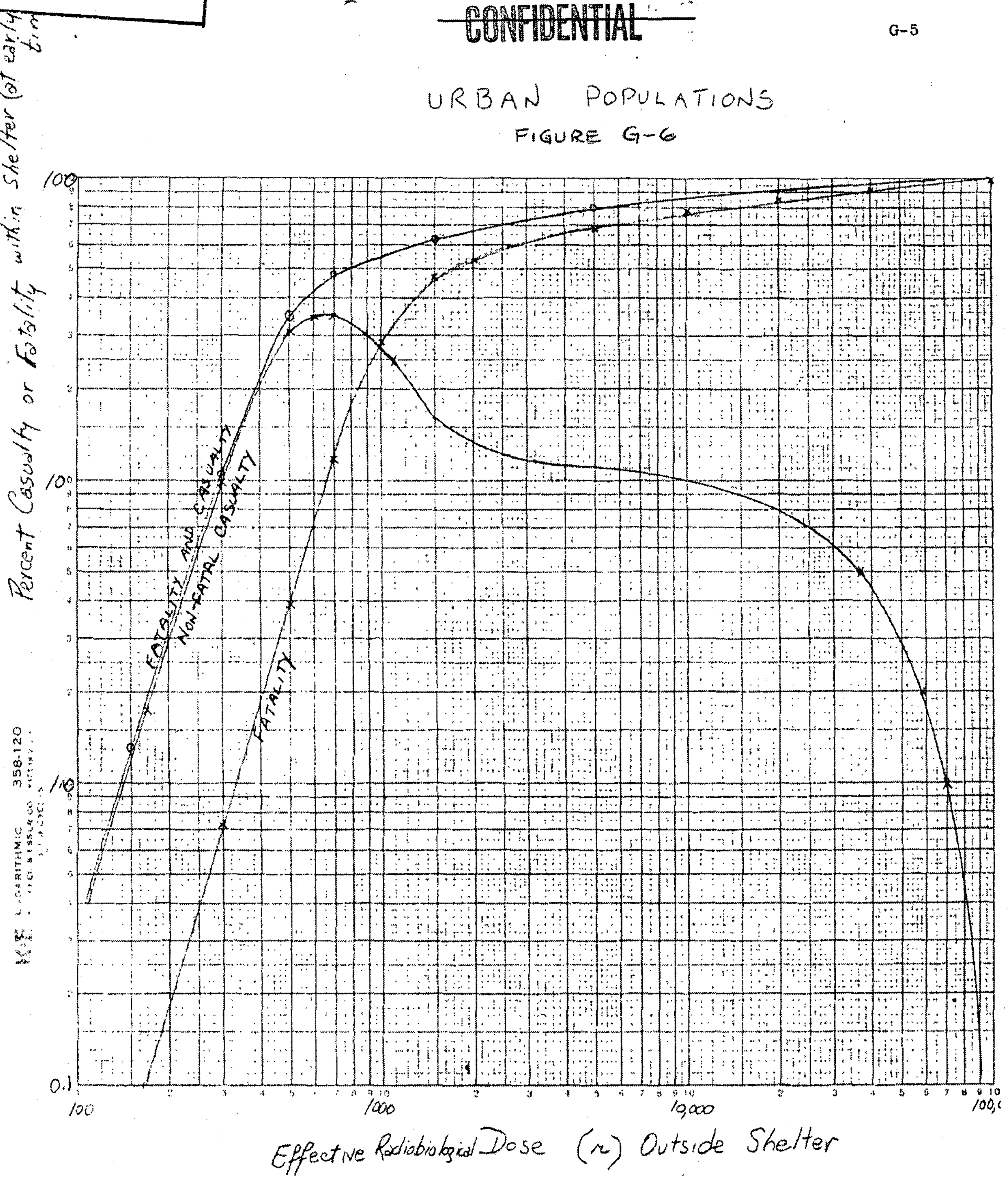
FIGURE G-5

CONFIDENTIAL

DOWNGRADED AT 12 YEAR INTERVALS;
NOT AUTOMATICALLY DECLASSIFIED
DOD DIR. 5200.10

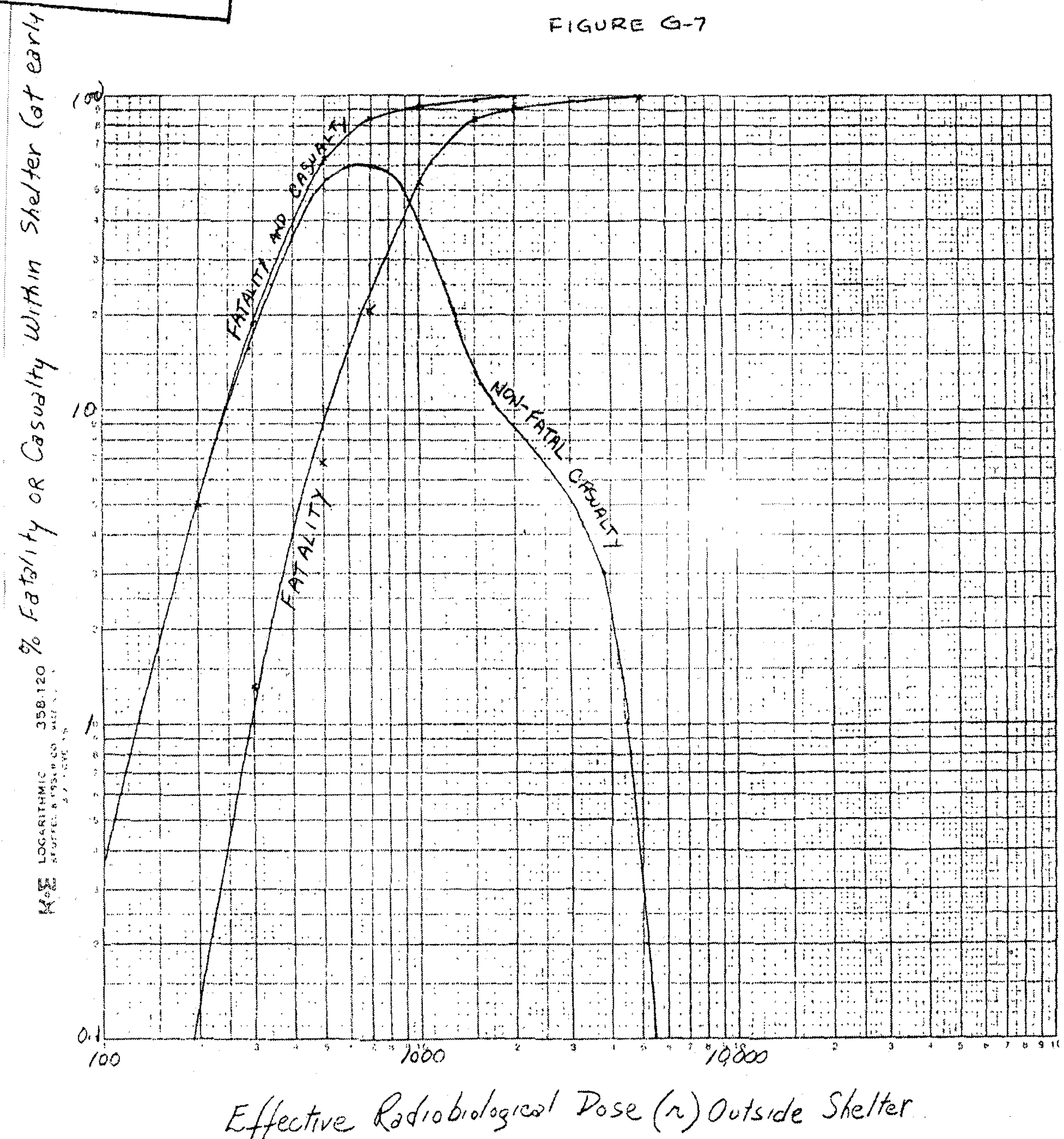
URBAN POPULATIONS

FIGURE G-6



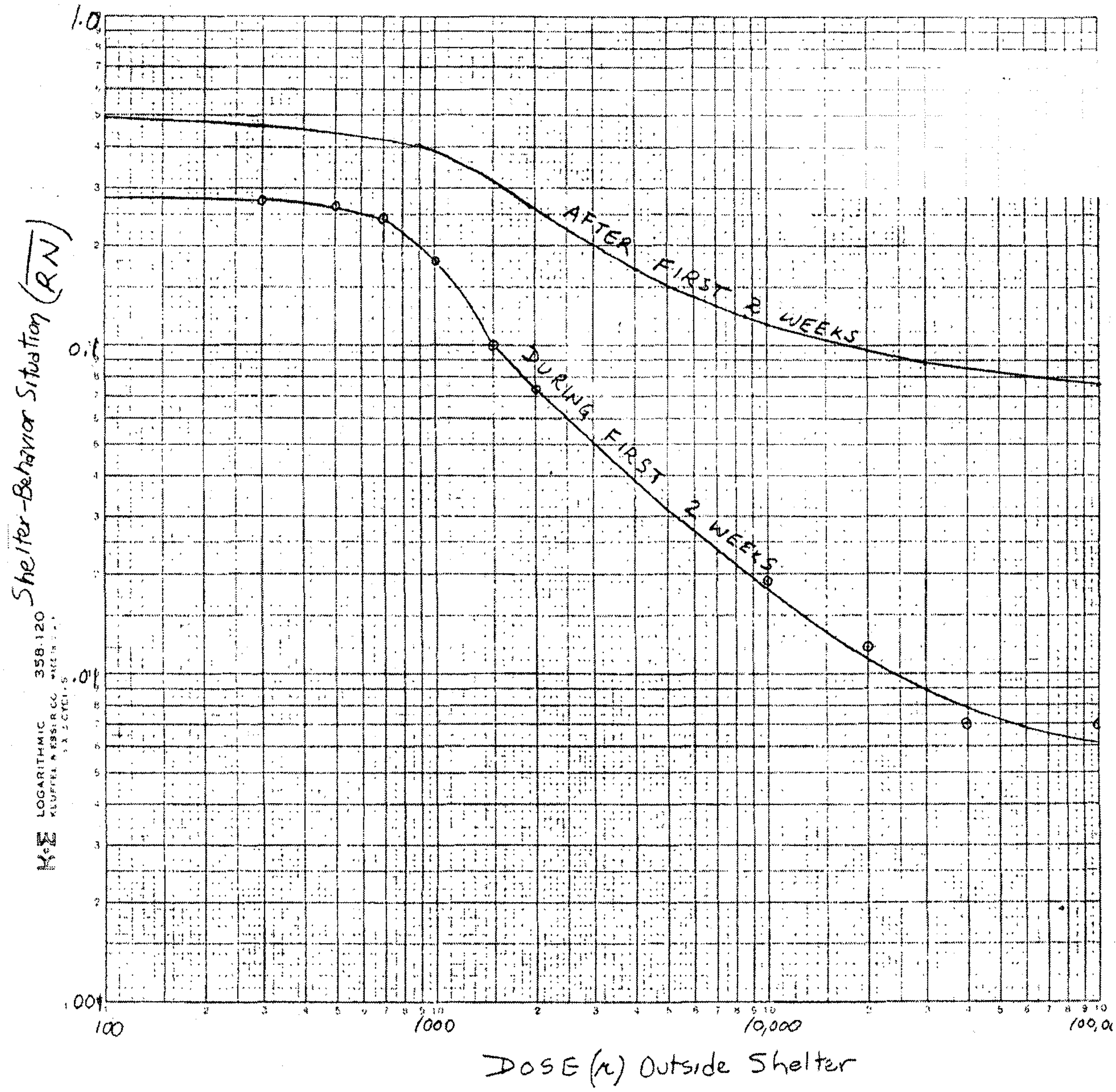
RURAL POPULATIONS

FIGURE G-7



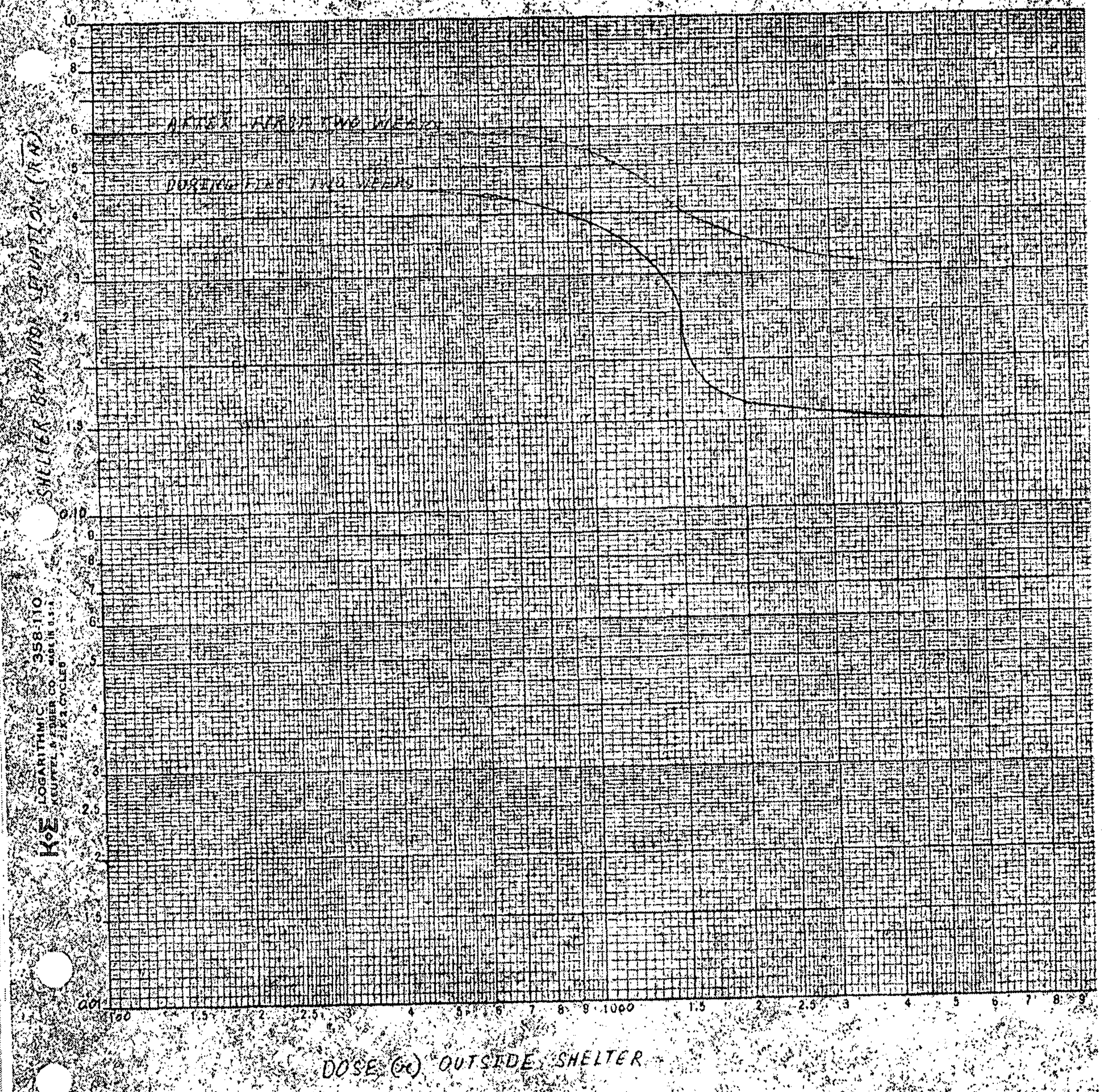
DOWNGRADED AT 12 YEAR INTERVALS;
NOT AUTOMATICALLY DECLASSIFIED
DOD DIR. 5200.10

Shelter-Behavior Situation of Survivors
URBAN
FIGURE G-8



SHELTER-BEHAVIOR SITUATION OF SURVIVORS RURAL

FIGURE G-9



ANNEX H

Fatality Criteria

The widely-used dosage of 450r is used to identify the 50% probability of death from acute radiation; the 50% probability of radiation casualty is 200r.

In translating from acute radiation dose to the more chronic fallout dose accumulation, the concept of effective radiobiological dose is used to express mathematically the fact that experiments on large animals show that they can survive larger doses of total radiation when administered over a prolonged period of time than when given acutely. The experimental results indicate that a portion of the sustained dose is not repairable biologically but that the remainder is repaired in time.

The factors currently approved by radiobiologists are 10% not repairable, the remainder repairable at a rate of 2½% per day. In a situation in which fallout radiation accumulation commences a few hours after burst, the accumulation rate exceeds the repair rate for the first 300 hours or so. By that time the fallout rate has decayed to the point where the recovery rate starts to exceed it and the effective dose decreases thereafter, finally reaching the irrepairable portion.

ANNEX I

Agricultural Contamination

(To be submitted)

ANNEX J

World-wide Fallout

(To be submitted)

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ANNEX K

Maps (attached)

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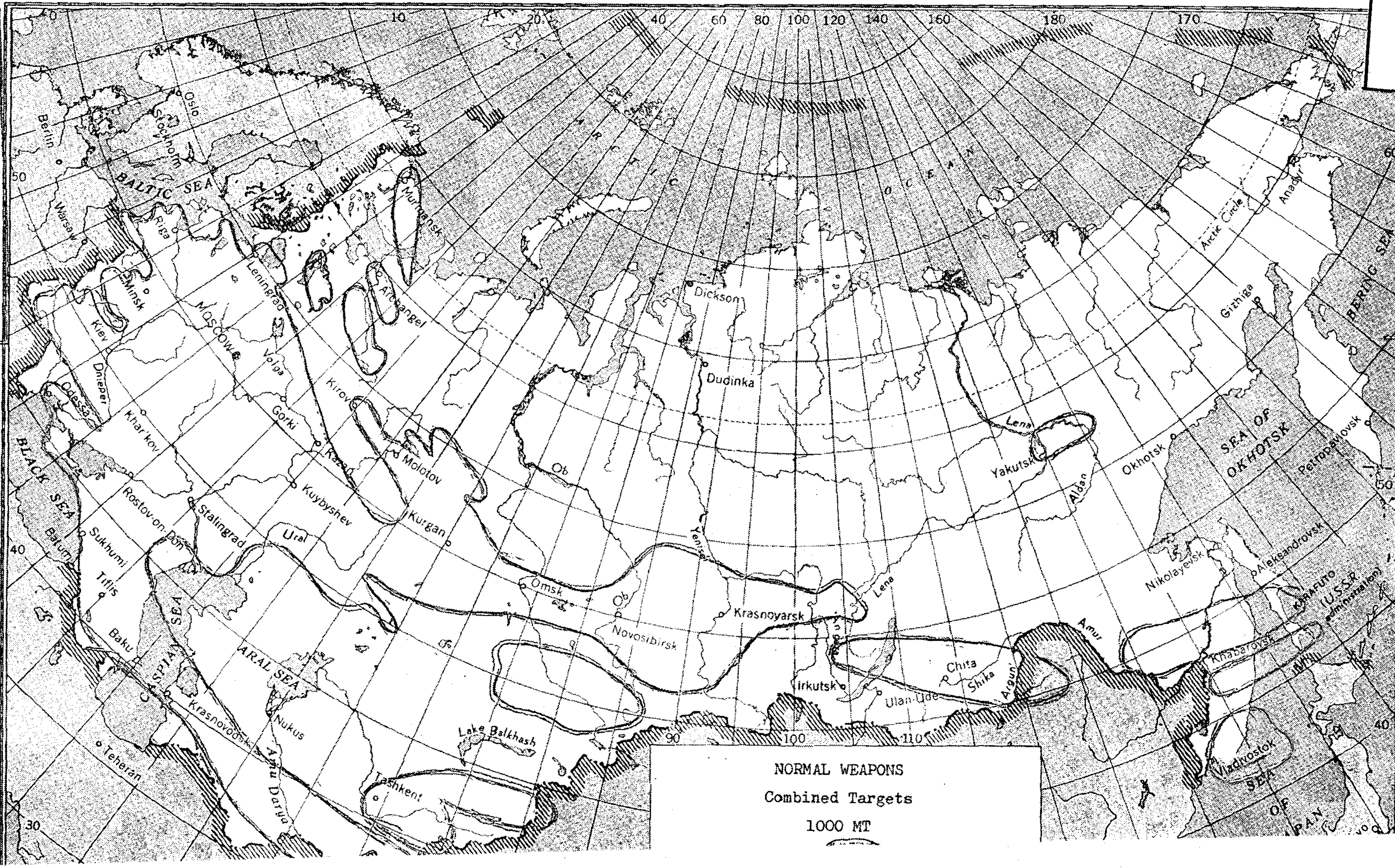

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