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APR 13 2005

Mr. John Greenewald, Jr.

Dear Mr. Greenewald:

This is the final response to your Freedom of Information Act (FOIA) requests to the Defense Threat Reduction Agency (DTRA). We received your requests in July 1998 and September 1999 and assigned them DTRA FOIA Case Numbers 00-004 and 00-005. The requests were subsequently renumbered 03-108.

A copy of the document you requested, Report AD Number C020813, titled "The Feasibility of Population Targeting" dated June 30, 1979 is enclosed.

We have determined that portions of this document contain information that is exempt from disclosure under Title 5 U.S.C. § 552(b)(1), (b)(3), and (b)(6).

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Sincerely,

Andrew Walker

Andrew Walker
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THE FEASIBILITY OF POPULATION TARGETING (U)

Science Applications, Inc.
8400 Westpark Drive
McLean, Virginia 22102

30 June 1979

Final Report for Period 1 November 1977—30 June 1979

CONTRACT No. DNA 001-78-C-0061

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Director
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Washington, D. C. 20305

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Industrial Damage	Sheltering	Fatalities
Uncertainties	Evacuation	Fallout
Prompt Effects	Retargeting	
Civil Defense	Host Cities	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

(U) The principal part of this work was done in support of the Nuclear Targeting Policy Review which was accomplished by the Office of the Secretary of Defense (International Security Affairs) during calendar year 1978. Population targeting was one of several targeting concepts examined in an effort to enhance deterrence of nuclear war and evaluate the strategic implications of the Soviet civil defense program. In effect, this work provides a quantitative assessment of the impact of Soviet civil (over)

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20. ABSTRACT (Continued)

defense on the effectiveness of population targeting, thus permitting the reader to make his own judgment as to whether the Soviets might consider that their civil defense program would offer a significant advantage in either crisis or in a nuclear conflict.

(U) Throughout this effort, Soviet civil defense practices were simulated as faithfully/as circumstances would permit using the Soviet CD Manual as a guide. The initial work dealt with individual cities (Kiev and Moscow); national-scale assessments followed. The effects of shelters (both deliberate and hasty) and evacuation were examined parametrically in order to determine the upper bound of effectiveness of this hypothetical approach to targeting in which population is the primary objective. Weapons requirements and fatality levels are the primary dependent variables; sheltering and evacuation are the independent variables of interest. Evacuation is examined in considerable detail for Soviet cities of population greater than 100,000; a hosting ratio of 2:1 (evacuees per host) is used. The results suggest that, given timely intelligence and retargeting capability, the U.S. could inflict substantial fatalities in the Soviet Union, even if sheltering and evacuation are accomplished. However, such targeting could have significant effects on weapons requirements and levels of industrial damage.

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(U) PREFACE

This study was sponsored by the Director, Defense Nuclear Agency, under Project V99QAXN, Task Areas H302 and J302, Work Units 01 and 05 "The Feasibility of Population Targeting". The work was performed by Science Applications, Incorporated (SAI) under DNA Contract 001-78-C-0061. This is the final report of that work.

The report incorporates pertinent results of work dealing with uncertainties in fallout casualty calculations as well as population targeting. The majority of effort was in the latter subject area, and the principal emphasis of the report reflects that fact, with the material on uncertainties being treated in appendices. A very considerable amount of additional work on uncertainties in casualty calculations may be found in DNA 4734Z, An Interim Report on Collateral Damage.

The contract monitors were Mr. M. Rubenstein, Lieutenant Colonel R. Edwards, and Major D. Williamson of DNA. The detailed SAI population data base was developed using the Eurasian Target Data Inventory (TDI) provided by the Defense Intelligence Agency as well as other studies by the Command and Control Technical Center (CCTC; formerly the National Military Command System Support Center or NMCSSC) of the Defense Communications Agency, the Stanford Research Institute, and RAND. Data pertaining to Soviet civil defense, fatalities and weapons requirements were researched and/or developed by SAI during the course of the study.

The principal author of the report was Mr. R. H. Craver. Mr. J. F. Schneider performed most of the analytical work in the population targeting area, and prepared Section 3, Methodology. Messrs. E. Swick, and W. Parker also made considerable contributions to the analytical effort. Dr. J. T. McGahan and Mr. E. Swick respectively wrote appendices A and B. Other contributors include Messrs. P. Kozemchak, S. Kravitz, J. Gilroy, and F. Hoeber. Dr. W. Layson provided both analytical contributions and overall direction of the effort.

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~~(SRD)~~ EXECUTIVE SUMMARY (U)

(U) The broad objective of this effort was to determine whether, in the light of Soviet civil defense programs, population targeting could be a feasible option for U.S. strategic forces. No attempt was made to address the question of whether the United States should or should not adopt such an option. Rather, the emphasis was on the feasibility of population targeting, since the Soviets presumably are able to make their own determination of U.S. capabilities and thus may be deterred from initiating nuclear conflict by virtue of their recognition of the U.S. capability to inflict unacceptable levels of fatalities irrespective of whether or not the United States actually plans such an option. Examination of this question derives its motivation primarily from our observation of the continuing Soviet civil defense (CD) program and the concern that the Soviets might be led to believe that their CD posture could offer a significant or decisive advantage either in crisis or in conflict, thereby inducing them to take more politically aggressive actions or greater risks with respect to nuclear war.

~~(C)~~ Three basic questions were addressed in order to examine the feasibility of the population targeting approach:

- How does Soviet civil defense affect fatality estimates?
- Is retargeting effective in restoring fatality levels?
- How much does retargeting degrade damage expectancy against industrial targeting?

~~(C)~~ The principal steps of the approach used to examine the questions cited above were as follows:

- Develop a data base reflecting realistic Soviet sheltering and evacuation capabilities.

- Target population as the primary objective.

- Perform a parametric analysis of sheltering and evacuation levels as they affect fatalities and weapons requirements.

- Examine the effects of retargeting weapons away from industry to compensate for fatality reductions resulting from evacuation.

~~(C)~~ The key assumptions were that

- Examination of the sheltering and evacuation of Soviet cities having population greater than 100,000 would be consistent with Soviet CD plans and sufficient to address the three fundamental study questions

[redacted] b(1)

- A hosting ratio of 2 to 1, i.e., two evacuees per host is a plausible estimate for use in evaluating the evacuation cases.

[redacted] b(1)

- The principal portion of fatalities (probably 80-90 percent) will be inflicted by prompt nuclear effects and for this study, in which population centers are attacked directly as the primary objective, the omission of fallout calculations will not introduce a significant bias in evaluating the feasibility of the targeting approach.

[redacted] b(1)

b(1) [redacted] Neverthe-less, they are wholly consistent with the objective of the study, and were in fact necessary to avoid biasing the study at the outset, i.e., if the United States chose to target population as an objective, a major question would be [redacted]

b(1)

~~(S)~~ Initially, Kiev was selected as a representative city in terms of the conditions one typically would encounter in Soviet cities having population greater than 100,000. Some would contend that there is some question as to whether or not Kiev is representative e.g., [redacted]

b(1)

Similar assessments were made later of Moscow because of its unique characteristics. Finally, the analysis was broadened to address the strategic implications of the Soviet CD program (e.g., sheltering and evacuation) for all Soviet cities having population greater than 100,000. In the process, all Soviet population centers were considered, either as hosting sites, potential targets, or both. Very detailed procedures were used to simulate evacuation. The population data base, for example, contained some [redacted]

b(1)

Evacuation procedures were consistent with published Soviet CD procedures and accounted for the actual demographic factors (distance, hosting space, and location of hosting sites with respect to evacuated cities).

~~(S)~~ The results of the Kiev-Moscow assessments are summarized as follows:

- Very substantial reduction in fatalities may occur as a result of Soviet CD actions -- certain combinations of sheltering and evacuation might reduce fatalities to levels [redacted]

- Retargeting excursions done for Kiev suggest fatality levels may be restored to [redacted]

- Prompt effects were by far the primary cause of fatalities -- fallout was a minor factor only

- In the cases examined, injuries equalled or nearly equalled fatalities, and occasionally exceeded them

- Damage expectancy against the primary industrial targets [redacted]

- [redacted]

- If Kiev may be considered typical of cities over 100,000 [redacted] Evacuation has a very significant impact on both weapons requirements and fatalities.

b(1)

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~~(SRD)~~ The results of the countrywide assessments for cities greater than 100,000 are summarized as follows:

b(1)

[redacted]

Targeted Weapons Required for 60 Million Soviet Fatalities - Sheltering Only (~~SRD~~)

[redacted]

b(3)

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~~(C)~~ SECTION 1

INTRODUCTION (U)

1.1 (U) PROBLEM

This study addresses the question of whether, in light of the Soviet civil defense program, population targeting is a feasible option for U.S. strategic nuclear forces.

1.2 ~~(C)~~ BACKGROUND (U)

1.2.1 (U) U.S. Strategic Doctrine

The cornerstone of current U.S. strategic doctrine is deterrence of nuclear war through maintenance of an assured destruction capability. In practical terms, this requires that we maintain the capability to absorb a first strike by the enemy and retaliate with an unacceptable level of damage on the Soviet Union. The question of what would constitute an unacceptable level of damage in the eyes of the Soviet leadership is less than clear. We do recognize now perhaps more than at anytime in our past, that Soviet views related to nuclear conflict are not entirely similar to our own. Moreover, it has become increasingly clear that while it may not be necessary to emulate Soviet doctrine, it is essential that we be aware of its nature and take it into account in structuring our own doctrine and the forces to carry it out. The Secretary of Defense's Annual Report for Fiscal Year 1979 expresses the assured destruction task as follows: "It is essential that we retain the capability at all times to inflict an unacceptable level of damage on the Soviet Union, including destruction of a minimum of 200 major Soviet cities." The report further spells out the need to maintain a condition of essential equivalence with the Soviet Union, which requires that:

- "Soviet strategic nuclear forces do not become usable instruments of political leverage, diplomatic coercion, or military advantage;

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- nuclear stability, especially in a crisis, is maintained;

- any advantages in force characteristics enjoyed by the Soviets are offset by U.S. advantages in other characteristics; and

- the U.S. posture is not in fact, and is not seen as, inferior in performance to the strategic forces of the Soviet Union."

These conditions for essential equivalence make it obvious that U.S. strategic doctrine is not one of "minimum deterrence', i.e., one which relies upon the assumption that the Soviets would be deterred solely by the knowledge that we can inflict a specified level of fatalities and industrial damage irrespective of the capabilities of their offensive forces. Essential equivalence recognizes the importance of Soviet perceptions of our capabilities versus theirs, which implicitly means that counterforce considerations are an important element of the policy. In point of fact, the U.S. has pursued counterforce targeting since the early days of its nuclear force development, and there is little doubt that the Soviets are aware of it.

1.2.2 ~~(C)~~ The Nuclear Targeting Policy Study (U)

~~(C)~~ The current administration first spelled out its intention to pursue essential equivalence in documents issued late in 1977, which also commissioned a number of strategic studies to be accomplished within the Department of Defense. One of those studies was the Nuclear Targeting Policy Study, directed by Mr. Leon Sloss' decision to examine a number of alternative targeting concepts. One of those concepts was punitive in nature and oriented on the assured destruction mission. Specifically, it was the concept of targeting population. This assessment was performed in support of that particular aspect of the Nuclear Targeting Policy Study. The rationale for examining population targeting has at least part of its roots in the assured destruction criteria set forth by former Secretary of Defense Robert McNamara.

At one point during the 60's he specified that assured destruction requirements were met if the United States could, in a retaliatory attack, kill roughly one-third of the Soviet population and destroy approximately one-half of their industry. There remains today some students of nuclear strategy who believe that McNamara's criteria still are adequate for deterrence. Further, there are others who believe that although these criteria are not in themselves sufficient for deterrence, they are either highly desirable or necessary to it. Thus, population targeting as a concept continues to be of interest, and the review of nuclear targeting policy would not have been complete without it. The relevance of the population targeting concept becomes even more interesting when coupled to increasingly obvious Soviet efforts to improve their civil defense. But civil defense is only a part of overall Soviet strategic doctrine, and it is appropriate to address the broad aspects of that doctrine before narrowing the view to civil defense.

1.2.3 (U) Soviet Strategic Doctrine

The Soviets have made it known that they do not believe in assured destruction in terms of economic and population resources being the key to victory. They have told us that they place the highest priority on the destruction of military forces, both nuclear and conventional. They have stated these views repeatedly since the 1950's. Unlike many western scholars of nuclear strategy, they do not believe that the advent of nuclear weapons has wrought a wholly fundamental change in the nature of warfare. They do not regard nuclear conflict as unwinnable. This approach to nuclear strategy has led some to describe it as a "warfighting" strategy. The flavor of Soviet views in connection with this description can be gleaned from a few quotations: "The Soviet concept, in the thermonuclear era as before, is founded on the belief that the primary ofjective of military operations is the destruction of hostile military forces, and not the annihilation of the economic population resources of the enemy."[1] "Wars are won only when the enemy's will to resist is broken and that can only be broken, as the experience of history shows, when the armed forces of the enemy are destroyed. Therefore, the objective of combat operations must be the destruction of the armed forces, and not strategic bombing of targets in the rear."[2] The Soviets have castigated our strategic bombing effort of World War II, saying that reliance on strategic bombing of the enemy's economy is a strategy "defective in its foundation" and that the American strategic bombing experience in the war bore witness to "the complete failure of the theory of winning the war by means of economic exhaustion of the enemy by aerial bombing."[3] Nevertheless, this is not to say that the Soviets ignore the value of economic-industrial targets, for as Sokolovskiy points out,"...the war may drag on and this will demand protracted and all-out exertion of army and people. Therefore, we must also be ready for a protracted war and get the human and material resources into a state of readiness for this eventuality."[4] He goes on to elaborate on this point, saying that "the protection of the rear area of the country and groups of armed forces from enemy attacks has the aim of preserving the vital functions of the government, of assuring the uninterrupted functioning of the economy and transportation, and preserving the combat readiness of the armed forces."[5] The relevance of this stance to the currently evolving civil defense program in the Soviet Union is obvious, and indeed it appears that the strategy has been pursued systematically over a period of years. Small wonder then, that there should be interest in the impact of Soviet civil defense upon the feasibility of population targeting.

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[1] Raymond Garthoff, Soviet Strategy in the Nuclear Age, Frederick A. Praeger, N.Y., 1958, p. 71.

[2] Ibid, pp. 72-73.

[3] Ibid, p. 73.

[4] Soviet Military Strategy, V. D. Sokolovskiy, Marshall of the Soviet Union, edited by Harriet Fast Scott, Crane, Russak & Co., Inc., N.Y. 1975. p. 211.

[5] Ibid, p. 296.

1.3 (U) TARGETING IMPLICATIONS

A detailed discussion of the Soviet civil defense program will be presented in Section 2 of this report. At this juncture, however, it is appropriate to provide a general description of what the Soviets are doing and the resultant implications for targeting policy. In basic terms, the Soviets are building shelters to protect their populace from the effects of a nuclear attack, and they are developing highly detailed plans to accomplish evacuation of major segments of their urban population. High priority is being accorded to the protection of their essential workers in key industries. The policy for new construction provides for shelters and dispersion of the industrial structures themselves. Steps are being taken to train personnel to reduce the vulnerability of industrial equipment by expedient sandbagging techniques. Training in the methods of constructing expedient shelters is being carried out. Clearly, these actions have the potential for reducing the effectiveness of a concept involving population targeting. Moreover, if this concept is to be pursued in the face of evacuation, i.e., if evacuated people are to be located and targeted, there are significant implications for command, control, communications and intelligence (C^3I), the possible degradation of damage expectancy (DE) against urban industrial targets (if weapons initially assigned to them are retargeted against evacuated people), and the impact upon weapons requirements that could result after tradeoffs in urban-industrial DE and fatality levels have been considered. In a broader sense, there is a need, in the face of the civil defense asymmetry that is developing between the United States and the Soviet Union, to determine whether there is any basis for believing that Soviet civil defense capabilities might encourage them deliberately to expose the USSR to a higher risk of nuclear attack. While this study does not aspire to address fully this broader question, it does contribute information useful in reaching an informed judgment.

1.4 (U) ANALYTICAL APPROACH

The Soviet city of Kiev was selected for initial evaluation of the targeting concept with subsequent expansion to a nationwide basis. Intelligence was obtained to ensure that shelter space and hardness, evacuation and hosting capabilities were realistically represented. Recognizing that uncertainties do exist in these areas, a parametric approach was chosen so that a range of combinations of sheltering and evacuation could be assessed as to their effectiveness. The work was structured to provide direct measures of the impact of population targeting upon weapons requirements and to determine the distribution of fatalities by city class (size) for selected combinations of sheltering and evacuation. Population was the primary attack objective, and because it was desirable to determine a plausible upper bound for the effectiveness of theis approach to targeting, it was assumed that shelters and hosting site locations could be determined in a manner permitting retargeting by U.S. forces where necessary. While it is appropriate to the purpose of the study, this is a significant assumption and the reader should recognize it as such. Finally, provisions were made to enable a rough evaluation of the relative potential of sheltering and evacuation to affect weapons requirements, to identify significant caveats pertaining to the study, and to identify the major implications pertaining to nuclear targeting policy.

~~(SRD)~~ SECTION 2

SOVIET CIVIL DEFENSE (U)

2.1 (U) BACKGROUND

The Soviet experience of World War II was vastly different from our own. Their homeland, unlike ours, was a principal battleground of that conflict and as a consequence, Soviet attitudes toward civil defense are likely to be somewhat different. This is not to suggest that the Soviets have been inclined to engage in crash programs to upgrade civil defense, for they have not. The Director of Central Intelligence[6] estimated in July of 1978 that during 1976, the Soviets spent something on the order of 400 million rubles on three major elements of their CD program: full time CD personnel, operation of military CD units, and blast shelter construction. Although the CIA has not been able to estimate the total annual costs of the Soviet civil defense program, they do suggest that the 400 million ruble figure represents something less than 1 percent of their estimate of total Soviet defense spending. If that estimate is reasonably correct (and there is no reason to think otherwise), then the Soviet CD program cannot be regarded as a crash program. Nevertheless, one must recognize that the relative magnitude of their program with respect to ours is something to be carefully considered. The U.S. equivalent of the 400 million rubles spent by the Soviets in 1976 would be approximately $2 billion --- a figure considerably greater than that which we spent in 1976 --- about $86 million.[7] Since the late 1960's the Soviets have devoted increased attention to civil defense, but their CD officials nevertheless appear to experience many of the same problems that ours do --- such as the conflict with higher priorities in the defense budget and a fair measure of apathy on the part of the public. Even so, few

[6] Soviet Civil Defense, NI78-10003, July 1978.

[7] Defense Report, U.S. Department of Defense, FY 75.

would contest the assertion that they have been able to accomplish more in the way of protecting their population than we have (shelter construction, evacuation planning, attention to expedient means of hardening key industrial facilities, and mandatory training). The result is a distinct asymmetry in the civil defense capabilities of the United States and the Soviet Union --- an asymmetry which calls into question whether the Soviets believe they could have a decisive advantage in a nuclear crisis and thus be encouraged to take greater risks. In this study, it is intended that Soviet civil defense capabilities which have a bearing on population targeting be represented as realistically as possible so that the results shed as much light as possible on that question.

2.2 ~~(SRD)~~ SCOPE AND MAGNITUDE OF THE SOVIET CIVIL DEFENSE PROGRAM (U)

2.2.1 (U) Overview

The CIA, in reference 5 estimates that more than 100,000 full time personnel are engaged in the Soviet CD program, and that a full time civil defense staff exists "at each echelon of the Soviet administrative structure: national, republic, oblast, city, and region, as well as at all significant economic institutions and enterprises." The entire structure is controlled by the military under General of the Army A. T. Altunin, who is also a Deputy Minister of Defense. Soviet actions in civil defense appear to be consistent with their declaratory policy. Their publications state that their objectives in the CD area are (1) protection of the people --- the leadership, key workers, and the general population; (2) protection of economic resources to ensure continuity of wartime productivity and postwar recovery; and (3) sustenance of the survivors of a nuclear attack so that postwar recovery can proceed. Blast shelter construction, evacuation planning, preparation for hasty hardening of industrial equipment, training in rescue and recovery operations and the stockpiling of food and medical supplies, as observed in the Soviet Union by various means, suggest that these stated objectives have been broken down into component parts, prioritized, and are being carried out systematically. The Soviets apparently do not share the attitude of some Western analysts who fear that substantive improvements in civil defense might lead to instability by virtue of making nuclear war more acceptable. Instead, they appear to be intent on convincing potential adversaries that their civil defense program, taken in context with their overall defense program, makes it highly unlikely that they can be defeated in a nuclear war. They do not appear to subscribe to the theory that the advent of nuclear weapons has made war unthinkable or unwinnable. Their annual budgets for civil defense, though relatively modest (approximately the equivalent of $2 billion in terms of U.S. standards during 1976) are directed toward specific long-term plans which, over a period of years, could result in substantive improvements.

2.2.2 ~~(SRD)~~ Shelter Program (U)

~~(SRD)~~ The Soviets are estimated[8] to have built more than 15,000 blast-resistant shelters as a part of their program for protecting the population. Priority is accorded to top national leadership and key workers, and there appears to be no compunction about providing these people better (harder) shelters than those available to the general population. Table 2-1 presents the hardness description of shelters used for various segments of the population as used in this study.

Table 2-1. ~~(S)~~ Shelter Types and VNTK* Descriptions (U)

Typical Urban Basements	Hardened Urban Shelters	Rural Single Story Buildings	Typical Rural Basements	Hasty Rural Shelters

b(1)

(U) * The Physical Vulnerability Number System, reference 4

(U) [8] Soviet Civil Defense, NI 78-10003, OCI, July 1978.

These hardnesses were selected by Science Applications, Incorporated (SAI) after reviewing the available information on the subject at the outset of the study. Other agencies may conclude that other hardnesses are more appropriate, especially as better information becomes available. The hardness of the last category, hasty rural shelters, was a matter of some disagreement at the time of study initiation. [redacted] We chose to use the upper end of this latter estimate because we thought it more consistent with the capability to be expected of evacuated personnel working under anticipated time constraints. The other shelter of major interest in this study is the hardened urban shelter. [redacted] Additional data pertaining to shelter posture and population distribution by city size is provided in Section 3, Methodology. Reference 5 states that the Soviets have a sufficient number of hardened urban shelters to accomodate from 10 to 20 percent of the total population in cities of more than 100,000 depending on whether the shelter occupancy factor is 0.5 or 1.0 square meters per person. Other estimates suggest that this figure might be revised upward to as much as 50 percent of the total population in cities over 100,000. Our approach to handling these differing estimates was to treat sheltering parametrically, so that a range of estimates could be accomodated and the sensitivity of weapon requirements and fatality levels to sheltering assumptions could be considered.

b(1)

b(3)

2.2.3 (U) Dispersal And Evacuation

Soviet civil defense publications distinguish between dispersal and evacuation, applying the former term to essential workers at key industrial installations and the latter to the remaining population at large. Their plans call for sheltering one shift within the

city and dispersing a second shift outside the city proper and
rotating so that a nearly continuous operation can be maintained. Dis-
persal of these essential workers is controlled so that transportation
facilities can be used for shift rotation. Evacuation procedures call
for the establishment of a "buffer zone" around each major Soviet city.
It is an annular-shaped area approximately 8 nautical miles (15 kilo-
meters) in thickness whose inner boundary is located along the periphery
of the city proper. It is intended to ensure that people evacuated
beyond this zone will not be subjected to more than 1.4 psi (0.1 kg/cm^2)
from yields of a megaton or less detonating along the city periphery.
Essential industrial workers disperse to locations beyond the buffer
zone, but close enough to hold travel time to city work sites within
practical limits. Urban populations other than essential workers who
are directed to evacuate also move to sites outside the buffer zone.
Distances traveled by this segment of the urban population vary ac-
cording to the availability of hosting sites - usually other cities
of limited population and not containing targets having a high proba-
bility of being struck in the attack. In this study, hosting ratios
(e.g., the number of evacuees per host) were limited to 2 to 1 and as
with sheltering posture, a parametric approach was adopted with respect
to evacuation levels. The percentage level of evacuation refers to that
percentage of the urban population in cities greater than 100,000 who
evacuate to areas beyond the buffer zone. Additional information on the
simulation of Soviet evacuation is contained in Section 3, Methodology.
Soviet policies regarding evacuation indicate that the necessary orders
for execution will be given during a period of tension. The decision to
evacuate is likely to be a difficult one, for it flies in the face of
Soviet nuclear doctrine, which advocates preemption of the adversary's
attack when the outbreak of war is imminent. Large scale evacuations
would be difficult to conceal. Time estimates for evacuations vary depending
on the level of evacuation and availability of transport assumed. Ma-
jor evacuations accomplished without the benefit of motor transport
might take more than a week, whereas maximum use of transport could

shorten the time to a period of several days. Reference 5 states that "on an average, two or three days would probably be required to evacuate the major portion of the Soviet population." Despite elaborate planning for evacuation, there remains considerable doubt as to the efficiency of execution. Major evacuations are undertakings of great complexity, and there is no hard evidence of large-scale exercises to actually practice the procedures required to attain the desired proficiency. Weather conditions, command and control, and adequate provisioning of shelters for evacuated personnel could pose serious obstacles to rapid and effective evacuation. Fallout protection must be provided for evacuees, of course, and Soviet CD plans provide for the modification and upgrading of existing structures as well as the construction of hasty rural shelters. Given a period of tension lasting 1 to 2 weeks, the degree of protection available to the population could be improved significantly, and fatalities could be markedly decreased. Several studies have estimated that in the absence of a U.S. capability to retarget evacuated population, the Soviets could limit their fatalities to a figure in the low tens of millions as opposed to the estimated 100 million they would suffer if CD measures were minimal. This poses a dilemma in decision-making for the Soviets: if, on the one hand, they do initiate an major evacuation, they run the risk of losing the opportunity for effective preemption. On the other hand, if they do not evacuate, their fatalities could be increased by a factor of 4 or 5, with the total approaching 100 million. Some students of Soviet civil defense note that recent versions of their CD manual appear to place greater emphasis on sheltering than an evacuation, whereas in earlier versions, the converse was true. This could be a reflection of an effort to solve the dilemma described above, or it could be simply a consequence of civil defense being accorded lower priorities (and hence a smaller budget) in the earlier period when the Soviets clearly were working very hard to improve their offensive strategic forces vis-a-vis the United States. If indeed the Soviets hope to use this approach to address the evacuation decision dilemma, they will have to increase their shelter-building program significantly, for the growth of urban population alone increases the total numbers of people to be protected by either sheltering or evacuation. The parametric approach to sheltering and evacuation assumptions used in this study enables consideration of a broad range of circumstances that could obtain in the future development of the CD programs.

~~(SRD)~~ SECTION 3

METHODOLOGY (U)

3.1 (U) OVERVIEW

3.1.1 Key Variables

The description of Soviet civil defense presented in the preceding section makes it clear that any evaluation of the feasibility of population targeting must take into account both sheltering and evacuation. The uncertainties surrounding such factors as the number and hardness of shelters, the ability to evacuate according to plan, and the availability of hosting sites for evacuees suggests very strongly that the approach should be a parametric one. In particular it is highly desirable to examine not only different levels of sheltering and evacuation, but different combinations of sheltering and evacuation. Past assessments of the potential impact of Soviet civil defense have been criticized for their simplistic approach. For example, before definitive information was available on the details of the Soviet civil defense (CD) program, a common practice for estimating the impact of evacuation (which received far more attention initially than did sheltering) was to reduce the urban population by some selected percentage and assume that those "evacuees" were uniformly distributed throughout the rural population. Mechanically, this meant that the urban population of the data base was reduced and the rural "cell" population was increased. This was acceptable as a first approximation, but it was recognized immediately that the reliability and realism of the approach were at least in question and perhaps misleading. Since there was no detailed evaluation of whether urban evacuees could in fact be hosted at realworld locations at reasonable distances from the evacuated cities, there understandably was concern for the possibility that Soviet capabilities were being overestimated. Recognizing this shortcoming, we decided at the outset of the study that a credible simulation of

Soviet evacuation would be essential. The techniques adopted for this simulation are detailed later in this report, as is the description of the treatment of sheltering.

3.1.2 Other Factors

The total population of the Soviet Union represented in the data base used for the study is 246 million. Soviet CD literature states that protection of the population from weapons of mass destruction can be achieved by dispersal of labor and service enterprises of large cities into outlying areas and evacuation from cities to rural areas of people. Approximately 94 million people reside in Soviet cities having population greater than 100,000 and this was chosen as the cutoff for evacuation, i.e., only cities greater than 100,000 were evacuated for purposes of the analysis. The rationale for this decision is presented in paragraph 2.2.3 of Section 2. Further, since the sensitivity of weapons requirements to population targeting was known to be of interest, it was convenient to determine some goal in terms of a fatality level that would develop adequately the relationship between weapons requirements and fatalities as a function of various levels of shelter and evacuation. The 60 million level was selected for this purpose, and the choice admittedly was somewhat arbitrary. A higher level would have served just as well, but it was known that the key relationships of sensitivity of weapons requirements as a function of shelter and evacuation would be adequately developed by use of the 60 million fatality goal, as will be apparent in the results section. The use of that goal did not bias the assessment in any way.

The initial work on assessing the impact of civil defense on the feasibility of population targeting was confined to a single city --- Kiev. Additional work was then done on Moscow. The results for both cities appear later in the report. Kiev was selected because it appeared to be a representative city for purposes of the assessment. The work was then expanded to a nationwide basis so that the broader implications of population targeting could be evaluated.

3.2 ~~(C)~~ METHODOLOGY FOR SELECTED CITIES (U)

3.2.1 ~~(C)~~ Problem Formulation (U)

The basic purpose in examining an individual city was to size the targeting problem in terms of an urban complex that was considered representative of Soviet cities having population greater than 100,000 before going on to a country-wide assessment. Answers were being sought to three questions:

- How does Soviet civil defense affect fatality estimates?
- Is retargeting effective in restoring fatality levels?
- How much does retargeting degrade damage expectancy against industrial targets?

3.2.2 ~~(C)~~ Approach (U)

~~(C)~~ The initial approach was to develop a sufficient amount of detail on a representative area, describe the civil defense posture in terms of sheltering and evacuation using a high resolution population distribution, and then perform the targeting and damage assessments required to determine both industrial damage and fatalities. Targeting procedures were to emulate those of the Joint Strategic Target Planning Staff (JSTPS) as much as possible. Airburst and surface burst options were to be compared, and where retargeting was found necessary [redacted] b(1) Kiev was the city selected for analysis on the basis of the size (approximately 2 million), the ratio of urban to non-urban population in the oblast, the variety of military and economic targets, and other factors. As the initial results for the Kiev analysis took shape, it became apparent that additional variations were desirable not only for Kiev, but for a larger city as well --- and thus Moscow was selected for examination.

3.2.3 (U) Follow-on Assessments of Kiev and Moscow

Additional assessments of Kiev were oriented on refinements in targeting, identifying the numbers of fatalities accruing due to prompt versus fallout effects, and the impact of varying degrees of retargeting in attempting to compensate for evacuation. Again, the results of air and surface burst attacks were compared. Details of the results of all of the simulated attacks on Kiev and Moscow are provided in Section 4.

3.3 ~~(SRD)~~ PROCEDURE FOR COUNTRYWIDE ASSESSMENTS (U)

3.3.1 (U) Q/A Parameters for Population Attacks

Research of existing assessment techniques revealed that in the early 1970's the Department of Defense National Military Command System Support Center (now the Command and Control Technical Center) had conducted a parametric analysis of urban population fatalities using weapons of varying yields, accuracy and reliability targeted against a number of countries including the Soviet Union. A total of 1532 USSR population centers representing a projected 1981 population of 144 million people were depicted by 10 city classes. Each city was defined by a number of population centers (P-95's) which varied from 1 to 92 in number, depending upon the size of the individual city. Radii of these P-95's varied from 0.25 to 1.0 nautical miles (nm), and the distribution of population within the P-95 was assumed to be circular normal. Weapons were allocated against this data base so as to maximize the effectiveness of each successive weapon considering the damage expectancy of all preceding weapons. The results of these hypothetical attacks provided the necessary data which, when subjected to curve-fitting and other analytical techniques, yielded two parameters, Q and A, for each combination of weapon yield, accuracy, and reliability.

These parameters are used in the formula

$$D_i(n) = 1 - Q_i^{n^A} , \qquad (3\text{-}1a)$$

where D_i is the fraction of population of city class i killed by n weapons of the type for which the Q/A parameters were calculated. Q_i is equal to one minus the single-shot kill probability (1-SSPK) of a single weapon, and A is a factor which modifies the exponent n to account for the nonuniform distribution of population and the overlapping coverage of successive weapons. In effect, the formula is a variation of the expression

$$DE_{cum} = 1 - \left\{ (1-DE_1)\ (1-DE_2).....(1-DE_n) \right\} , \qquad (3\text{-}1b)$$

which is used to calculate the cumulative damage expectancy (DE_{cum}) to a single target resulting from the application of several different (n) weapons. The Q/A formula simply uses a modified version of this basic expression to represent the cumulative damage to the several P-95's of a given city from n weapons having identical characteristics.

3.3.2 (U) Associated Assumptions

Several important assumptions were embodied in the original development of the original Q/A approach. First, the entire population was assumed to be located in multistory concrete buildings and in an unwarned nighttime posture. The weapons height of burst was optimized for the multistory structure. Next, the fatality calculations considered only blast and prompt radiation effects. Finally, the aimpoint of the n^{th} weapon was optimized given the fatalities expected from the preceding n-1 weapons.

3.3.3 (U) Advantages of Q/A

Despite the limitations described above, there are several very attractive features in the technique. In addition to the fact that the basic procedure is already in being, the computer resources required are minimal, thus permitting a large number of attack alternatives to be analyzed economically. Further, the data base contains a large portion of the Soviet population. Nevertheless, certain modifications to the original Q/A data base were required before it could address the key issue of the study, namely the impact of nationwide, updated shelter posture and evacuation capabilities upon the feasibility of population targeting. These modifications are discussed in the following sections.

3.3.4 ~~(SRD)~~ Modification of the Population Data Base (U)

3.3.4.1 (U) City Classes

The original Q/A data base consisted of 1532 population centers, 800 of which had a population of 20,000 or more and 732 additional locations chosen because of their proximity to either military or industrial installations having a high potential for targeting. These complexes accounted for approximately 50 percent of the total Soviet population. The additions to the data base made for this study resulted in a total of 52,879 population centers, accounting for more than 90 percent of the total Soviet population. The additional population centers ranged from 800 to 20,000 in size and necessitated the creation of 3 new city classes and a change in the original class 10 (see Table 3-1). City classes 1-9 contain the same number of cities as the original data base. City class 10, representing populations from 15,000-23,000, contains fewer cities than the original data base since about 500 of the original class 10 cities are moved to classes 11-13 under the new class definitions. Table 3-1 indicates the average population for each city class and the average number of P-95's per city as listed in the Target Data Inventory (TDI). The radius for a single equivalent P-95 was computed using the equation

$$\text{Radius (P-95)} = 0.5125 \ln (1.3 + 0.2P), \qquad (3\text{-}2)$$

where the radius is in nautical miles and the population (P) in the

~~SECRET~~

Table 3-1 ~~(S-RD)~~ Modified Soviet Population Data Base (U)

City Class	Number of Cities*	Average Population (Millions)+	Average No. P-95's	Equivalent Large P-95 (NM)	Density Distribution Large Urban	Small Urban	Rural
1	1	7.64	92	3.76	100	0	0
2	1	3.87	33	3.41	98	2	0
3	3	1.77	38	3.02	94.1	3.7	2.2
4	11	1.16	24	2.80	95.4	3.6	1.0
5	14	.88	22	2.66	91.2	5.9	2.4
6	24	.53	18	2.40	84.0	11.1	4.9
7	93	.28	8	2.10	85.6	9.3	5.1
8	207	.11	5	1.66	73.7	16.8	9.5
9	435	.04	3	1.20	41.8	34.9	23.3
10	25[illegible]	.02	1	0.91	10.3	20.0	69.7
11	1,163	.009	1	0.57	0	0	100
12	20,326	.003	1	0.32	0	0	100
13	30,318	.001	1	0.21	0	0	100

* ~~Same as~~ original Q/A for Classes 1-9.

+ 1976 Population Figures

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complex is in thousands. This algorithm was developed by the RAND Corporation based on statistical analysis of demographic data for the European continent. Use of this single equivalent P-95 offered certain advantages in the countrywide evacuation assessment as will be obvious in the description of the POPEYE code presented later in the report. Fatality calculations done using the more detailed CIVIC code, of course, used the actual P-95's of the cities in the data base.

3.3.4.2 (U) Density Categories

Earlier work by the Stanford Research Institute (SRI) indicated that the types of construction in an urban area (and hence the type of sheltering available) depend not only upon the total population of a city but also upon the density of P-95's which comprise the city complex. The density categories developed by SRI are given in Table 3-2.

Table 3-2. Density Categories By City Size

City Population	P-95 Density* (Population/(nm)^2)		
	Rural	Small Urban	Large Urban
200,000 ≥	---	---	All
100,000 to 199,999	< 2,500	2,500 to 4,999	≥ 5,000
50,000 to 99,000	< 5,000	5,000 to 9,999	≥10,000
20,000 to 49,999	< 7,500	7,500 to 14,999	≥15,000
10,000 to 19,999	<10,000	10,000 to 19,000	≥20,000
2,000 to 9,999	<12,000	12,500 to 24,999	≥25,000
≤ 2,000	All	---	---

*The P_{95} radius is used to determine the area.

These data were used to prepare the weighted distributions of urban population by city class as shown in Table 3-1. Those distributions then were used to develop shelter postures as discussed in paragraph 3.3.5.

3.3.5 ~~(C)~~ Shelter Parameters (U)

~~(C)~~ The baseline sheltering distribution for countrywide analysis is given at Table 3-3. It is identical to that which was used in the CIVIC code for the detailed city calculations described in Section 3.2. When the shelter types given by density category in Table 3-3 are correlated with the density distribution for each city class in Table 3-1, it is possible to develop a shelter distribution by city class such as is given at Table 3-4. Earlier it was mentioned that a parametric approach to shelter and evacuation levels was adopted. At this point it is appropriate to explain the meaning of a given level of sheltering, i.e., the specific conditions associated with 10 percent, 20 percent or 50 percent sheltering. In the context of this study the percent shelter refers to portion of the urban population located in the [redacted] shelters. Shelter variations in this study involved only modification of the distribution of large urban population between the hard shelters and existing basements; the shelter posture of small urban and rural populations was held constant. b(1)

3.3.6 ~~(SRD)~~ The Equivalent Yield Adaptation (U)

~~(SRD)~~ Multiple shelter categories involving a range of hardnesses were not a part of the original Q/A formulation --- it had only a single category. Since a meaningful assessment requires the use of multiple shelter categories, a concept of equivalent yield was introduced to bridge the gap. In this study, the term "equivalent yield" is defined as that yield (in kilotons) which has the same weapon radius against the single shelter hardness of the original Q/A data base as the yield of current interest has against a new shelter category of interest. In basic terms, the equivalent yield concept was an abstraction which permitted use of the original Q/A data while taking into account the changes in sheltering assumptions that were appropriate for this study. [redacted] b(3)

Table 3-3 ~~(C)~~ Baseline Sheltering Posture (U)

(b)(1)

Table 3-4 (U) Shelter Distribution* of Soviet Population by City Class (U)

City Class	Large Urban Basement	Large Urban Shelter	Rural and Small Urban		
			Single Story	Basement	Shelter
1	50.0	50.0	0	0	0
2	49.0	49.0	.2	.8	1.0
3	47.05	47.06	.59	2.36	2.94
4	47.70	47.90	.46	1.84	2.3
5	45.82	45.82	.83	3.3	4.13
6	41.99	41.99	1.60	6.41	8.01
7	42.81	42.80	1.44	5.76	7.19
8	36.88	36.86	2.62	10.5	13.1
9	20.71	20.90	5.82	23.28	29.0
10	5.15	5.16	8.97	35.88	44.8
11	0	0	10	40	50
12	0	0	10	40	50
13	0	0	10	40	50

*Figures indicate percentage of the city population in a given shelter type.

Table 3-5 ~~(SRD)~~ Weapon Radii for Selected Yields and Shelter Categories (U)

b(3)

Table 3-6 ~~(SRD)~~ Equivalent Yields for Calculating Q/A Yields (U)

b(3)

[redacted]

weapon radius is a function of yield, height of burst and target hardness. In this study, all weapons employed against large urban areas, i.e., the hardened shelters were surface burst, while all weapons employed against small urban and rural populations were burst at the height which optimized the weapon radius for prompt effects. The hardened shelters in urban areas require a relatively low height of burst to maximize damage, and it was decided that a surface burst should be used to take advantage of the additional fatalities that might accrue due to fallout in these built-up highly populated areas. [redacted] Table 3-5 presents the weapon radii used against the various types of shelters. Table 3-6 lists the equivalent yields developed according to the procedure described above. Subsequent portions of this report explain the manner in which these various equivalent yields are treated in assessing attack effectiveness, i.e., the technique used to evaluate the use of several pseudo-weapons in simulating what would be only a single weapon in the actual attack.

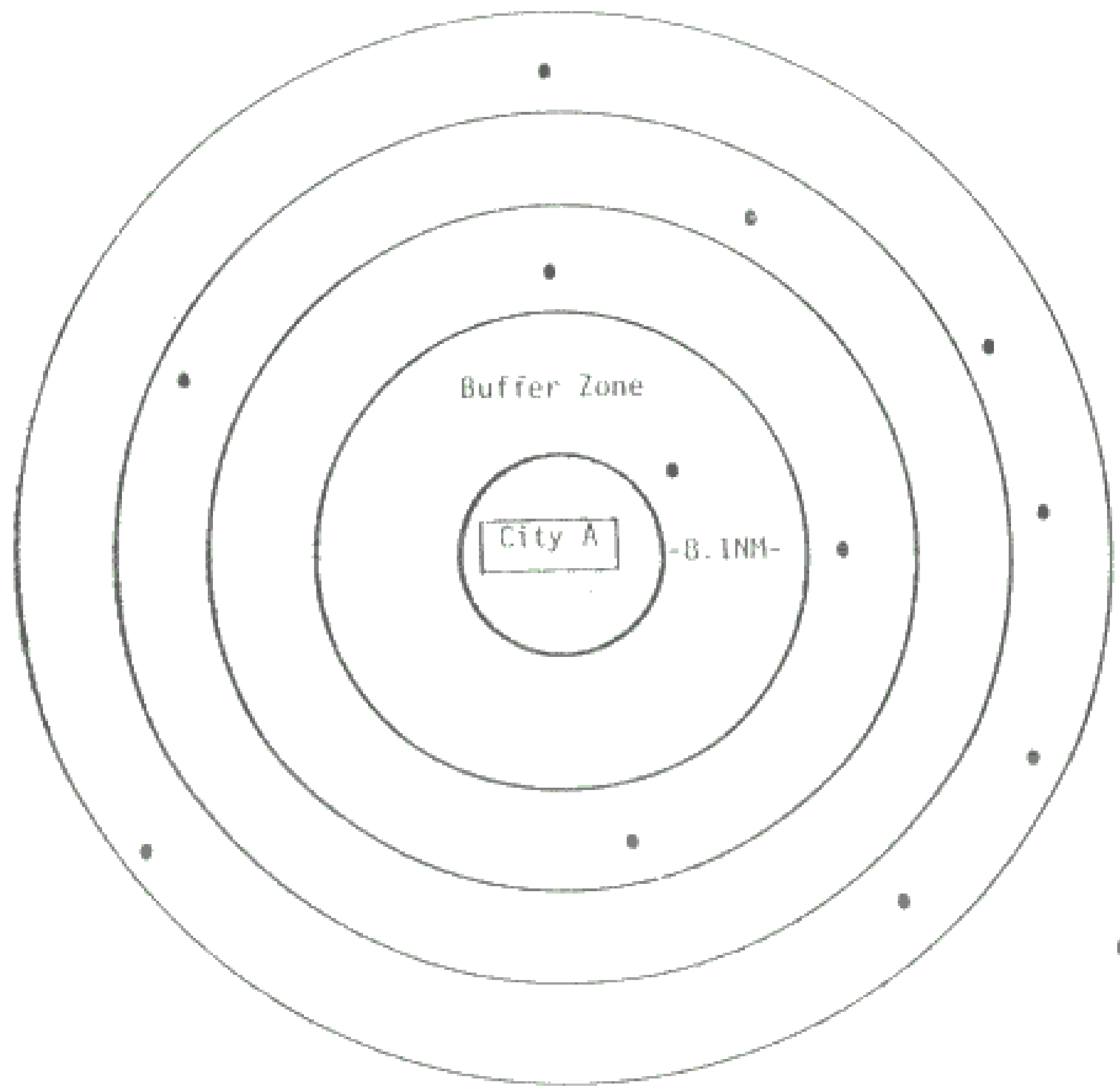
3.3.7 (U) Simulating Evacuation

A satisfactory simulation of evacuation capabilities on a realistic, nationwide basis (either as an adjunct to sheltering or as an alternative to it) require a methodical, detailed procedure for redistributing the urban population. It was necessary to identify which cities were to be evacuated, the distance the evacuees were to move and the resulting population densities in the hosting cities. As with sheltering, the percentage of the city population evacuated was treated parametrically. The methodology employed was selected after review of Soviet CD literature and was done at a level of aggregation appropriate to the magnitude of the task and the desired level of confidence in the results. The specifics of this procedure are given below.

3.3.7.2 The Mechanics of Evacuation

As was mentioned earlier it was decided that cities of 100,000 and greater would be evacuated. There were 267 Soviet cities in this category and the total population in those cities was approximately 94 million. In terms of city classes, these 267 cities account for all of classes 1-7, and the first 120 cities in class 8.[9] An annular-shaped buffer zone having a thickness 8 nautical miles (approximately 15 kilometers) was placed around each city. Definition of this zone is consistent with the practices described in Soviet CD manuals and is intended to ensure that areas beyond the buffer zone are not subjected to overpressures exceeding 1.4 psi (0.1 kg/cm^2) from weapons of a megaton or less which detonate along the periphery of the city proper, i.e., the inner boundary of the buffer zone. The radius of the city proper was taken as the equivalent P-95 radius shown in Table 3-1. The aggregate population of the buffer zones around the 267 cities was 23 million. The buffer zones were evacuated entirely for every level of city evacuation used in the analysis. This may be somewhat unrealistic for low levels of evacuation, e.g., 10 percent, but it was a convenient criterion which could be applied consistently throughout the calculations without introducing a serious bias. A modified version of the SAI ESCAPE code (Appendix A) was used to accomplish the redistribution of population. Concentric annular rings having

[9]There were 2 subclasses in class 8 -- one of 120 cities of population greater than 100,000 (average size 137,050) and the other with 89 cities of less than 100,000 (average 84,230).



● Indicates a Potential Host City
Successive rings outside the buffer zone are 5 nm thick.

Figure 3-1a Identification of Host Cities

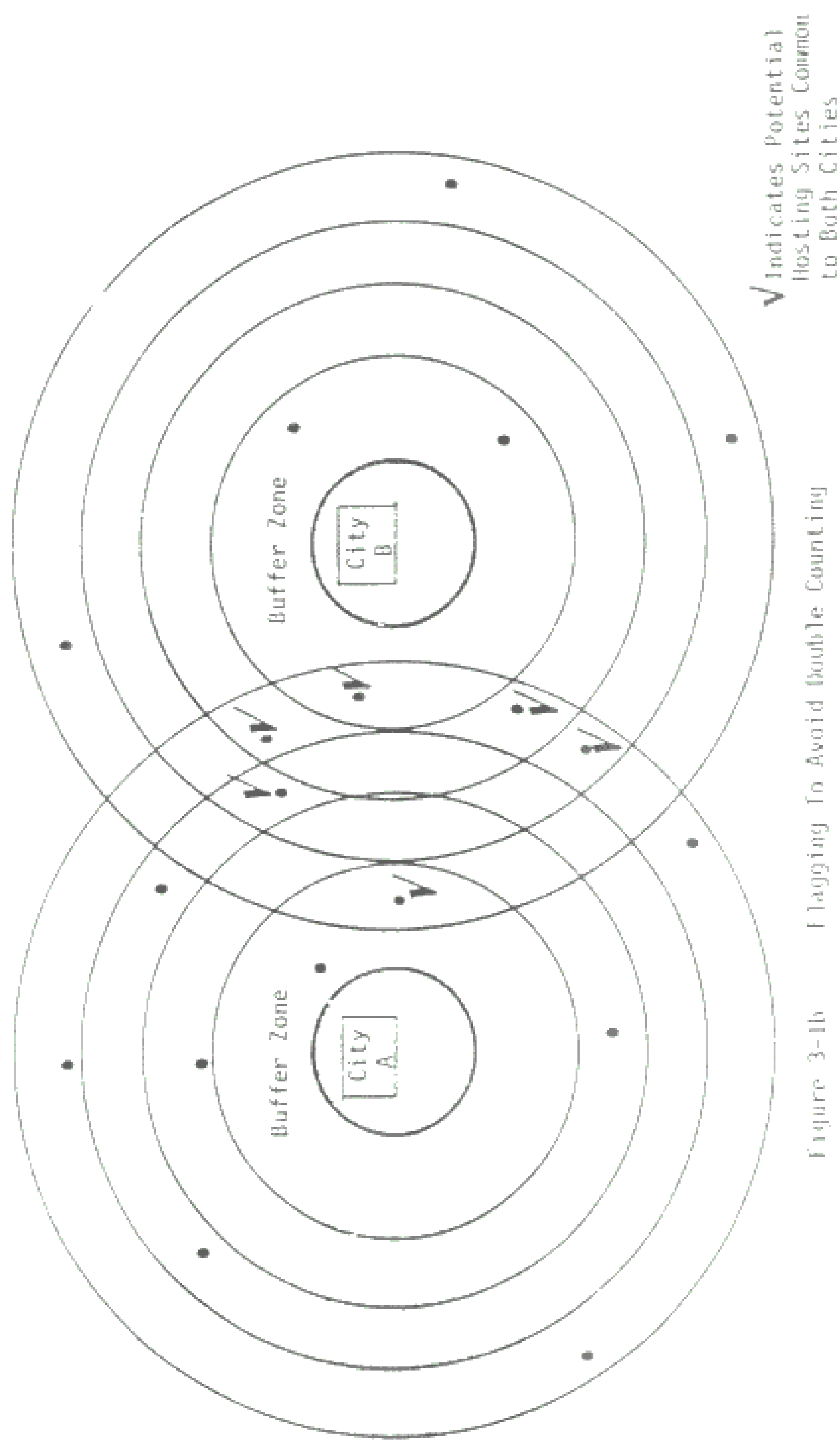


Figure 3-1b Flagging To Avoid Double Counting

a thickness of 5 nautical miles were created outside the buffer zone (Figure 3-1a) and a count made of the number of potential hosting cities by city class showing the total population within each ring. Using Soviet CD literature as a guide, only cities having populations less than 28,000 were designated as potential hosting cities. In terms of the countrywide data base, this corresponds to approximately 52,000 cities in classes 10-13. Cities were flagged to avoid double-counting as calculations proceeded (Figure 3-1b). The results of this procedure are summarized in Table 3-7 which shows the number of host cities by class at various distances beyond the buffer zone and the associated aggregate population. The table indicates that there is a host population of 30.3 million within 15 nm of the buffer zones (9.6 million at 0-5 nm and 20.7 at 5-15 nm). Thus if a host ratio of 2:1 (2 evacuees per host) is assumed, 60 million evacuees could be accomodated at distances no more than 15 nm from the buffer zones. Table 3-8 shows the number of people to be evacuated as a function of the percentage of evacuation of cities over 100,000. The number to be evacuated includes the constant increment of 23.1 million associated with the buffer zone, for as was pointed out earlier, it is always evacuated regardless of the level of evacuation in the city proper. It follows that once the population to be evacuated has been determined and the host ratio has been selected, the required number of host cities (from classes 10-13) can be calculated.

3.3.7.3 Potential Hosting Capability

Figure 3-2 is the cumulative hosting population as a function of distance beyond the buffer zone (city centers are generally 10-12 nm inside the buffer zone). The curve shows that with a 2:1 host ratio, 50 percent of the large urban population (i.e., in cities of 100,000 and larger) can be accomodated within 20 nm of the edge of the buffer zones, and 90 percent within 30 miles. This somewhat surprising and rather significant relationship is a consequence

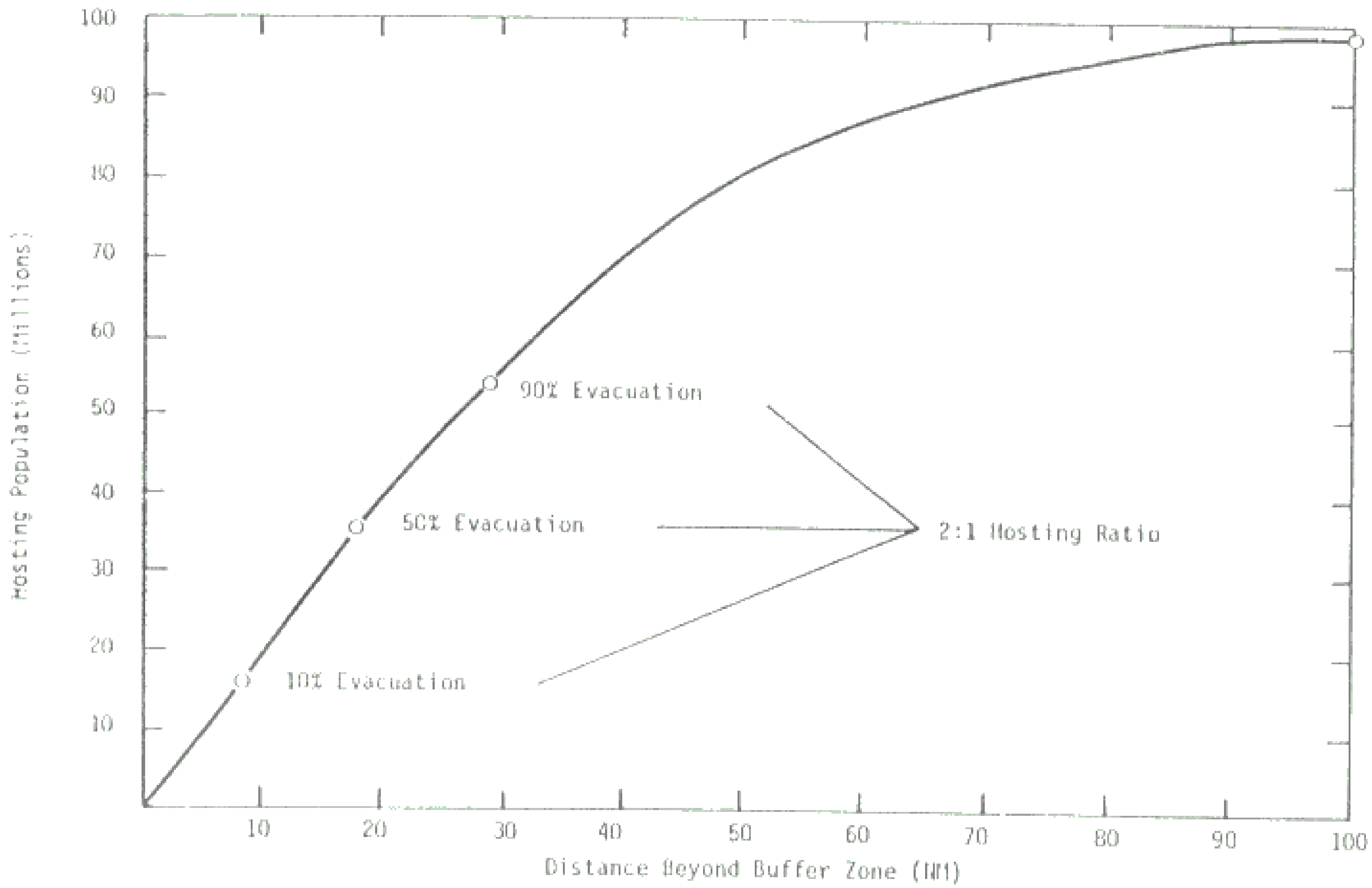


Figure 3-2 Distribution of Potential Hosting Population*

* Cities 8000-28000 Population

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Table 3-7 Distribution of Host Cities With Distance From Evacuated Cities

City Class	Class Total	Buffer Zone	Number of Cities: 0-5 NM*	5-15 NM	15-30 NM	30-50 NM	50-100 NM
10	257	30	20	43	49	35	49
11	1,169	363	126	165	220	158	93
12	20,326	2,793	1,563	3,321	4,617	4,100	3,799
13	30,338	3,157	2,201	5,398	7,042	5,724	4,488
Population (M)	121.9	23.1+	9.6	20.7	27.1	22.5	18.2

* Distance Beyond Buffer Zone
\+ Includes Population of Class 8 and 9 Cities in Buffer Zone

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Table 3-8 Population To Be Relocated As A Function of Percentage Urban Evacuation

Percent Evacuation*	Number of People** (Millions)
10	32.5
20	42.0
30	51.4
40	60.9
50	70.3
60	79.7
70	89.2
80	98.6
90	108.0
100	117.5

*Percentage of total population in cities greater than 100,000 population

**Includes buffer zone population of 23.1 million of the large number of small cities identified in the data base as being in relatively close proximity to the large cities.

3.3.8 ~~(SRD)~~ The POPEYE Code (U)

3.3.8.1 (U) Structure of the Calculation Process

The existing Q/A data set was incorporated into an independent optimal allocation dubbed POPEYE (Population Optimized Equivalent Yield Evaluation). The code was structured to accomodate up to five equivalent yields, each associated with a particular shelter hardness as described earlier in this section. Q/A parameters were calculated for each equivalent yield for city classes 1-9. Since classes 10-13 were developed specifically for this study, new Q/A parameters had to be defined for application to those classes. This was a relatively simple process because the cities were small, represented by a single P-95 in the data base, and never required more than one weapon in a laydown. Therefore, in the equation

$$D_i(n) = 1 - Q_i^{n^{A_i}} , \qquad (3\text{-}3a)$$

A was set equal to 1.0 and the expression

$$Q = (1\text{-}SSPK)\ (POA) \qquad (3\text{-}3b)$$

was used for the Q parameter, where the POA (Probability of Arrival) is taken as the system reliability and the SSPK was calculated from the formulas

$$SSPK = 1 - e^{-\ln 2 \left(\frac{0.96WR}{CEP_a} \right)^2} \qquad (3\text{-}4)$$

and

$$CEP_a = \sqrt{(CEP)^2 + 0.231\ (P\text{-}95)^2} \qquad (3\text{-}5)$$

In equation (3-4) on the preceding page, WR is the weapon radius calculated using the Defense Intelligence Agency's Physical Vulnerability Handbook, and CEP_a is the circular error probable adjusted for the joint distribution of area target elements and delivery error, allowing the use of the simpler form of the SSPK calculation.

(U) In equation (3-5) CEP is the actual circular error probable of the system and P-95 is the radius of the P-95 circle comprising the area target.

(U) Table 3-5 presents the weapon radii for yields and shelter types used in the study. The P-95 radii are given at Table 3-1. The values of the parameter Q for city classes 10-13 were calculated using these data. The effects of the various equivalent yield weapons are combined in accordance with the formulas

$$F_{ij}\ (N_j) = \left(1 - Q_{ij}^{N_i}\right)^{A_{ij}} P_i f_{ij} \tag{3-6}$$

$$F_i\ (N_j) = \sum_{j=i}^{5} \left(1 - Q_{ij}^{N_i}\right)^{A_{ij}} P_i f_{ij} \tag{3-7}$$

where F_{ij} represents the number of people in city class i and shelter category j killed by N weapons of a given equivalent yield. Q_{ij} and A_{ij} are the appropriate Q/A parameters, P_i is the average population of a city in class i and f_{ij} is the fraction of the population in city class i in shelter category j. Equation (3-7) is the expression for the total number F_i of people in city class i killed by all the various equivalent yields up to a maximum of five. Table 3-9 provides a typical set of f_{ij} values by city class. Figure 3-3 is a simplified flow diagram of the POPEYE code. Specified values of shelter hardness and weapon yield enable calculation of equivalent yields. These, combined with weapon accuracy, weapon reliability and input of the Soviet shelter posture, permit the calculation of Q/A parameters. The marginal return of the next weapon is determined against each city class using

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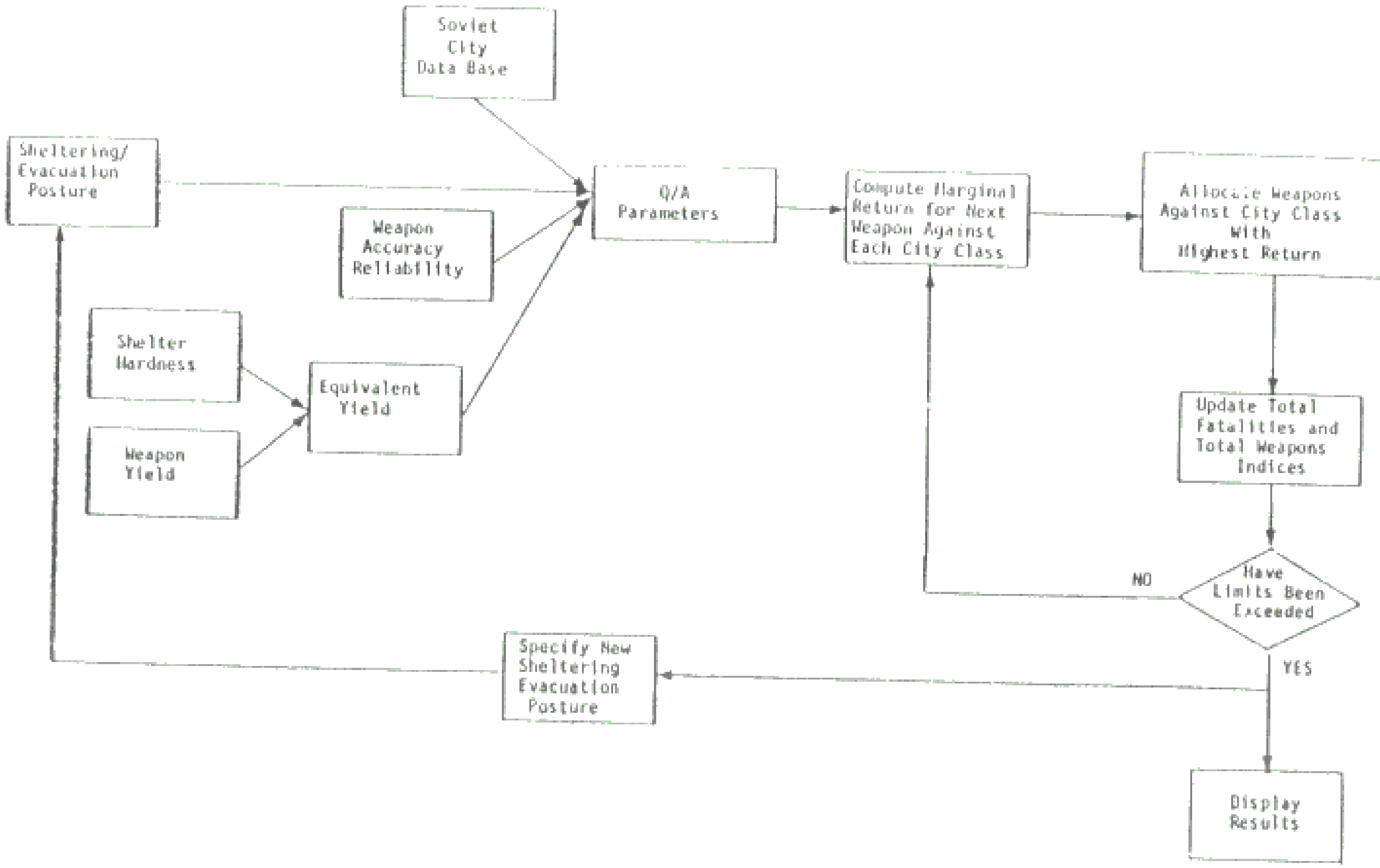

Figure 3-3 Flow Diagram of POPEYE Code

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Table 3.9 ~~(SRD)~~ Fractional Damage Values* for City Classes 10-13 (U)

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the expression

$$R_i\ (N_i) = F_i\ (N_i) - F_i\ (N_i - 1), \qquad (3\text{-}8)$$

where R_i (N_i) is the marginal return (in terms of people killed) resulting from the N^{th} weapon against city class i, and F_i (N_i) and F_i $(N_i - 1)$ are the numbers of people killed in city class i by N and N - 1 weapons respectively. The purpose of the calculation is to determine the optimal weapon allocation, and hence each succeeding weapon is targeted against the city class yielding the greatest marginal return. Totals of weapons expended and the associated number of fatalities are maintained dynamically, and the process continues until a predetermined limit on either the number of weapons or the number of fatalities is reached. At run termination, the TEKTRONIX Plotter graphs fatalities as a function of number of targeted warheads.

3.3.8.2 (~~SRD~~) Underlying Assumptions (U)

~~(SRD)~~ There are several important assumptions embodied in the procedure described above which the reader should recognize. First, since the various equivalent yields are only surrogates for a single yield weapon, the equivalent yield weapons must of necessity have the same desired ground zero (DGZ). Further, the population centers corresponding to each of the various sheltering categories all are assumed to have circular normal distribution and a common center. There are instances where this is not entirely true --- for example, for intermediate-sized cities (e.g., classes 8 and 9), the sheltering distributions were derived from a mix of P-95's consisting of large urban, small urban, and rural designations. Another aspect of the sheltering distribution assumption relates to target definition. (b)(3)

Point target representations require specific locations, however, and these were not available within the timeframe of the study. Moreover, it is reasonable to assume that since the weapon aimpoints would often be offset toward the centers of value of the hard shelter distributions in a detailed targeting process and the softer targets would not be very sensitive to aimpoint offsets the bias associated with the assumption of common centers for the various distributions would not be significant.

3.3.9.3 ~~(SRD)~~ Verification of POPEYE With CIVIC (U)

~~(SRD)~~ The developers of POPEYE recognized the desirability of validating its reliability. To this end, two [redacted] attacks of the city of Kiev were assessed: one as developed by POPEYE, the other, a more detailed laydown, by CIVIC. The magnitude of the attack was determined by observing that in a base case countrywide attack [redacted] were allocated to cities of class 3 (which applies to Kiev) in the process of achieving 60 million fatalities -- the established cutoff. [redacted] The same laydown was then assessed using CIVIC, which calculated the fatalities resulting from prompt effects only and from prompt plus fallout (POPEYE does not have the capability to assess the effects of fallout). The CIVIC results are displayed as a vertical line above the [redacted] point on the abscissa located just under the POPEYE curve. The upper limit of the CIVIC line corresponds to the number of fatalities resulting from prompt plus fallout effects; the lower limit corresponds to prompt effects only. The CIVIC runs assessed the [redacted] targeted against the largest P-95's in Kiev. The distribution of

b(1)
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Figure 3-4 ~~(SRD)~~ Verification of POTIVE Against CIVIC (U)

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fatalities across the different shelter categories is shown in the inset of figure 3-4.

Fallout effects may be more significant for other city classes. However, in this case the CIVIC run shows good agreement with POPEYE and supports the contention that countrywide assessments of this study are not unacceptably biased from the results that would be achieved through more detailed calculations.

~~(SRD)~~ SECTION 4

RESULTS (U)

4.1 ~~(SRD)~~ KIEV-MOSCOW ASSESSMENTS (U)

4.1.1 (U) Overview

The assessments of Kiev were done to provide fairly high resolution data of the impact of Soviet civil defense on targeting objectives. Addtional work was done on Moscow because of its unique character as the largest city in the Soviet Union. As was described in Section 3, Kiev was selected because it was considered representative of the conditions of interest in Soviet civil defense, i.e., sheltering and evacuation --- the magnitude of that effort and the effect on U.S. targeting. In point of fact, each city is probably unique in these aspects for a host of reasons; some geographic, some in terms of available facilities (shelters, transportation, etc.), and some human. The reader may or may not agree that Kiev is representative of the problem under examination, but it is nevertheless useful to avail oneself of the insight offered by the analysis of the simulated attacks on specific individual cities before proceeding to the countrywide problem.

4.1.2 ~~(SRD)~~ The Kiev Attacks (U)

4.1.2.1 ~~(SRD)~~ First Assessment - Essential Elements (U)

~~(SRD)~~ The initial assessment of Kiev addressed two basic cases with respect to civil defense --- the unevacuated and evacuated situations. In the former, 10 percent of the urban population (skilled laborers) were assumed to be in hardened underground shelters and the remaining 90 percent in available basements. In the evacuated case, 10 percent of the urban population (skilled laborers) were in underground shelters, 20 percent (also skilled laborers) were in a dispersal area outside the city proper, within 5 kilometers of an all-weather route such that the round-trip commute did not exceed 6 hours, and the remaining urban population (70 percent of the total) was evacuated to host locations outside the city and hosted at a ratio of two evacuees per host. The sheltering available to dispersed and evacuated people is discussed later in this section. Resolution of the population was down to a 50 person unit where necessary to the accuracy of the analysis. Weapons were targeted by a method analogous to that used by the Joint Strategic Target Planning Staff (JSTPS). This initially resulted in a [redacted] The probability of arrival [redacted] for the first assessment. There were [redacted] installations in Kiev, [redacted] which were considered primary, e.g., power plants, war-supporting industry, port facilities, military headquarters and other key military facilities. A separate analysis was done for the primary targets. Retargeting was accomplished in the evacuated case to determine the effect on both fatalities and damage expectancy to industrial facilities (the objective of retargeting being the achievement of higher fatality levels). [redacted] b(1)

[redacted] The weapons used in the initial laydown are given in Table 4-1 below.

Table 4-1 (~~SRD~~) Weapons Targeted in Initial Kiev Assessment (U)

[redacted] b(3)

Vulnerability criteria for fatality estimates used as appropriate for the evacuated and unevacuated cases were as follows:

Table 4-2 ~~(SRD)~~ Vulnerability Criteria (U)

b(3)

The assumptions used for fallout calculations varied according to the density distribution classification (large urban, small urban and rural). These are described in detail in paragraph 3.3.4.2 of Section 3. Table 4-3 on the following page presents a summary of essential data used for the fallout calculations.

Table 4-3 (U) Assumptions for Fallout Calculations (U)

	Single Story	Multi-Story	Basements	U.S. Shelters
	Population Distribution (Percent in Shelter)			
Large Urban	0	0	90	10
Small Urban	5	5	85	5
Rural	20	0	80	0
	Shelter Protection Factor			
Large Urban	5	12	200	1000
Small Urban	4	8	60	1000
Rural	3	5	15	1000

- October Most Probable Winds
- Fallout Dose Integration Time - 6 Months

4.1.2.2 ~~(S)~~ First Case - Results (U)

~~(S)~~ In addition to the basic laydown, two alternative attacks were examined -- b(1)

The objective of retargeting was, as mentioned earlier, to recoup some of the fatalities lost as a result of the evacuation. Retargeted weapons were directed at hosting sites for evacuees. Table 4-4 on the following page provides a summary of the results. The ground burst option was examined in the alternative attacks to determine the impact of fallout on the results.

Table 4-4 ~~(S)~~ Summary of Results - First Kiev Case (U)

(b)(1)

These results for Kiev suggest that evacuation might reduce fatalities to approximately [redacted] However, such retargeting can be expected to reduce damage to industrial facilities [redacted] It appears (at least for Kiev) that the magnitude of additional weapons requirements to compensate for major evacuation might be on the order of [redacted] targeted against Kiev in the basic laydown, i.e., the "no evacuation" case. This does not imply that the increase of weapons would be in the range [redacted], for in such attacks it is likely that only a fraction of the total weapons would be targeted against urban-industrial targets.

b(1)

b(1)

b(1)

b(1)

4.1.2.3 ~~(S)~~ Second Kiev Assessment - Essential Elements (U)

~~(S)~~ Additional work was done on Kiev in the later stages of this study in order to examine the sensitivity of results to certain parameters [redacted], to refine certain data pertaining to shelter hardnesses and protection factors, to determine the relative numbers of fatalities versus total casualties (e.g., fatalities plus injured) and to discover the outcome of certain specific combinations of sheltering and evacuation levels which proved to be of interest during the course of briefings presented to various officials in the Department of Defense. As will be seen, the focus of this second Kiev assessment was on population as opposed to industrial damage. As in the first assessment, various levels of retargeting were accomplished with the aim of increasing fatality levels. [redacted]

b(1)

b(1)

Table 4-5 ~~(SRD)~~ Weapons Targeted in the Second Kiev Assessment (U)

Vulnerability criteria for this assessment were modified somewhat from the initial data to examine the impact of improved shelter blast hardnesses and fallout protection, including the effect of hasty shelter construction by evacuating population.

Table 4-6 ~~(SRD)~~ Adjusted Vulnerability Criteria (U)

b(3)

There are three general cases in terms of the level of evacuation of Kiev in this assessment: no evacuation, 50 percent evacuation, and 90 percent evacuation. The distribution of population for each of these cases is given in Table 4-7 as a function of the density distribution classes described earlier. As in the previous assessment, the hosting ratio for evacuees was 2 to 1.

Table 4-7 Population Distribution, Second Kiev Assessment

Percent Evac.	Large Urban		Small Urban			Rural	
	Basements	Underground Shelters	Basements	Hasty Shelters	Underground Shelters	Basements	Hasty Shelters
0	50	50	60	30	10	50	50
0	90	10	60	30	10	50	50
50	--	50	60	30	10	50	50
90	--	10	60	30	10	50	50

4.1.2.4~~(S)~~ Second Kiev Assessment - Results (U)

~~(S)~~ The Figures below portray the results. In all cases, the percent sheltering refers to the proportion of population in the hardened underground shelters located within the "large urban" areas of the city. Surface bursts were used in the evacuated cases in an attempt to recoup fatality losses. Incremental levels of retargeting of evacuated population were examined; [redacted]

4.1.3 ~~(SRD)~~ The Moscow Assessment (U)

4.1.3.1~~(SRD)~~ Essential Elements (U)

~~(SRD)~~ The forces used in the attack of Moscow were considerably greater than those used against Kiev. [redacted]

Table 4-8 ~~(SRD)~~ Weapons Targeted Against Moscow (U)

[redacted]

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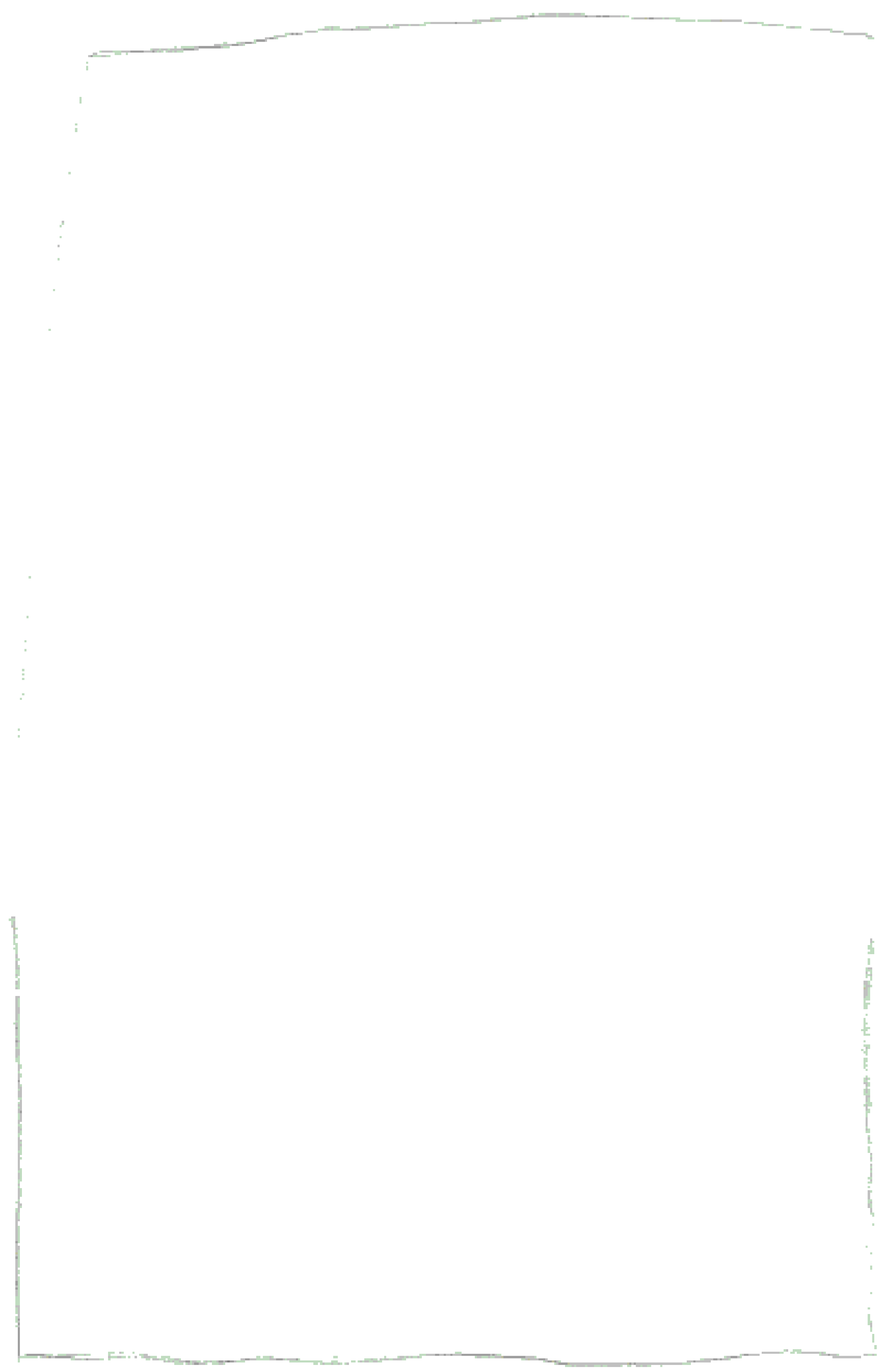

Figure 4-1a ~~(S)~~ Second Kiev Assessment, Unevacuated Case (U)

Figure 4-1b ~~(S)~~ Second Kiev Assessment,
50% Evacuation Case (U)

(1)

Figure 4-1c ~~(S)~~ Second Kiev Assessment,
90% Evacuation Case (U)

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Vulnerability criteria used for Moscow were identical to those used for the second assessment of Kiev, and the population distribution by shelter type was also identical to the Kiev situation with one exception, in which all of the urban population, including those who evacuated, were assumed to be in shelters, either the hardened, deliberate or hasty type. This exception is the 100% sheltering case in the results that follow.

[redacted]

b(1)

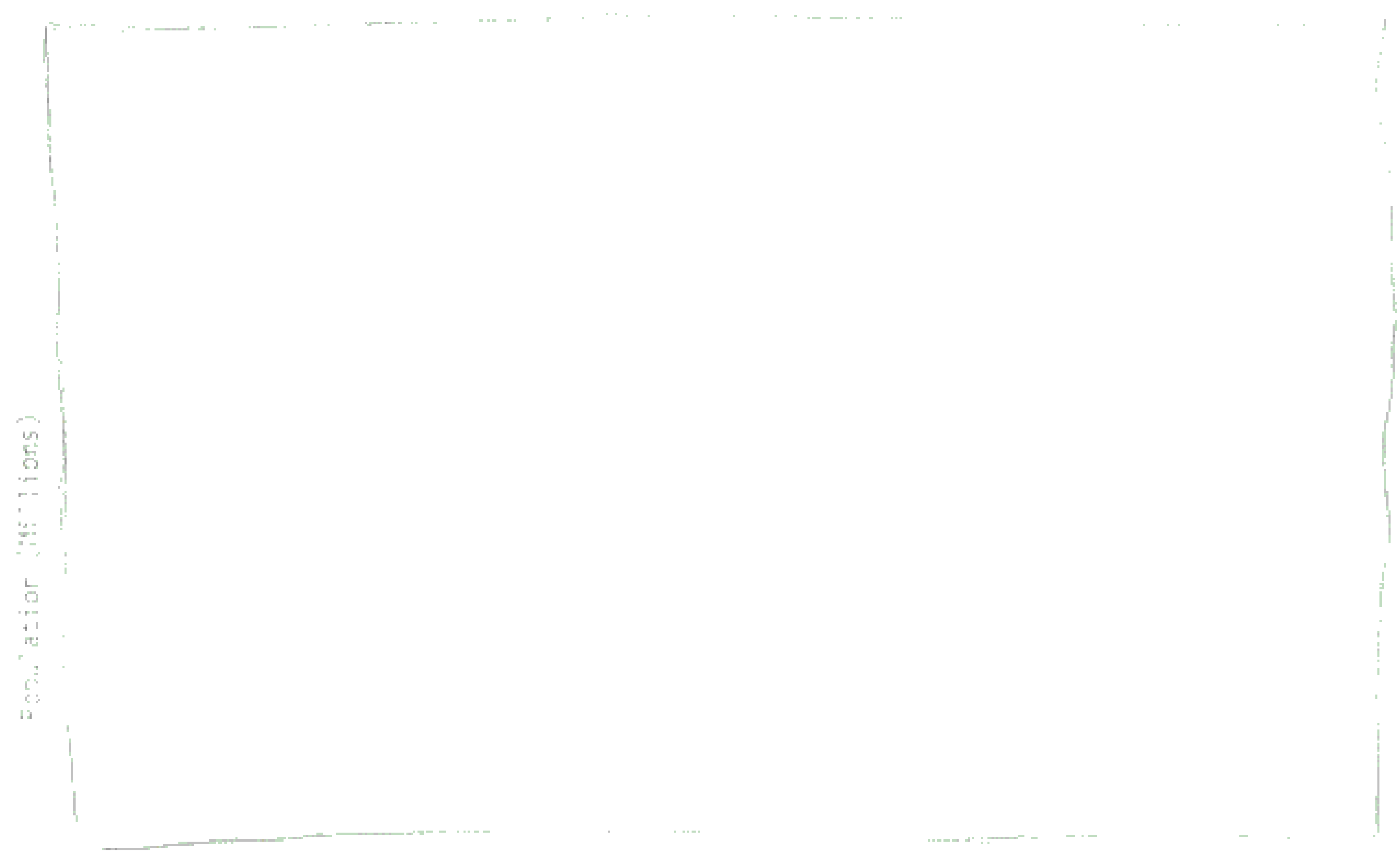

Figure 4-2a [redacted] Moscow Assessment, Unevacuated Case (U)

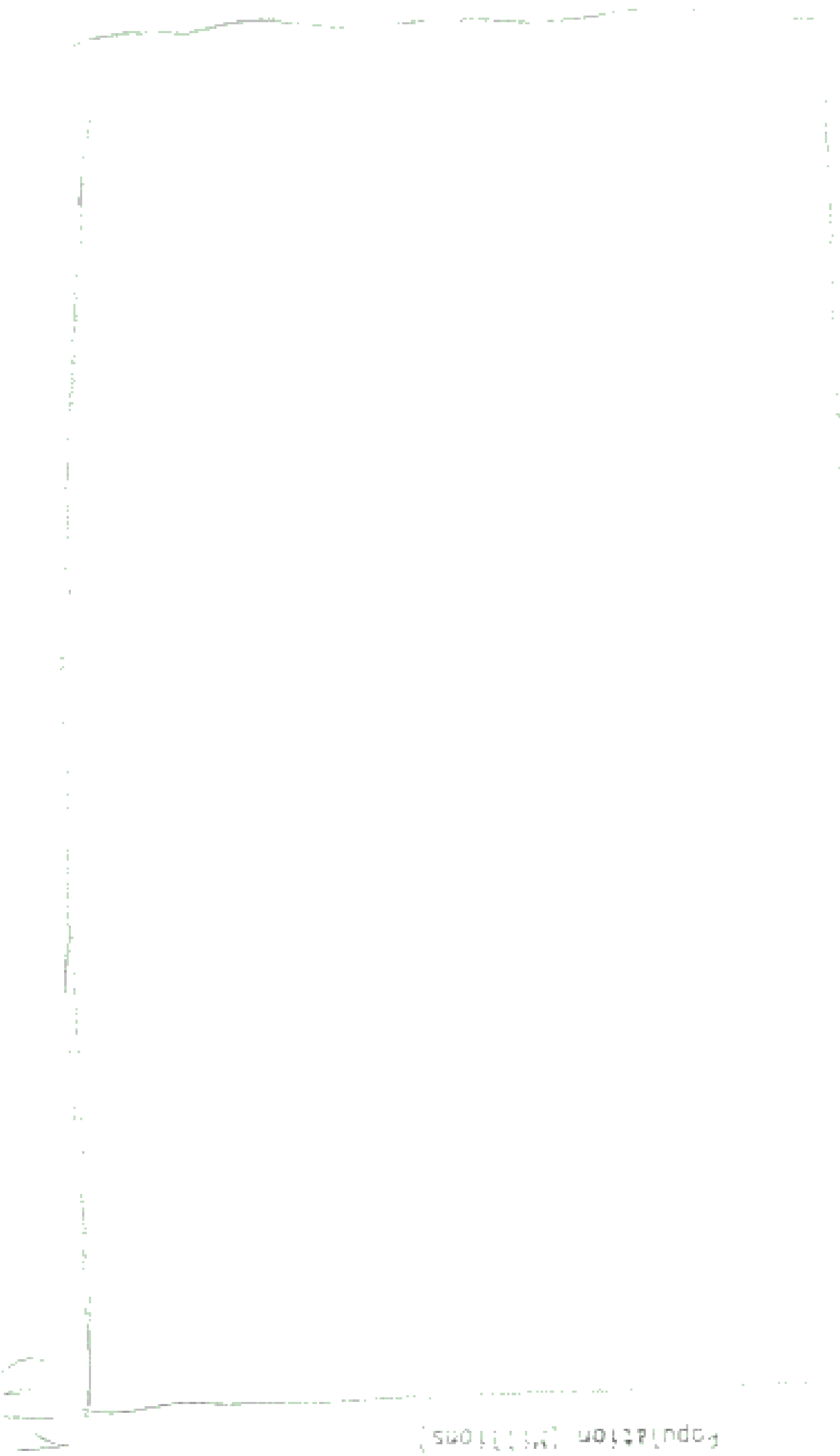

Figure 4-2b ~~(S)~~ Moscow Assessment, Evacuated Case (U)

4.1.4 [redacted] Summary of the Kiev-Moscow Assessments (U)

[redacted] The results of the Kiev-Moscow assessments suggest that very substantial reductions in fatalities may occur as a result of Soviet CD actions. Assumptions regarding levels of evacuation, sheltering and retargeting obviously play an important role. Certain combinations of sheltering and evacuation might reduce fatalities to levels varying from

Restoration of fatality levels, of course, becomes more difficult as the hardness and total numbers of shelters increases. In many of the variations examined, injuries nearly equaled fatalities and in some instances exceeded them. Prompt effects were by far the primary cause of fatalities, particularly for the higher levels of sheltering. There is little question that the United States could inflict substantial numbers of fatalities and casualties despite significant Soviet CD measures.

4.2 [redacted] COUNTRYWIDE ASSESSMENTS

4.2.1 [redacted] The Potential Impact of Sheltering (U)

4.2.1.1 [redacted] Sensitivity to Weapon Yield (U)

[redacted] The Single Integrated Operational Plan (SIOP) is the realworld plan for the employment of U.S. strategic weapons. It is developed by the Joint Strategic Target Planning Staff at Offutt AFB, Nebraska using a broad range of weapon yields, accuracies and reliabilities.

The most economical, effective and operationally sound application of those weapons requires in most instances that a mix of weapons systems and yields be used in accomplishing any major SIOP task, including the options for urban-industrial attacks. Recognizing that this is so, and that the countrywide methodology of this study permits only assessments of attacks employing a single yield, one of the first tasks was to establish the sensitivity of population attacks to weapon yield. Fortunately the Q/A date includes realistic yields. [redacted] b(3)

The fundamental relationship of interest was the number of fatalities as a function of the number of targeted warheads. Since there exists some uncertainty as to the amount of urban population that can be accomodated in hard urban shelters, two initial calculations were made - one at 10 percent (Figure 4-3), and one at 50 percent (Figure 4-4). It should be noted that throughout the study, the quantitative description of sheltering (e.g., 10 percent, 20 percent, 50 percent, etc.) refers to the fraction of large urban population in hard shelters. Only the large urban sheltering was varied - small urban and rural sheltering remained constant as described in Section 3, Figure 3-3. In all combinations of sheltering examined, that portion of the large urban population not in hard shelters were assumed to be in urban basements, e.e., if 10 percent were in hard shelters, 90 percent were in basements. The relationship exhibited in Figures 4-3 and 4-4 are not surprising. [redacted] b(3) Under similar targeting assumptions, the realworld number of weapons [redacted] since that attack would contain a mix of yields

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(3)

1.

and delivery systems. A comparison of these data with those of Figure 4-4 (the 50 percent sheltering case) gives some appreciation of the potential effectiveness of hard shelters in protecting the population and in increasing weapon requirements. Table 4-9 provides this comparison.

Table 4-9 [redacted] Sensitivity to Sheltering (U)

[redacted]

b(3)

the "base case" level of sheltering for this study is the 50 percent level, i.e., that which is shown in Figure 4-4. [redacted] b(3) Selection of the 50 percent level of sheltering for the base case is [redacted] However, the need not agree with this estimate in order to derive useful information from the sheltering analysis. Figures 4-6a and 4-6b portray the potential impact of sheltering parametrically, enabling an evaluation which recognizes the uncertainty of the sheltering estimate.

4.2.1.2 [redacted] Attack Effectiveness as a Function of Shelter Posture (U)

[redacted] The independent variable of Figures 4-6a and 4-6b is the percent urban sheltering, i.e., the fraction of large urban population in [redacted] b(1) [redacted] b(3) The reference point [redacted] b(1) at the 50 [redacted]

percent sheltering level appears on both Figures. It is relevant to note that doubling the shelter level from 40 to 80 percent requires a [redacted] and doubling from 80 percent to complete (100 percent) sheltering would require [redacted] b(3)

[redacted] Figure 4-5b is based on a fixed budget [redacted] gives a measure of how fatalities can be reduced by increasing hard urban shelter space given the weapon constraint. [redacted] b(3)

[redacted] Obviously, fewer weapons would be required if larger yields were used.

4.2.2 ~~(SRD)~~ The Potential Impact of Evacuation (U)

4.2.2.1 (U) Approach

While there is some rationale to support the view that in a crisis, the Soviets might order the population to take shelter without executing a major evacuation, there is little basis for the converse view, i.e., that they would evacuate without sheltering. There is a high probability that major urban evacuations would be discovered by the United States and thus an effective preemption on the part of the Soviets would be in jeopardy. It is true that movement to shelters might also be discovered, but the probability is lower than that associated with evacuation and more importantly, the time required to take shelter would be significantly less than that of evacuation. For these reasons, evacuation was analyzed in combination with sheltering rather than apart from it. At this point, it is useful to review the assumptions and procedures associated with the evacuation assessment. They are as follows:

- Evacuate all cities with population greater than 100,000
- Evacuate a buffer zone around each city

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- Identify potential host cities as a function of distance from evacuated cities
- At selected levels of evacuation, assign evacuees to host cities using established guidelines:
  - Host cities to have population less than 28,000
  - Use a 2:1 hosting ratio, i.e., 2 evacuees to 1 host
  - Assume no increases in the number or capacity of hard urban shelters over those used in the foregoing analysis of sheltering
  - Maintain the same distributions of sheltering for small urban and rural locales as were used in the foregoing sheltering analysis
- Use Optimum allocation of weapons against population assuming knowledge of shelter and host city locations

4.2.2.2 ~~(SRD)~~ Attack Effectiveness as a Function of Evacuation (U)

~~(SRD)~~ The sensitivity of attack effectiveness to evacuation posture is presented in Figures 4-6a and 4-6b, where the independent variable is the percent evacuation. As was the case with the earlier figures pertaining to sheltering, the dependent variables are the numbers of targeted warheads and fatalities. The percent of evacuation refers to the fraction of the urban population in cities over 100,000 that are evacuated. The combined effect of sheltering and evacuation is provided for two levels of sheltering -- the 10 percent and 50 percent cases discussed earlier.

When the base case sheltering of 50 percent is combined with 50 percent evacuation, more than must be targeted to achieve 60 million fatalities (Figure 4-6a).

b(3)

Targeted Warheads

65

~~SECRET~~

There is another interesting relationship embedded in these graphs. For equal fractions of the population protected by combinations of sheltering and evacuation, the numbers of weapons and fatalities are approximately equal. For example, on Figure 4-6a a sheltering/evacuation combination of 10/50 requires to produce 60 million fatalities --- and a sheltering/evacuation combination of 50/10 (again a total of 60 percent protected) requires about The same relationship exists with respect to fatalities, leading to the conclusion that, at least for the conditions assumed in this study, sheltering and evacuation are roughly equal in ability to affect weapons requirements and fatality levels.

4.2.2.3 ~~(S)~~ Distribution of Fatalities by City Class (U)

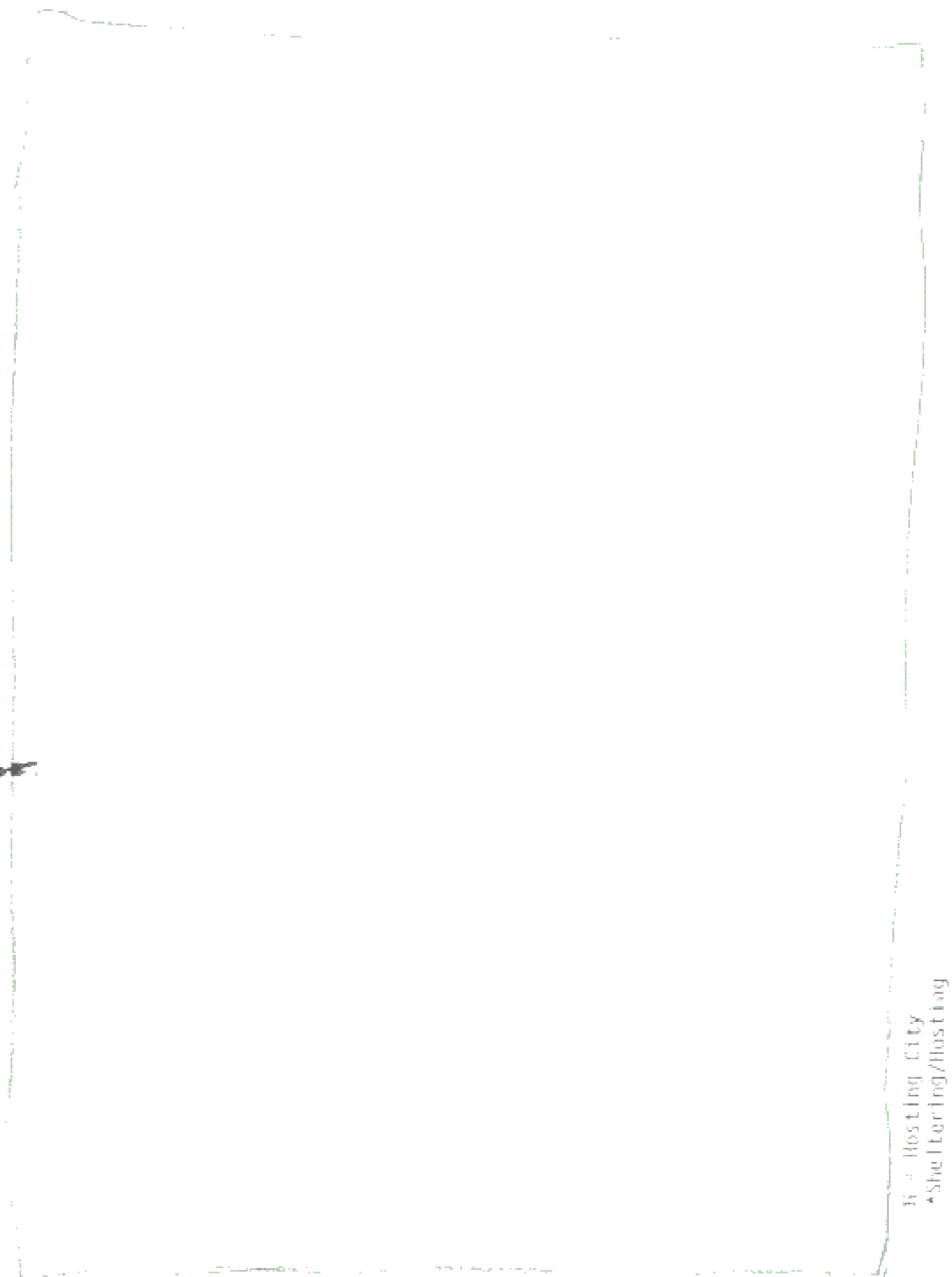
~~(S)~~ Four separate combinations of sheltering and evacuation are examined in Figures 4-7a and 4-7b in terms of the distribution of fatalities. The ordinate of these plots is the fraction (percentage) of 60 million fatalities inflicted in the attack; the abcissa is city class. A total of 50 percent of the urban population is protected in the two cases of Figure 4-7a using sheltering/evacuation combinations of 50/0 and 10/40. All of the urban population is protected in Figure 4-7b where the sheltering/evacuaiton combinations are 50/50 and 10/90. In all four cases, a total of 60 million fatalities were achieved. A significant aspect of these results is the distinct shifting of fatalities toward the smaller (higher numbered) city classes in the two cases involving higher levels of evacuation, i.e., the 50/50 and 10/90 cases. The reason for this shifting is that as greater numbers of people evacuated, host cities become more remunerative targets than the cities of origin.

[redacted] b(3)

4.2.2.4 ~~(SRD)~~ Relative Effectiveness of Sheltering and Evacuation Postures (U)

~~(SRD)~~ A somewhat different view of the potential impact of sheltering and evacuation is obtained by examining the relationship between fatalities and numbers of targeted warheads for several plausible combinations of sheltering and evacuation. This relationship is provided at Figure 4-8. Weapons requirements increase sharply as the percentage of total urban population protected is increased. [redacted] b(3) The use of larger yields would require fewer weapons.

~~SECRET~~



~~SECRET~~

~~SECRET~~

b(3)

Number of Targeted Warheads

Figure 4-P ~~(SRD)~~ Relative Effectiveness of Four Sheltering/Evacuation Postures (U)

~~RESTRICTED DATA~~

~~SECRET~~

~~(C)~~ SECTION 5

LIMITATIONS (U)

5.1 ~~(C)~~ CONSTRAINTS ASSOCIATED WITH ASSUMPTIONS AND ANALYTICAL TOOLS (U)

5.1.1 ~~(C)~~ Assumptions (U)

~~(C)~~ The infliction of fatalities was the sole targeting objective in this study. Only those Soviet cities with population exceeding 100,000 were evacuated, and [redacted] These assumptions, although appropriate to the objective of the study (i.e., the determination of the feasibility of population targeting) impose certain limitations on the use of the results. First, it is unlikely that the targeting policy for U.S. strategic nuclear forces will ever restrict targeting objectives to population alone. Military installations, national leadership, and industrial capabilities clearly require attention in the targeting process and it is highly unlikely that they will be neglected in any future employment policy. The use of the assumptions of this study simply provides a useful means of assessing the feasibility of population targeting... the objective of the study.

b(1)

[redacted] Selection of the 100,000 cutoff for urban evacuation, although consistent with the available information on Soviet CD, is not the only cutoff one might wish to examine. Some believe that 50,000 might be a more appropriate choice, and that there should be a special attempt to assess our ability to target the key industrial workers who disperse away from the city proper in times of crisis. Finally, one recognizes that it may be desirable to do a more

b(1)

discriminating analysis of potential targets in identifying host cities so that evacuees are not located in cities which contain inviting strategic targets. Time and resource limitations simply did not permit examination of all of these various facets of the problem.

5.1.2 (U) Analytical Tools

Except for the CIVIC runs on Kiev and Moscow, the computer codes used in this study provided only fatalities resulting from prompt effects --- no casualties were calculated, nor were the effects of fallout taken into account in the countrywide analyses. Prompt effects clearly would be the major cause of fatalities in population attacks, but certainly some additional fatalities would result from fallout in those cases where surface bursts are employed. Depending on the weapons used, and the magnitude of the attack and the burst heights we estimate that inclusion of fallout fatalities might increase total fatalities by 10-20 percent. The Q/A approach to population targeting limits one to weapons of a single yield for a given attack, and as was mentioned earlier, this is not the nature of real-world attacks. One can compensate for this shortcoming by examining several different attacks using variations in yield (as was done in this study), but a mixed weapon attack is not within the capabilities of the Q/A methodology. If a single "best estimate" of population fatalities is desired (as opposed to a probable range), a mixed-weapon attack is clearly desirable.

5.1.3 (U) Uncertainty Perspective

Ideally, one would like to examine the potential effects of the more obvious uncertainties as they pertain to the fatality calculations. What are the implications of Soviet sheltering and evacuation in the absence of adequate intelligence and a retargeting capability? What is the impact on targeting effectiveness if our estimates of levels of sheltering and evacuation are not accurate? Recognizing the enormous complexity of executing such a large-scale CD plan (especially major evacuations), how effectively would Soviet command and control, transportation, provisioning, and other logistical activities be carried out? These questions address only those uncertainties associated with Soviet CD and U.S. targeting capabiltiies. Quite apart from these are additional questions relating to weapons effects and personnel response to them. It was not possible to examine adequately all of these questions during the course of the study, and the results should be evaluated in recognition of the fact that significant uncertainties do exist. Specifically, it should be kept in mind that the study results are tied to the assumption of adequate C^3I to locate and retarget sheltered and evacuated urban population.

~~(SRD)~~ SECTION 6

SUMMARY (U)

6.1 ~~(SRD)~~ SIGNIFICANT RESULTS (U)

~~(SRD)~~ The objective of the study was to determine whether, in light of the Soviet CD program, population targeting is a feasible option for the United States. The results of this study indicate that the United States has the capability to inflict substantial fatalities if population is a targeting objective. However, retargeting to maximize fatalities in a sheltered and evacuated Soviet population could result in reduced levels of industrial damage as well as significant increases in weapons requirements. [redacted]

b(1)

b(3)

The plausibility of evacuation is supported by the determination made in the study that most of the Soviet urban population in cities exceeding 100,000 could be hosted within 30-40 nautical miles of those cities without exceeding a hosting ratio of 2 to 1 (Figure 6-1). This is not an unrealistic hosting ratio, nor are the distances so great that they could not be traversed in the space of a day or two, given adequate advance planning. Nevertheless, conclusions regarding the effectiveness of Soviet civil defense must be tempered by recognition of the remaining uncertainties as discussed in the previous section. Large scale evacuation in particular would be an enormously complex undertaking, and it would surely create a crisis in itself (if it were done "out of the blue"), or markedly deepen any existing crisis, creating the need for some very difficult decisions by the U.S. leadership. Hopefully, this study has provided some insight into the possible alternatives and consequences that should be examined before such a crisis arrives.

6.2 (U) COMMENTS ON THE IMPLICATIONS

The principal implications of the results are associated with C^3I capabilities, weapons requirements, and the feasibility of a large-scale evacuation of Soviet cities. It appears that targeting population could be a feasible targeting objective, but not without significant consequences in C^3I investments and probable increases in the total number of weapons required to accomplish all of the strategic targeting objectives set forth in national policy. A better estimate of the impact of population targeting on weapons requirements can be made given criteria for other objectives such as the damage expectancy goals for economic targets. Estimating the costs of acquiring adequate C^3I capabilities to accomplish timely and accurate retargeting is a more complicated task, but not an insurmountable one. The surprising degree of relative proximity of host cities to accomodate large scale evacuations suggests that it is not unrealistic to consider at this point what U.S. alternatives would be if we were to observe such an evacuation in progress. Some believe Soviet CD activities call into question the adequacy of our own civil defense program. Others insist that major improvements in civil defense by the United States and the Soviet Union would only make nuclear war more acceptable, thus eroding what all agree is the key objective --- deterrence. At this point, there does not appear to be a basis for asserting that Soviet advantages over the U.S. in civil defense are such that in themselves, they would encourage the Soviets to risk starting a nuclear war. Perhaps an important distinction to make here is the difference that Soviet civil defense measures could have on the outcome of a nuclear war as opposed to the effect it could have on the initiation of one. Most analysts would agree that despite the existence of the civil defense asymmetry, the initiation of a nuclear war is at present a low probability event. On the other hand, one must recognize that because of their better preparation, the Soviet CD program probably would be more effective than our own in an actual conflict, and it is uncertain as to just how critical this difference might be. This study has addressed only one facet of that very difficult question --- the potential impact of Soviet CD on the feasibility of population targeting.

(U) Section 7.0

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(U) APPENDIX A

FALLOUT UNCERTAINTIES

This appendix is concerned with many of the important uncertainties related to fallout as it affects the estimation of casualties. The specific areas to be addressed include fallout models, shelter parameters, wind variations and finally, latent effects which are possibly associated with exposure levels lower than that required for acute effects. There are other factors which will not be discussed here such as dependence on height-of-burst and fractionation of activity with particle size. These have been addressed in earlier investigations[1].

An important limitation of the analysis presented here is that uncertainties were assessed for either a single burst or a localized cluster of bursts and not for a nationwide attack. Consequently the results must be regarded more as trends than as definitive or comprehensive.

A.1 MODEL COMPARISON BY SAI

An evaluation[2] of the SIDAC (Single Integrated Damage Assessment Code) model used by CCTC pointed out what appeared to be significant variations in the prediction of fallout between codes. The codes considered were DELFIC, SEER and the version of WSEG-10 in SIDAC. DELFIC is considered the most comprehensive model and as such should serve to calibrate the other two models which are designed for systems application such as damage assessment. The two principal results of that variation were that

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[1] McGahan et. al. Sensitivity of Fallout Predictions to Initial Conditions and Model Assumptions, DNA 3439 F, December 1974.

[2] Drake, et. al., Evaluation of the Single Integrated Analysis Capabil- (SIDAC) Model, Final Report by Science Applications for DNA, April 1977.

1. SEER tended to overpredict the area enclosed by a specified dose rate and that this overprediction occurred consistently for most yields and dose rate levels. It was recommended that SEER-predicted dose rates be reduced by 35 percent as a quick-fix.

2. WSEG-10 tended to underpredict the area for a given dose rate and that this underprediction got worse with increasing dose rate and/or decreasing yield. A simple renormalization would not be a sufficient corrective action.

This comparison of models was conducted for a single wind field which though presumably representative, might possibly have influenced unduly the outcome. Fortunately, there has been a more recent comparison[3] that considered a dozen different wind fields. The results support the above conclusions, in particular the evident bias in the WSEG-10 code. An example of this is shown for a 1 MT surface burst (all fission) in Figure A.1. For each of the twelve cases, the dependence of enclosed area on the one hour dose rate was plotted. The Figure shows the envelopes of the resulting curves for both WSEG-10 and DELFIC. At low dose rates (e.g., 300 R/hr) there is overlap between the two models. At higher levels, however, the DELFIC area is greater. For example at 1000 R/hr, the DELFIC prediction is 410 ± 170 Km^2 compared with the WSEG-10 calculation of 34^{+80}_{-34} Km^2. In eight of the twelve cases, WSEG-10 predicted zero area. The choice of a dose rate level at which comparisons should be made clearly depends on the scenario. But 1000 R/hr from a signle 1 MT (all fission) burst corresponds to a mid-lethal level of 450 rads over 30 days for the following conditions:

1. 3 1 MT (all fission) bursts with closely spaced aim points so that the individual patterns mostly overlap

2. a shelter protection factor of 20

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[3]Norment, H. G., Analysis and Comparison of Fallout Prediction Models, DNA 4569F, March 1977.

3. an initial stay time of 3 days followed by a period of 27 days where 8 hours is spent outside the shelter each day

This is not a uniquely suitable set of conditions; it is merely illustrative. However, it does indicate, more substantially than previous examination, that there is a problem in the use of WSEG-10 for damage assessment.

A.2 SHELTER PARAMETER VARIATION

As in the scenario example used in the previous section, there are several parameters whose variations and uncertainties need to be examined. Specifically, they are:

1. the protection factor for the shelter to which people would go on warning of an attack; this can be called the primary shelter.

2. stay time in this primary shelter, which depends on storage capability of food stocks and water, on plumbing and ventilation, etc.

3. the protection afforded by residential shelters such as basements, to which people would return after their stay in the primary shelter

4. the number of hours per day spent outside this secondary shelter

In the following it is assumed that 8 hours per day is spent outside the secondary shelter. The first three parameters are then varied to examine their sensitivities. The assessment was performed in terms of the lethal area (450 r over 30 days) following a single 1 MT surface burst with 50 percent fission. The DELFIC code was used for the predictions with the set of wind profiles discussed in the previous section. Table A.1 shows the results for the primary protection factor, PF, having coding values of 200, 20 and 3; the corresponding stay time, T_I, being 3 days, 7 days and 2 weeks and the secondary protection factor, PF_2, having values of 20 or 3. These latter might correspond respectively to the basement and upper level of a residence.

Several observations can be noted. For example, with PF_1 = 20, a factor of two increase in T_1 leads to a 50 percent reduction in area while at PF_1 = 200, a similar increase in the primary shelter stay time results in only a 20 percent reduction. In other words, the higher the primary protection factor, the less the sensitivity on stay time. The sensitivity to variations in the secondary protection factor is also evident in Table A.1. Increasing it from 3 to 20 leads to a 30 to 50 percent reduction in area. In general, however, the biggest sensitivity can be found in the primary protection factor. Increasing it from 20 to 200 causes large variations and might result in lethal areas that are insignificant.

One might ask which sets of values for the parameters in Table A.I can be considered significant. For a 1 MT surface burst, the area for which the minimum overpressure is 6 psi is 55 km^2. In this analysis, this level is taken to be comparable in effects to 450 r over 30 days from fallout. The latter is defined to be significant when its area exceeds the blast area. The cases of significance are given in Table A.2. For example, with PF_1 = 200, the primary stay time must be no more than 3 days for the fallout lethal area to be greater than the blast area. It should be remembered that this conclusion pertains only for a single 1 MT blast. The results are liable to be different when there are clustered aim points as will be seen in the next section.

A.3 EFFECTS OF CLUSTERED BURSTS

Many of the observations noted in the previous sections are dependent on the degree to which adjacent fallout patterns overlap and also on the distribution of urban areas with high population density. To examine this a hypothetical attack was constructed involving 14 clustered targets. A Mk 11 RV (surface burst) was employed at each aim point. One hundred wind profile samples were selected using the nearest reporting station. In the same region as the aimpoints are nine urban areas which will be termed monitor points. Their locations as well as those for the targets are shown in Figure A.2. The free-field dose (over 30 days) was determined for each monitor point taking all bursts into account. The CIVIC code with its built-in SEER fall-out model, was used in this assessment. The results are stated in terms of risk. This is defined as the probability that 450 rads over 30 days would be recieved by the populace at a given monitor point. (It should be pointed out over 30 days the mid-lethal dose would be 730 rads provided supportive care was provided.) Sheltering parameters were allowed the same variation as discussed in Section A.2.

One initial question is what is the probability at each monitor point for complete fallout avoidance. This is shown in Figure A.3 along with the prevailing wind direction for the region of interest. Note that for monitor point 2, which is downwind (with respect to the prevailing wind direction,) of the target cluster, there is about a 50 percent chance of complete fallout avoidance. Conversely for monitor point 6, which is about 90 degrees off the prevailing wind vector, and hence, might be expected to infrequently receive fallout, the probability for fallout avoidance is only 50 percent. Obviously on a given day with a wind pattern that is fairly uniform over the entire region, monitor points 2 and 6 wouldn't both receive high intensity fallout.

Shown in Figure A.3 is the risk, as defined above, for each of the monitor points when the primary and secondary protection factors are both equal to 20 and the primary stay time is 3 days. Note that monitor point 6 which had a 50 percent chance of avoidance has a risk of about 20 percent while monitor point 2 which had the same avoidance chance has a larger risk of 30 percent. Monitor point 3 has a surprisingly high risk, about the same as for monitor point 6. The risk determined for each monitor point over the range of shelter parameters is given in Table A.3. The order of monitor points is according to an intuitive assessment of risk based on the prevailing wind direction. By and large, this is supported by the calculations as shown in the last column. An important result is that only for 3 of the monitor points did the shelter parameter extremes result in more than a 9 percent absolute change in risk with the maximum variation being only 10 percent.

In general, one would have assumed that monitor points 3, 4 and 7 would have very high (~100 percent) risk. The impact of wind variability is to essentially distribute the risk over more monitor points. The aggregate risk (i.e., risk summed over the nine monitor points) appears to be about the same. The assessment conducted here, though, would tend to suggest that wind effects should be treated statistically where uniform population distributions cannot be assumed (i.e., where the population varies widely between monitor points).

A.4 LATENT EFFECTS

There is presently much interest in the effects of low radiation exposures. Latent effects include radiation-induced cancers that occur over a lifetime; included are leukemia and cancers of the lung, GI track, bone, pancreas and breast. Genetic effects will not be discussed here. The incidence of post-exposure cancer typically occurs during a plateau period of time (i.e., with an equally likely chance in any year) which is subsequent to a latent period of many years. Both the latent and plateau period vary with each type of cancer (Table A.4). The calculations performed for this study are based on the WASH-1400[4] methodology used by the Nuclear Regulatory Commission for predicting the consequences of reactor accidents. (The radionuclide inventory in the fallout was determined with the DELFIC code.)

[4]WASH 1400 (NUREG-75/014), Reactor Safety Study, An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants, U.S. Nuclear Regulatory Commission, October 1975.

The population is taken to have the average U.S. age distribution. A younger population would have greater chance for latent effects from the same exposure while an older population would have less. The dose pathways include:

1. external exposure to contaminated ground
2. inhalation of resuspended radionuclides
3. ingestion of contaminated food such as milk and fresh vegetables

The cancer incidence due to external exposure and inhalation is calculated in terms of total cancers per person per unit dose rate of the fallout intensity at H+1 hour. The incidence due to ingestion is given in terms of total cancers resulting from consumption of food produced per km^2 of land and per unit dose rate at a given location. It was assumed that the agricultural land use fraction and productivity were equal to the U.S. average.

Typical results are presented in Table A.5 using the laydown discussed in Section A.3. The shelter conditions assumed were that the primary and secondary shelter protection factors were equal to 20 and that the primary shelter stay time was 7 days. The risk is based on the wind variation as defined previously. Note that the risk for 10 percent incidence of latent cancer is essentially the same as the risk for a 50 percent incidence of early mortality. The risk for 50 percent incidence of latent cancer is some what lower but certainly not negligible.

A.5 CONCLUSIONS

Based on the above analysis, several conclusions appear to be warranted. They are as follows:

1. WSEG-10 is seriously biased in situations where there is moderate to good sheltering. This bias may not be evident in situations where many bursts are clustered.

2. There is significant sensitivity to sheltering conditions when the population is fairly uniformly distributed over large areas. The sensitivity is much less when the people are located in discrete regions small in size to the total contaminated area and there are many overlapping bursts.

3. Wind variability causes a redistribution of risk (defined as the probability of receiving a lethal dose). This effect should be considered in situations where the population distribution is irregular.

4. For limited laydowns, it appears that the risk for 10 percent incidence of latent cancer is about the same as for a 50 percent incidence of early mortality. The corresponding risk for 50 percent incidence of latent cancer is about one-third less.

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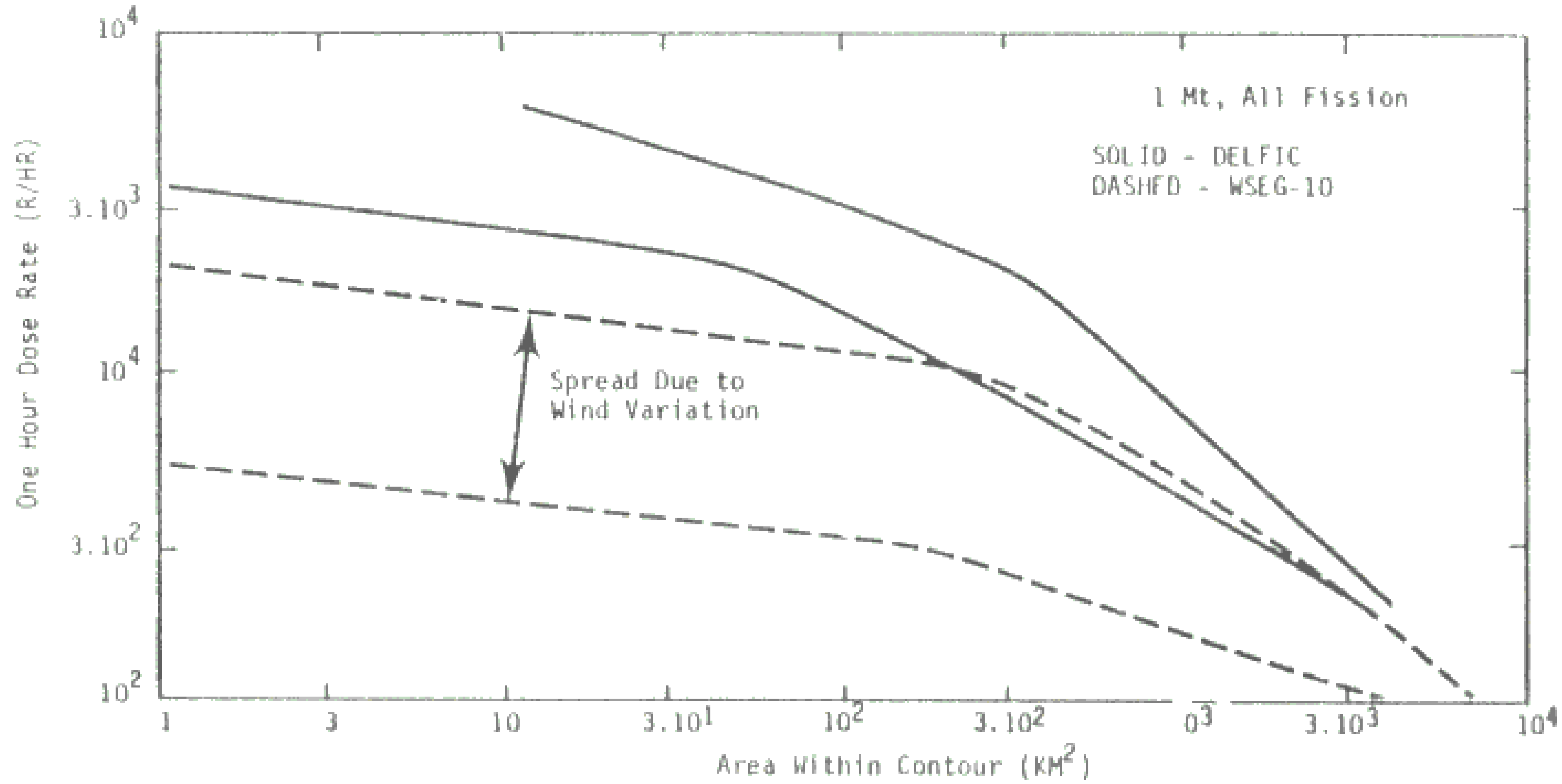

Figure A.1 Comparison of DELFIC and WSEG-10 Over a Variety of Wind Conditions.

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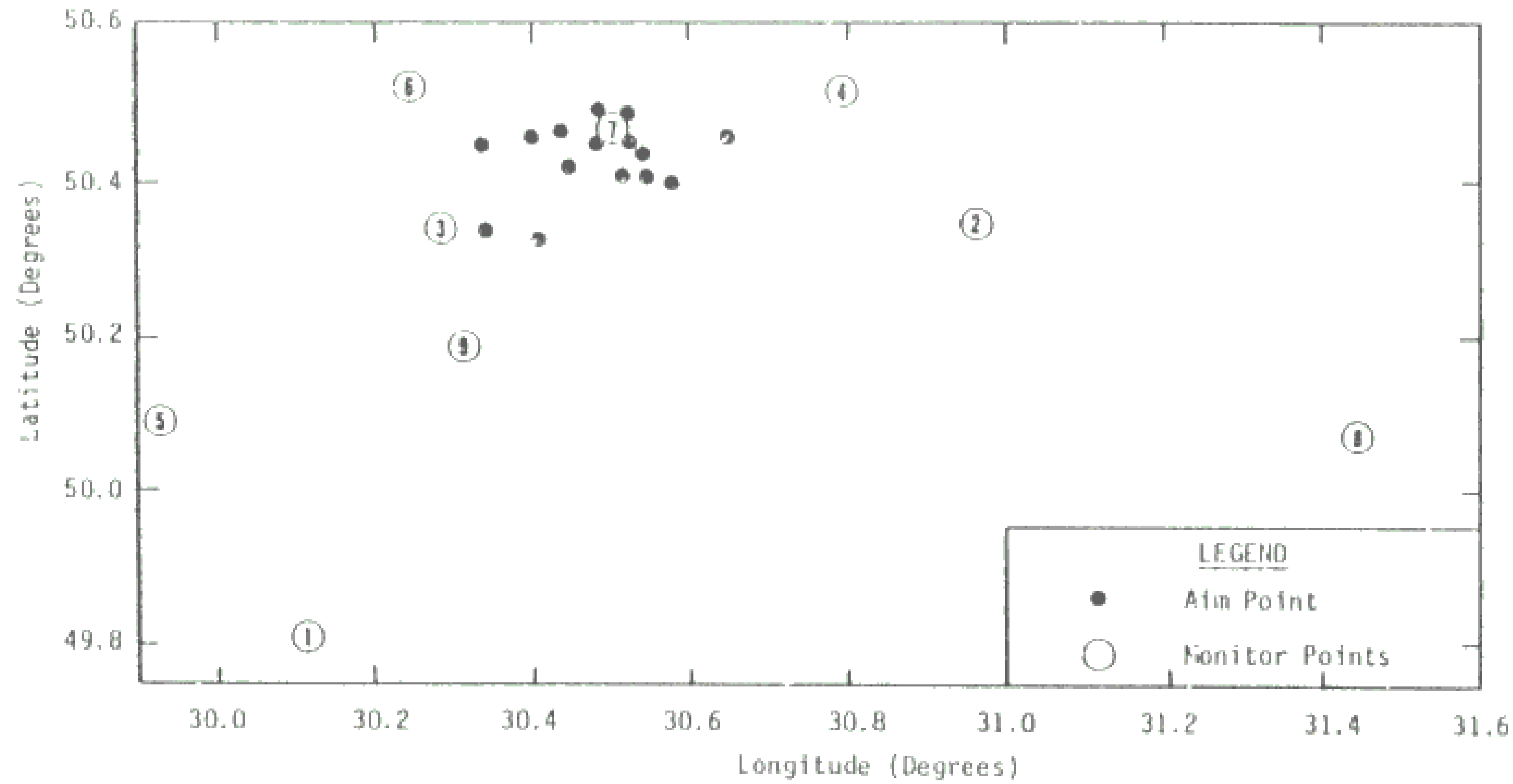

Figure A.2 Location of Aim Points and Population Centers

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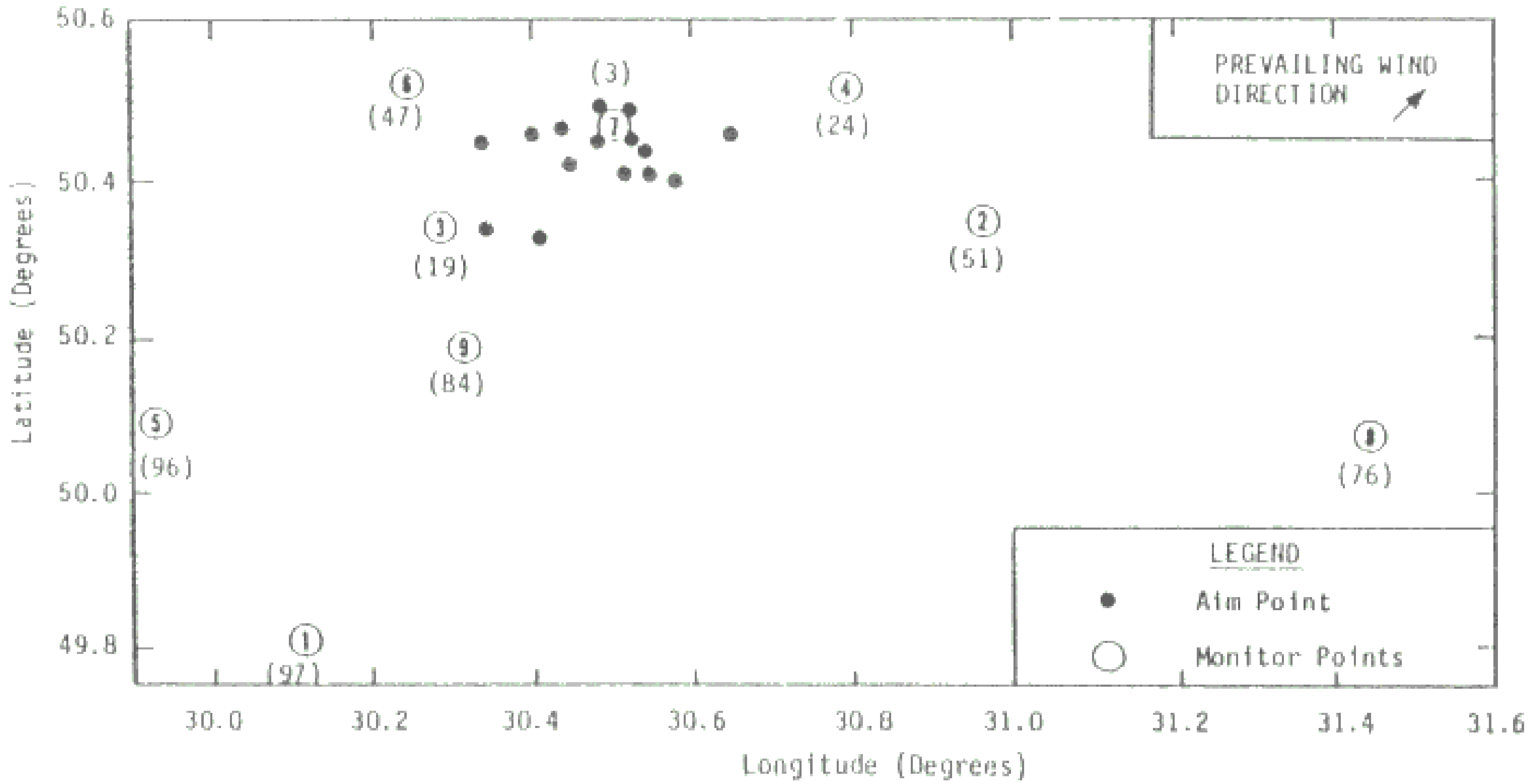

Figure A.3 Probability (%) for Fallout Avoidance (Parenthetical numbers are the probabilities for the monitor points)

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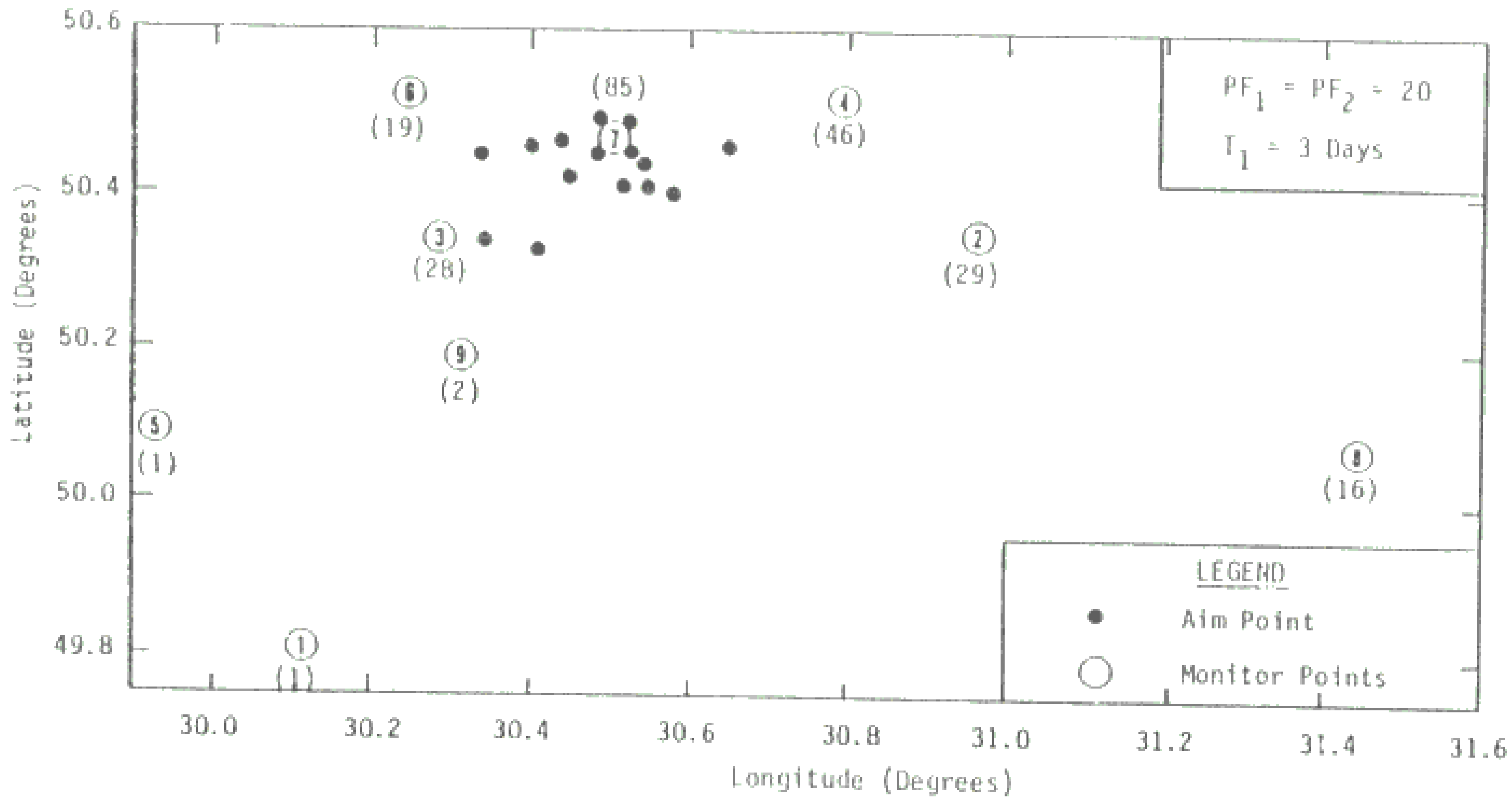

Figure A.4 Risk (Probability (%) for Exceeding 450R)
(Parenthetical numbers are the probabilities
for the monitor points)

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Table A.I Lethal Area for a 1 Mt (50% Fission) Burst.

PF_1	PF_2	T_1	Area (Km^2)
200	20	3D	0.5 - 60
		7D	0 - 12
		2 Wks	0
	2	3D	12 - 200
		7D	0.3 - 40
		2 Wks	0 - 1.0
20	20	3D	12 - 200
		7D	3 - 100
		2 Wks	0.3 - 40
	3	3D	70 - 400
		7D	12 - 200
		2 Wks	3 - 100
3	3	3D	200 - 600
		7D	200 - 600
		2 Wks	200 - 600

Table A.2 Sensitivities in Shelter Parameters

CASES OF SIGNIFICANCE*		
PF_1	PF_2	T_1 (Days)
200	3-20	<3
20	20	<10
20	3	<21
3	3	ALL

*Defined as fallout lethal area exceeding the 6 psi area (55 Km^2)

Table A.3 Summary of Risk Dependence on Shelter Variations

Monitor* Point	Probability (%) of Fallout	Risk (Probability (%) of D > 450 R+)	Order of Risk
7	97	82 - 91	1
4	76	34 - 47	2
3	81	24 - 29	3
2	49	24 - 33	4
6	53	14 - 20	5
9	16	2	7
8	24	7 - 17	6
5	4	1	8
1	3	0 - 1	9

*Ordered according to intuitive assessment of risk.

+Range is over various shelter conditions.

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Table A.4 Upper Bound Risk Coefficients for Latent Cancer Fatalities

Type of Cancer	Age at Time of Irradiation	Latent Period (years)	Plateau Period (years)	Risk Coefficient (deaths/ 10^6/yr/rem)
Leukemia	*In utero*	0	10	15
	0-9.9	2	25	2
	10+	2	25	1
Lung	10+	15	30	1.3
Gastrointestinal tract:				
Stomach	10+	15	30	0.6
Rest of alimentary canal	10+	15	30	0.2
Pancreas	10+	15	30	0.2
Breast	10+	15	30	1.5[(a)]
Bone	0-19.9	10	30	0.4
	20+	10	30	0.2
All other	*In utero*	0	10	15[(b)]
	0-9.9	15	30	0.6[(c)]
	10+	15	30	1[(d)]

(a) Includes males and an assumed 50 percent cure rate.
(b) "All other" includes all cancers except leukemia.
(c) "All other" includes all cancers except leukemia and bone.
(d) "All other" includes all cancers except those specified in table.

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Table A.5 Risk Comparison

Monitor Point	Risk		
	LD_{50}*	LC_{10}+	LC_{50}+
2	28	28	15
4	39	40	30
6	18	18	13
7	89	89	65

*50 percent early somatic mortality.

+10 and 50 percent latent cancer.

(U) APPENDIX B

POPULATION DATA BASE GENERATION AND THE SIMULATION OF EVACUATION BY THE ESCAPE CODE

Census Population Data Base (Unevacuated)

The development of the unevacuated population data file is based on procedures developed under SAI's TANDEM upgrade program. In this procedure, operational maps are employed in conjunction with a graphics tablet (digitizing tablet), a Tektronix terminal and display screen, and a computer.

Using the Operational Graphics Maps (Scale 1:250,000), each map is placed on the digitizing tablet and a software routine is used to establish the coordinate reference scale for the map. For each non-TDI place of significance (determined by visual inspection of the places shown on the map), the digitzing pen is employed to mark the outer extremeties of the place (two points along a diameter). Software routines then compute the center between the two points which is used as the center of the P-95 circle and half the distance between the two points is used as the P-95 radius.

If population data for the particular place is available, which for the most part comes from a population listing provided by CIA (originally generated by DMA), this data is used. Otherwise population is based on a RAND-developed algorithm which relates P-95 radius to population. This algorithm was based on examination of demographic data for Eastern European countries and is as follows:

$$\text{P-95 Radius (nm)} = 0.5125 \ln (1.3 + 0.2P)$$

$$P = \text{population in thousands}$$

Because all the places shown on the maps cannot be digitized, (the size of the data base would be so large as to preclude useful employment of casualty assessment codes), and because population data for all the very small places is not available, a tallying procedure based on known Oblast data is used.

The ESCAPE Code

ESCAPE is a code developed by SAI for the purposes of developing an evacuated population data base from an unevacuated (census) population data file under preset, user specified, civil defense parameters. The code is intended for application against a census data base in which all the population places are represented by discrete P-95 circles. The basic operation of the code is described below.

Input to the code is a list of cities (including coordinates) to be evacuated. For each city to be evacuated, the code accesses the census population data file and sums the population from each of the P-95 circles belonging to the same city. From this population total a single P-95 radius is computed from the equation

$$P_{95} \text{ (nm)} = 0.5125 \ln (1.3 + 0.2 P)$$

where P = population in thousands

This algorithm was developed by the RAND Corporation based on statistical analysis of demographic and map data for the European continent.

From the area contained within this large P-95 circle, a selected percentage of the population is assumed to remain in the city to carry out vital functions, an additional percentage (also skilled laborers) is assumed to be dispersed into a zone which is within a five hour round trip commuting distance from the center of the city, and the remainder is assumed to be evacuated beyond the dispersal zone into the evacuated zone.

A weapons effects radius of 8.1 nm is added to radius of the P-95 circle. This radius acts as a buffer to 1.4 psi (0.1 kg/cm^2) blast effects for a 1 MT weapon and also accounts for some irregularities that may be present in the areal shape of the city being evacuated. The population in this buffer zone is also assumed to be evacuated beyond the dispersal zone.

The digitizing work is done by Oblast because this is the smallest entity for which year-by-year data is published by the USSR (In their statistical handbook). The population from all the digitized population places in the Oblast is summed, and added to the TDI data (which is used in its entirety) for the Oblast. This is then compared to the total Oblast population given in the 1976 statistical handbook. If the populations differ, the population places where the algorithm has been used are uniformly adjusted until the total population data is in agreement with the statistical handbook data.

The resulting population data base is thus a combination of TDI places plus the smaller digitized places that have been adjusted to account for the extremely small rural places that have not been digitized.

It should be noted that when each map has been digitized, a copy is made (on same scale as map) and overlayed on the map to verify the digitizing procedure

Evacuated Population Data Base

Two methods of generating evacuated population data bases have been employed. The first is based on a hand analysis which examines evacuation factors in fine detail. In this procedure, available transportation and transportation routes are taken into account and used in conjunction with material contained in Soviet civil defense manuals to arrive at an evacuated population representation.

Because this procedure is extremely time consuming and cannot be realistically employed for all major cities in the USSR, an alternate automated procedure has been developed. This procedure embodied in the "ESCAPE CODE" (a description of which is included) has been cross-checked with the detailed hand analysis procedures. While some differences in the resulting data base do occur (most of them minor in nature), these differences become insignificant in the overall damage assessment analysis procedures. Thus, we believe the automated procedure provides as valid a representation as the detailed procedures and even further provides the opportunity to easily change the evacuation parameters or factors for parametric analyses.

For the city of Kiev , two evacuated population representations were then developed. The first was based on a 90 percent evacuation of Kiev while the second was based on 50 percent evacuation. These were believed to be realistic bounds on the degree of evacuation that might be considered by the Soviets taking into account the potential spread in blast shelters believed to be available in the city of Kiev.

For the Moscow area, only one evacuated representation was developed and this was based upon a 50 percent evacuation of Moscow.

Analysis Tools

The CIVIC code was employed to determine detailed population fatalities and casualties resulting from the weapon laydowns employed.

This casualty assessment code (which includes fallout assessment) categorizes each population place (P-95 circle) as large urban, small urban, or rural based upon population density (Population divided by P-95 circle area). The user can then input at run time a distribution of shelter types in each P-95 circle (up to four types) according to this categorization. Inputs associated with each structure type are VNTK values for blast fatalities and casualties (along with damage sigma), fallout protection factors, and gamma and neutron transmission factors for the prompt radiation environment.

For the purposes of these analyses, distribution of population into four shelter types was made. These included single story residences, basements, hasty rural fallout shelters, and hardened urban blast shelters. Variations in the shelter distributions were also included in the analysis (as a function of the degree of evacuation) to determine the influence of this parameter on fatality estimates.

In concentric rings of five nm increments from the inner boundary of the dispersal region (P-95 radius + 8.1 nm), all population places contained within the annulus are accessed from the census population data file and assumed to sustain a hosting ratio of two (two people hosted for every person in the hosting location). As each population place is hosted, a running summation of the hosted population is maintained so that when the desired proportion of the population to be dispersed is reached, further hosting for the dispersal region will not be accomplished by the code. In this hosting procedure, no town larger than 28,000 in population is hosted because of the assumption that these may also contain targets against which weapons will be assigned. If the particular five nm annulus cannot host all the population to be dispersed, the next annulus of five nm is incremented and the process continued until all the population to be dispersed is accounted for. This then establishes the <u>inner</u> boundary of the <u>evacuation</u> zone.

The code now continues to access and host population places in terms of a 10 nm annulus to account for all population to be <u>evacuated</u> (from the city proper plus the buffer zone). A running total of the hosted population is maintained until all evacuated personnel have been accounted for at which time the evacuated population file for the city is complete. Each city designated for evacuation is completed in the same manner.

In the hosting process (dispersal and evacuated zones), every town for which hosting has been accomplished is flagged to prevent double hosting for those cases where there may be overlapping evacuation or dispersal regions due to closely spaced cities designated for evacuation.

It should be noted that the specific civil defense parameters, i.e., buffer zone radius, percentages of populations to be dispersed and evacuated, and hosting ratios are built into the code based on data from Soviet civil defense manuals. These parameters can be changes quite easily within the code structure, and if desired, the code can be changed to handle this data in the form of input variables.

As stated earlier, the code is oriented toward a specific type of population representation (all P-95 circles) such as contained in the TANDEM data bases maintained by SAI for the Defense Nuclear Agency. Thus, the READ, WRITE format statements in the code are specifically oriented toward the TANDEM population place record format. These can readily be changed if other similar types of data bases are to be employed.

The development of this code was initiated by SAI because of the highly time-consuming task of generating refined evacuated data bases which account for such details as the availability of evacuation routes, etc. (such as was accomplished by SAI for the city of Kiev). A comparison of data for the city of Kiev by the detailed process and by the automated procedure, showed some variations in the distribution of the population, but not enough to make significant differences occur in fatality and casualty estimates.

(U) APPENDIX C

ABBREVIATIONS

AFB	Air Force Base
CCTC	Command and Control Technical Center
CD	Civil Defense
CEP	Circular Error Probable
CIA	Central Intelligence Agency
C^3I	Command, Control, Communications & Intelligence
DCI	Director of Central Intelligence
DE	Damage Expectancy
DGZ	Desired Ground Zero
DIA	Defense Intelligence Agency
JSTPS	Joint Strategic Target Planning Staff
KFT	Kilofoot
KT	Kiloton
kg/cm^2	Kilograms per square centimeter
ln	Natural Logarithm
MT	Megaton
nm	nautical mile
NMCSSC	National Military Command System Support Center
PF	Protection Factor
POA	Probability of Arrival
psi	Pounds per square inch
P-95	Population circle as defined by the radius (in nautical miles) which encompass 95 percent of the built-up urban structures in the area
Q and A	Numerical parameters used in calculating fatalities (see Section 3)
RAD	Radiation Absorbed Dose
SAI	Science Applications, Inc.
SIOP	Single Integrated Operational Plan
SRAM	Short Range Attack Missile

SRI	Stanford Research Institute
SSPK	Single Shot Probability of Kill
TDI	Target Data Inventory
TF	Transmission Factor
VNTK	Vulnerability Number Target K-factor
WR	Weapon Radius

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