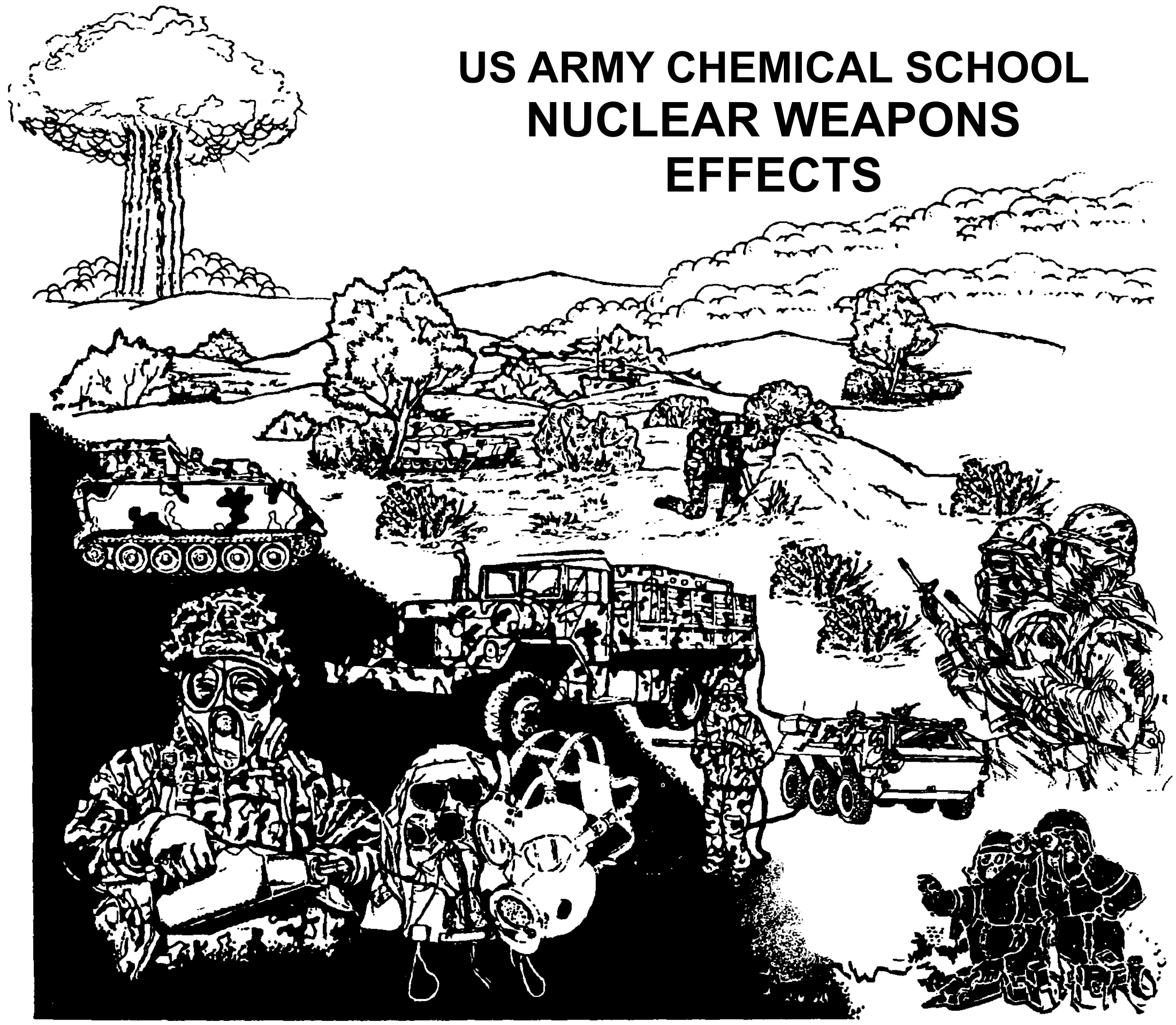
SUBCOURSE
CM5206

EDITION
B

US ARMY CHEMICAL SCHOOL
NUCLEAR WEAPONS EFFECTS



THE ARMY INSTITUTE FOR PROFESSIONAL DEVELOPMENT
ARMY DISTRIBUTED TRAINING PROGRAM

AIPD
READINESS/PROFESSIONALISM THRU GROWTH

NUCLEAR WEAPONS EFFECTS

Subcourse Number CM5206

EDITION B

United States Army Chemical School
Fort McClellan, Alabama 36205-5020

16 Credit Hours

Edition Date: August 1997

SUBCOURSE OVERVIEW

We designed this subcourse to teach you about nuclear burst information, procedures for yield estimation, fallout predictions, radiological monitoring, surveys, and operations, as well as radiological decontamination.

There are no prerequisites for this subcourse.

This subcourse reflects the doctrine which was current at the time it was prepared. In your own work situation, always refer to the latest official publications.

Unless otherwise stated, the masculine gender of singular pronouns is used to refer to both men and women.

TERMINAL LEARNING OBJECTIVE

ACTION: You will identify nuclear burst information; yield estimation; wind vector plots; fallout predictions; radiological monitoring, surveys, operations and decontamination.

CONDITION: Given information about nuclear bursts; wind vector plots; yield estimation; fallout predictions; radiological monitoring, surveys, operations and decontamination.

STANDARD: To demonstrate competency of this task, you must achieve a minimum of 70% on the subcourse examination.

REFERENCES: FM 3-3-1, FM 3-5 and GTA 3-6-8.

TABLE OF CONTENTS

LESSON 1

NUCLEAR BURST INFORMATION

Critical Task: 031-503-3005
031-506-2052

OVERVIEW

LESSON DESCRIPTION:

In this lesson you will learn to evaluate nuclear burst information in order to prepare an NBC 1 (Nuclear) Report.

TERMINAL LEARNING OBJECTIVE

ACTION: Prepare an NBC 1 (Nuclear) Report.

CONDITION: Given information about nuclear burst reporting, required information, and proper format for an NBC 1 (Nuclear) Report.

STANDARD: Demonstrate competency of the task skills and knowledge by responding to the multiple-choice test covering preparation of NBC 1 (Nuclear) Reports.

REFERENCE: FM 3-3-1.

INTRODUCTION

This lesson presents information on nuclear weapons effects which will enable the commander and the troops to continue to operate effectively and successfully in a radiological environment. Nuclear burst information and yield estimation are used to prepare an NBC 1 (Nuclear) Report.

PART A - NUCLEAR BURST AND YIELD ESTIMATION

The use of nuclear weapons is as much a threat today as before. The first use of a nuclear weapon by the enemy will require reporting procedures which are rapid and accurate. In a nuclear threat situation there are specific segments of information which must be obtained. To make an estimate of a nuclear situation, it is necessary to know ground zero, yield, time of burst, and type of burst. Furthermore, in order to prepare either a detailed or simplified fallout prediction, it is necessary to know the location of ground zero, yield, and time of burst.

This information is derived from nuclear burst reports submitted by reporting units. The providing of correct data requires both knowledge and attention to procedures by personnel of the reporting unit.

Under conditions of nuclear warfare, unit commanders at all echelons are interested in obtaining a quick "gross" fix on the location of ground zero (GZ) for any nuclear burst that is close enough to be observed. This information is used by the commander in making an estimate of the situation and in determining what impact, if any, the burst will have on executing the assigned mission.

The location of GZ may be determined in several different ways simultaneously at the various levels of command. Locally, the commander may be able to ascertain location of GZ of very small nuclear explosions by direct observation. If so, the GZ location will be reported as indicated in the NBC 1 (Nuclear) report.

For larger yields and more distant nuclear bursts, the unit can use the azimuth and flash-to-bang distance from its observation point to determine GZ location. Generally, units reporting large nuclear detonations will be from 10 to 50 kilometers (km) from ground zero. They will report flash-to-bang time, coordinates of observer location, and azimuth to the nuclear burst cloud along with other items specified in the nuclear burst report. This data will be plotted by the NBCC and the GZ locations determined from intersecting azimuths from two or more observation points. When azimuth data is incomplete, GZ location can also be determined from intersecting arcs using radii of flash-to-bang distances from two or more observation points. Ground zero will normally be determined by the NBCC from the intersection of azimuths from two or more observation points using report data corresponding to the same date and time of detonation. Combinations of arcs using radii of flash-to-bang distances and azimuths from observation points can also be used.

1. Nuclear Cloud Development.

Development of nuclear clouds is divided into three stages for the purpose of yield estimation. The fireball stage exists from the instant of detonation until the generally spherical cloud of explosion products ceases to radiate a brilliant light. During this stage the fireball must not be observed because the very brilliant light is capable of causing permanent damage to the eyes. As the brilliant light fades into a dull reddish glow, the fireball stage transforms into the nuclear burst cloud stage. The nuclear burst cloud stage begins when the light of the fireball has faded to the point that the cloud from the explosion can be safely observed by the unprotected eye. At this time the nuclear burst cloud may be seen as either a spherical cloud (high airburst) or a mushroom-type cloud (low air or surface burst).

Relatively low yield nuclear surface bursts have clouds similar to those produced by surface bursts of conventional explosives. Severe turbulence and rapid growth in height and width are characteristics of this stage of development. This nuclear burst cloud stage continues until the cloud ceases to grow in height (stabilizes in height), although the width may continue to increase. Height stabilization occurs from about 4 to 14 minutes after the explosion, depending upon the yield. When the cloud ceases to grow in height, the stabilized cloud stage begins and continues as long as the cloud is detectable. Development of the cloud formation phases of a typical surface nuclear burst is illustrated in Figure 1-1.

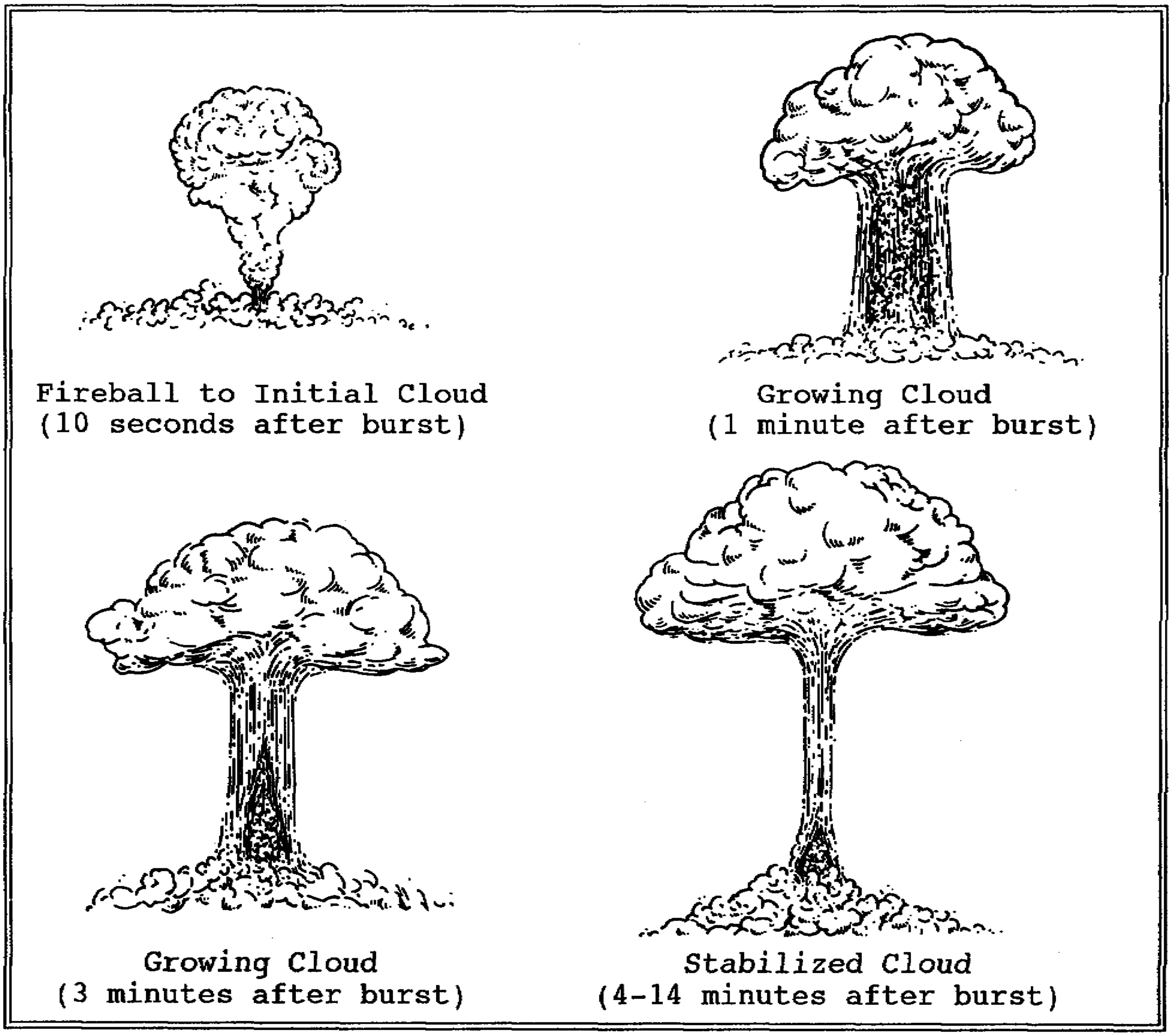


Figure 1-1. Nuclear Cloud Development (Surface Burst)

2. Nuclear Burst Parameters for Yield Estimation.

Nuclear burst parameters have been correlated with yield and are presented in nomograms, each of which is an independent means of determining an estimated yield (Figures 1-3 and 1-4). An estimated yield can be determined from nomograms, if any of the following combinations of burst parameters (listed in order of decreasing reliability) are known.

- Distance to ground zero (or flash-to-bang time) and nuclear burst angular cloud width, measured 5 minutes after detonation.
- Stabilized cloud-top or cloud-bottom height.
- Distance to ground zero (or flash-to-bang time) and stabilized cloud-top or cloud-bottom angle.
- Illumination time (least reliable).

A primary measurement is the time from "flash-to-bang". This is the time interval, in seconds, between the detonation, "blue-white flash," and arrival of the sound of the explosion or the shock wave at the observer's position. The sound of the explosion travels at an average velocity of 350 meters (1122.8 ft.) per second. The distance, in meters, from an observer to ground zero can be estimated by multiplying the flash-to-bang time in seconds by 350. Divide the product by 1000 to obtain the distance in kilometers from the explosion to the observer. The distance may be obtained directly from the nomogram using the scales on the right side, as shown in Figure 1-4.

A second measurement is the azimuth from the observer to the mushroom stem or cloud center. This reading should be made immediately after the passage of the shock wave or bang from the explosion. This measurement is reported to the TOC of higher headquarters to assist in locating ground zero. The width of the nuclear cloud burst is measured by an observer 5 minutes after the time of detonation. This angular dimension is measured in mils or degrees.

Two important cloud angle measurements are (1) stabilized cloud-top angle and (2) stabilized cloud-bottom angle. Each of these measurements is made approximately 10 minutes after the burst.

The stabilized cloud-top angle is the vertical angle in mils or degrees measured from ground level to the top of the cloud. Likewise, the stabilized cloud-bottom angle is the vertical angle in mils or degrees measured from ground level to the intersection of the stabilized cloud and the stem (Figure 1-2).

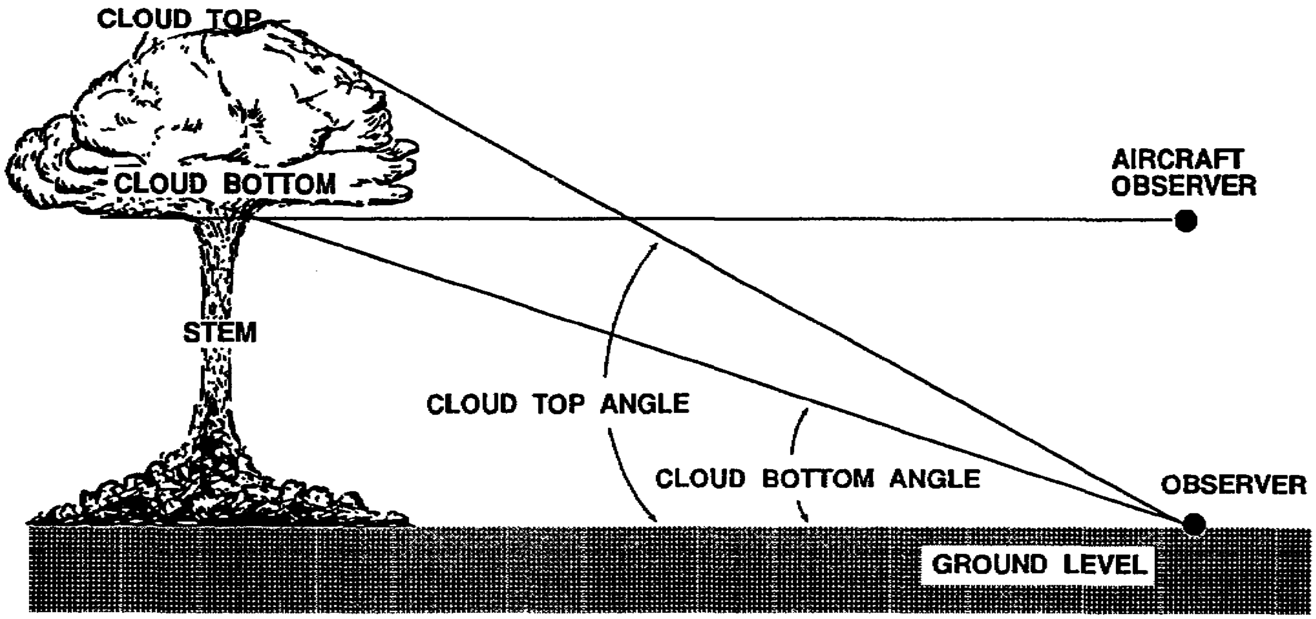


Figure 1-2. Stabilized Nuclear Burst Cloud (Surface Burst)

a. Nuclear Burst Angular Cloud Width.

Figure 1-3 is used to determine yield from nuclear burst angular cloud width and distance to ground zero (or flash-to-bang time). The right-hand scale is the nuclear burst angular cloud width in mils or degrees, the center scale is the flash-to-bang time in seconds and the distance in kilometers to ground zero, and the left-hand scale is the yield in kilotons (KT). To use Figure 1-3, place a hairline from the point of the right-hand scale, representing the nuclear burst angular cloud width at 5 minutes after detonation, through the point on the center scale representing flash-to-bang time or distance to ground zero. At the point of intersection of the hairline and the left-hand scale, read the yield.

Example: A nuclear burst has occurred and you have obtained the following information.

Flash-to-bang time	=	60 seconds
Angular cloud width	=	280 mils

Using the yield estimation nomogram, Figure 1-3, determine the approximate yield. It is emphasized that these yield calculations are field estimates.

- Using the hairline, connect 280 mils on the right hand scale with 60 seconds in the Flash-to-Bang column.

- Read the KT yield from the left-hand column where the hairline intersects.

- The yield is approximately 50 KT.

b. Stabilized Cloud-Top Height or Cloud-Bottom Height.

Cloud-top or cloud-bottom height, when stabilized, can be closely measured by an observer in an aircraft. If cloud width or angles cannot be measured, the use of tactical aircraft for this purpose may be justified. Measurements (in meters or feet above the surface of the ground) should be made at approximately 10 minutes after the burst.

c. Stabilized Cloud-Top Angle or Cloud-Bottom Angle.

Figure 1-4 is used to determine yield from distance-to-ground zero (or flash-to-bang time) and either stabilized cloud-top angle or stabilized cloud-bottom angle measurements. The right-hand scale gives the flash-to-bang time in seconds on the left side and distance in kilometers to ground zero on the right side. The center scale is the cloud-top angle or cloud-bottom angle, measured in mils on the left of the scale and in degrees on the right of the scale. The left-hand scale is actually two scales. On the left of the left-hand scale are listed the yields to be read when using stabilized cloud-bottom angle measurements; on the right of this left-hand scale are listed the yields to be read when using the stabilized cloud-top angle measurements.

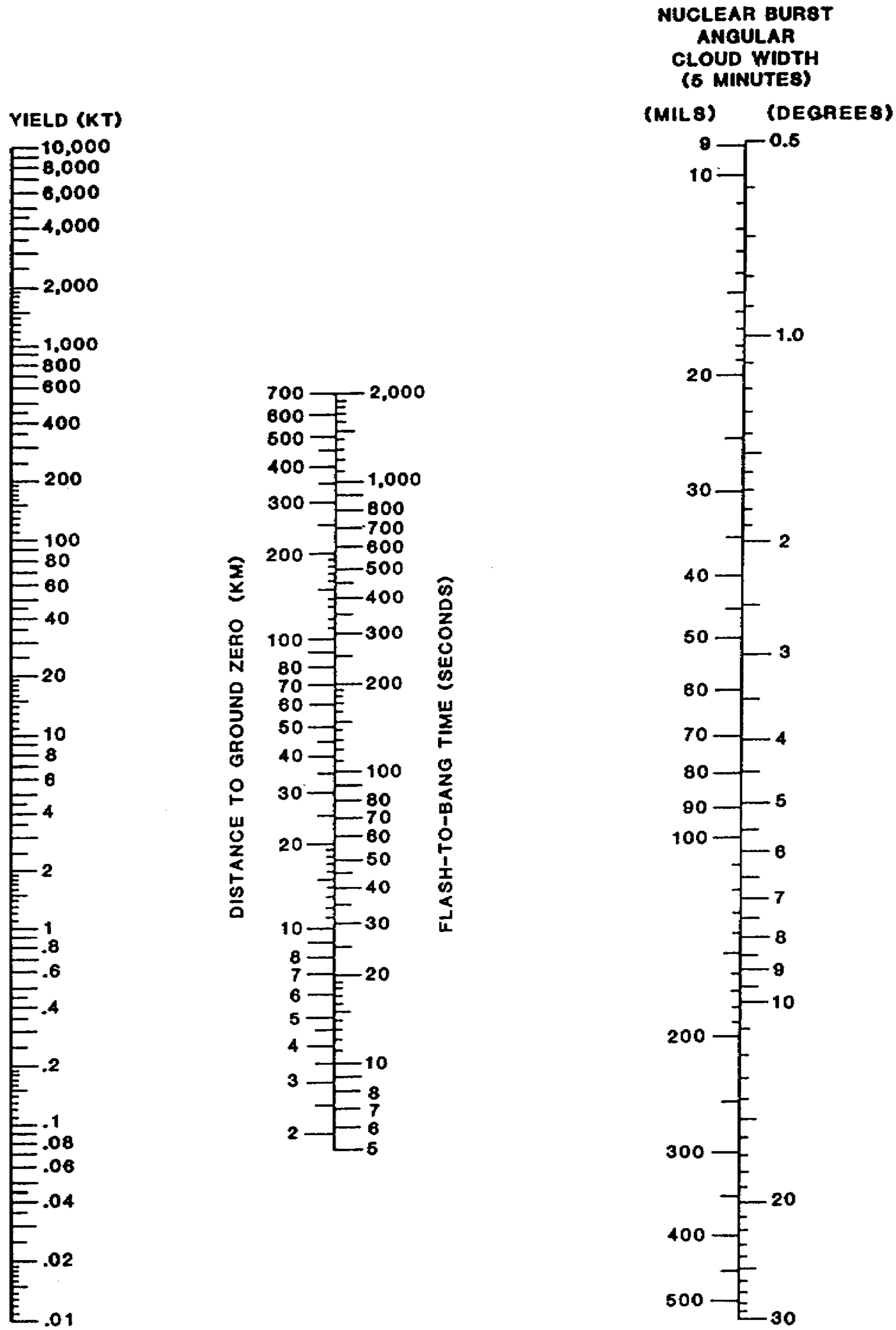


Figure 1-3. Yield Estimation
(Flash-to-Bang Time or Distance to Ground Zero Versus Nuclear
Burst Angular Cloud Width At 5 Minutes After Detonation)

To use Figure 1-4, place a hairline through the point on the right-hand scale representing distance-to-ground zero or flash-to-bang time and through a point on the center scale representing either the cloud-top angle measurement or the cloud-bottom angle measurement. At the point of intersection of the hairline and the left-hand scale, read the yield. If a cloud-top angle measurement is used on the center scale, read the yield on the right side of the left hand scale entitled "Yield (Cloud Top)." If a cloud-bottom angle measurement is used, read the yield on the left side of the left-hand scale entitled "Yield (Cloud Bottom)." For example, an observer reports a flash-to-bang time of 120 seconds, angle to cloud top of 300 mils, and angle to cloud bottom of 200 mils. Place a hairline from 120 seconds on the flash-to-bang time scale through 300 mils on the left side of the angle scale; the yield is read as 60 KT on the right side (cloud top) of the yield scale. Place a hairline from 120 seconds on the flash-to-bang time scale through 200 mils on the left side of the angle scale; the yield is read as 60 KT on the left side (cloud bottom) of the yield scale.

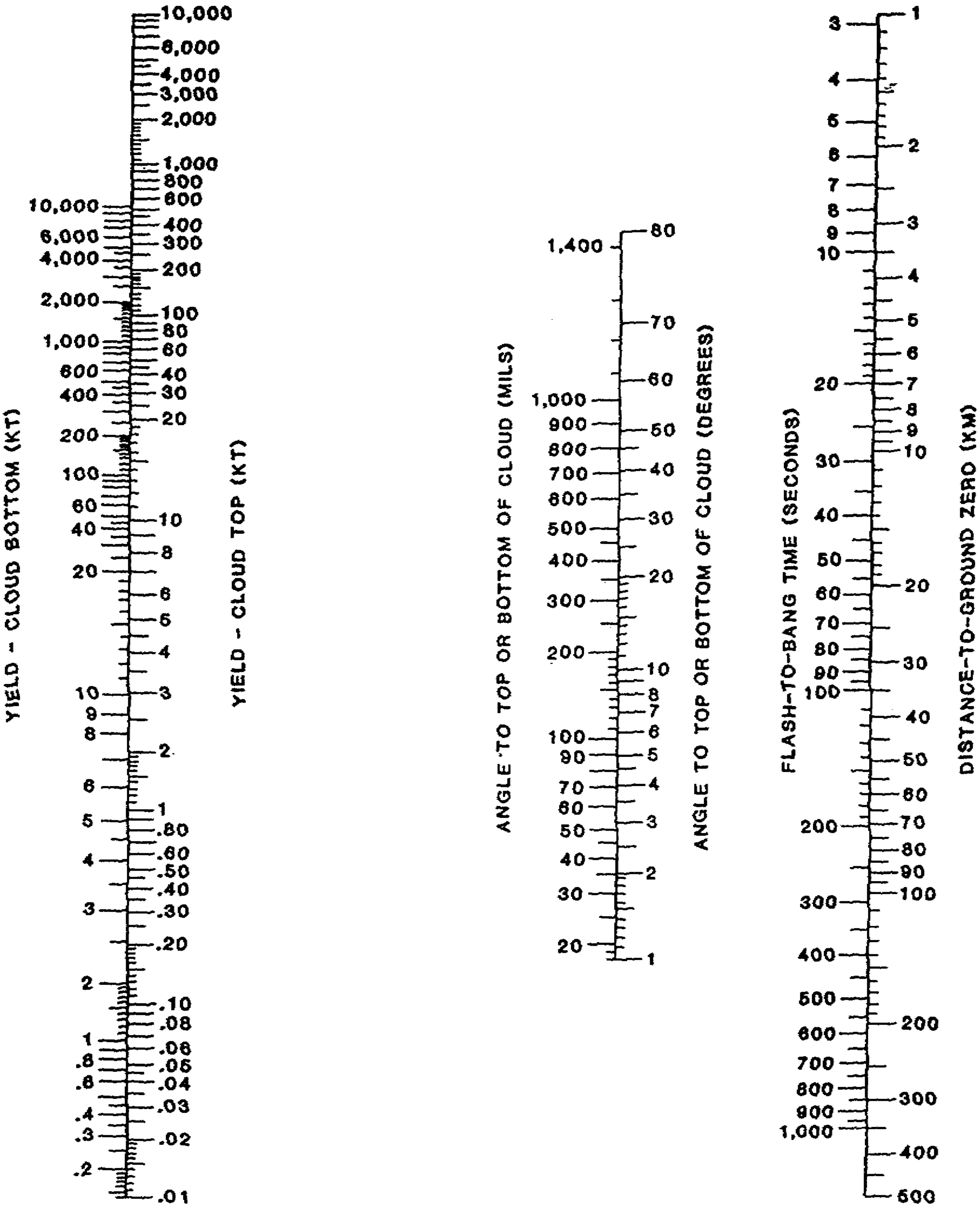


Figure 1-4. Yield Estimation
(Flash-to-Bang Time Versus Stabilized Cloud-Top Angle
or Stabilized Cloud-Bottom Angle)

d. Illumination Time.

As a field expedient, yield may be estimated from the measurement of the illumination time of a nuclear burst, especially during hours of darkness or poor visibility. However this method should be used only if it is impossible to obtain cloud parameters as discussed, since this method only gives a yield estimate on the order of a factor-of-10. Techniques for measuring illumination time will vary, depending on the situation, but under no circumstances should the observer attempt to look directly at the fireball since this can result in permanent damage to the eyes. The illumination time may be estimated by the observer who has taken shelter in a foxhole by noting the light reflected into the foxhole. The observer can look at the floor of the foxhole and still sense the duration of the flash or reflected light. Counting in seconds will probably be the most effective way of determining the illumination time since the “dazzle” (flash blindness) effect will preclude the reading of watches.

The chart below shows rough estimations of yield, using illumination time.

Illumination Time (Seconds)	Yield (KT)
less than 1	1 to 2
1	2.5
2	10
3	22
4	40
5	60
6	90
7	125
8	160
9	200
10	250
12	325
14	475
16	700

3. Nuclear Yield Calculator.

The M4A1 Nuclear Yield Calculator, a component of the M28A1 Nuclear Calculator Set, is designed to provide a rapid method for calculating nuclear yield from a nuclear burst. The old M4 Nuclear Yield Calculator, a component of the M28 Nuclear Calculator Set, should not be used because it gives a yield estimate that is inaccurate.

a. General.

The calculator permits estimation of yield when the illumination time is known and when the flash-to-bang time (or distance from burst) and any of the following parameters are known:

(1) Stabilized cloud-top angle.

(2) Stabilized cloud-bottom angle.

(3) Nuclear burst angular cloud width (measured at 5 minutes after the burst).

b. Description.

Instructions for the use of the M4A1 Calculator are as follow:

(1) To obtain yield from cloud bottom or top:

(a) Align flash-to-bang time with elevation angle.

(b) Read yield on appropriate scale under pointer.

(2) To obtain yield from cloud width:

(a) Align flash-to-bang time with cloud width.

(b) Read yield under pointer.

(3) TO obtain yield from illumination time:

(a) Set pointer to illumination time.

(b) Read yield under pointer.

c. Sample calculations using M4A1.

(1) Yield from cloud width:

(a) Align 30 seconds on flash-to-bang time scale with 300 mils on observed cloud width scale; read answer under pointer. Answer: 8 ± 2KT.

(b) Align 35km on distance-to-ground zero scale with 180 mils on observed cloud width scale; read answer under pointer. Answer: 50 ± 2KT.

(2) Yield from fireball illumination time. This method of estimating yield is to be utilized only when other methods of calculations are not possible. Determine fireball illumination time and read yield off yield scale.

(3) Yield from stabilized cloud bottom or top angle. Align 60 seconds on flash-to-bang scale with 250 mils on elevation angle scale; read answers under pointer. Answer: Cloud bottom 10.8 ± 2KT, cloud top 3.1 ± 2KT.

PART B - NUCLEAR BURST REPORTING

The present reporting system is prescribed in NATO STANAG 2103. The format provides a rapid means of disseminating information. If security is necessary, the commander may direct that rapid and secure means be used, if available. When a first-use report is transmitted, it must be under a FLASH precedence. This initial NBC 1 (Nuclear) Report is sent to the next higher headquarters. Subsequent NBC 1 (Nuclear) Reports are under an IMMEDIATE precedence to the same headquarters.

1. Nuclear Burst Reporting.

Nuclear burst information must be obtained and reported to provide data for determining the location of ground zero and estimating nuclear yield. Normally, only headquarters units of field artillery and air defense artillery battalions and batteries are the most suitable units for collecting and reporting of nuclear burst data. Appropriate commanders may designate other units at their discretion. Small units should train specific personnel to collect nuclear burst data. Small units not specifically designated as reporting units should submit NBC 1 (Nuclear) reports only when requested to do so by higher headquarters. It is unlikely that any single unit will be in a position to obtain all the information specified in the nuclear burst report.

2. Fallout.

Exclusive of the damage from the explosion, the harm from fallout may be extensive. Fallout may be simply defined as the settling to the earth of airborne particles of radioactive material resulting from a nuclear explosion. The final location of fallout depends primarily on (1) the heights from which the fallout particles begin their descent and (2) the wind structure between the ground and the various parts of the nuclear cloud when fallout begins.

It is important to expect militarily significant fallout from a surface burst. This occurs because a considerable amount of soil is vaporized and a large amount of dirt is drawn upward by the updraft created by the rising fireball. As a result, the radioactive material condenses into relatively large particles which fall back to earth rather quickly. While the area covered is not as large as a comparable airburst, the radioactivity in any one place can be considerable.

The fallout from an airburst is not normally militarily significant. In an airburst, no soil is vaporized into the fireball and only a relatively small amount of dirt is carried up into the fireball by the up-draft. The materials condense into very small particles which do not fall to earth very rapidly. Some of these particles may travel around the world several times before finally settling on the ground as fallout. This means the contamination will be spread over a large area, but the activity will have decayed to a low level.

These are the two primary nuclear bursts to which the military must be attentive and assure that NBC reports are prepared, transmitted, and processed rapidly.

3. The Nuclear Burst Report (NBC 1).

The purpose of the NBC 1 is to provide nuclear burst information to commanders, as quickly as possible. This information is essential to commanders and staffs for analysis and estimation of the situation and for fallout prediction.

The format for NBC reports is contained in the Graphic Training Aid, GTA 3-6-3. This GTA card is pocket sized. It is designed to be carried by the individual soldier. On the inside of the card are the formats for NBC reports. On the back of the card are explanations of each alphabetical letter used in the reports.

The Initial NBC 1 (Nuclear) Report gives basic data compiled at unit level and is submitted as soon as possible after the attack. This report should contain, as a minimum, the date/time of detonation, type of burst, and direction of attack from the observer. This information is reported as lines BRAVO, CHARLIE, DELTA, and HOTEL. When available, information on lines JULIET and KILO also should be reported in the Initial NBC 1 (Nuclear) Report. When additional information becomes available, it is forwarded using a Subsequent (follow-up) NBC 1 (Nuclear) Report. An explanation of each line item in the NBC 1 (Nuclear) Report is given in GTA 3-6-3.

When an Initial or Subsequent NBC 1 (Nuclear) Report is prepared, the letter lines are preceded by six lines which identify the report. These lines state the precedence, date/time of the report (local or ZULU), security classification, sender, receiver, and type of report, see Figure 1-5.

A Subsequent NBC 1 (Nuclear) Report has the same format. It will include additional letter items as more information is obtained. Additional subsequent NBC 1 Reports may be submitted until all known information has been transmitted.

1. PRECEDENCE
2. DATE/TIME
3. SECURITY CLASSIFICATION
4. FROM
5. TO
6. NBC 1 (NUCLEAR) REPORT
   BRAVO (POSITION OF OBSERVER)
   CHARLIE (DIRECTION OF ATTACK)
   DELTA (DATE/TIME ATTACK STARTED)
   HOTEL (TYPE OF BURST - AIR, SURFACE, OR UNKNOWN

Figure 1-5. NBC 1 (Nuclear) Report

4. Nuclear Burst Data Collection.

Whether you are a designated observer or an alternate unit observer, there is a recommended sequence for obtaining nuclear burst data.

At the instant of the "blue-white flash," hit the ground facing away from the burst. Start counting slowly - 1000 and one, 1000 and two, and so on until arrival of the shock wave or bang. Remain in position, preferably under cover, until the shock wave arrives and continue counting one more second.

After passage of the shock-wave and the bang, read your watch and observe the developing cloud. Record the count (seconds) on which the shock-wave and bang arrived at your location (letter item J). Also record the time (local or ZULU) of the burst (letter item D).

If you observe a thick dense stem connected to the mushroom part of the cloud, record "SURFACE" as letter item H. If the stem is not connected to the mushroom part of the cloud, report "AIR." Should you not be able to make a positive determine, report "UNKNOWN" as letter item H.

If you are able to observe ground zero (GZ) determine the coordinates of GZ and record them as letter item F.

If you cannot observe GZ, measure the azimuth from the observer's location to the center of the stem or mushroom cloud. Enter this azimuth in mils or degrees as letter item C.

Complete letter item B and submit the initial nuclear burst report (NBC 1).

LESSON 1

PRACTICE EXERCISE

The following items will test your grasp of the material covered in this lesson. There is only one correct answer for each item. When you complete the exercise, check your answer with the answer key that follows. If you answer any item incorrectly, study again that part of the lesson which contains the portion involved.

Situation: While on a mission, you are advised that there has been a report of a nuclear burst in your area of operation. You must be able to collect and transmit the correct information.

1. The yield estimation of a nuclear burst is associated with nuclear cloud development. Which is included in this development?

   A. Blast stage
   B. Fireball stage
   C. Nuclear cloud fallout stage
   D. Upward draft stage

2. Approximately how many minutes after a burst can a nuclear cloud be expected to stabilize?

   A. 1 to 3
   B. 4 to 14
   C. 15 to 20
   D. 25 to 30

3. Which is transmitted by a FLASH precedence?

   A. An initial NBC 1 (Nuclear) Report
   B. An NBC 3 (Nuclear) Report
   C. An NBC 4 (Nuclear) Report
   D. A subsequent NBC 1 (Nuclear) Report

4. Which precedence is used to send subsequent NBC 1 (Nuclear) Reports?

   A. FLASH
   B. IMMEDIATE
   C. ROUTINE
   D. URGENT

5. Small units should train specific personnel to collect nuclear burst data. Under what circumstances will this data be reported to higher headquarters?

   A. For all observed nuclear bursts
   B. When artillery units are not in the area
   C. Only when specifically requested
   D. When a surface burst is observed

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LESSON 1

PRACTICE EXERCISE

ANSWER KEY AND FEEDBACK

Item	Correct Answer and Feedback	
1.	B	Fireball stage The fireball stage . . . light. Part A, p. 1-2, para 1
2.	B	4 to 14 Height stabilization . . . yield. Part A, p. 1-3, para 1
3.	A	An initial NBC 1 (Nuclear) Report When a . . . precedence. Part B, p. 1-12, Intro
4.	B	IMMEDIATE Subsequent NBC 1 . . . headquarters. Part B, p. 1-12, Intro
5.	C	Only when specifically requested Small units . . . headquarters. Part B, p. 1-12, para 1

LESSON 2

WIND VECTOR PLOT

Critical Task: 031-506-3046

OVERVIEW

LESSON DESCRIPTION:

In this lesson you will learn about the purpose of a wind vector plot, upper air wind data, the ML-556/UM Fallout Prediction Plotting Scale and how to prepare a wind vector plot.

TERMINAL LEARNING OBJECTIVE

ACTION: Prepare a wind vector plot.

CONDITION: Given information and illustrations about the purpose of a wind vector plot, upper air wind data, Fallout Prediction Plotting Scale, ML-556/UM, and the procedures for preparing a wind vector plot using the plotting scale and the manual method.

STANDARD: Demonstrate competency of the task skills and knowledge by responding correctly to the multiple-choice test covering the use of upper air wind data and preparation of wind vector plot using the Fallout Prediction Plotting Scale, ML-556/UM, and the manual method.

REFERENCE: FM 3-3-1.

INTRODUCTION

During a nuclear attack, radiation in large quantities will be present. Through the use of the procedures taught in this lesson, you will be able to identify and determine the nuclear burst parameters for field estimation, as well as the procedures for conversion of the upper air wind data for use in the NBCC to prepare the fallout wind vector plot.

PART A - THE PURPOSE OF THE WIND VECTOR PLOT

On the battlefield of today, it is important that commanders have the capability of evaluating the effects of enemy nuclear weapons on units and operations. Nuclear weapons differ from high explosive conventional weapons, not only in explosive effects, but in the widespread effects of radioactive fallout. Most of the fallout will settle back to earth within the area of ground zero. However, large quantities of fallout particles will be carried downwind of ground zero by the upper air currents. Due to the lethal effects of fallout on personnel, commanders must have the personnel, equipment, and knowledge necessary to determine the hazard area. Through this determination, the commanders can take the necessary actions to protect troops and equipment. A current Effective Downwind Message in the hands of trained personnel can provide the commander with the information necessary for a life-saving decision. To develop the information, it is necessary to know how to make a wind vector plot, compute nuclear data, prepare an Effective Downwind Message, and the procedures for disseminating the Effective Downwind Message.

When a nuclear weapon is detonated, it is characterized by the mushroom cloud reaching high into the air, the brilliant flash, and the tremendous blast. The mushroom cloud created by a surface or low air burst is debris being picked up, vaporized, and becoming radioactive. The majority of this material will fall back to earth in the vicinity of ground zero; however, a large amount of these radioactive particles will remain aloft and will be carried away from ground zero by the wind. The final location of fallout depends mainly on the heights from which the fallout particles start their descent and the wind structure between the ground and various parts of the nuclear cloud when these particles are falling. The heights from which the particles start falling depend on the yield of the weapon, the size of the particle, and existing weather conditions. Thus, since the yield is determined from nuclear burst information, the reliability of the fallout prediction depends to a great extent on the upper air wind data and the nuclear burst information available.

The wind vector plot is used to determine the lateral limits of fallout, the effective downwind direction, and the effective wind speed. This plot is prepared by the NBC Center (NBCC) on receipt of new upper air wind data. It is prepared on overlay paper, oriented to grid north, and drawn to convenient scale. The plot consists of a series of vectors representing wind layers between the surface of the earth and the height to which upper air wind data are obtained. The vectors are plotted head to tail, and each vector represents the distance and direction a nominal size particle would travel over the earth while falling through the wind layer. The nominal size particle is defined to be of such size (a spherical particle 143 microns in diameter) as to require 3 hours to fall from a height of 11,000 meters to the ground. The significance of the wind vector plot is that after it is oriented by the GZ tickmark and grid north, it represents a series of points on the ground where the nominal size particles are expected to land. That is, a nominal size particle starting its downwind drift (fall) from a height of 30,000 meters is expected to land on the ground at the point represented by 30,000 meters on the wind vector plot. Similarly, a nominal size particle starting at 29,000 meters is expected to land on the ground at a point halfway between 28,000 meters and 30,000 meters on the wind vector plot. A line drawn from GZ through a particular height point on the wind vector plot represents the locus of points on which all fallout particles from that particular height are expected to land. Heavier particles will land closer to ground zero than will the lighter ones, but all the particles starting from that particular height are expected to land along this line. The plot is available at the NBCC and is ready for use when a fallout-producing nuclear burst occurs.

1. Field Artillery Upper Air Wind Data.

Upper air wind data for fallout prediction by tactical units are normally obtained from division or corps field artillery meteorological sections. These sections forward meteorological information to fire direction centers (FDC) and to appropriate fire support coordination facilities (FSCC/FSE), using the procedures and format established by Army Field Manuals and unit standing operating procedures.

The network of field artillery meteorological sections in the corps sector provides all FDC and FSCG/FSE within the corps with the: (1) average wind speed in knots for each 2,000 meter layer above the mean altitude of the reporting meteorological section; and (2) wind direction to the nearest 10 mils from which the winds are blowing. This data is reported in accordance with the following heights and schedules:

a. To 30,000 meters or the bursting height of the balloon, whichever comes first, four times daily at 0600, 1200, 1800, and 2400 hours Greenwich Mean Time (GMT) /ZULU time. Minimum acceptable height is 24,000 meters.

b. To 18,000 meters eight times daily at 0200, 0400, 0800, 1000, 1400, 1600, 2000, and 2200 hours GMT/ZULU time. Minimum acceptable height is 14,000 meters.

Table 2-1 shows an example of upper air wind data as it is received from an artillery meteorological section.

The data listed in the table are transmitted to the NBCC by means of established communication nets. Division and Army FSCC/FSE monitor this net to obtain data directly. The FSCC/FSE relays the upper air wind data to the NBCC.

U.S. Army Field Artillery upper air wind data is preferable to wind data from other sources when the data is obtained from an observation point not more than one and one-half times as far from the actual or expected ground zero as the data from other sources.

Table 2-1. Field Artillery Upper Air Wind Data

WIND LAYER (10^3 Meters)	WIND DIRECTION (Mils)	WIND SPEED (Knots)
0-2	1240	9
2-4	1420	13
4-6	1600	18
6-8	1780	13
8-10	1960	9
10-12	2310	9
12-14	2850	13
14-16	3200	13
16-18	3560	18
18-20	3740	14
20-22	3820	18
22-24	3910	27
24-26	3910	26
26-28	3910	34
30 Balloon burst		

NOTE
To convert mils to degrees, divide the number of mils by 17.8.

2. Upper Air Wind Data From Other Sources.

Upper air wind data for fallout prediction, when U.S. Army Field Artillery wind observations are not available, may be obtained from other sources. These upper air wind data must provide wind speeds and directions from consecutive wind layers above the observing station or altitude layers above mean sea level. For example, wind direction to the nearest 10 degrees from the true north and wind speed to the nearest knot may be obtained from Air Weather Service (AWS) detachments within the Field Army. The primary source for upper air wind data in the continental United States is the U.S. Weather Bureau, which reports wind direction to the nearest 10 degrees and wind speed to the nearest knot. Wind direction is the direction from which the wind is blowing. Upper air wind observations are transmitted over various Federal Aviation Agency (FAA) and military weather communications circuits in a standard upper air wind code agreed upon internationally through the World Meteorological Organization. Decoding procedure is given in TM 1-300. If current wind data is not given to the required height, the latest available data from previous reports for the higher levels are used to extend the plot. Up-to-date wind data that has been obtained from a source as close as possible to the actual or expected ground zero should be used. Data from other sources, which report wind direction, speed, and height in units other than mils, knots, or kilometers, may be converted by using Tables 2-2 and 2-3 on page 2-6.

Table 2-2. Distance Conversion Table

TO CONVERT	TO	MULTIPLY BY
KILOMETERS	MILES	0.62
KILOMETERS	NAUTICAL MILES	.54
MILES	KILOMETERS	1.61
MILES	NAUTICAL MILES	.87
NAUTICAL MILES	KILOMETERS	1.85
NAUTICAL MILES	MILES	1.15

3. Air Weather Service (AWS) Constant Pressure Surface (Isobaric) Wind Data.

The AWS detachments, attached to major command headquarters within the field army, have the capability of providing estimates of the wind structure, using constant pressure surface charts. When local upper air wind data is not available, the wind structure, determined from constant pressure surface charts, may be used to prepare a local fallout wind vector plot. In addition to supplementing local field artillery and AWS wind measurement capabilities, the constant pressure surface charts can be used for two special purposes:

a. Since they cover very large areas, they may be used to obtain upper air wind data for fallout prediction at distant locations.

b. They may also be used to forecast wind speeds and directions used for fallout predictions for periods from 24 to 48 hours.

Table 2-3. Mils to Degrees Conversion

MILS	DEGREES	MILS	DEGREES
0	0	3,300	186
100	6	3,400	191
200	11	3,500	197
300	17	3,600	203
400	23	3,700	208
500	28	3,800	214
600	34	3,900	220
700	40	4,000	225
800	45	4,100	231
900	51	4,200	237
1,000	57	4,300	242
1,100	62	4,400	247
1,200	67	4,500	253
1,300	73	4,600	259
1,400	79	4,700	264
1,500	84	4,800	270
1,600	90	4,900	276
1,700	96	5,000	281
1,800	101	5,100	287
1,900	107	5,200	293
2,000	113	5,300	298
2,100	118	5,400	304
2,200	124	5,500	310
2,300	130	5,600	315
2,400	135	5,700	321
2,500	141	5,800	327
2,600	147	5,900	332
2,700	152	6,000	337
2,800	157	6,100	343
2,900	163	6,200	349
3,000	169	6,300	354
3,100	174	6,400	360
3,200	180		

NOTE: To convert degrees to mils multiply the number of degrees by 17.8.

NOTE: To convert degrees to mils, multiply degrees by 17.8.

A constant pressure surface chart depicts the altitude at any location at which a specific pressure surface will be found. From these constant pressure surface charts, the wind directions and speeds can be obtained for various altitudes. Constant pressure surfaces above mean sea level (Table 2-4) are used for this purpose.

Table 2-4. Constant Pressure Surfaces above Mean Sea Level

CONSTANT PRESSURE SURFACE (MILLIBARS)	AVERAGE ALTITUDE (FEET)
850	5,000
750	10,000
600	14,000
500	18,000
400	24,000
300	30,000
200	39,000
150	45,000
100	53,000

The wind directions obtained are reported in degrees from which the winds are blowing, and the wind speeds are reported in knots.

PART B - USE THE FALLOUT PREDICTION PLOTTING SCALE TO PREPARE A WIND VECTOR PLOT

In preparing the fallout wind vector plot, successive vectors for each wind layer are laid off from the downwind end of the preceding vector, starting with the lowest height level and working upward. The direction of each vector is the same as the wind direction for that layer, the length of the vector is the product of the wind speed and a weighting factor. The weighting factor represents the time a nominal size fallout particle will spend in the altitude layer of interest multiplied by the appropriate distance conversion factor. The weighting factor is multiplied by the wind speed in knots (nautical miles per hour) so that the vector length is in kilometers. The wind of each vector is labeled with the height of the top of the layer it represents, and other identifying data is added.

1. Fallout Prediction Plotting Scale, ML-556/UM.

The plotting is facilitated by the use of a plotting scale to reduce the number of steps involved. Some of the operations that are eliminated are the conversion of the direction from which the winds are blowing to the direction toward which the winds are blowing and the calculation of the vector length.

The Fallout Prediction Plotting Scale, ML-556/UM, illustrated in Figure 2-1, permits plotting of the wind vectors directly from Field Artillery or Air Weather Service upper air wind data. The plotting scale is constructed of clear plastic and consists of two main parts. The Fallout Prediction Plotting Scale, ML-556/UM, is requisitioned through supply channels using FSN 6675-868-8094.

a. An azimuth dial with an inner scale in degrees and an outer scale in hundreds of mils.

b. A series of 11 slots representing various wind layers (altitude zones) with wind speeds graduated in knots along each slot for use with three different map scales signified by three colors: green, red, and black. The weight factors have been used to convert wind speeds from knots (nautical miles per hour) to vector lengths in kilometers.

2. Prepare a Wind Vector Plot Using the Fallout Prediction Plotting Scale, ML-556/UM.

Most NBC Centers within the U.S. Army will have access to Field Artillery meteorological upper air wind data on a regular basis. The plotting scale usually is available for preparation of wind vector plots. Because of the speed and accuracy of preparing a wind vector plot using the plotting scale, this is normally the preferred method.

3. Plotting Air Weather Service (AWS) Upper Air Wind Data.

Plotting AWS upper air wind data with the plotting scale is accomplished in much the same manner as for Field Artillery upper air wind data, except that different slots are used for the wind layers; for heights above 45,000 feet, the vector is drawn to a point on the slot scale equal to one half of the reported wind speed. Table 2-5 provides weighting factors and plotting scale data to be used with AWS wind data.

The following example problem illustrates the preparation of wind vector plot, using the plotting scale and U.S. Army Field Artillery upper air wind data. Assume that the field artillery upper air wind data, Table 2-1 on page 2-4, have been received by the NBCC. Using the fallout prediction plotting scale, prepare the fallout wind vector plot.

NOTE: To convert mils to degrees, divide mils by 17.8.

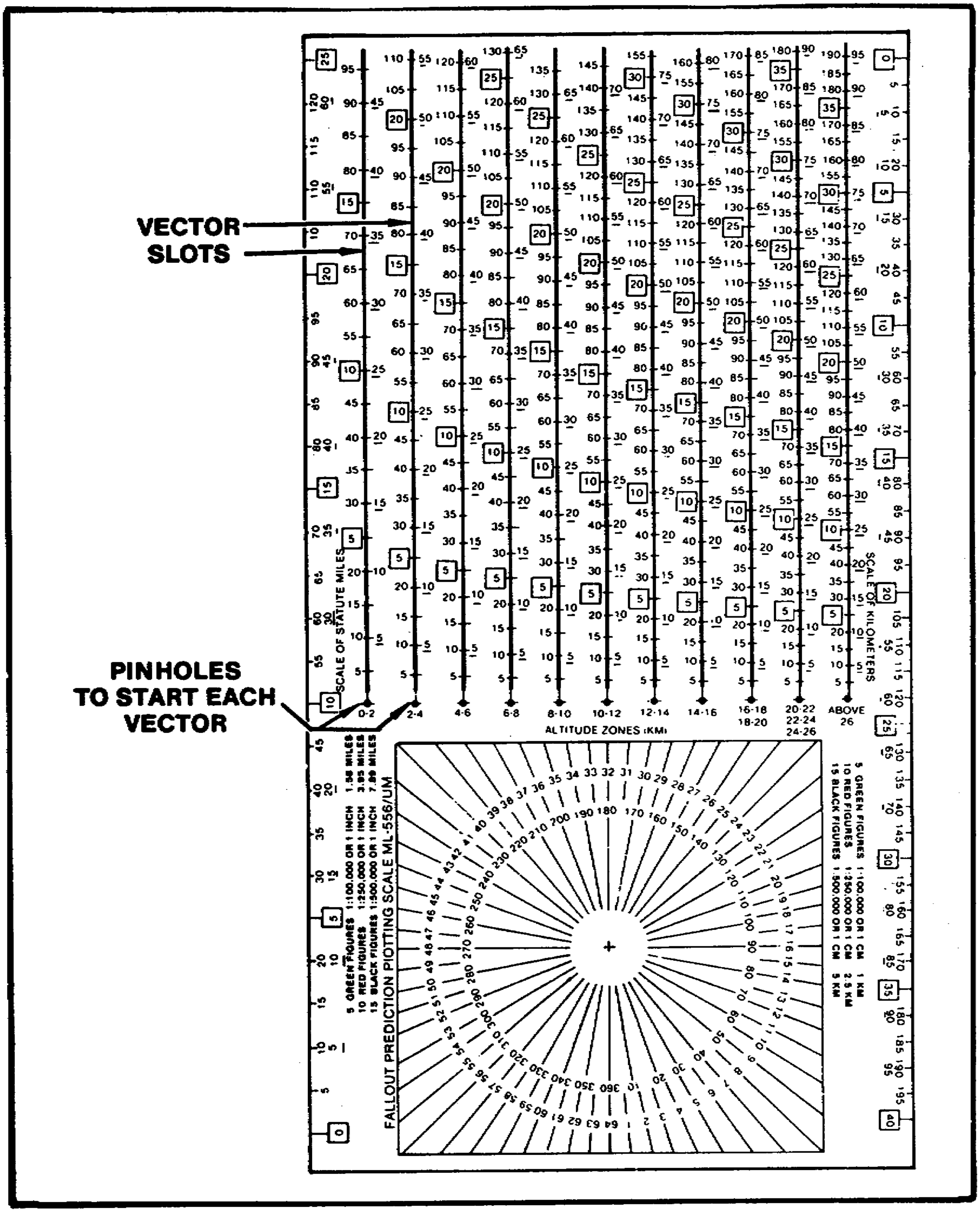

Figure 2-1. Fallout Prediction Plotting Scale

Table 2-5. Weighting Factors and Plotting Scale Data for 5,000 Foot Wind Layer
(To be used with Air Weather Service wind data)

WIND LAYER 10^3 FT	TIME IN LAYER (HOURS)	WEIGHTING FACTOR (Multiply wind speed in knots by this factor to get kilometers)	PLOTTING SCALE SLOT (To be used with the wind layer that is indicated)	ADJUSTMENT FACTOR (Multiply reported wind speed by this factor before plotting)
0-5	0.51	0.94	6-8	1
5-10	0.46	0.85	10-12	1
10-15	0.43	0.80	12-14	1
15-20	0.41	0.76	14-16	1
20-25	0.39	0.72	16-18	1
25-30	0.37	0.68	20-22	1
30-35	0.35	0.65	26-28	1
35-40	0.34	0.62	28-30	1
40-45	0.32	0.59	28-30	1
45-50	0.31	0.57	2-4	1/2
50-55	0.30	0.56	2-4	1/2
55-60	0.30	0.56	2-4	1/2
60-65	0.29	0.54	2-4	1/2
65-70	0.28	0.52	2-4	1/2
70-75	0.28	0.52	2-4	1/2
75-80	0.27	0.50	4-6	1/2
80-85	0.27	0.50	4-6	1/2
85-90	0.27	0.50	4-6	1/2
90-95	0.27	0.50	4-6	1/2
95-100	0.26	0.48	4-6	1/2
100-105	0.24	0.44	6-8	1/2
105-110	0.24	0.44	6-8	1/2
110-115	0.24	0.44	6-8	1/2
115-120	0.23	0.43	6-8	1/2
120-125	0.23	0.43	6-8	1/2
125-130	0.23	0.43	6-8	1/2
130-135	0.22	0.41	8-10	1/2
135-140	0.22	0.41	8-10	1/2
140-145	0.22	0.41	8-10	1/2
145-150	0.21	0.39	12-14	1/2
150-155	0.21	0.39	12-14	1/2
155-160	0.21	0.39	12-14	1/2

4. Plotting Field Artillery Upper Air Wind Data.

The following procedures are followed in the preparation of a wind vector plot, using the plotting scale and U.S. Army Field Artillery upper air wind data.

Step 1. Attach overlay paper to a piece of graph paper, a map, a firing chart, or any other paper with parallel lines that can serve as north-south grid lines. Mark GZ, scale, and grid north on the overlay paper.

Step 2. Lay the plotting scale on the chart so that the hole at the end of the slot labeled "0-2" lies over the starting point (GZ).

Step 3. Secure the scale to the chart by inserting a sharpened instrument (hard lead pencil or a pin) through the hole, and rotate the scale so that the line on the azimuth dial representing the wind direction for the lowest (0 to 2,000 meters) wind layer is parallel to the north-south grid lines and is oriented with the azimuth representing the wind direction pointing north. Note that the wind direction in this case is the wind direction as read directly from the field artillery upper air wind data.

Step 4. Hold the scale firmly and, using the "0-2" slot, draw a line to the point which represents the wind speed in knots for the 0 to 2,000 meter layer as read directly from the field artillery upper air wind data. This point will be determined by using the map scale selected (indicated by the color legend from the plotting scale). Lift the scale and mark this point with the number 2 (to indicate the top of the layer it represents). Draw a small circle "O" at the end of the vector just drawn (Figure 2-2 on page 2-13).

Step 5. Next move the scale so that the hole at the end of the slot labeled "2-4" lies over the outer end of the wind vector just plotted. Orient the scale in the manner described in Step 3; however, this time use the wind direction for the 2,000 to 4,000 meter layer. Using the "2-4" slot, draw a line to the point representing the wind speed in the 2,000 to 4,000 meter layer. Lift the scale and mark this point with the number 4, and add a small circle (Figure 2-3 on page 2-14).

Step 6. Repeat this procedure for each wind layer until the plot is completed. Be sure to use the appropriate slot for each wind layer being plotted. Note that starting with the "16-18" slot, each slot is used to plot several vectors.

The steps and Figures 2-2 through 2-5 on pages 2-13 through 2-16 show the above procedures and use the air wind data in Table 2-1.

Step 1. Attach overlay paper to a piece of graph paper, a map, a firing chart, or any other paper with parallel lines that can serve as north-south grid lines. Mark GZ, scale, height dimensions, and grid north on the overlay paper. Place the pinhole at the end of slot 1 (marked "0-2") over the point marked GZ; stick a pin or sharp pencil through the hole to hold that pinhole on GZ; rotate the plotting scale until the 1240-mil line on the azimuth dial is parallel to any north-south line and directed toward grid north; draw a line in the 0-2 slot to 9 (9 knots) at the selected map scale. Mark the end of this vector with the number 2 to indicate 2,000 meter height and add a small circle (Figure 2-2).

Step 2. Place the pinhole at the end of slot 2 (marked "2-4") at the end of the first vector; stick a pin or sharp pencil through the hole to hold the pinhole there; rotate the plotting scale until the 1,420-mil line on the azimuth dial is parallel to any north-south line and directed toward grid north; draw a line in the 2-4 slot to 13 (13 knots) at the selected map scale. Mark the end of this vector with the number 4 to indicate 4,000 meter height and add a small circle (Figure 2-3).

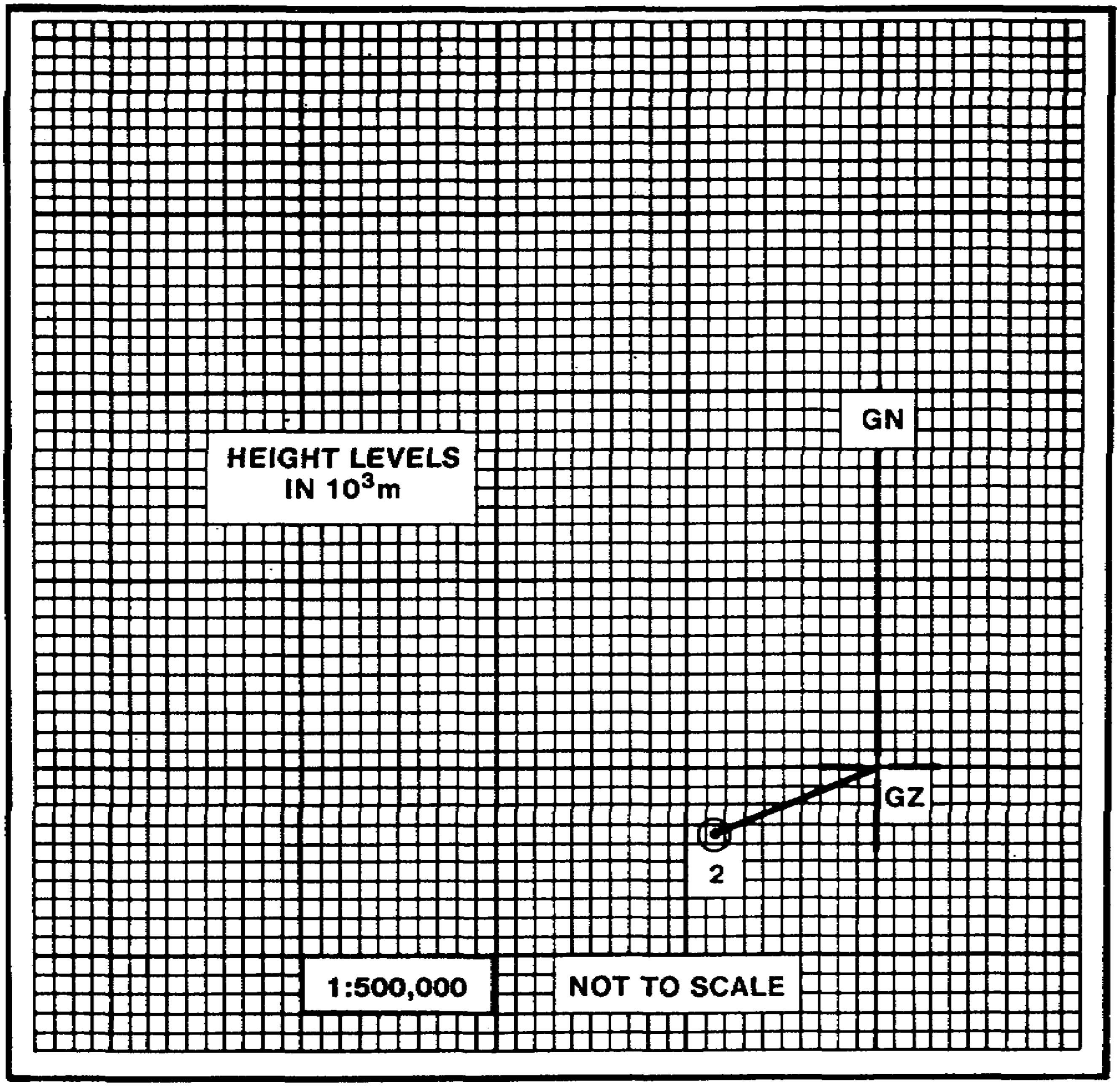

Figure 2-2. Preparation of Wind Vector Plot
from Field Artillery Upper Air Wind Data
(Example Problem)

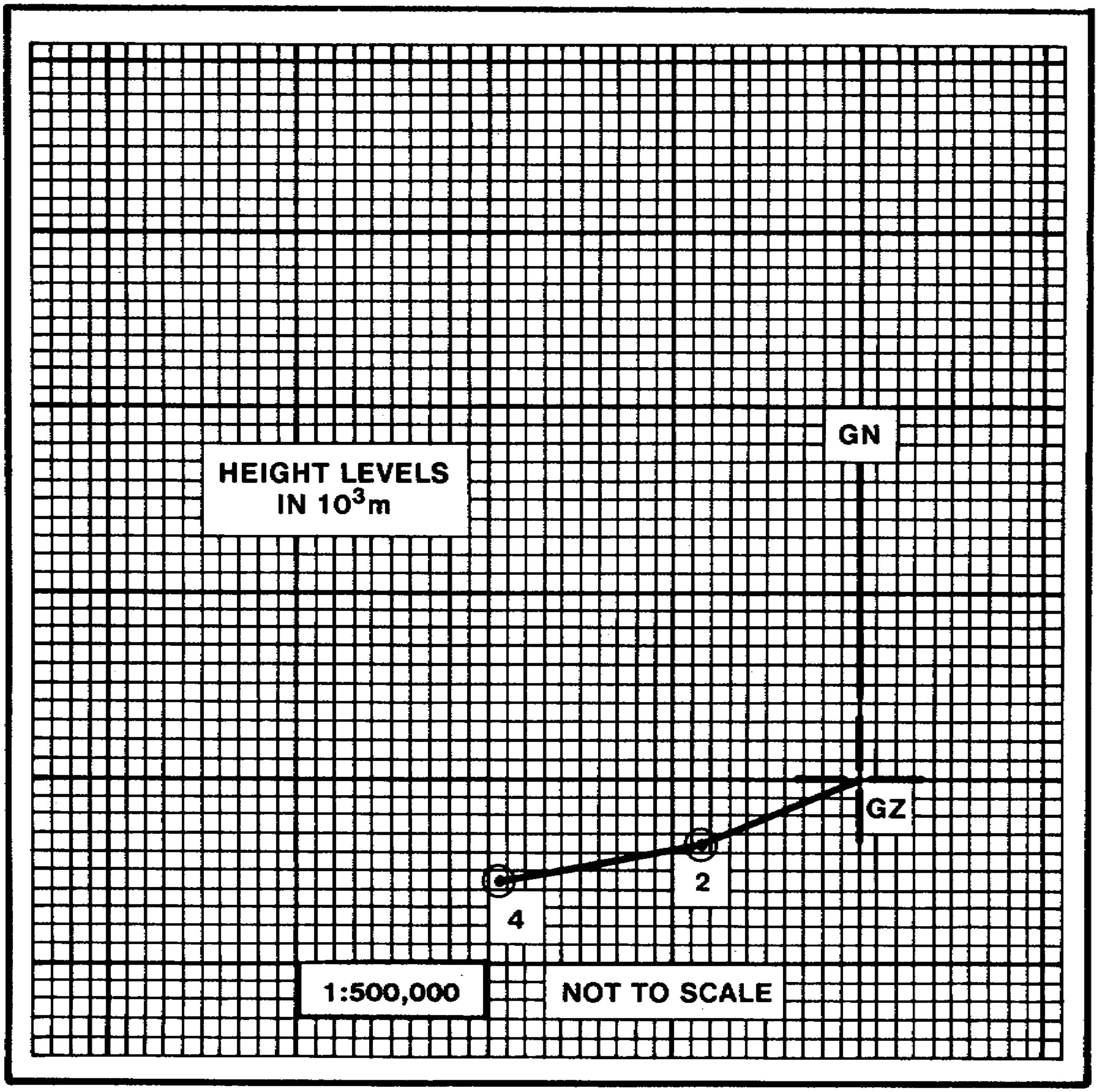

Figure 2-3. Example Problem, Continued

Step 3. Place the pinhole at the end of slot 3 (marked "4-6") at the end of the second vector; stick a pin or sharp pencil through the hole to hold the pinhole there; rotate the plotting scale until the 1,600-mil line on the azimuth dial is parallel to any north-south grid line and directed toward grid north; draw a line in the 4-6 slot to 18 (18 knots) at the selected map scale. Mark the end of this vector with the number 6 to indicate 6,000 meter height and add a small circle (Figure 2-4).

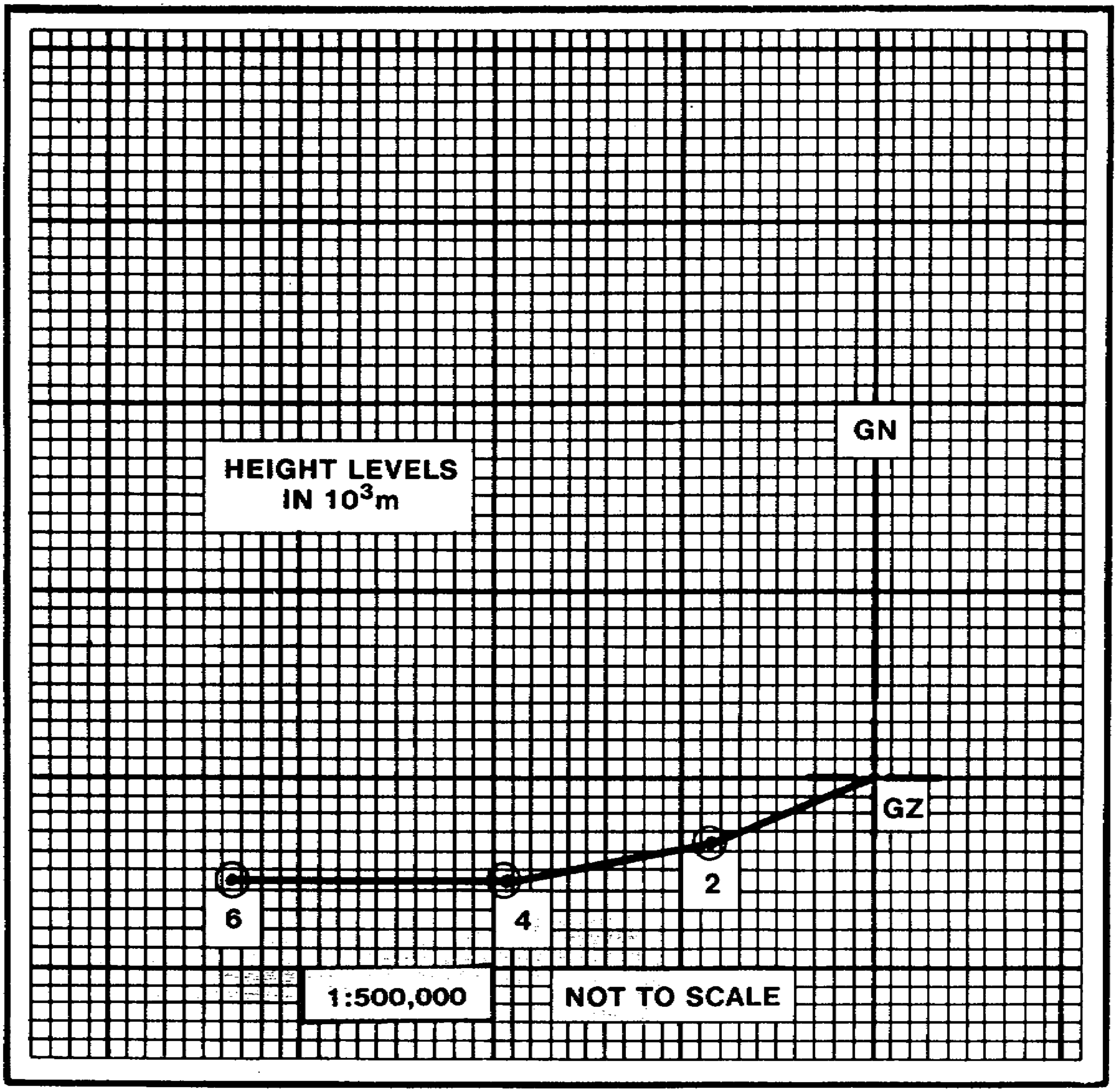

Figure 2-4. Example Problem,Continued

Step 4. Plot the remaining vectors in the same manner and label the end of each vector with the height it represents. Figure 2-5 shows the completed wind vector plot.

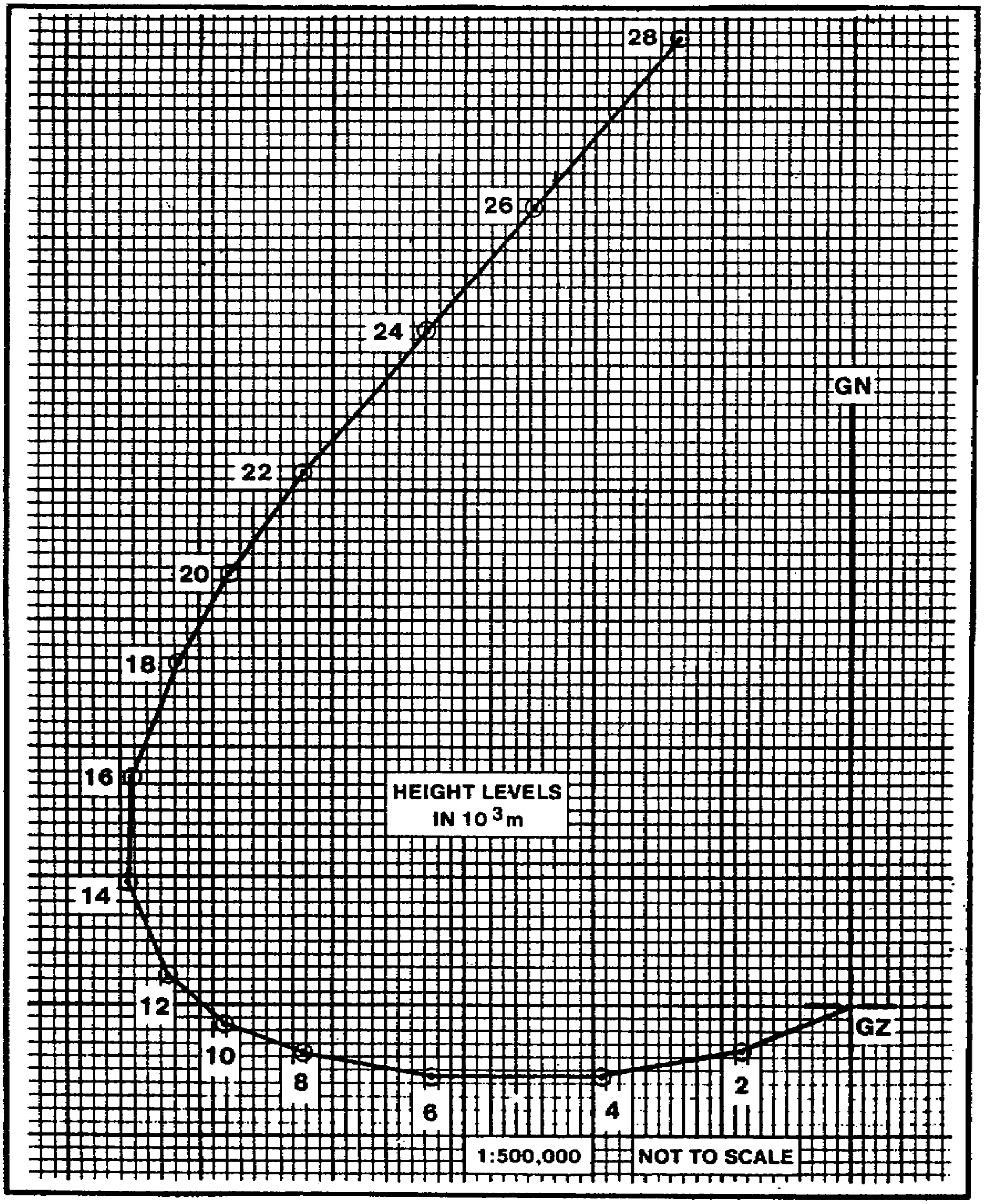

Figure 2-5. Example Problem, Continued

PART C - PREPARE A WIND VECTOR PLOT USING THE MANUAL METHOD

There may be instances when there is no plotting scale available to the NBCC for the preparation of a wind vector plot. To prepare a wind vector plot in these instances, the manual method of plotting must be employed. Though this method is somewhat more complicated and time consuming the and result and the principles for plotting are the same as those using the plotting scale. When preparing a wind vector plot without the aid of a plotting scale, there are mathematical adjustments which must be applied to the wind data. As was pointed out in Part A, the wind direction as received is the direction from which the wind is blowing. For wind vector plotting purposes, this must be changed to the direction toward which the wind is blowing. To accomplish this, if the given wind direction is more than 3,200 mils, subtract 3,200 mils. EXAMPLE: Given wind direction is 3900 mils (direction from which wind is blowing), subtract 3200 mils; result, 0700 mils (direction toward which wind is blowing). If the given wind direction is less than 3,200 mils, add 3,200 mils. EXAMPLE: Given wind direction is 1500 mils (direction from which wind is blowing) add 3200 mils; result, 4700 mils (direction toward which wind is blowing). The wind speed given in knots must be converted to a vector length in kilometers. This is accomplished by multiplying the wind speed by the weighting factor from Table 2-6.

1. Example.

If the wind speed given in the meteorological data for the 6000-8000 meter layer is 12 knots, you would multiply 12 X .93 (weighting factor from Table 2-6) to find a vector length of 11.2 kilometers.

Once the proper adjustments to the wind data have been completed, the wind vector plot is drawn using a protractor, a straightedge, and a graphic (bar) scale (from a map of the scale to which the wind vector plot is to be drawn) or any other scale convenient to the plotter. The example problem on the following pages illustrates the procedures to be followed for plotting a wind vector plot using the manual method.

2. Situation.

Assume that the field artillery upper air wind data (Table 2-1 on page 2-4) have been received by the NBCE. Prepare the fallout wind vector plot.

NOTE:

To convert mils to degrees divide the number of mils by 17.8.

WIND LAYER (10^3 METERS)	TIME IN LAYER (HOURS)	WEIGHTING FACTOR (MULTIPLY WIND SPEED IN KNOTS BY THIS FACTOR TO GET KILOMETERS)
0-2	0.68	1.26
2-4	.59	1.09
4-6	.52	.96
6-8	.50	.93
8-10	.48	.89
10-12	.45	.83
12-14	.42	.78
14-16	.40	.74
16-18	.39	.72
18-20	.38	.70
20-22	.37	.69
22-24	.36	.67
24-26	.36	.67
26-28	.35	.65
28-30	.34	.63
30-32	.34	.63
32-34	.33	.61
34-36	.33	.61
36-38	.32	.59
38-40	.31	.57
40-42	.31	.57
42-44	.30	.55
44-46	.30	.55
46-48	.29	.54
48-50	.29	.54

Table 2-6. Weighting Factors for 2,000 Meter Wind Layer (To be used with US Army Field Artillery Wind Data)

Step 1. Adjust wind data.

a. The directions reported in upper air wind data are the directions from which the winds are blowing. Using the reported direction, obtain the direction toward which the fallout particles are being blown while falling through a wind layer by adding or subtracting 3,200 mils as applicable (add 3,200 mils if the reported direction is less than 3,200 mils and subtract if it is more than 3,200 mils).

b. The horizontal distance in kilometers traveled by a nominal size particle (a spherical particle 143 microns in diameter) while falling through a wind layer is obtained by multiplying the reported wind speed in knots for the layer by the appropriate weighting factor. Table 2-7 shows Step 1.

Table 2-7. Adjusted Upper Air Wind Data

WIND LAYER (10^3 METERS)	WIND DIRECTION (MILS) FROM	TO	WIND SPEED (KNOTS)	× WEIGHTING FACTOR (FROM TABLES)	= VECTOR LENGTH (KM)*
0-2	1240	4440	9	1.26	11.3
2-4	1420	4620	13	1.09	14.2
4-6	1600	4800	18	.96	17.3
6-8	1780	4980	13	.93	12.1
8-10	1960	5160	9	.89	8.0
10-12	2310	5510	9	.83	7.5
12-14	2850	6050	13	.78	10.1
14-16	3200	6400	13	.74	9.6
16-18	3560	360	18	.72	13.0
18-20	3740	540	14	.70	9.8
20-22	3820	620	18	.69	12.4
22-24	3910	710	27	.67	18.1
24-26	3910	710	26	.67	17.4
26-28	3910	710	34	.65	22.1
30 BALLOON BURST					

* ROUND OFF TO NEAREST TENTH OF A KILOMETER.

Step 2. Attach overlay paper to a piece of graph paper, a map, a firing chart, or any other paper with a set of parallel lines that can serve as north-south grid lines, select and mark a point which represents ground zero, and draw in and label a grid north line.

Step 3. Select and record a map scale. (In this example, a map scale of 1:500,000 will be used.)

Step 4. Plot the wind direction and vector length for each wind layer, starting with the lowest layer.

a. Plot the vector for the lowest (0 to 2,000 meter) wind layer which represents a wind with a speed of 9 knots blowing from 1,240 mils. From GZ, plot a line toward 4440 mils 11.3 kilometers long. Mark the end of this vector with the number 2 to indicate 2,000 meter height and add a small circle (Figure 2-6).

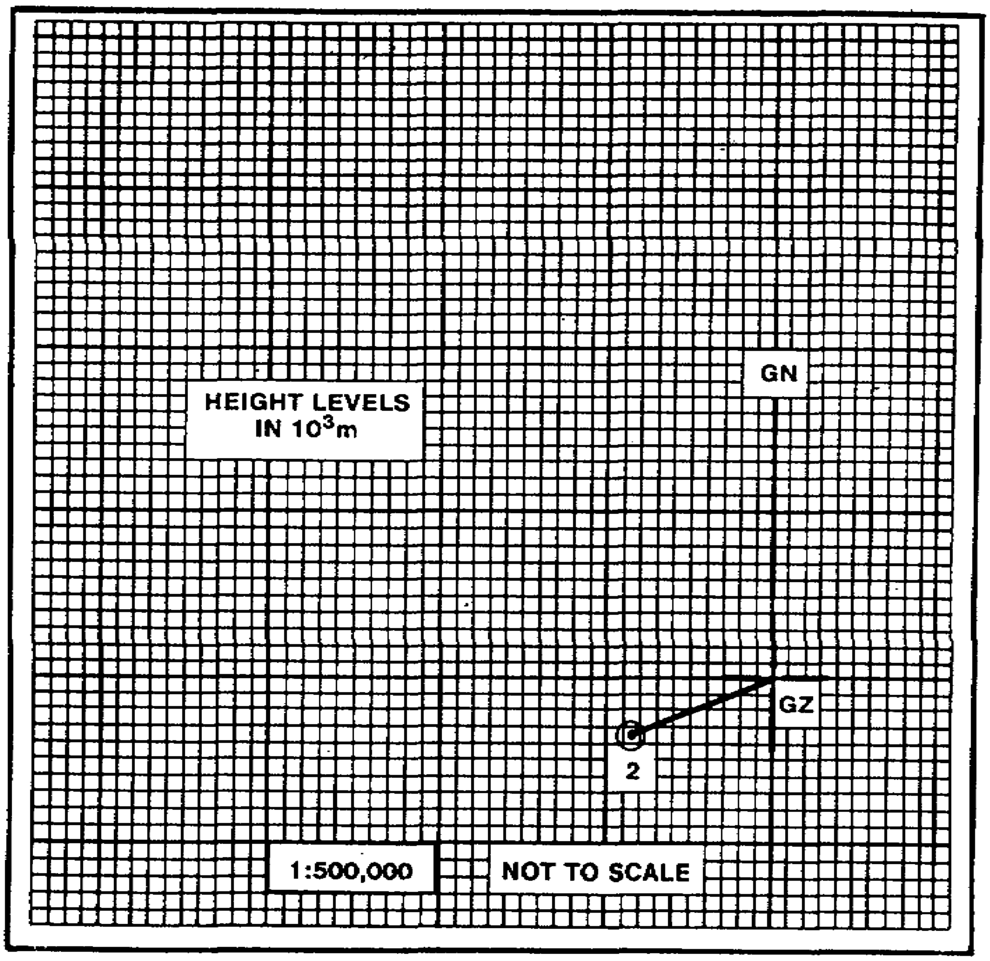

Figure 2-6. Preparation of Wind Vector Plot from Field Artillery Upper Air Wind Data (Example Problem)

b. Starting at the point where the first vector ended, plot the second vector for the 2,000 to 4,000 meter layer which represents a wind with a speed of 13 knots blowing from 1420 mils. This vector is plotted 14.2 kilometers long toward 4620 mils. Mark the end of this vector with the number 4 to indicate 4,000 meter height and add a small circle (Figure 2-7).

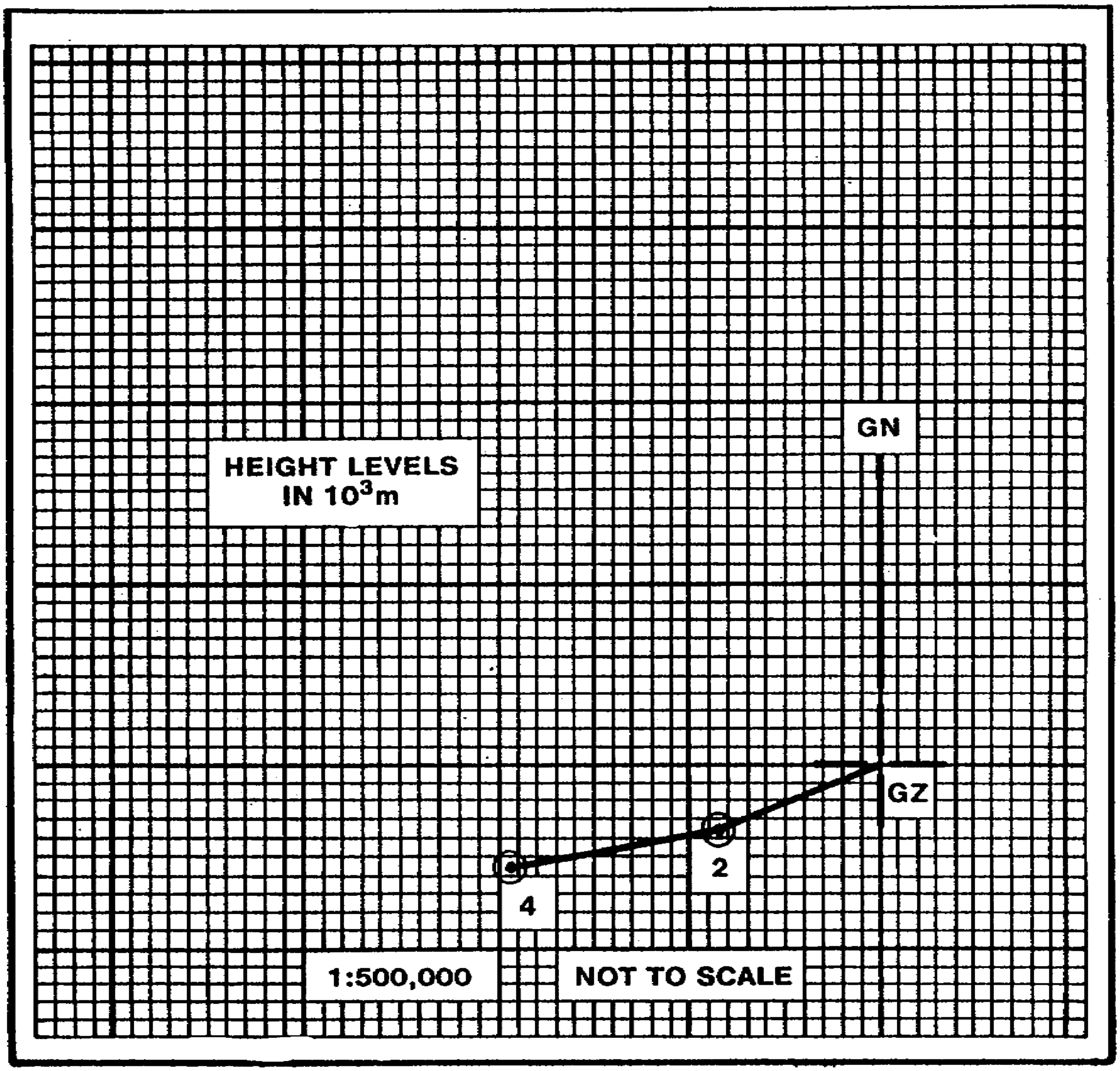

Figure 2-7. Example Problem, Continued

c. Starting at the point where the second vector ended, plot the third vector for the 4,000 to 6,000 meter layer, which represents a wind with a speed of 18 knots blowing from 1600 mils. This vector is plotted 17.3 kilometers long toward 4800 mils. Mark the end of this vector with the number 6 to indicate 6,000 meter height and add a small circle (Figure 2-8).

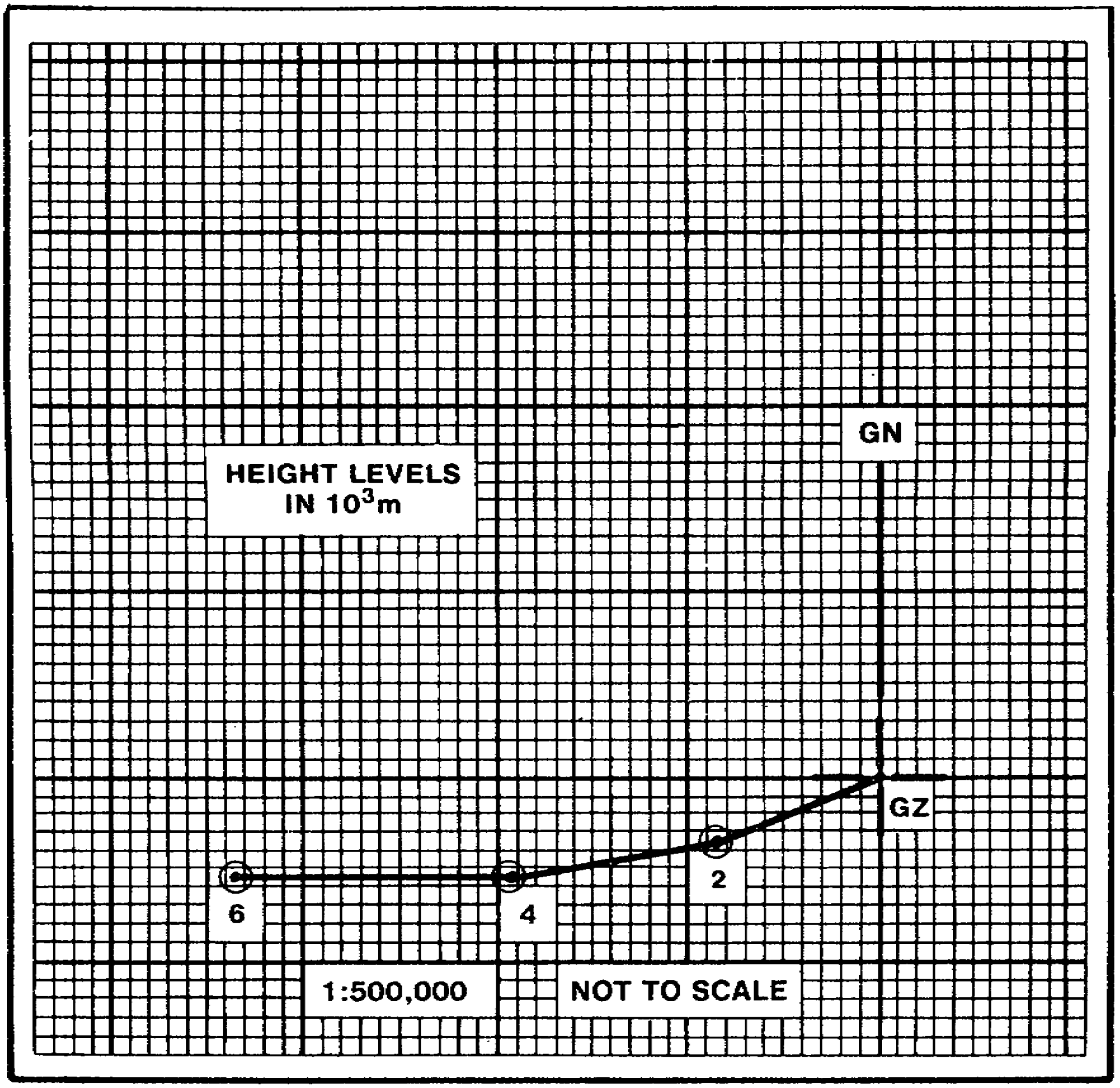

Figure 2-8. Example Problem, Continued

d. Plot the remaining vectors in the same manner, and label the end of each vector with the height it represents and add a small circle (Figure 2-9).

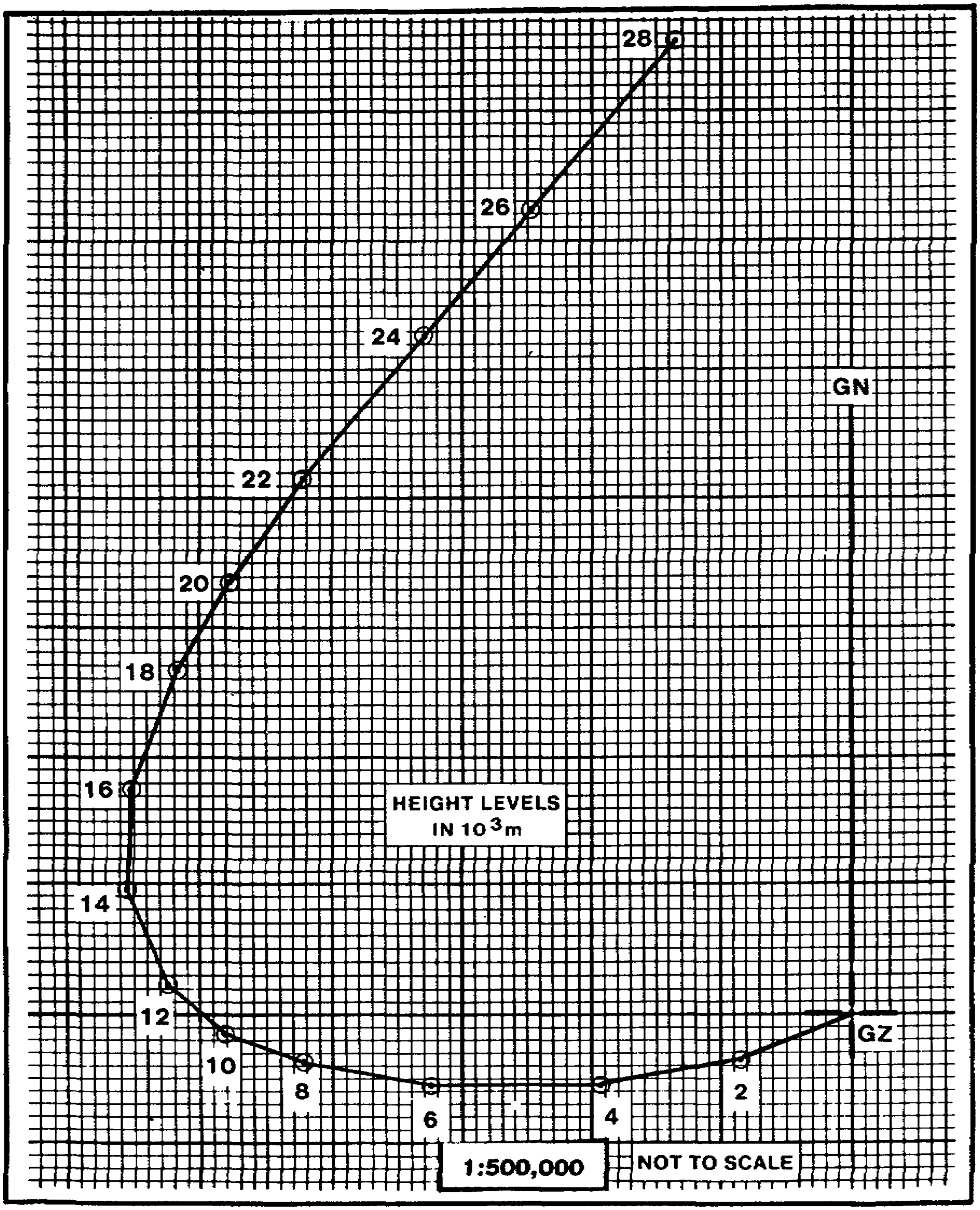

Figure 2-9. Example Problem, Continued

LESSON 2

PRACTICE EXERCISE

The following items will test you grasp of the material covered in this lesson. There is only one correct answer for each item. When you complete the exercise, check you answer with the answer key that follows. If you answer any item incorrectly, study again that part of the lesson which contains the portion involved.

Situation: You have been assigned to help prepare the wind vector plots based upon the available data. This must be as accurate as possible.

1. Which determines the height from which a fallout particle starts its fall back to earth?

   A. Yield of weapon
   B. Size of target
   C. Size of balloon
   D. Weather reports

2. Who is responsible for preparing the wind vector plot?

   A. Field Artillery Meteorological Section
   B. Fire Support Element
   C. NBC Center
   D. Corps Fire Support Center

3. How many times per day do Field Artillery Meteorological Sections report upper air wind data up to 30,000 meters?

   A. 2
   B. 4
   C. 6
   D. 8

4. Ten nautical miles is equal to how many kilometers?

   A. 14.5
   B. 15.2
   C. 16.8
   D. 18.5

5. The Fallout Prediction Plotting Scale, ML-556/UM, is designed for use with how many map scales?

   A. 1
   B. 2
   C. 3
   D. 4

6. Where do you place the pinhole of the 2-4 slot to draw the 4,000 meter vector using the ML-556/UM?

   A. At the end of the first vector
   B. On ground zero
   C. Approximately 1/4-inch beyond the 2,000 meter vector
   D. On the 2,000 meter vector so the start of the slot is on the 2,000 meter mark

7. Using the manual method to draw the wind vector plot, what azimuth will you use to draw the 2,000--4,000 meter vector when the wind direction for the 2,000--4,000 meter level is 1400 mils?

   A. 1400
   B. 3200
   C. 4600
   D. 4800

LESSON 2

PRACTICE EXERCISE

ANSWER KEY AND FEEDBACK

Item	Correct Answer and Feedback	
1.	A	Yield of weapon The heights . . . conditions. Part A, p. 2-2, para 2
2.	C	NBC Center This plot . . . data. Part A, p. 2-2, para 3
3.	B	4 To 30,000 . . . time. Part A, p. 2-3, para 1a
4.	D	18.5 Part A, p. 2-5, Table 2-2
5.	C	3 Part B, p. 2-9, Figure 2-1
6.	A	At the end of the first vector Place the . . . scale. Part B, p. 2-12, Step 2
7.	C	4600 If the . . . mils. Part C, p. 2-17, Intro

LESSON 3

FALLOUT PREDICTIONS

Critical Task: 031-506-2004
031-506-2005
031-506-3043

OVERVIEW

LESSON DESCRIPTION:

In this lesson you will learn how to prepare detailed and simplified fallout predictions.

TERMINAL LEARNING OBJECTIVE

ACTION: Prepare detailed and simplified fallout predictions.

CONDITION: Given an NBC 2 (Nuclear) Report, a wind vector plot, compass, protractor, hairline or straightedge, fallout prediction worksheet, paper and pencil.

STANDARD: Demonstrate competency of the task skills and knowledge by responding to the multiple choice test covering the preparation of detailed and simplified fallout predictions and using an Effective Downwind Message.

REFERENCE: FM 3-3-1.

INTRODUCTION

The need for a fallout prediction system stems from the large area radiological contamination hazard that can develop from fallout-producing nuclear detonations. This large area hazard is capable of producing mass casualties, if its presence is not detected, or if commanders at all echelons do not understand its effects and take action to minimize those effects. Thus, fallout has a considerable impact on military planning and operations.

PART A - INTRODUCTION TO FALLOUT PREDICTIONS

There are many occasions when a commander will require a fallout prediction. Three occasions that may occur are:

- When the commander plans the use of a nuclear weapon that lacks a 99-percent probability of being fallout safe or whenever a contact backup fuze is used, a prestrike fallout prediction is prepared as part of the target analysis.

- When information indicates that fallout is occurring or that fallout probably will occur from a nuclear burst (friendly or enemy), a fallout prediction is required to enable the commander to warn higher, adjacent, and subordinate units.

- When a fallout-producing burst occurs, an evaluating procedure is initiated which will answer the commander's questions about the fallout hazard. However, a time lag of several hours to a day or more may occur between the time of burst and the availability of measured data (from radiological monitoring and/or survey), which would permit evaluation of the actual hazard. During this time lag, the fallout prediction (area of expected hazard), or at best the fallout prediction supplemented by measured radiation data, may be the only available information for estimating the effects of the radiation hazard on tactical operations or plans. This time lag occurs because meaningful measured data cannot be obtained until fallout in an area of interest is complete. Militarily significant fallout in an area may not be complete for a period of several hours after the burst, depending upon the yield, distance from ground zero (GZ), and upper air wind structure. The obtaining of measured data may also be delayed by the difficulties of night survey or the operational situation. Several additional hours may be required for the reporting and processing of measured data into usable form.

1. Fallout Prediction Procedures.

To satisfy command requirements at all echelons, two procedures for predicting fallout from a single detonation are established as explained below.

a. The Detailed Method.

The detailed method is used by the NBCE in preparing fallout predictions at headquarters having a meteorological capability. These predictions are employed by commands and subordinate units.

When information is needed to plan surveys or other aspects of the collection effort, the fallout prediction establishes an outline of the expected hazard that can be used for this purpose. Fallout prediction is a procedure used to estimate the probable areas of radiological contamination from a nuclear burst before actual arrival of fallout. The detailed fallout prediction is normally prepared by the NBCE. It is based upon data for a specific yield or target analysis information, and upper air wind data.

The upper air wind data are rapidly processed into a fallout wind vector plot when received. Using a current wind vector plot, the NBCE can prepare a detailed fallout prediction for dissemination within minutes after receiving required nuclear burst information.

The completed prediction delineates two zones of hazard. A detailed fallout prediction must contain the following information.

(1) Identification of grid north (GN), map scale, GZ coordinates, and date-time of burst.

(2) Two radial lines, drawn from the ground zero point at azimuths determined from the wind vector plot and radioactive cloud and stem parameters, dependent on yield. If wind speeds are below 8 KMPH, the fallout prediction is considered a special case, and you will have a circular pattern.

(3) Two downwind arcs, representing the downwind distances of Zone I and Zone II.

(4) A circle drawn around GZ with a radius equal to the stabilized cloud radius.

(5) Two tangents drawn from the ground zero circle to the points of intersection of the two radial lines with the Zone I arc.

(6) One or more time-of-arrival arcs (dashed), representing the expected time of arrival of fallout as it moves downwind from ground zero. Only those time-of-arrival arcs that are located within the zones are normally indicated on the fallout prediction (Figure 3-1).

The NBCC will prepare the detailed fallout prediction plot overlay for use within the tactical operations center (TOC) and elsewhere, as required. The detailed fallout prediction plot may be disseminated as an NBC 3 (Nuclear) report to other staff agencies both within and outside the TOC and to higher, adjacent, and subordinate units, as appropriate and indicated in the SOP.

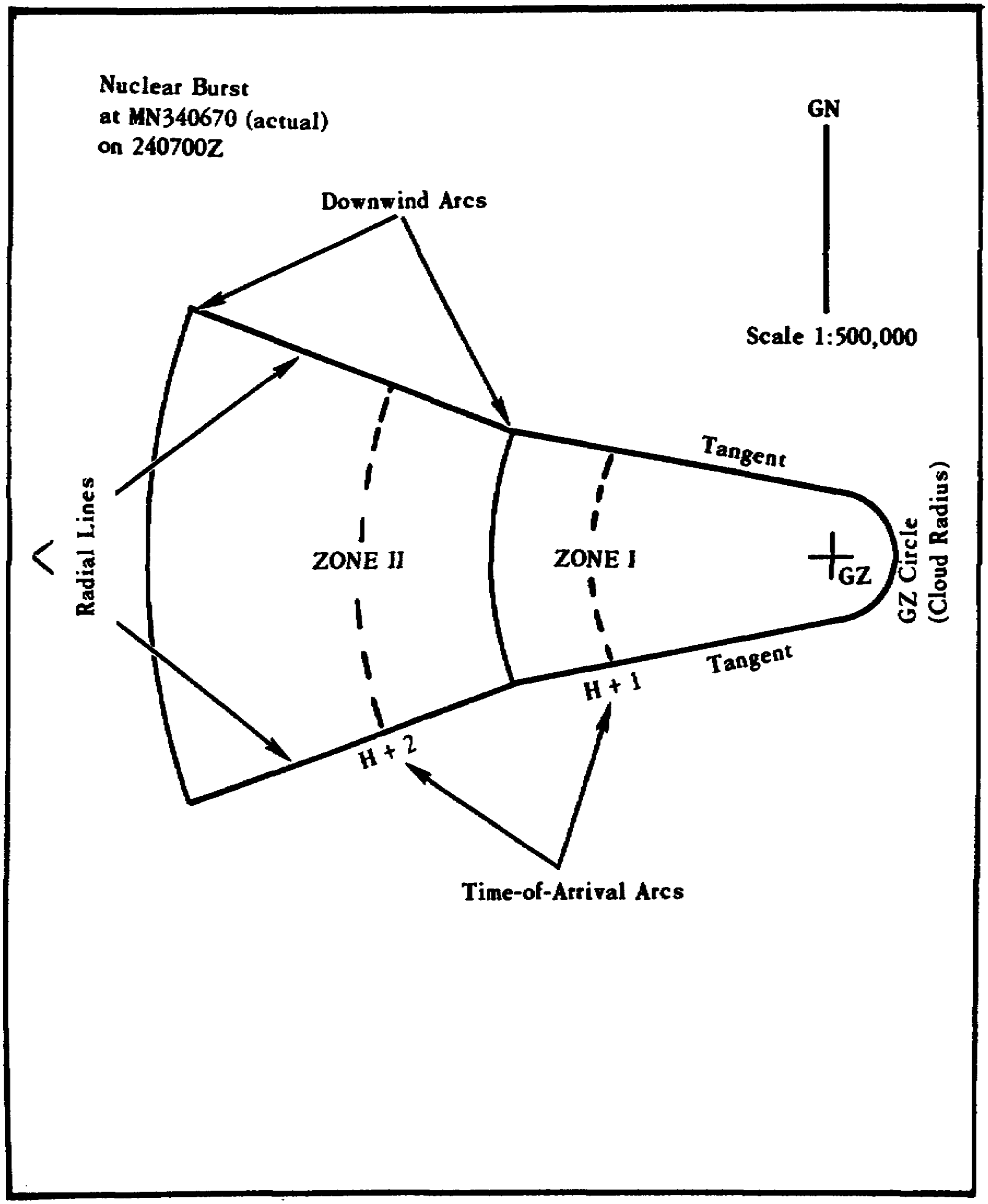

Figure 3-1. Detailed Fallout Prediction

b. The Simplified Method.

The simplified method can be used by any unit in preparing fallout predictions. The simplified method employs a simplified fallout predictor which may be either the standard M5A2 Radiological Fallout Area Predictor or a field-constructed simplified fallout predictor. In a nuclear war, it may be expected that small, mobile units will be operating in widely dispersed areas.

In such situations, receipt of a detailed fallout prediction, NBC 3 (Nuclear) Report, from major command headquarters may be delayed for significant periods of time. The simplified procedure provides small unit commanders an immediate capability of estimating the location of a potential fallout hazard, thereby allowing greater unit self-sufficiency. The estimate made of the fallout hazard using the simplified method will be less accurate than that made using the detailed method.

2. Significance of Predicted Fallout Zones.

In both simplified and detailed prediction, the predicted zones define those areas within which exposed, unprotected personnel may receive militarily significant total doses of nuclear radiation which may result in a reduction in their combat effectiveness, within 4 hours after actual arrival of fallout. A zone of primary hazard (Zone I) and one of secondary hazard (Zone II) are predicted.

a. Primary Hazard (Zone I).

Zone I delineates the area of primary hazard and is called the Zone of Immediate Operational Concern. It is defined as a zone within which there will be areas where exposed, unprotected personnel may receive doses of 150 centigrays, the emergency risk dose, or greater, in relatively short periods of time, less than 4 hours after actual arrival of fallout. Major disruptions of unit operations and casualties among personnel may occur within portions of this zone. The actual areas of major disruption are expected to be smaller than the entire area of Zone I; however, the exact locations cannot be predicted. The exact dose which personnel will receive at any location inside Zone I is dependent upon the dose rate at their location, the time of exposure, and protection available. There is, however, a reasonably high assurance that personnel outside the boundary of Zone I will not be exposed to an emergency risk dose in less than 4 hours. The radiation produced from neutron-induced activity will be closely confined to the area around ground zero, which will be well within the limits of Zone I. The induced radiation will therefore have no effect on the extent of Zone I but will cause higher dose rates in the area around ground zero. Thus, the dose from induced radiation was not considered in determining the extent of Zone I. (Figure 3-2).

b. Secondary Hazard (Zone II).

Zone II delineates the area of secondary hazard and is called Zone of Secondary Hazard. It is defined as a zone within which the total dose received by exposed, unprotected personnel is not expected to reach 150 centigrays within a period of 4 hours after the actual arrival of fallout, but within which personnel may receive a total dose of 50 centigrays (the negligible risk dose), or greater, within the first 24 hours after the arrival of fallout. However, only a small percentage of the personnel in the zone are expected to receive these doses. The exact dose personnel will receive at any location within Zone II is dependent upon the dose rate at their location, the time of exposure, and protection available. Personnel located close to the extent of Zone I will normally receive higher doses than those located close to the extent of Zone II. (Figure 3-2) Personnel with no previous radiation exposure may be permitted to continue critical missions for as long as 4 hours after the actual arrival of fallout without incurring the emergency risk dose. If personnel in this zone have previously received significant radiation doses, a cumulative dose of 150 centigrays or more, serious disruption of unit mission and casualty-producing doses may be expected.

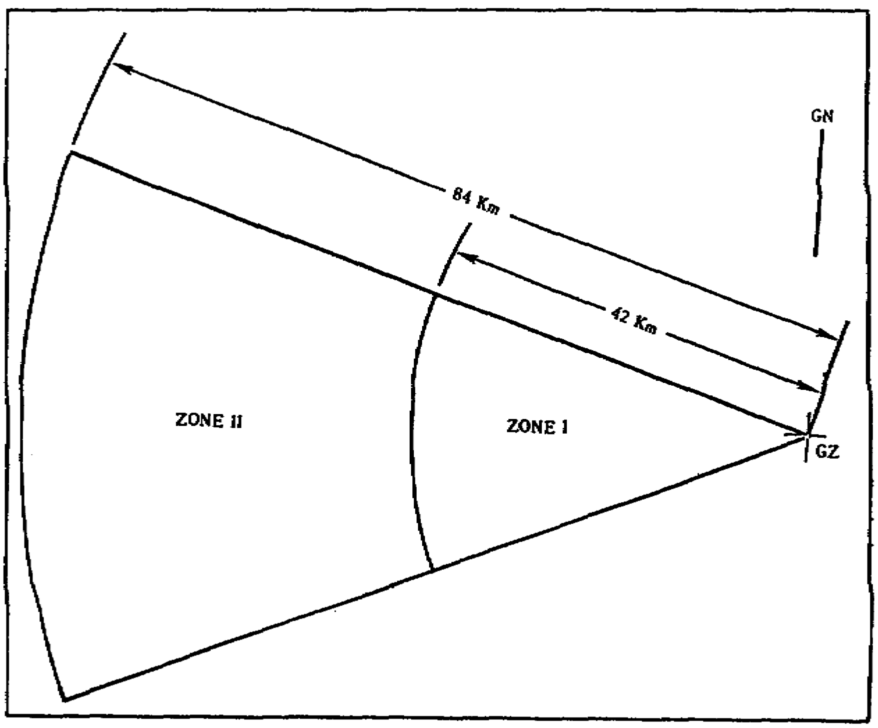

Figure 3-2. Zone I and Zone II

3. Outside the Predicted Area.

Outside the predicted area, exposed, unprotected personnel may receive a total dose that does not reach 50 centigrays in the first day (24 hours) after actual arrival of fallout. The total dose for an infinite time of stay outside the predicted area should not reach 150 centigrams. Therefore, outside the predicted area, no serious disruption of military operations is expected to occur if personnel have not previously been exposed to nuclear radiation. Appreciable previous exposure should be considered. In either case, periodic monitoring coupled with routine radiological defense measures will normally provide adequate protection.

4. Reliability.

The predicted zones of fallout are larger than the actual ground area that will be covered by fallout. These zones represent areas of hazard, somewhere within which radioactive particles are predicted to fall. Because of uncertainties of weather and nuclear burst input data, the precise locations of fallout within the zones cannot be reliably predicted, but must be ascertained by monitoring and survey after fallout has settled. The zones, therefore, have been developed so that there is reasonably high assurance that the expected fallout will not occur outside them. They represent an expected hazard area that can be quickly predicted immediately after receipt of actual or planned nuclear burst information.

5. Interpretation.

The lines enclosing the fallout prediction are not to be construed as absolute boundaries for the occurrence of fallout. It is emphasized that as these predicted zones are approached from the outside, the likelihood of encountering hazardous fallout will increase as will the dose rate. Therefore, units should not normally be relocated based upon predicted fallout areas but, rather, upon actual radiological monitoring and survey information.

PART B - PREPARE A DETAILED FALLOUT PREDICTION

All NBC weapons have an inherent residual effect that presents a hazard to the forces engaged. Nuclear bursts create local contamination of an area around ground zero and may produce radioactive fallout which can contaminate thousands of square kilometers. The contamination effects of nuclear weapons are a necessary consideration in preplanning operations in which friendly forces may be required to occupy contaminated terrain.

Fallout prediction is a procedure of estimating probable areas of radiological contamination from a nuclear burst before the actual arrival of fallout. The detailed fallout prediction is normally prepared by the NBCE. It is based on data for a specific yield, or target analysis information, and upper air wind data. The upper air wind data are rapidly processed into a fallout wind vector plot each time they are received. With a current wind vector plot, the NBCC can have a detailed fallout prediction ready for dissemination in a matter of minutes after required nuclear burst information is available.

To competently prepare a detailed fallout prediction, it is necessary to perform steps as follow:

Step 1. Preparation of Fallout Wind Vector Plot.

The fallout wind vector plot is prepared each time new upper air wind data are received. Every prediction made from the current fallout wind vector plot should be prepared on a separate overlay, so that the current fallout wind vector plot may be saved for further use. The fallout wind vector plot may be drawn to any convenient map scale.

Step 2. Determination of Nuclear Burst Information.

A convenient worksheet for recording data for the detailed fallout prediction method is shown in Figure 3-3. This worksheet may be reproduced locally. Nuclear burst information is recorded on lines a through e.

Step 3. Determination of Cloud Parameters.

Cloud parameters are read from Figure 3-4. Enter Figure 3-4 with the yield by placing a hairline so that the values on the left yield index scale and on the right yield index scale are the same. Read all parameters under the hairline. Cloud parameter values are recorded on lines f through j of the worksheet.

Step 4. Initial Determination of Lateral Limits of the Fallout Prediction.

Mark points representing the cloud-top height, cloud-bottom height, and two-thirds stem height on the fallout wind vector plot; and draw radial lines from the ground zero point through these height points (interpolate linearly between the wind vectors if necessary). Disregard all wind vectors below the two-thirds stem height point and above the cloud-top height point for the prediction being prepared. If wind vectors between the two-thirds stem height point and the cloud-top height point fall outside the radial lines drawn from ground zero through these points, expand the angle formed by these two radial lines to include these outside wind vectors.

Step 5. Determination of the Effective Wind Speed.

Measure the length of the radial line, in kilometers, from GZ to the cloud-bottom height point. Record this value on **line k** of the worksheet. Read the time of fall from the cloud bottom (determined in Step 3), from the worksheet (Figure 3-3, **item j**). Compute the effective wind speed as shown below and record on **line 1** of the worksheet.

FALLOUT PREDICTION WORKSHEET-SURFACE BURST

For use of this form, see FM 3-3-1; the proponent agency is TRADOC

a.	Time of burst (date-time group)	______	DELTA DDtttt (local or ZULU)
b.	GZ Coordinates	______	FOXTROT yyzzzzzz (actual or estimated)
c.	FY/TY Ratio (from target analyst for friendly weapons only)	______	
d.	HOB (from target analyst for friendly weapons only)	______	meters
e.	Yield	______	KT or MT
f.	Cloud-top Height (Fig. 4-3)	______	10^3 meters or feet
g.	Cloud-bottom Height (Fig. 4-3)	______	10^3 meters or feet
h.	2/3 Stem Height (Fig. 4-3)	______	10^3 meters or feet
i.	Stabilized Cloud Radius (Fig.4-3)	______	ZULU rr (KM)
j.	Time of Fall from Cloud Bottom (Fig.4-3)	______	hours
	Fallout Wind Vector Plot (Enter f, g, and h radial lines on wind vector plots and measure distance from GZ to cloud-bottom height)		
k.	Radial Line Distance from GZ to Cloud-Bottom Height	______	km
l.	Effective Wind Speed $= \dfrac{\text{k (GZ to CB dist)}}{\text{j (Time of fall)}} =$ ______ $\dfrac{\text{km}}{\text{hr}} =$	______	ZULU sss (kmph)
m.	Downwind Distance of Zone 1 (Enter Fig. 4-7 with l and e)	______	km
n.	Adjustment = FY/TY Factor______ (Enter Fig. 4-8 with e and c or use a 1) x HOB Factor______ (Enter Fig.4-9 or 4-10 with d and e or use a 1) =	______	
o.	Adjust Downwind Distance of Zone 1 (m x n)	______	ZULU xxx (km)
	Fallout Wind Vector Plot (Check lateral limits for 40 degrees)		
p.	Azimuth of Left Radial Line	______	YANKEE dddd (mils or degrees)
q.	Azimuth of Right Radial Line	______	YANKEE cccc (mils or degrees)
r.	NBC 3 Nuclear		
	ALFA AAA ___ ___ ___		(Strike Serial Number)
	DELTA DDtttt ___ ___ ___ ___ ___ ___		(Local or ZULU)
	FOXTROT yyzzzzzz ___ ___ ___ ___ ___ ___ ___ ___		(GZ coordinates-actual or estimated)
	YANKEE ddddcccc ___ ___ ___ ___ ___ ___ ___ ___		(Azimuths or radial lines-mils or degrees)
	ZULU sssxxxrr ___ ___ ___ ___ ___ ___ ___ ___ (effective wind speed) (downwind distance) (cloud radius)		

DA FORM 1971-4-R, SEP 94 EDITION OF SEP 86 IS OBSOLETE

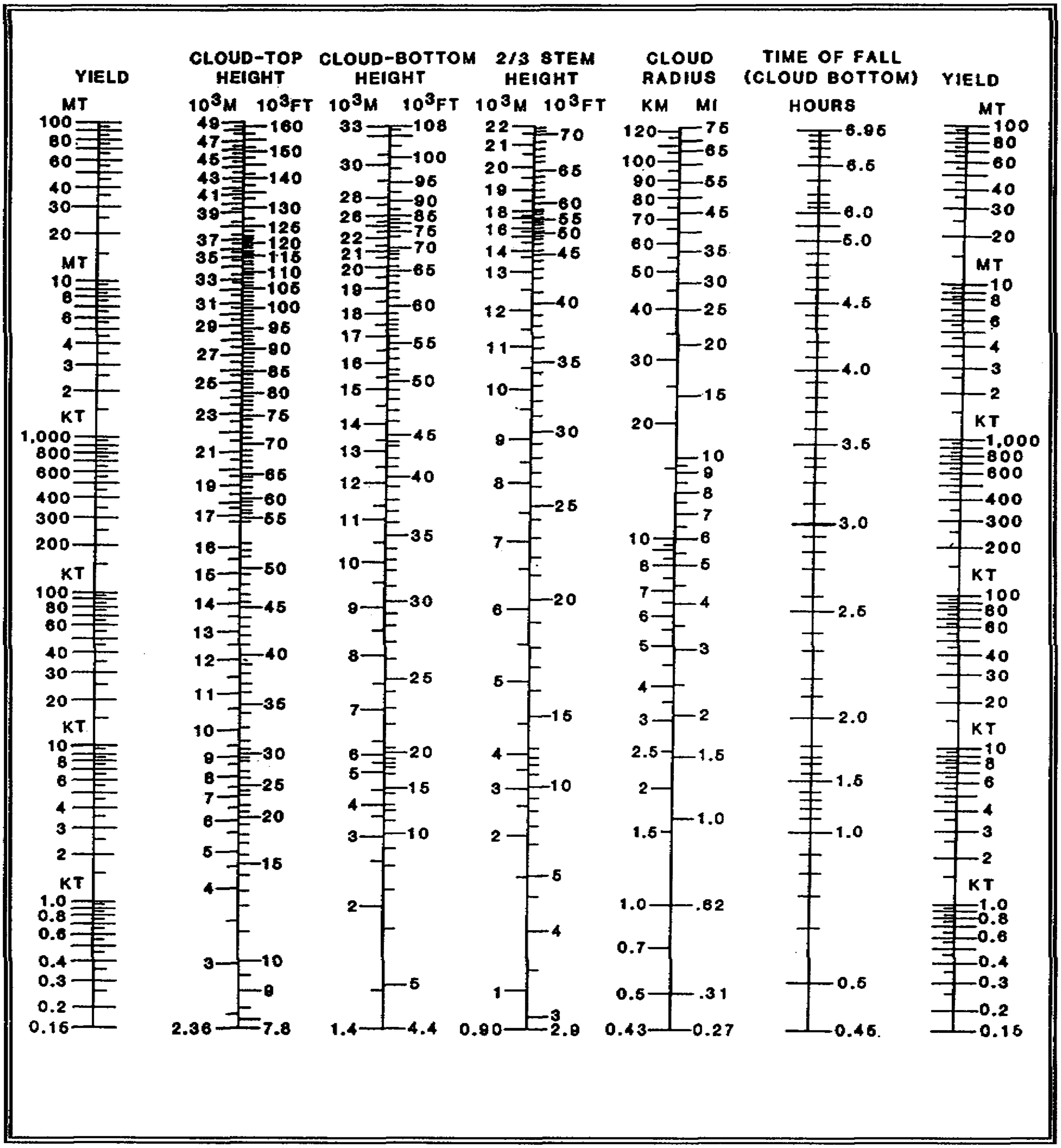

Figure 3-4. Radioactive Cloud and Stem Parameters
(Stabilized at H + 10 Minutes)

Step 6. Zones I and II Downwind Distance Determination.

a. Using Figure 3-5, align a hairline from the yield on the right-hand scale to the value of the effective wind speed on the left-hand scale; at the intersection of the hairline with the center scale, read the value of the downwind distance of the Zone of Immediate Operational Concern (Zone I) for a surface burst. Record this value on **line m** of the worksheet.

b. If the Fission Yield/Total Yield (FY/TY) ratio is known, obtain the FY/TY adjustment factor from Figure 3-6. This information along with the height of burst (HOB) is received from fire direction personnel for friendly bursts. Lay a hairline from the total yield on the left hand scale to the value of the FY/TY ratio on the right-hand scale; at the intersection of the hairline with the center scale, read the FY/TY adjustment factor. If the FY/TY ratio is not known, assume the yield to be 100 percent fission and use an FY/TY adjustment factor of 1. Record the FY/TY adjustment factor on **line n** of the worksheet.

c. If the height of burst is known (as in the case of a prestrike friendly burst), obtain the height of burst adjustment factor for yields equal to or less than 100 KT or for yields greater than 100 KT. Lay a hairline from the yield on the left-hand scale to the value of the height of burst on the center scale; at the intersection of the hairline with the right-hand scale, read the height of burst adjustment factor. If height of burst is not known, assume a zero height of burst and use a height of burst adjustment factor of 1. Record on **line n** of the worksheet.

d. Multiply the Zone I downwind distance for a surface burst, by both the height of burst adjustment factor and the FY/TY adjustment factor to obtain the adjusted downwind distance of Zone I for the given conditions. Record this value on **line o** of the worksheet.

e. Double the distance found to obtain the adjusted downwind distance of the Zone of Secondary Hazard (Zone II).

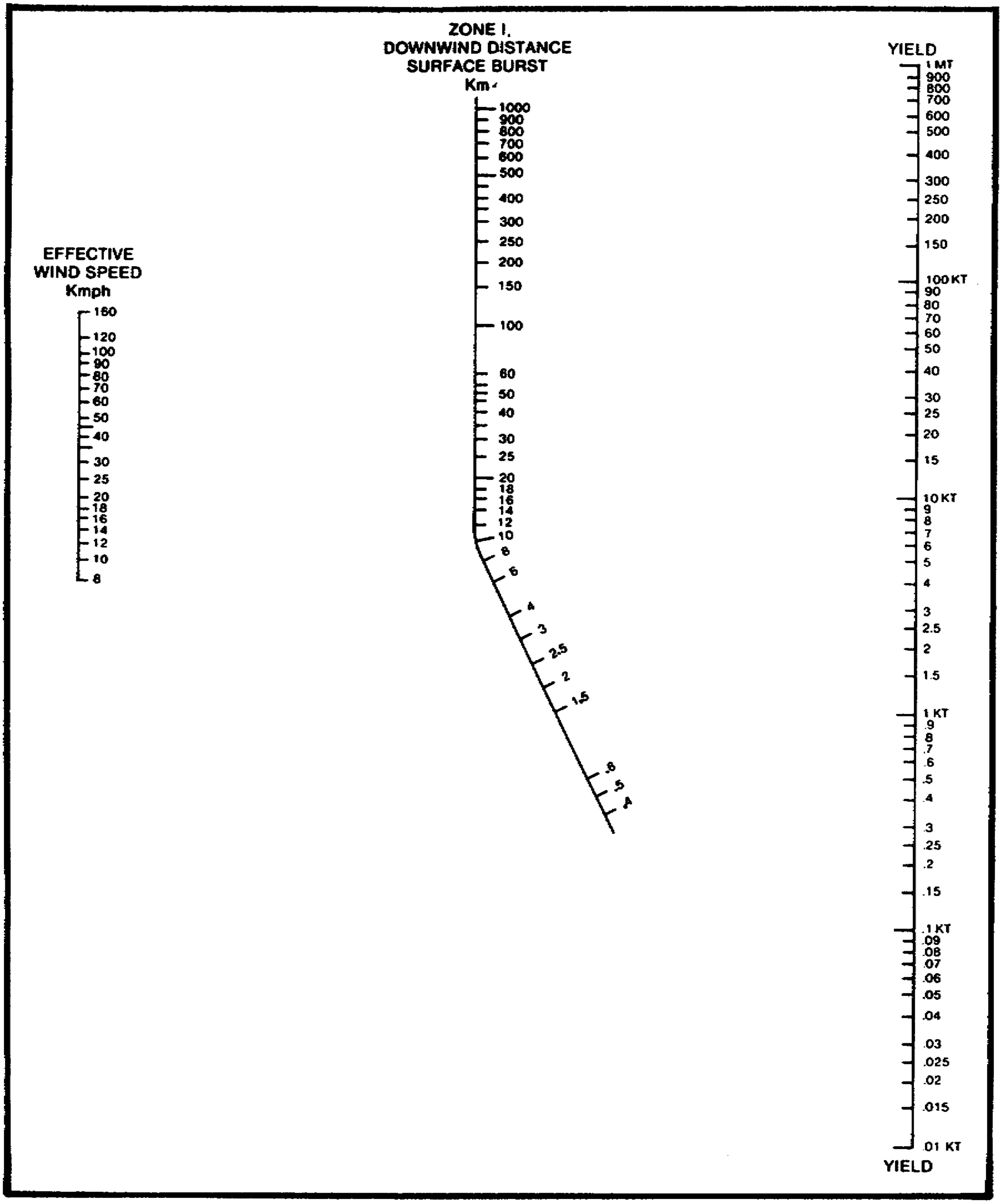

Figure 3-5. Zone I Downwind Distance, Surface Burst

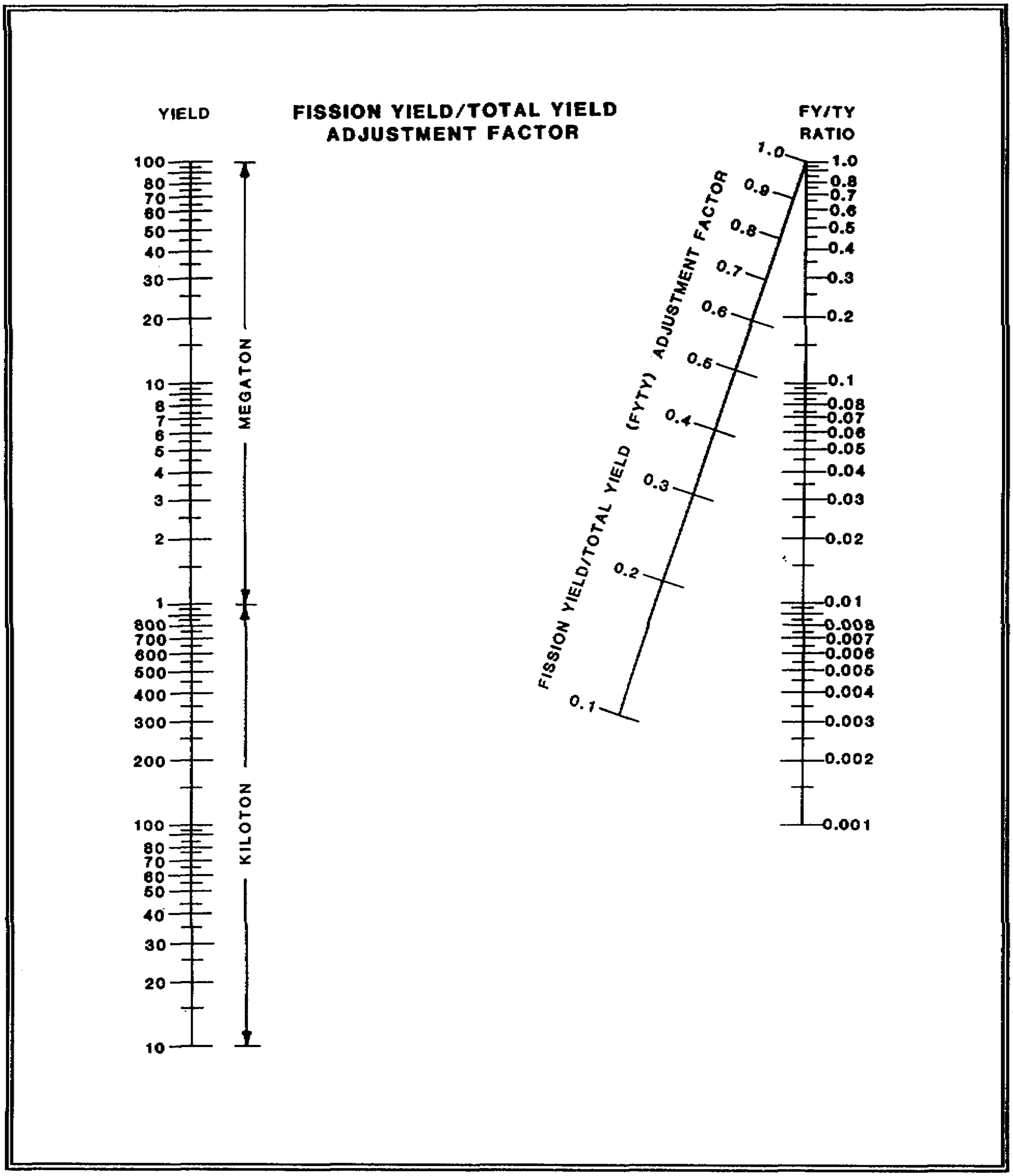

Figure 3-6. FY/TY Adjustment Factor

Step 7. Construction of the Left and Right Radial Lines.

a. Measure the angle formed by the radial lines drawn from ground zero to the cloud-top height and two-thirds stem height points on the fallout vector plot (or the radial lines which have been expanded to include vectors between the two-thirds stem height and the cloud-top height). If the angle formed is 40 degrees or greater, proceed as outlined in Step 8.b. If the angle formed is less than 40 degrees, bisect the angle and expand the angle formed by the two radial lines to 40 degrees, 20 degrees on each side of the bisector, (Figure 3-7).

b. Measure the azimuths, in mils or degrees from grid north, of the final left and right radial lines and record on **lines p and q** of the worksheet (use four digits).

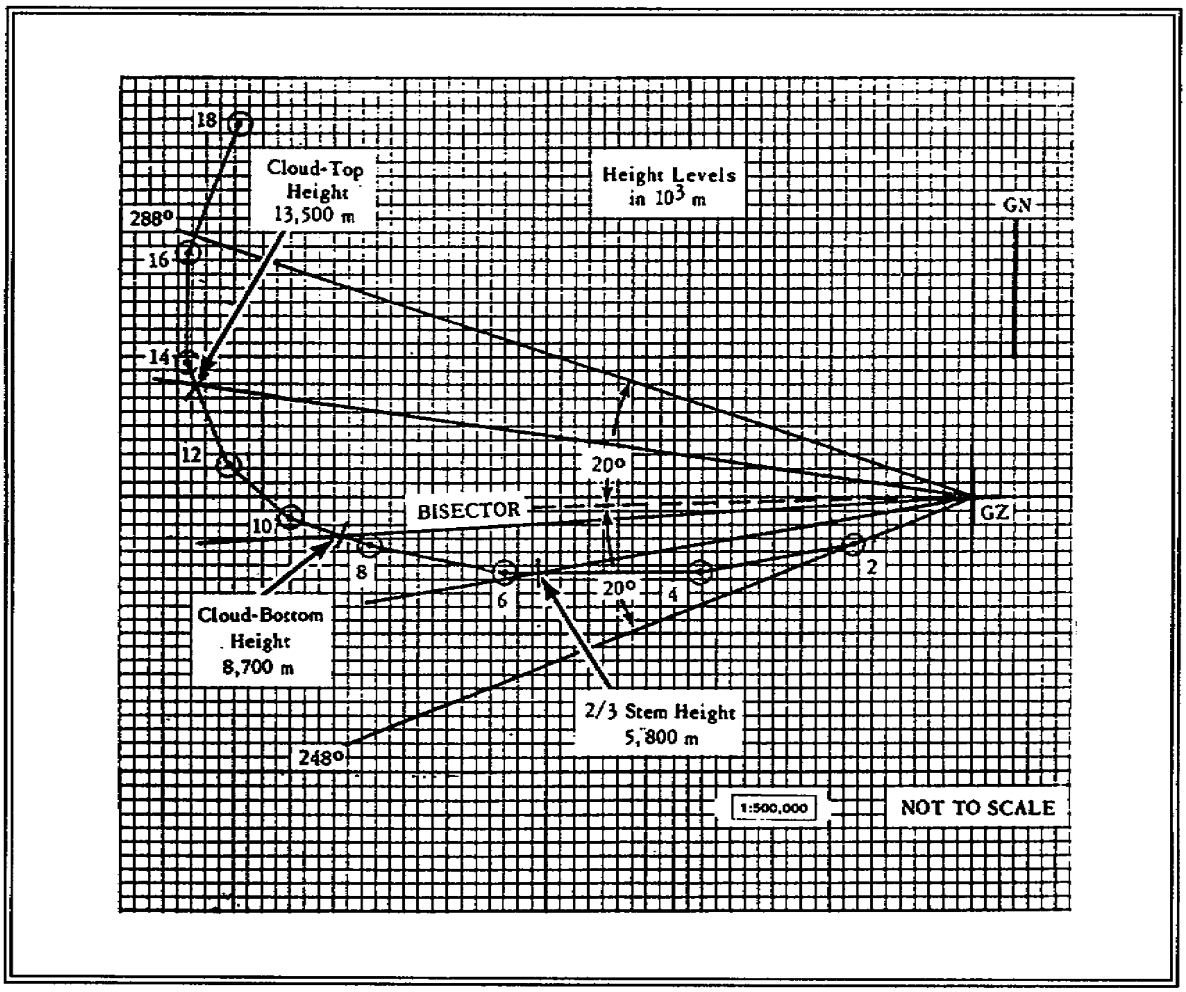

Figure 3-7. Radial Lines

Step 8. Completion of the Fallout Prediction.

a. Start with GZ on an overlay at the selected map scale and extend the radial lines at their proper azimuths to any convenient distance. Mark grid north on this overlay. The fallout wind vector plot was originally drawn to a convenient map scale; for example, 1:500,000. If it is more convenient, a different map scale can now be used to complete the fallout prediction.)

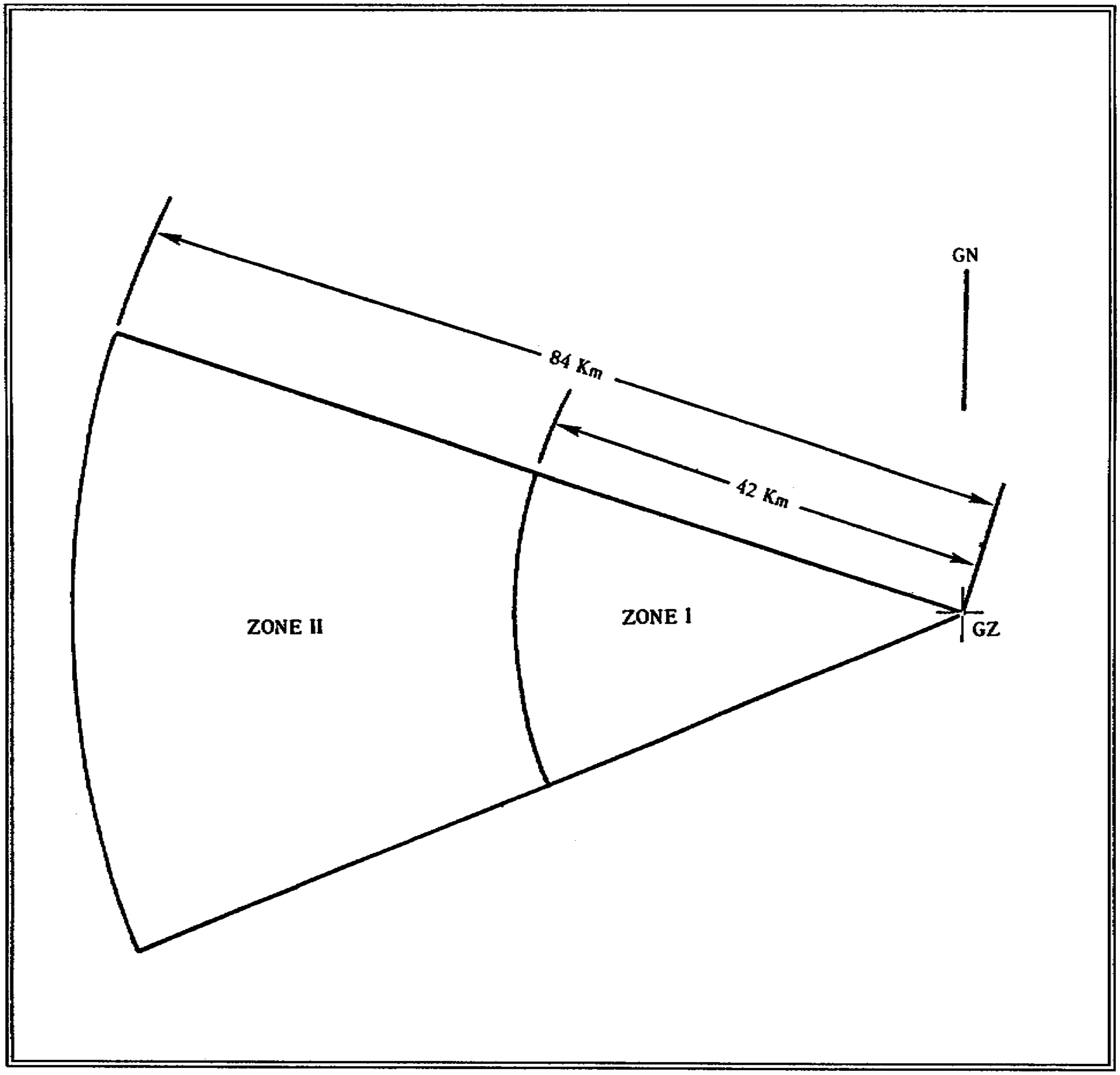

Figure 3-8. Zone I and Zone II

b. Between the two radial lines drawn from ground zero, and using ground zero as center, draw two arcs with radii equal to the Zone I and Zone II downwind distances found in Step 6 (Figure 3-8).

c. Using ground zero as center, draw a circle around ground zero with a radius equal to the cloud radius at the selected map scale (Figure 3-9).

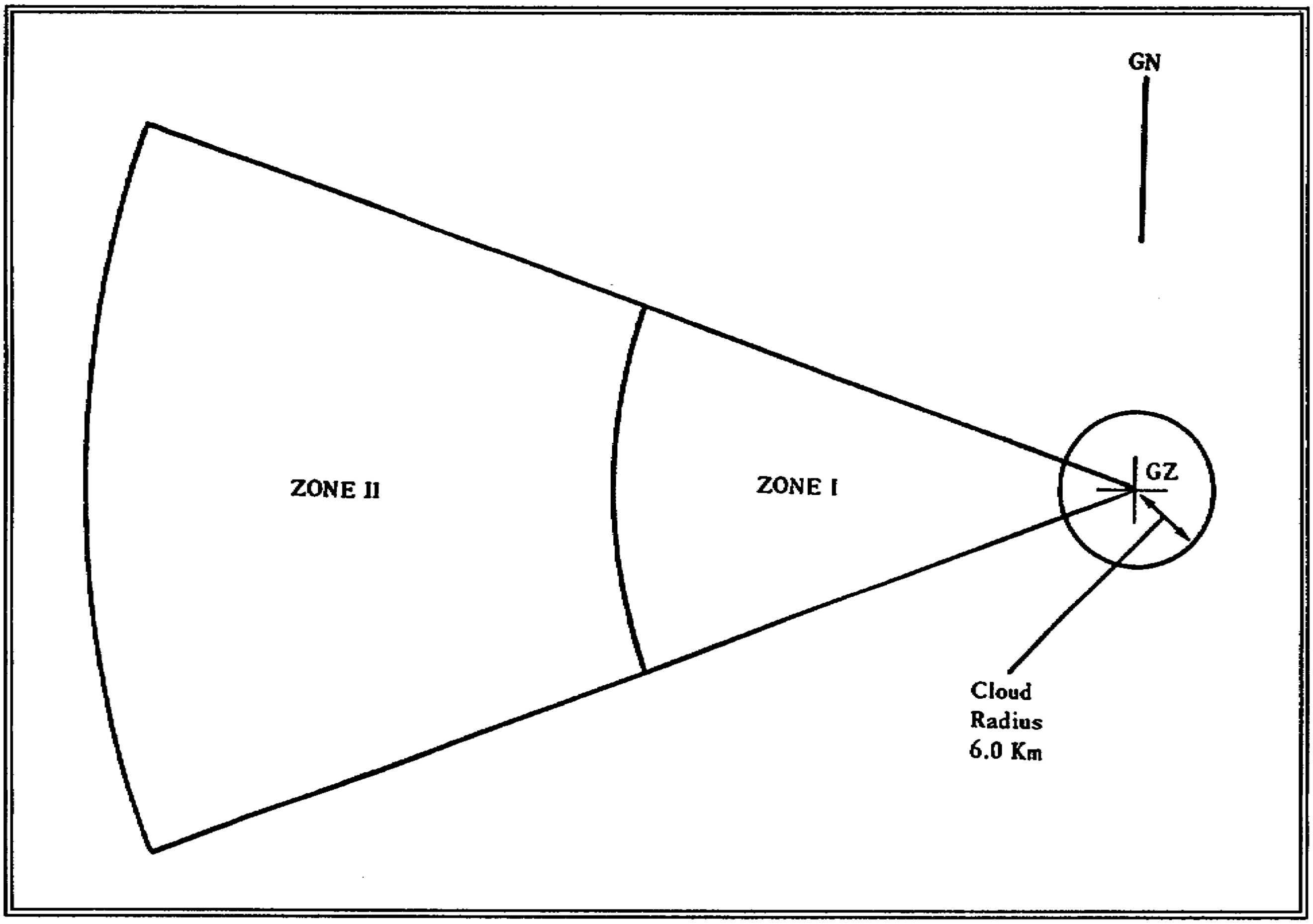

Figure 3-9. Cloud Radius Circle

d. Draw two tangents extending from the ground zero circle to the points of intersection of the two radial lines with the Zone I arc (Figure 3-10).

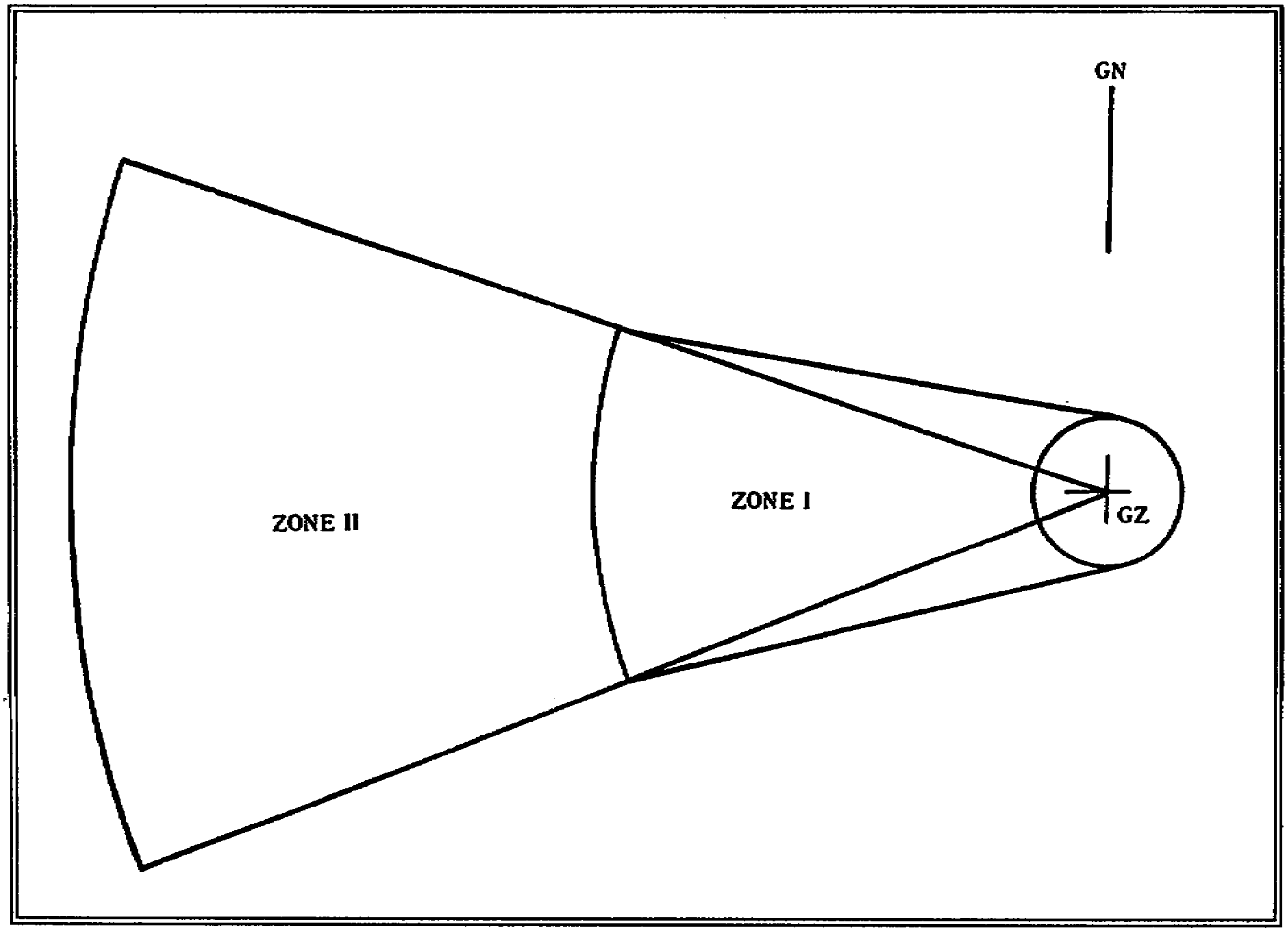

Figure 3-10. Tangent Lines

e. Using ground zero as center, indicate the estimated times of arrival of fallout by drawing dashed arcs downwind at distances equal to the product of effective wind speed and each hour of interest (Figure 3-11).

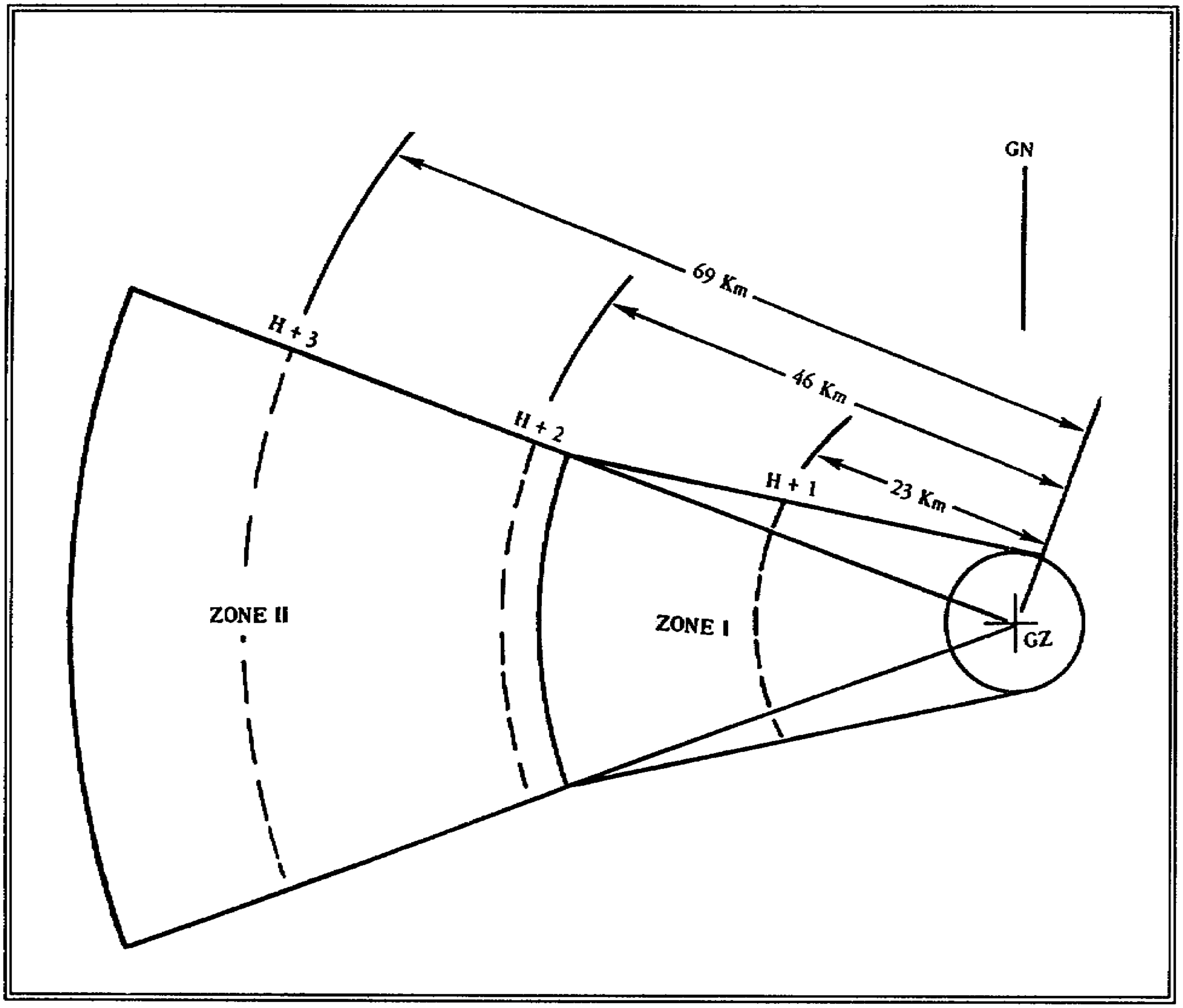

Figure 3-11. Time of Arrival Arcs

f. To refine the prediction, place a clean sheet of overlay paper over the prediction, and draw in the outer boundary of the prediction; include the Zone I and Zone II arcs, estimated time-of-arrival arcs, and other essential data (Figure 3-12).

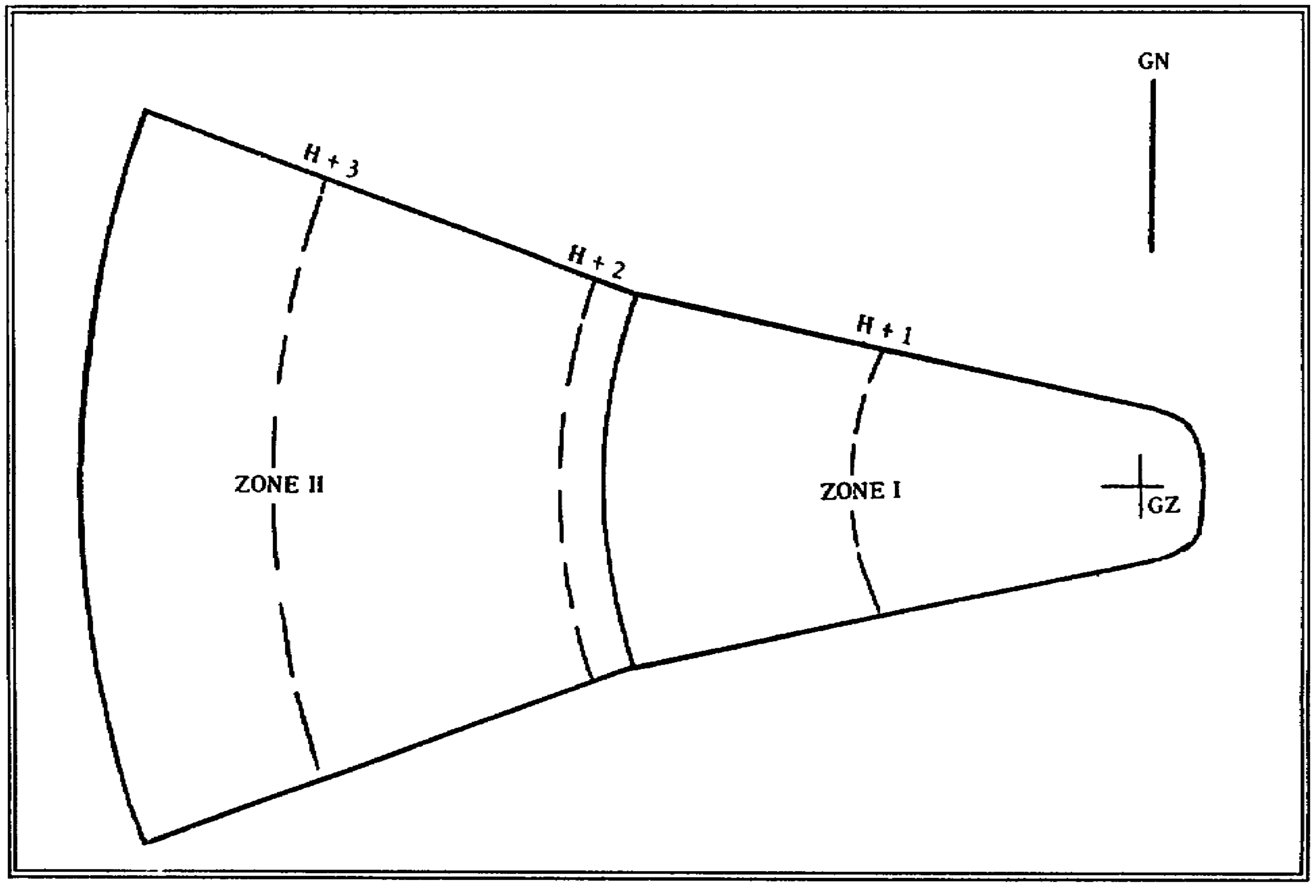

Figure 3-12. Fallout Prediction Overlay

Step 9. Preparation and Dissemination of the Detailed Fallout Prediction Message/NBC 3 (Nuclear) Report.

The report is completed by recording the strike serial number and then by entering the data from lines **a, b, p, q, l, o, and i** (in that order) on line r of the worksheet.

a. Complete **line r** on the NBC 3 (Nuclear) Report of the worksheet.

NBC 3 (NUCLEAR) REPORT

ALFA	Strike Serial Number (if known)
DELTA	DDtttt (Local or ZULU, state which, only ZULU times will be used by NATO Offices)
FOXTROT	yyzzzzzz (actual or estimated, state which)
YANKEE	ddddcccc (mils or degrees, state which)
ZULU	sssxxxrr

b. The significance of each letter item is indicated below:

(1) **ALFA**. This line is the strike serial number (if known). The strike serial number will be assigned by the NBCE at the operations center responsible for the area in which the strike occurs.

(2) **DELTA DDtttt**. This line is the date-time group of the burst, with **DD** the day and **tttt** H-hour in local or ZULU time, state which.

(3) **FOXTROT yyzzzzzz**. This line provides the actual or estimated coordinates of ground zero, state which, with **yy** the two letters representing the appropriate 100,000-meter grid square and **zzzzzz** the coordinates of ground zero within this grid square.

(4) **YANKEE ddddcccc**. This line provides the azimuths of the two radial lines to the nearest mil or degree from grid north, with **dddd** the azimuth of the left radial line and **cccc** the azimuth of the right radial line. Left and right are those angles as they would appear to an observer located at ground zero looking downwind. The unit of measurement (mils or degrees) of the azimuths must be indicated.

(5) **ZULU sssxxxrr**. This line provides prediction dimensions, with **sss** the effective wind speed to the nearest kilometer per hour (kmph), **xxx** the downwind distance of Zone I to the nearest kilometer (km), and **rr** the radius of the stabilized cloud (GZ circle) to the next higher kilometer if the value is not a whole number. This line contains only three digits (downwind distance of Zone 1) when the effective wind speed is less than 8 kilometers per hour.

c. Prepare the report, using the format for the NBC 3 (Nuclear) Report. Data entered in the ZULU line of the NBC 3 (Nuclear) Report, (**line r** of the Detailed Fallout Prediction Worksheet) are rounded as explained below.

The effective wind speed (**sss**) is rounded off the nearest kilometer per hour. The downwind distance of Zone I (**xxx**) is rounded off to the nearest kilometer.

The cloud radius (**rr**) is rounded up to the next kilometer if the value is not a whole number.

d. Disseminate the report in accordance with the unit SOP.

PART C - PREPARE A SIMPLIFIED FALLOUT PREDICTION

The simplified fallout prediction method is provided to enable small unit commanders to make an immediate estimate of the location of the potential fallout hazard without waiting for a detailed fallout prediction message, NBC 3 (Nuclear) Report.

The simplified prediction method requires nuclear burst information, a current effective downwind message, and a simplified fallout predictor.

The lateral or angular limits of a simplified fallout predictor are fixed at 40 degrees; this is in contrast to the determination of lateral limits from current winds in the detailed method. These fixed angular limits or radial lines are based upon climatic studies. In most cases these fixed angular limits are sufficient to encompass the fallout area of hazard.

1. Effective Downwind Message.

Use of a simplified fallout predictor requires knowledge of the effective wind speed and downwind direction. This information is prepared by the NBCE as an effective downwind message and is transmitted to subordinate and adjacent units each time new upper air wind data are received. The latest effective downwind message should always be used. Effective downwind messages more than 12 hours old should not be used for fallout prediction.

The format for the effective downwind message will be a series of eight lines preceded by the phrase **Effective Downwind Message**.

Effective Downwind Message

ZULU	DDTTTT (local or ZULU, state which)
ALFA	dddsss
BRAVO	dddsss
CHARLIE	dddsss
DELTA	dddsss
ECHO	dddsss
FOXTROT	dddsss
GOLF	dddsss

The significance of each letter item is indicated below:

a. **ZULU DDTTTT.** This line is the date-time at which the winds were measured, with **DD** the day and **TTTT** the hour in local or ZULU time (Greenwich Mean Time).

b. The remaining lines provide data for the seven preselected yield groups, where **ddd** is the effective downwind direction in degrees from grid north and **ss** is the effective wind speed to the nearest kilometer per hour.

(1) **ALFA dddsss** is the data line for the 2-kiloton (KT) or less yield group.

(2) **BRAVO dddsss** is the data line for the more than 2-KT through 5-KT yield group.

(3) **CHARLIE dddsss** is the data line for the more than 5-KT through 30-KT yield group.

(4) **DELTA dddsss** is the data line for the more than 30-KT through 100-KT yield group.

(5) **ECHO dddsss** is the data line for the more than 100-KT through 300-KT yield group.

(6) **FOXTROT dddsss** is the data line for the more than 300-KT through 1-megaton (MT) yield group.

(7) **GOLF dddsss** is the data line for the more than 1-MT through 3 MT yield group.

For example, if the DELTA line of an effective downwind message reads DELTA 090025, the person using this information would know that the DELTA line is used when the yield of the weapon is in the range from more than 30 KT through 100 KT. The contents of this DELTA line would indicate that the fallout prediction would be determined from an effective downwind direction of 90 degrees and an effective wind speed of 25 kilometers per hour.

Any one or more of the data lines of the effective downwind message may contain only three digits when the effective wind speed is less than 8 kilometers per hour. In this case, only the Zone 1 downwind distance is given for the highest yield represented in that line.

2. M5A2 Radiological Fallout Area Predictor.

The M5A2 Radiological Fallout Area Predictor, Figure 3-13, is a transparent device used to outline the hazard zones resulting from surface or near-surface bursts for preselected yield groups.

The M5A2 Radiological Fallout Area Predictor is composed of two simplified predictors and a nomogram for determining the downwind distance of Zone I. One simplified predictor is drawn to a scale of 1:50,000, with five preselected yield groups (A, B, C, D, E); and one predictor is drawn to a scale of 1:250,000, with six preselected yield groups (A, B, C, D, E, F). It may be requisitioned through supply channels using FSN 6665-106-9595.

Each simplified predictor consists of three major parts:

a. An azimuth dial for orientation.

b. Semicircles depicting stabilized nuclear cloud radii drawn about ground zero and sh@ing the area of contamination for each of the preselected yield groups.

c. A map scale calibrated in kilometers along two radial lines extending out from the center of the azimuth dial, fixed at 400.

d. The nomogram (Figure 3-14), consisting of three scales, is positioned between the radial lines of the M5A2 Radiological Fallout Area Predictor and is used to determine the downwind distance of Zone I. The nomogram is not required for field constructed predictors.

(1) The left-hand scale is the effective wind speed in kilometers per hour.

(2) The center scale is the downwind distance of Zone I in kilometers.

(3) The right-hand scale is the yield in kilotons.

3. Procedures for Use of Simplified Method.

a. Information Required.

Use of the M5A2 Radiological Fallout Area Predictor requires a current effective downwind message, an actual or estimated yield of the nuclear weapon detonated, and location of ground zero. Normally, the user of the M5A2 will have to obtain the yield and the location of ground zero from measured data or from the NBC 2 (Nuclear) Report.

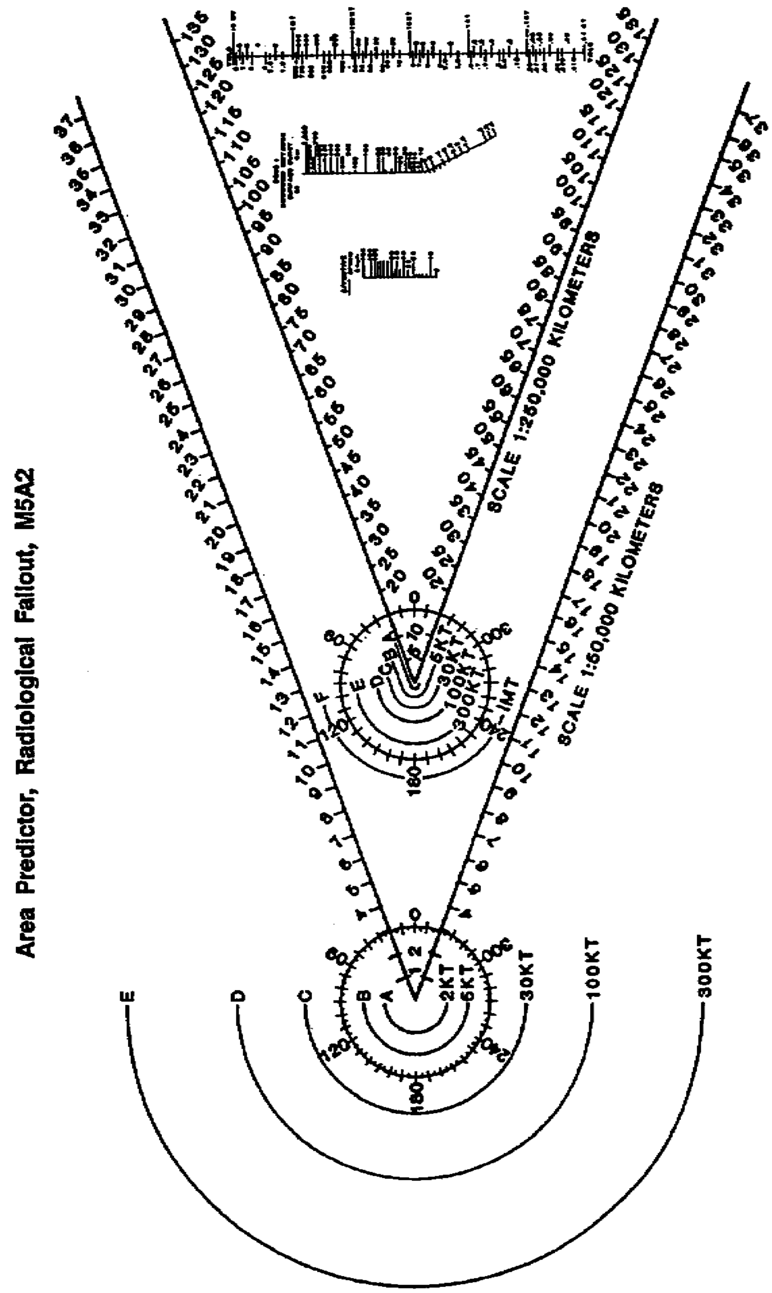

Figure 3-13. M5A2 Radiological Fallout Area Predictor

b. Identification of the Prediction.

The prediction is identified by recording the location of ground zero and the date-time of burst on the predictor.

c. Effective Wind Speed and Downwind Direction.

The effective wind speed and downwind direction for the burst are taken from the appropriate yield group data line of the effective downwind message.

d. Downwind Distances of the Zones.

The downwind distance of the zone of Immediate Operational Concern (Zone I) is determined from the nomogram on the M5A2 Fallout Predictor. This determination is made by connecting the value of the effective wind speed and the point on the yield scale representing the yield (using the actual or estimated yield, not the yield group) with a hairline. The value of the downwind distance of Zone I, in kilometers, is read at the point of intersection of the hairline and the Zone I downwind distance scale. The downwind distance of Zone II is twice that of Zone I. Arcs are drawn between the two radial lines, using GZ as center, with radii equal to the two downwind distances determined.

e. Tangents.

Tangents are drawn from the cloud radius line for the yield group considered to the points of intersection of the radial lines of the predictor with the arc representing the downwind distance of Zone I.

f. Perimeter.

Zones I and II are labeled, and the remainder of the prediction perimeter is darkened with a grease pencil to emphasize the area of hazard.

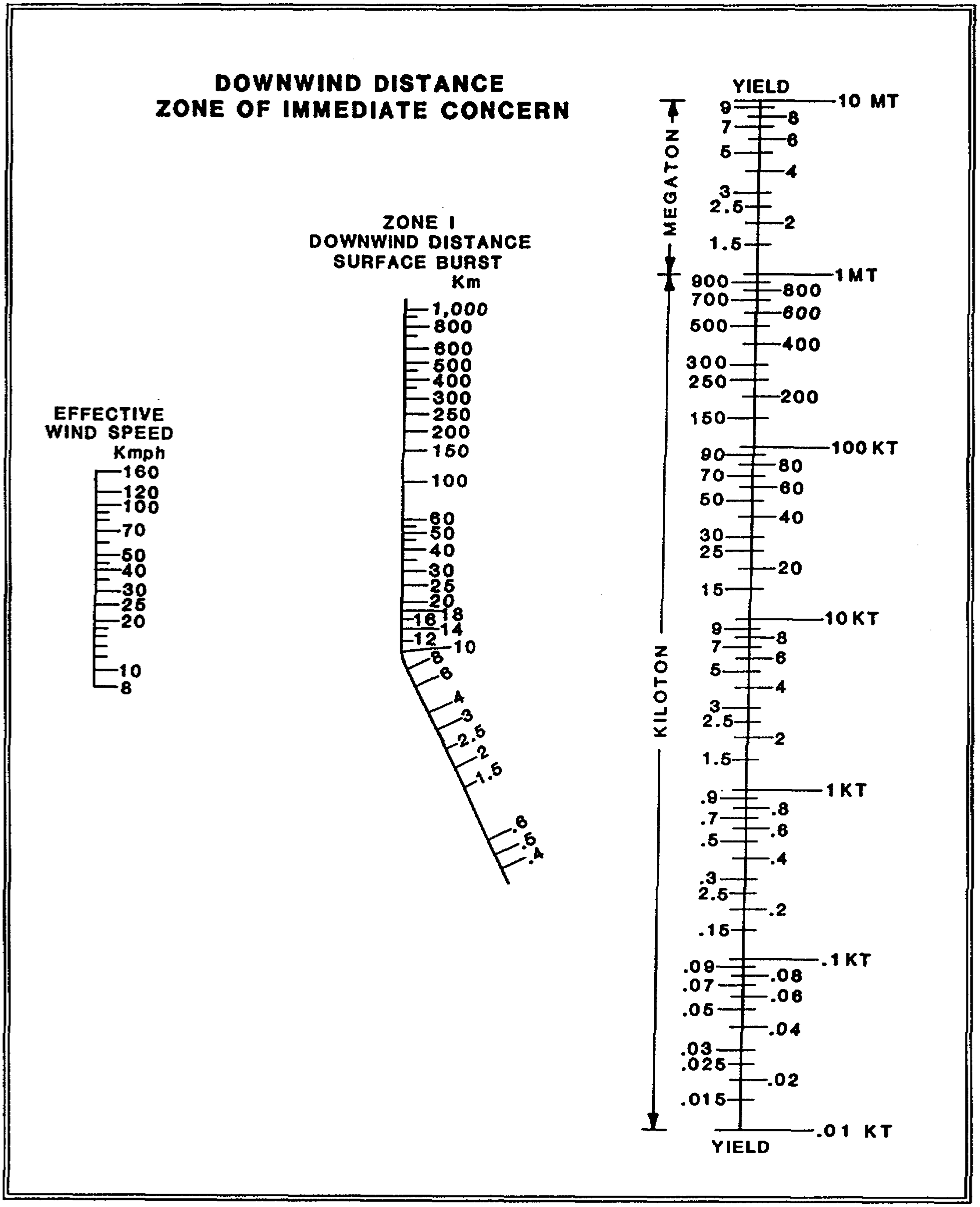

Figure 3-14. Zone I Downwind Distance Nomogram

g. Time-of-Arrival Arcs.

Time-of-arrival arcs of interest are drawn in, using the effective wind speed and the procedure in Part A.

h. Orientation.

Next, the fallout predictor ground zero point is placed over the actual or assumed GZ on the map, and the entire fallout predictor is rotated until the effective downwind direction in degrees on the azimuth dial is pointing toward grid north. The scale of the M5A2 Fallout Predictor and the map must be the same.

i. Evaluation.

The simplified fallout prediction is now complete, and the operational aspects of the fallout hazard can be evaluated.

4. Special Cases.

a. Infrequently, the fallout wind vector plot prepared by the NBCE may indicate a warning area angle greater than 40 degrees. In these instances, the greater angle will be given beside the particular line of the effective downwind message for the yield group affected. Using units will expand the warning area beyond the fixed 40-degree angle of the simplified fallout predictor to correspond with the angle given at the side of the particular line of the effective downwind message.

b. A special case may arise when one or more of the data lines on the effective downwind message may contain only three digits. The three digits are the Zone I downwind distance for the highest yield in the yield group of interest and an effective wind speed of 8 kmph, determined from the nomogram (Figure 3-14).

The example problem (below) illustrates the use of the M5A2 Radiological Fallout Area Predictor in the preparation of a simplified fallout prediction.

Example Problem. Use of the M5A2 Radiological Fallout Area Predictor.

c. Situation.

Assume that the S3, 2d Bn, 62d Inf, has the following effective downwind message available:

Effective Downwind Message

ZULU	240600Z
ALFA	080015
BRAVO	085015
CHARLIE	090016
DELTA	100010
ECHO	110025
FOXTROT	120020

At 240730Z a nuclear burst occurred at a point estimated to be MN553298. A measurement of the flash-to-bang time and nuclear burst cloud width indicates an estimated yield of 16 KT.

d. Action.

Use the M5A2 Radiological Fallout Area Predictor to make a fallout prediction. The estimated yield (16 KT) lies within the yield group CHARLIE (5+ to 30 KT). Therefore, use the effective downwind direction and effective wind speed from line CHARLIE of the effective downwind message, and use the "C" semicircle on the fallout predictor.

From the nomogram on the predictor, using a yield of 16 KT and an effective wind speed of 16 kilometers per hour, read the downwind distance of the Zone of Immediate Operational Concern (Zone I) to be 18 kilometers. Draw an arc between the radial lines of the predictor at a distance of 18 kilometers downwind from ground zero. Double this distance, and draw a second arc between the radial lines of the predictor at a distance of 36 kilometers downwind from ground zero.

Draw straight lines tangent to the 30 KT cloud radius semicircle and extending to the intersection points of the Zone I arc with the radial lines. The area enclosed by the two lines, the 30 KT semicircle and the 18 kilometer arc, is the predicted Zone of Immediate Operational Concern (Zone I). The area enclosed by the 18 kilometer and 36 kilometer arcs and the radial lines is the predicted Zone of Secondary Hazard (Zone II).

Draw a series of dashed arcs at distances equal to the product of the effective wind speed (16 kilometers per hour) and the hours of interest after the burst to represent the estimated times of arrival of fallout (16 kilometers at H + 1 and 32 kilometers at H + 2). Arcs that fall outside Zone II need not be drawn.

Draw a straight line from the center of the azimuth dial through the effective downwind direction (90 degrees) on the azimuth dial, and label the line grid north (GN). Place the center of the azimuth dial on the predictor over the estimated GZ (MN553298) on the map (the scales of the map and predictor must correspond), and rotate the predictor around the ground zero point until the GN line is pointing toward grid north. The predictor is now oriented so that fallout is going toward 90 degrees. The area covered by fallout can now be evaluated.

5. Field Construction of Simplified Fallout Predictor.

If the fallout predictor shown in Figure 3-13 on page 3-25 is not available, a predictor can be constructed from any pliable, transparent material to any desired map scale by the following procedure:

Step 1. Select an appropriate map scale. On a piece of pliable, transparent material or overlay paper, draw a thin dotted line (reference line) to a scaled length of 50 kilometers from a point selected to represent ground zero (Figure 3-15).

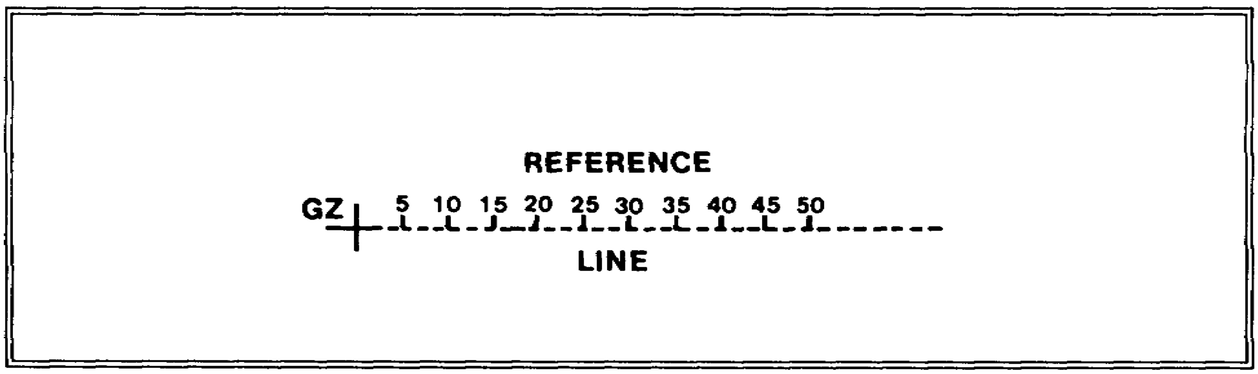

Figure 3-15. Reference Line

Step 2. Draw and graduate in kilometers two radial lines from ground zero at angles of 20 degrees to the left and to the right of the dotted reference line (Figure 3-16).

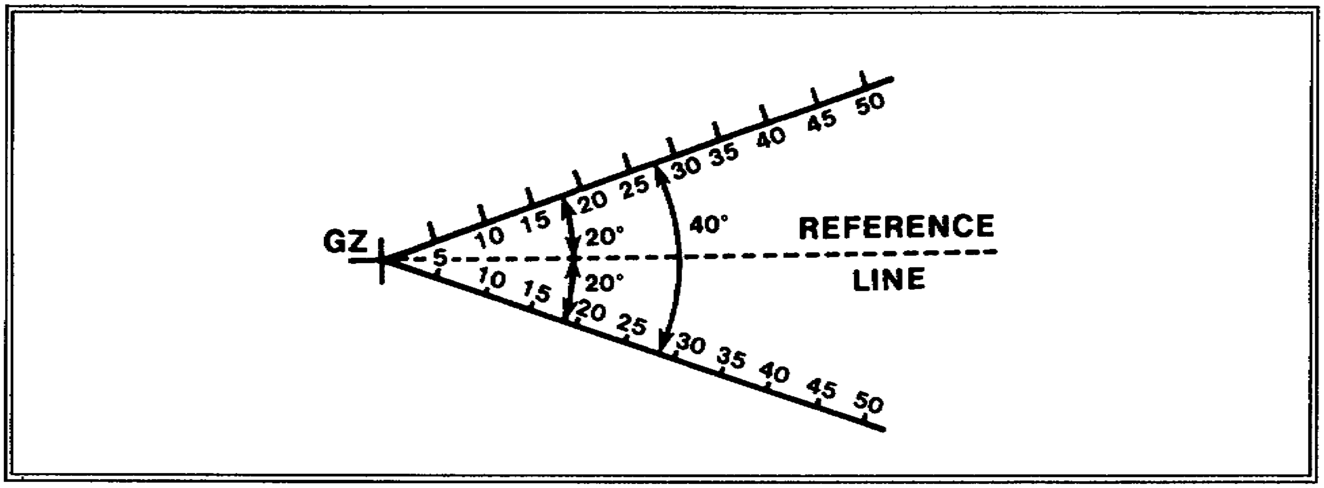

Figure 3-16. Radial Lines

Step 3. On the side of ground zero opposite the reference line, draw a series of concentric semicircles (using the selected map scale) having radii of 1.2 kilometers, 1.9 kilometers, 4.2 kilometers, 6.8 kilometers, 11.2 kilometers, and 18.0 kilometers, which correspond to stabilized cloud radii from nuclear bursts with yields of 2 KT, 5 KT, 30 KT, 100 KT, 300 KT, and 1 MT (1,000 KT) respectively (Figure 3-17).

Step 4. Label the semicircles constructed in Step 3. Starting with the semicircle closest to GZ and moving up from GZ, label the semicircles A,B,C,D,E, and F; moving down from GZ, label the semicircles 2, 5, 30, 100, 300 KT, and 1 MT (1,000 KT).

To use the field-constructed fallout predictor, determine the downwind distance of the Zone of Immediate Operational Concern from Figure 3-18 and complete the simplified fallout prediction, using the procedures discussed on pages 3-24 through 3-30. The resulting prediction is then oriented by placing a protractor over an actual or assumed GZ on the map and drawing a line to represent the effective downwind direction for the yield group of interest. Place ground zero of the predictor over ground zero on the map, and rotate the predictor until its reference line coincides with the effective downwind direction.

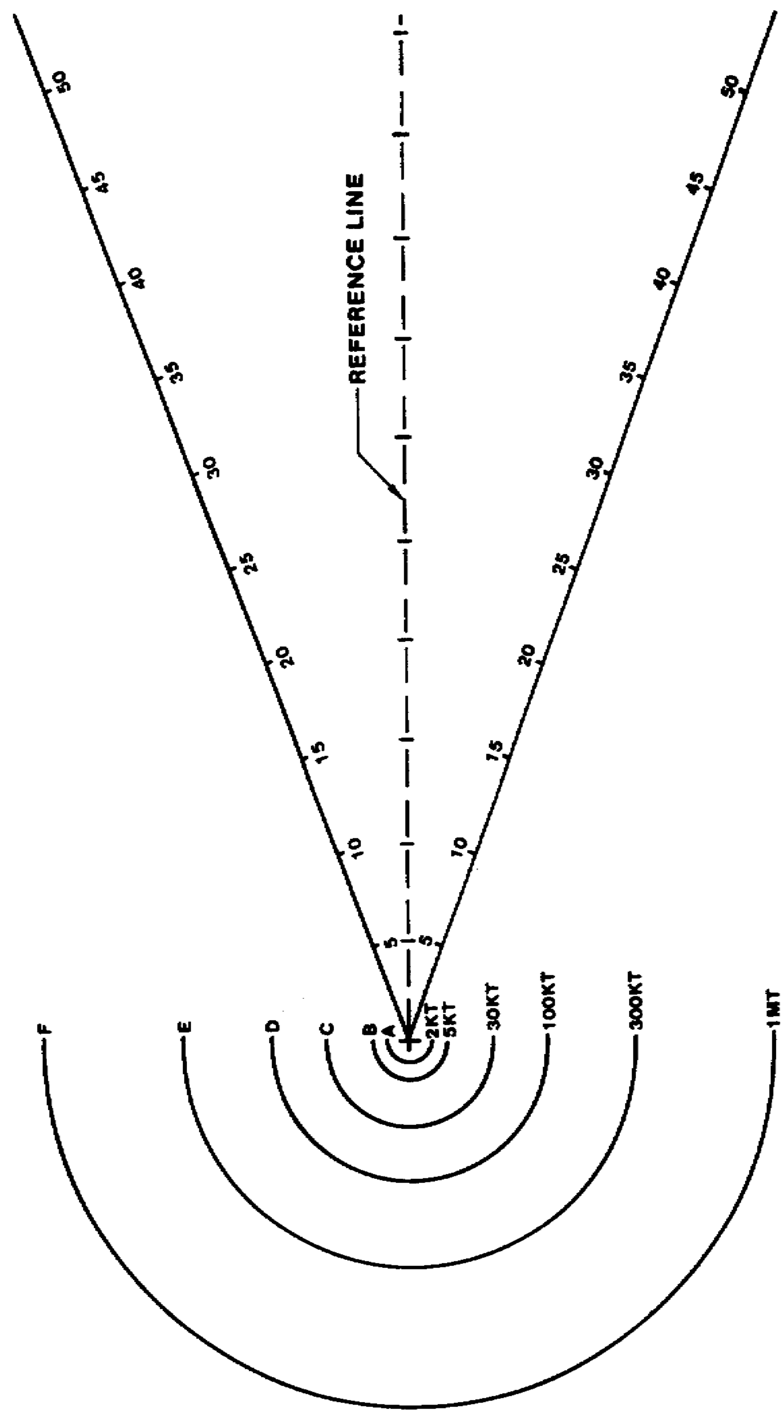

Figure 3-17. Draw and label semicircles

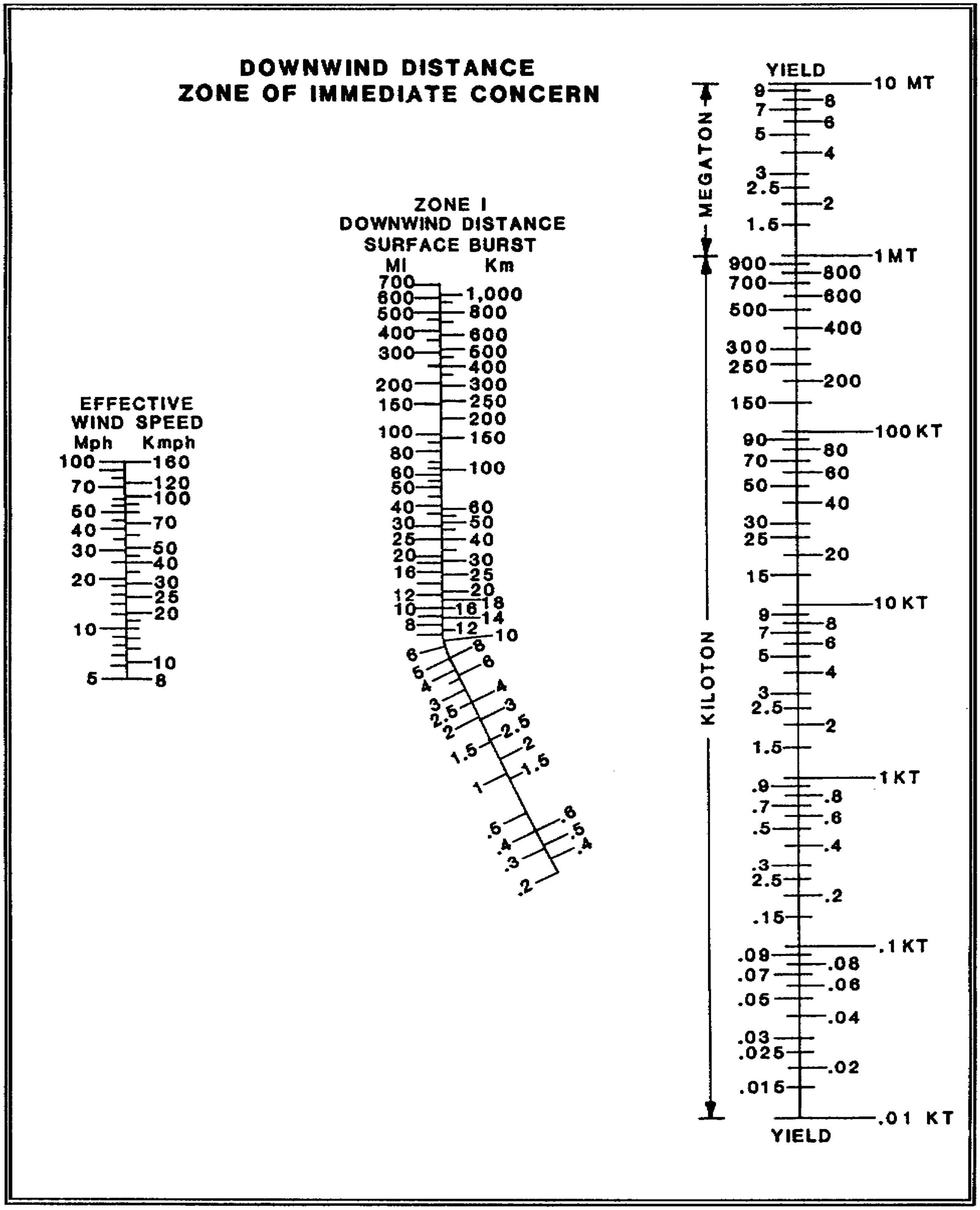

Figure 3-18. Zone I Downwind Distance Nomogram

LESSON 3

PRACTICE EXERCISE

The following items will test you grasp of the material covered in this lesson. There is only one correct answer for each item. When you complete the exercise, check you answer with the answer key that follows. If you answer any item incorrectly, study again that part of the lesson which contains the portion involved.

Situation: Your unit has received information indicating that fallout is occurring and a fallout prediction is required to enable the commander to warn other units.

1. The detailed fallout prediction is based upon which item?

   A. Friendly burst
   B. Simplified fallout predictor
   C. Total dose
   D. Upper air wind data

2. What is recorded on **lines a through e** of the Detailed Fallout Prediction Worksheet?

   A. Angle of the nuclear cloud width
   B. Azimuths of the radial lines
   C. Nuclear burst information
   D. The ZONE I downwind distance

3. Line ZULU of the NBC 3 (Nuclear) Report will normally contain how many digits?

   A. 6
   B. 8
   C. 10
   D. 12

4. For which yield group is Line BRAVO used?

   A. 2 KT or less
   B. 2+ KT through 5 KT
   C. 10 KT to 15 KT
   D. 15 KT to 30 KT

5. The simplified prediction method requires which item?

   A. A detailed fallout prediction
   B. Current effective downwind message
   C. M5A2 Fallout Area Predictor
   D. Target analysis

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LESSON 3

PRACTICE EXERCISE

ANSWER KEY AND FEEDBACK

Item		**Correct Answer and Feedback**
1.	D	Upper air wind data It is . . . data. Part A, p. 3-3, para 1
2.	C	Nuclear burst information Nuclear burst . . . **e**. Part B, p. 3-8, Step 2
3.	B	8 Part C, p. 3-10, Figure 3-3
4.	B	2+ KT through 5 KT BRAVO dddsss . . . group. Part C, p. 3-23, para b(2)
5.	B	Current effective downwind message Use of . . . zero. Part C, p. 3-24, para 3a

LESSON 4

RADIOLOGICAL MONITORING AND SURVEYS

Critical Task: 031-506-2020

OVERVIEW

LESSON DESCRIPTION:

In this lesson you will learn how to conduct radiological monitoring and surveys.

TERMINAL LEARNING OBJECTIVE:

ACTION: Conduct radiological monitoring and surveys.

CONDITION: Given information about the need for radiological monitoring and surveys, the types and techniques of monitoring and surveys, reporting dose rate, and correlation and transmission factors.

STANDARD: Demonstrate competency of the task, skills, and knowledge by responding to the multiple-choice test covering radiological monitoring and surveys.

REFERENCE: FM 3-12.

INTRODUCTION

While in an area which has been exposed to nuclear radiation, there is a need to perform radiological monitoring and surveys. You will learn the monitoring and survey types and techniques, reporting dose rate, and correlation and transmission factors.

PART A - AREA MONITORING

Radiological monitoring is the act of detecting the presence of radiation and measuring it with RADIAC instruments. Monitoring provides warning of a hazard that otherwise might go undetected. For example, monitoring alerts the command to the arrival of fallout or alerts units on the move when they contact a contaminated area. The RADIAC instrument used in monitoring radiologically contaminated areas is the survey meter. The AN/VDR-2 RADIAC Set is used to locate and measure radioactivity in the form of Gamma Rays and Beta particles. It is used to measure fallout contamination after the nuclear burst, normally H+48 hours or longer.

The AN/VDR-2 can be operated in mounted or dismounted mode in tactical Army ground vehicles. It provides a means for conducting dismounted and vehicular radiological surveys and monitoring personnel and equipment.

Monitoring is included in normal intelligence and reconnaissance activities and provides the following:

- Small units. Unit monitors keep the unit commander informed of the degree of radiological hazard in his unit area.

- Brigade, battalion, and comparable units. Monitoring reports from subordinate units are used in conjunction with fallout predictions in developing radiological intelligence.

- Division or higher or similar organizations. Monitoring reports, screened by intermediate headquarters, are one of the forms of information used by major organizations having area responsibilities in developing the radiological contamination overlay. If sufficient data are collected from monitoring efforts and if reports are not delayed in transmission, a radiological survey may not be required.

- Company/troop/battery units or smaller units. These units operating independently monitor for radiation once nuclear operations have commenced. Monitoring may be either periodic or continuous.

1. Types of Monitoring.

a. Periodic Monitoring.

Periodic monitoring is the periodic check of the units area for radiation. The purpose of periodic monitoring is to assure the commander that the unit area is not contaminated and to warn him if contamination arrives. All units (normally platoon level and above) should routinely monitor a designated point in their unit area a minimum of once during each 1-hour period. The unit SOP should give detailed guidance on monitoring procedures and times so that subordinate units will monitor at essentially the same time and in the same manner. Units having several survey meters on hand may need to use only one instrument for this purpose.

b. Continuous Monitoring.

Continuous monitoring is a continuous surveillance for radiation in the unit area of operations or along a route of march and is performed by units, using monitoring techniques on the following pages.

Continuous monitoring requires that the monitor have the survey meter turned on at all times; the frequency of readings will depend upon the current situation. For example, the monitor will take more frequent readings when fallout is actually arriving on the unit position than when the unit is simply warned that it may be in the fallout area.

Units initiate continuous monitoring in the following situations:

- When a fallout warning (NBC 3 Report) is received.
- When ordered by the unit commander.
- After a nuclear burst has been sighted, heard, or reported.
- When the unit is moving.
- During reconnaissance and patrol activities.
- When radiation above 1 cGyph is detected by periodic monitoring.

Units discontinue continuous monitoring on orders from higher headquarters or when the dose rate falls below 1 cGyph except for units on the move.

2. Monitoring Techniques.

Monitoring techniques vary, depending upon such factors as ground dose rate, operational or tactical conditions, dose status of monitor, type of survey meter, and whether the monitor is stationary or moving. The technique used must provide sufficient information to allow evaluating agencies to calculate the ground dose rate at the monitor's location. DA Form 1971-R is used for recording monitoring data and for survey data when point or preselected dose rate techniques are used.

a. Direct Technique.

The direct determination of ground dose rate is the simplest and most precise of the monitoring techniques. The unshielded ground (outside) dose rate may be determined directly by standing at the desired location, holding the survey meter waist high in a vertical position (face up), turning with the survey meter in all directions, and recording the highest dose rate reading observed. The preferred procedure is to take readings in the open at least 10 meters away from buildings, other large structures, or objects that may shield out a portion of the radiation. If there are points of operational interest where this procedure cannot be used, additional readings can be taken at those points. Thus, if a road through a narrow cut or defile is of operational interest, readings should be taken both in the open near the cut and in the cut. In cities or built-up areas, readings are taken in the center of the streets or at street intersections. In all these cases, no correlation factor data are required since the readings are representative of the area of interest. Safety considerations may preclude the direct determination of ground dose rates except--

- When in low dose-rate areas.

- While monitoring for the initial detection of contamination.

- While obtaining transmission factor data.

- While moving through a contaminated area on foot.

b. Indirect Technique.

(1) Monitoring inside shelters.

Within the contaminated area, monitoring will normally be performed from within shelters or fortifications. The reading is obtained by noting the highest dose rate measured by the survey meter when it is held in the center of the shelter, 1 meter above the floor, and pointed in all directions. The outside dose rate is then obtained by applying the correlation factor to the inside dose rate reading.

(2) Monitoring inside vehicles.

Monitors mounted in ground or aerial vehicles use the ground or aerial survey procedures to obtain monitoring information.

3. Correlation Factor Data.

All monitoring reports, except those made using the direct technique must include correlation factor information so that shielded dose rates can be converted to unshielded ground dose rates. If the situation permits, it is preferable to determine the correlation factor directly. When correlation factors cannot be obtained directly, the type of structure or vehicle should be identified in the monitoring report and the appropriate correlation factor should be obtained from Figure 4-1.

ENVIRONMENTAL SHIELDING	LOCATION OF SURVEY METER	CORRELATION FACTOR
	VEHICLES	
M60 TANK	TURRET, REAR TOP	25.0
	TURRET, FRONT	53.0
	CHASSIS, NEAR DRIVER	23.0
M113 APC	DIRECTLY IN FRONT OF DRIVER ON FRONT WALL	3.6
	NEAR FIRST SQUAD MEMBER ON LEFT FACING FORWARD	3.6
M1 TANK		20.0
M2 IFV		9.1
M3 CFV		3.6
M109 SP HOWITZER	NEAR DRIVER, LEFT SIDE	3.5
	REAR, RIGHT SIDE	3.4
M88 RECOVERY VEHICLE	COMMANDER POSITION	6.9
M577 COMMAND POST CARRIER	NEAR DRIVER, RIGHT SIDE	3.2
	REAR, LEFT SIDE	2.5
M551 ARMORED RECON AIRBORNE ASSAULT VEHICLE	NEAR DRIVER, RIGHT SIDE	4.6
	TRUCKS	
3/4-TON		1.7
2 1/2-TON		1.7
4 TO 10-TON / M1008 HEMMT		2.0
5 1/4-TON M998 HMMWV		1.7
	STRUCTURES	
MULTI-STORY BUILDING	TOP FLOOR	100.0
	LOWER FLOOR	10.0
FRAME HOUSE	FIRST FLOOR	2.0
	BASEMENT	10.0
UNDERGROUND SHELTER (3-FT. EARTH COVER)		5,000.0
INDIVIDUAL FIGHTING POSITION		10.0

NOTE: Correlation factors are based on the inverse of the transmission factor for the given vehicle at the prescribed location for the RADIAC instrument.

Figure 4-1. Location of Survey Meter and Corresponding Correlation Factor for Residual Radiation

a. Procedure.

The correlation factor data required consist of two dose-rate determinations that must be made within 3 minutes of each other. One is a direct determination of ground dose rate made at a location 10 meters from the shelter, if possible, unless the shelter is underground. The other is a reading made with the survey meter held in the center of the shelter, 1 meter above the floor, and pointed around in the circle in all directions.

b. Example.

A company monitor is located in an open front shelter dug into the side of a hill. Since there is no published correlation factor for a shelter of this type, a spot outside the shelter has been selected at which the ground dose rate will be taken. A nuclear burst occurs several kilometers away and about 30 minutes later the monitor detects the arrival of fallout. After the completion of fallout, the monitor takes a dose-rate reading of 2 cGyph with the survey meter at the center of the shelter, 1 meter above the shelter floor, and then goes immediately to the selected location outside the shelter and takes a ground dose-rate reading of 10 cGyph. The monitor returns immediately to the shelter to avoid unnecessary exposure. The two dose-rate readings were made within 3 minutes of each other; thus the correlation factor data for this shelter are:

Inside dose rate (ID) = 2 cGyph
Outside ground dose rate (OD) = 10 cGyph

The correlation factor is determined as shown below:

$$\text{Correlation Factor (CF)} = \frac{OD}{ID} = \frac{10\ \text{cGyph}}{2\ \text{cGyph}} = 5.$$

NOTE

In this example, the transmission (TF), discussed later in this subcourse, is 1/5; that is, 1/5 of the outside dose rate was received inside the shelter.

PART B - AERIAL RADIOLOGICAL SURVEYS

Radiological contamination information can be obtained by using the AN/VDR-2 RADIAC Set in a rotary or fixed-wing aircraft. Since aerial surveys are conducted rapidly and at a distance from the radiation source, the aerial survey party would be exposed to considerably less nuclear radiation than a ground survey party, if an equivalent ground survey were conducted over the same area. Thus, aerial surveys can be employed over areas that have dose rates unacceptably dangerous to ground survey parties.

Because of speed and flexibility, aerial surveys can be employed to advantage over large areas, unoccupied areas of operational concern, and areas of difficult accessibility to ground troops. Aerial survey is preferable when conducting surveys of large areas. The advantages of aerial survey over ground survey are speed and flexibility of employment, lower radiation doses to survey party, and minimum requirements for equipment, personnel, and communications. However, the dose rate readings are not as accurate as those obtained by ground survey. Another disadvantage is that dose rates for specific points on the ground are not provided by aerial survey.

1. Simplified Aerial Survey.

Battlefield conditions or the operational situation may preclude the preparation of the detailed radiological contamination overlay, and a simplified radiological contamination overlay may be needed to satisfy the commander's requirements. A simplified aerial survey will normally be required to complete the overlay.

a. Purpose.

The simplified aerial radiological survey is designed to provide the minimum essential information for evaluating the contamination hazard. The minimum essential information is that required to determine the outer limits of the area of militarily significant contamination, a few dose rates in the most heavily contaminated parts of the area, and dose rates at points of operational interest. The simplified survey must be accomplished and the information provided to the control party as soon as possible after contamination is on the ground.

b. Techniques.

The techniques of conducting simplified aerial surveys are the same as for detailed aerial surveys with the following exceptions:

(1) The simplified survey requires considerably less detail than the detailed survey.

(2) The simplified survey may cover only those parts of the contaminated areas which are of immediate operational concern.

(3) The control party preplans only the general area in which the simplified survey will be conducted. After arriving over the area, the survey party selects the check points, routes, and course legs.

(4) A debriefing is held by the control party after this survey is performed.

2. Detailed Aerial Survey.

Simplified aerial survey information and monitoring reports do not normally provide sufficient information for the preparation of the detailed radiological contamination overlay, and a detailed aerial survey is usually required.

a. Planning.

The basis for planning a detailed aerial survey is the checkpoint overlay. Checkpoints that are easily identified from the air and on a map (small bodies of water, streams, or road junctions) are selected for the entire area in advance by the chemical officer (or TOC) representative in coordination with the aviation officer. These checkpoints are maintained as an overlay by these two staff officers. Then, when a survey requirement is established, the control party selects a series of course legs, routes, and points where data will provide sufficient ground dose rate information to evaluate the contaminated area. Figure 4-2 shows an overlay plan for an aerial survey after a surface burst occurred in the division area. This overlay is to be used with Figure 4-3, which illustrates a division area with selected checkpoints.

b. Techniques.

The techniques used to conduct detailed aerial surveys include: **route, course leg, and point techniques.** In using the **route technique**, the pilot flies between two checkpoints, following the route of some predominant terrain feature such as a road that connects the two checkpoints, heavy dashed lines, Figure 4-2. In using the **course leg technique**, the pilot flies a straight line course (course leg) between two checkpoints, thin dashed lines, Figure 4-2. The procedure followed in obtaining dose-rate information between checkpoints is the same, using either the route technique or the course leg technique. When the dose-rate information obtained from use of either technique is processed, the result is a series of ground dose rates spaced at equidistant intervals along the path over which the aircraft was flown. The **point technique** is used to determine the ground dose rate at points of operational concern and is normally employed to obtain more precise dose-rate information at those points than can be obtained by use of other aerial survey techniques. Processed data from dose rate information obtained using the point technique are ground dose rates existing at each of the selected points. The course leg and point techniques are described in the following paragraphs.

3. Procedures for Using Course Leg Technique.

The course leg technique requires that the aerial survey party fly a straight line course, course leg, between two checkpoints. The pilot maintains as nearly as possible a constant height above the ground, a constant ground speed, and a straight flight direction between the starting and ending checkpoints of each course leg.

a. The pilot locates the starting checkpoint of a course leg to be flown and either locates the end checkpoint or determines the azimuth of the course leg.

b. The pilot flies the aircraft on the proper course to pass over the initial checkpoint on a straight path to the end checkpoint. When on course, the pilot alerts the monitor and gives the height above ground. Shortly before reaching the initial checkpoint, the monitor records the time and height above ground.

c. The pilot commands “Mark” when the aircraft is directly over the starting checkpoint at which time the monitor reads the survey meter, records the dose rate, and begins timing preselected time intervals (for example, every 15 seconds).

d. The pilot again alerts the monitor when the aircraft approaches the end checkpoint. When the aircraft is directly over the end checkpoint, the pilot commands **“Mark.”** At this time the monitor reads and records the final dose rate for the course leg.

4. Procedures for Using Point Technique.

Procedures for using the point technique vary according to the situation.

a. When the situation permits, the aircraft lands near the point of interest and the monitor dismounts, proceeds to the selected point, and takes the reading by using normal ground monitoring procedures.

b. When the situation does not permit use of the above procedure, an estimation of the ground dose rate may be made by use of an air-ground correlation factor and an aerial dose-rate reading.

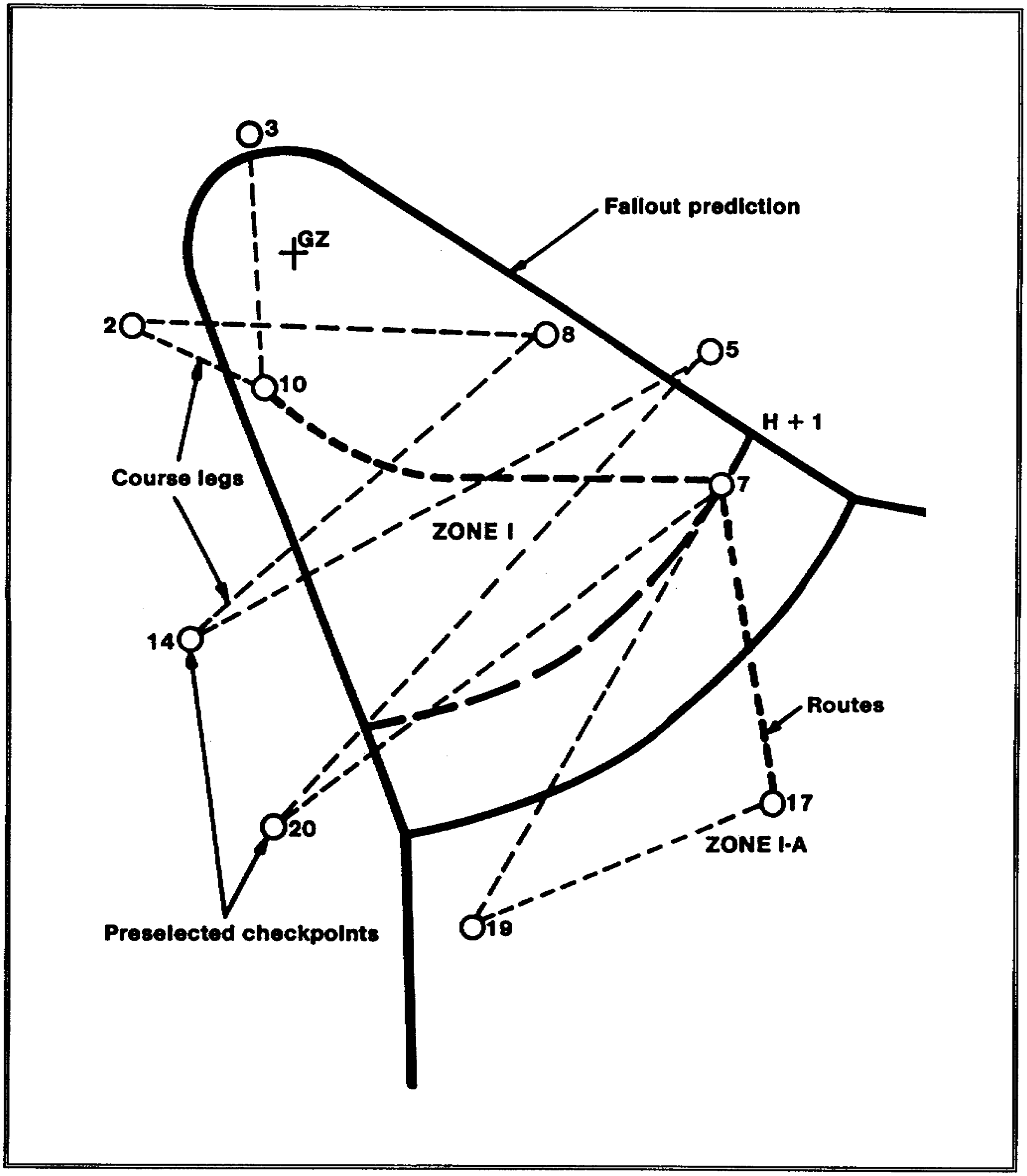

Figure 4-2. Fallout Prediction and Planned Aerial Survey Overlay

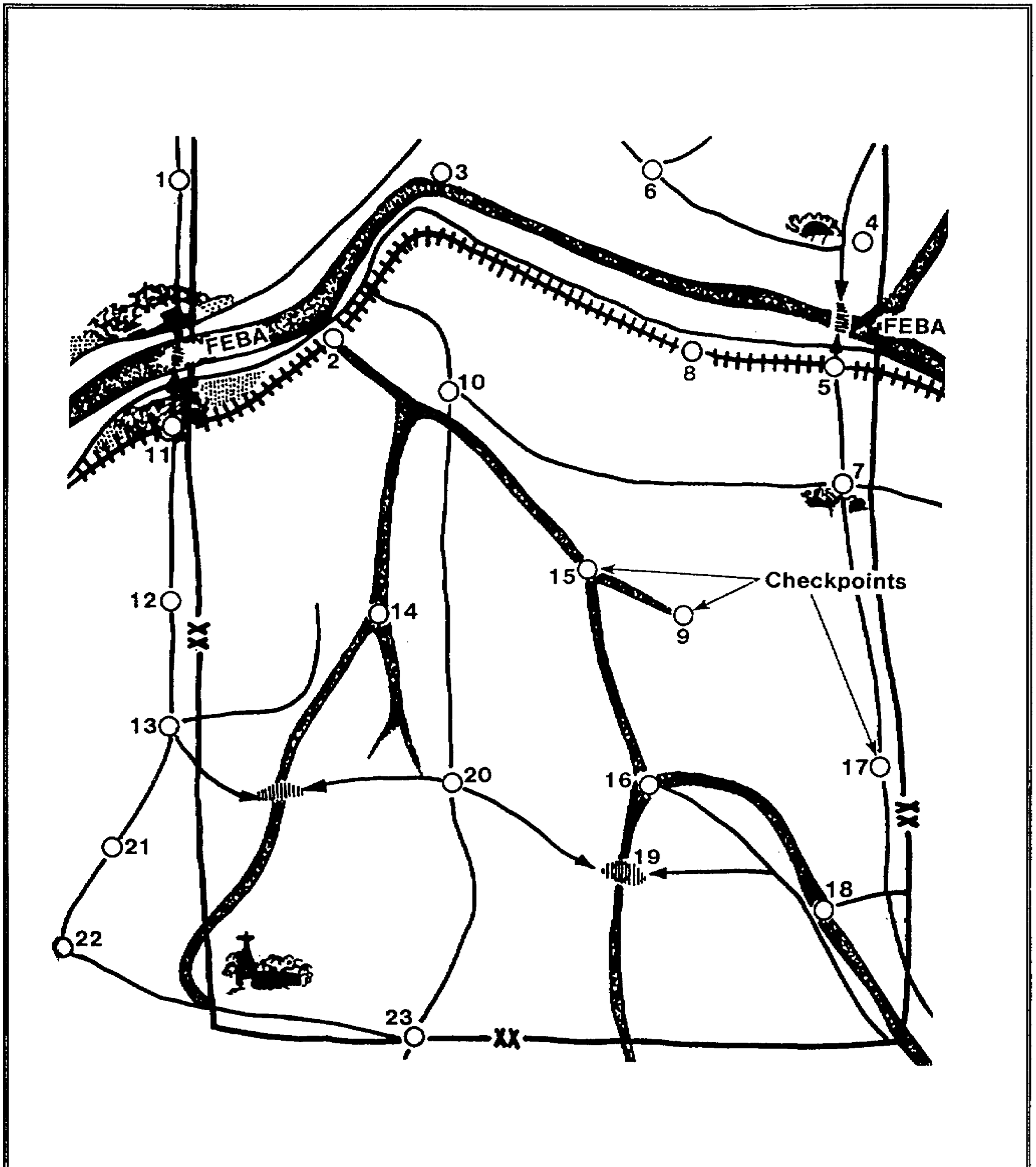

Figure 4-3. Sketch Map of Division Area
Showing Preselected Checkpoints

5. Survey Meter Location in Aircraft.

A specific location for the survey meter in the aircraft must be selected for each aerial survey. The best survey meter locations for several aircraft are given in Table 4-1. If the air ground correlation factors from Table 4-2 are to be used, the survey meter MUST be located within the aircraft as shown in Table 4-1.

When air-ground correlation factor data are to be determined during the survey, the location of the survey meter may be as given in Table 4-1, or the location may be selected for the convenience of the pilot and monitor. When aircraft not included in the table are used, such as the OH-58 and AH-1G, the survey meter location must be selected. All dose-rate readings in a survey must be made with the meter in the selected location.

TABLE 4-1. LOCATION OF SURVEY METER DURING AERIAL SURVEY

Aircraft[1]	Survey Meter Location
OH-6A	Held in front of the left rear seat.[2]
UH-60	In the passenger compartment, held in front of the second seat from the left side of the aircraft.
OH-58A	Must be selected
AH-1G	Must be selected

[1]Order of preference of currently available aircraft or use in aerial survey is as listed

[2]This location recommended in the OH-6A aircraft, for which air-ground correlation factors are not available.

6. Air-Ground Correlation Factors.

An air-ground correlation factor (CF) is required for calculation of ground dose rates from aerial dose rates taken in an aircraft during a survey. The air-ground correlation factor is the ratio of a ground dose-rate reading to a reading taken at approximately the same time in an aircraft at survey height over the same point on the ground. There are two techniques for obtaining the air ground correlation factor.

The preferred technique is by direct determination of ground and aerial dose rates during the survey and subsequent calculation of the air-ground correlation factor. The air ground correlation factor may be calculated as shown below, using the aerial dose rate taken at survey height and ground dose rate.

Ground dose rate = 20 cGyph

Aerial dose rate (60-meter survey height) = 5 cGyph

$$\text{Air/ground correlation factor} = \frac{\text{Ground dose rate}}{\text{Aerial dose rate}} =$$

$$\frac{20 \text{ cGyph}}{5 \text{ cGyph}} = 4 \text{ cGyph}$$

Then, by multiplying the reading taken in the aircraft at a survey height of 60 meters by the air-ground CF, the 1-meter above ground level reading can be estimated. The procedure for determining the ground dose-rate reading involves landing near the selected point. The monitor proceeds to that point and takes the ground dose-rate reading, using normal monitoring procedures.

Air-ground correlation factor data are obtained if possible for each two to four course legs or routes flown. The sites for obtaining air-ground correlation factor data should be selected to approximate average foliage and ground surface conditions in the contaminated area. Accuracy of the air-ground correlation factor data as to position, height above ground, and dose rate is of primary importance. New data must be obtained when survey height changes by 15 meters or more, when ground foliage or average ground surface conditions change significantly, if the aircraft or the survey meter is changed, or if weather conditions change drastically during monitoring.

When the tactical situation, terrain conditions, high radiation dose rates, or other factors do not permit the use of the preferred technique, the air-ground correlation factors shown in Table 4-2 are used. To estimate a ground dose rate, multiply the aerial dose rate obtained by the correlation factor from Table 4-2 for the type of aircraft and the height above ground at which the reading was taken. For example, while flying at a 150-meter survey height in a UH-1, a reading of 10 cGyph is obtained; the air-ground correlation factor for a UH-1 at a height of 150 meters is 8.2.

Ground dose rate = Aerial dose rate x Air-ground CF
= 10 cGyph x 8.2 = 82 cGyph

TABLE 4-2. AIR-GROUND CORRELATION FACTORS		
Height above ground		Aircraft[2]
Meters	Feet	UH-1
30	100	2.2
60	200	3.2
90	300	4.5
120	400	6.2
150	600	8.2
300[3]	1,000[3]	29.0
600[3]	2,000[3]	300.0
900[3]	3,000[3]	2,600.0

[1]The figures have been rounded to two significant digits for practical use.

[2]Air-ground correlation factors for the OH-6A, OH-58A, and AH-1G aircraft are under development.

[3]The use of the air-ground correlation factors with readings taken at these heights result in approximation of ground dose rates.

7. Capability of Aircraft.

Light fixed-wing aircraft or helicopters are satisfactory for conducting aerial surveys; however, because of the slow speeds required, helicopters are the most desirable. Light fixed-wing aircraft and helicopters have approximately the same survey area coverage capability of between 130 and 450 square kilometers per hour per aircraft, depending upon the detail required. Order of preference of currently available aircraft for use in aerial surveys is contained in Table 4-1.

8. Recording and Reporting.

a. Recording.

The Radiological Data Sheet, designed for recording data obtained by monitoring and survey, will be used for recording data obtained during aerial surveys. Data obtained, using the route or course leg technique, is recorded on the radiological Data Sheet, DA Form 1971-1-R; data obtained by use of the point technique is recorded on DA Form 1971-R. Headings provided in blocks are self explanatory. In using the form, any heading not applicable-to the situation may be lined through by the monitor. Space is provided for use of the control party, as indicated, for entry of the air-ground correlation factor and normalized readings. The REMARKS block is to be used by the monitor in providing any additional information that will be of value to the control party. This block is also used by the control party to enter time of nuclear burst and computations of the air-ground correlation factor, normalizing factor, and overall correction factor. A completed radiological data sheet, showing data collected by use of the course leg technique during aerial survey and NBCC calculations, is illustrated in Figure 4-4 on page 4-17.

b. Reporting. The survey data collected are delivered to the control party at the completion of each aircraft mission by physical drop, radio, or telephone from the nearest landing area. If communications equipment is available, the data may be transmitted by radio directly to the control party as the survey is being conducted.

9. Guidance for the Aerial Survey Party.

The control party planning the aerial survey may not be familiar with the survey area or the current tactical or operational situation that exists. However, the control party has ready access to the latest information available to the headquarters conducting the survey and provides guidance to the survey party at the briefing. In addition to information about the area, the control party provides the detailed aerial survey party the course legs or routes to be flown, tentative survey height, and approximate time periods. The control party also may furnish the survey party with the operation exposure guide, turn-back dose, and turn-back dose rate.

10. Survey Party Determinations.

The aerial survey party determines the following items, as applicable:

a. The actual height above ground at which each course leg or route is to be flown.

b. The ground speed for each course leg or route.

c. The direction of flight for each course leg or route.

d. The locations for determining air-ground correlation factor data.

e. The time intervals between readings.

f. Whether to delay the flight of a course leg or route.

11. Guidance.

As a guide to the survey party, the tactical, operational, and weather conditions existing at the time of survey and the dose should be weighed against the following factors:

a. The slower the aircraft speed and the shorter the time interval between readings, the more accurate the results.

b. The unreliability of survey data obtained at heights of more than 150 meters above the ground. A height of 60 meters is considered optimum.

c. High winds have no effect on the response time of the AN/VDR-2.

d. The combination of ground speed and reading time interval should be selected so that the ground distance between readings is not more than 500 meters. For increased plotting accuracy, at least 10 readings between checkpoints are desirable.

e. Air-ground correlation factor data should be taken where aerial and ground dose rates can be read most accurately on the survey meter, for example, in the dose rate range of 5 to 10 cGyph.

12. Factors Influencing Reliability.

With the guidance and procedures outlined, aerial surveys provide the control party with adequate and sufficiently reliable data. Generally, the dose rate determined by aerial survey varies from the true dose rate at the ground location. Reasons for variance are survey meter, pilot, and monitoring errors and errors due to contamination of aircraft at touchdown for ground reading, and the overall system errors.

Radiological Data Sheet--Route or Course Leg Technique (Ground and Aerial Survey) For use of this form, see FM 3-3-1; the proponent agency is TRADOC.	Date	Page No.	No. of Pages

Survey Party Designation	Monitor (Print Name)

Map Used	Aircraft or Vehicle Type	Instrument Type

Route or Course Leg Designation			
Time at Start of Leg or Route			
Time Route Completed (for Ground) Or Survey Height (for Aerial)			
Distance or Time Interval Used			

Remarks:

Reading No.	Dose Rate (cGyph)	Do Not Use**	Reading No.	Dose Rate (cGyph)	Do Not Use**	Reading No.	Dose Rate (cGyph)	Do Not Use**
1			1			1		
2			2			2		
3			3			3		
4			4			4		
5			5			5		
6			6			6		
7			7			7		
8			8			8		
9			9			9		
10			10			10		
11			11			11		
12			12			12		
13			13			13		
14			14			14		
15			15			15		
16			16			16		
17			17			17		
18			18			18		
19			19			19		
20			20			20		

* Times of start and stop are reported for each route or portion of route completed at one time by ground survey. If a route is done in parts, use a separate column for each part.

** Do Not Use--for control party use only.

Air-Ground or Vehicle Correlation Factor Data

Location	Height (Feet) (Air Only)	Dose Rate (cGyph)		CF **
		Inside Air	Outside Ground	

DA Form 1971-1-R, JAN 93

Figure 4-4. Radiological Data Sheet (DA Form 1971-1-R)

PART C - GROUND RADIOLOGICAL SURVEYS

Ground radiological surveys are normally performed by personnel mounted in wheeled or tracked vehicles. The radiological information can also be obtained by personnel on foot but, because of the resultant high radiation doses to personnel, foot surveys should be conducted only under exceptional circumstances. Armored vehicles reduce doses received by personnel and will be used whenever possible. Ground survey lacks the speed and flexibility of aerial survey, results in higher nuclear radiation doses to personnel, places a larger load of communications facilities, and requires diversion of more personnel and equipment from the mission. However, a ground survey is independent of weather conditions, can be conducted at night, and provides more accurate information than an aerial survey. All echelons can perform ground surveys within their areas of responsibility, using regularly assigned personnel and equipment.

1. Techniques.

The techniques used to conduct ground surveys include: **point, route, and the preselected dose-rate techniques.**

a. Point Technique.

In using the point technique, the ground dose rate is determined at a selected point of particular operational concern. The reading can be obtained by dismounting from the vehicle and taking a direct ground dose-rate reading or by taking the dose-rate reading inside the vehicle. From the standpoint of accuracy, the first method is preferred. If the dose rate is taken inside the vehicle, the ground dose rate will be determined by the control party by using a correlation factor. When obtaining readings, while dismounted, monitors should move away from the vehicle a distance of at least 10 meters to make final readings. This procedure prevents undue shielding of the radiation field by the vehicle.

b. Route Technique.

In using the route technique, dose-rate readings are taken inside the vehicle at selected distance intervals between checkpoints along a designated route. Ground dose rates will be determined by the control party by using a correlation factor. Most ground surveys are performed by use of the route technique.

c. Preselected Dose-Rate Technique.

In using the preselected dose-rate technique, locations of preselected dose rates are determined along assigned routes. This technique is normally employed only for survey of old fallout contamination, after H + 48 hours, or radiological agent contamination where the decay is very slow. Dose rates and locations can be plotted directly without further processing.

2. Guidance for Ground Survey Party.

Normally, survey parties are briefed prior to conduct of the survey. This briefing may be centralized or conducted on an individual basis and may vary in detail from an area assignment to specific route and point assignments for each survey party. Basically, more general assignments facilitate the initiation of the survey, whereas the more specific assignments reduce security, communication, and interpretation difficulties. The degree of briefing detail depends upon the time available to plan the survey, feasibility of a centralized briefing, and status of training of survey party personnel.

3. Planning.

The plan for the ground survey is similar to the aerial survey plan; that is, a series of routes and points are selected along which dose-rate data are obtained. Dose-rate readings are recorded and reported by the monitor of the survey party.

4. Survey Meter Location in Vehicles.

Most dose-rate readings taken during a ground survey by mounted personnel, using the route technique will be taken inside the vehicle and later converted to ground dose rates, using a correlation factor. For operational situations, it is preferred that the correlation factor data be obtained by the survey party for the control party in calculating ground dose rates. The survey meter should be located as indicated in Table 4-3. If the vehicle being used is not one with the location of the survey meter designated, the survey meter should be held in a vertical position (face up) by the monitor who is positioned in the assistant driver's seat. The monitor should take the readings with the survey meter consistently located in the selected position. When correlation factor data cannot be obtained by the survey party, published correlation factors may be used from Table 4-3 on pages 4-22 and 4-23.

5. Correlation Factor Data.

a. Requirement.

Correlation factor data are required in order to convert the reported readings taken inside the vehicle to ground dose rates existing outside the vehicle. That is, to convert shielded total dose rate to unshielded total dose rate.

b. Providing Data.

Data for the vehicle correlation factor are provided by the survey party and consist of a set of two readings taken at the same location. One reading is taken inside the vehicle with the instrument located as indicated in Figure 4-1 on page 4-5. All subsequent inside readings reported for the survey must be taken with the meter in this same position. The other reading is taken immediately as a normal ground monitoring reading at the same location with the vehicle pulled away at least 10 meters. One or two additional sets of data should be taken at different locations so that the control party can use an average vehicle correlation factor. The sites for obtaining vehicle correlation factor data should be selected to approximate average foliage and ground surface conditions for the contaminated area. New data must be obtained if these conditions change significantly or if the survey meter or vehicle is changed. Additional correlation factor data taken because of changes should not be averaged into previously collected data, but should be used for applicable routes or points. Accuracy of the correlation factor data is of great importance.

6. Recording and Reporting.

a. Recording.

The radiological data sheet, designed for recording data obtained by monitoring and survey will be used for recording data obtained during ground surveys. Data obtained, using the route technique, is recorded on DA Form 1971-1-R. Data obtained, using the point or preselected dose-rate technique, is recorded on DA Form 1971-R.

b. Reporting.

Data from ground surveys are reported as rapidly as possible to the control party directing the survey, without screening or evaluation by intermediate headquarters. The reporting is accomplished, using communication methods in the preference order indicated below:

1. The survey party reports by radio direct to the control party.

2. The survey part reports by radio to the nearest area communications center and then to the control party.

3. The survey party proceeds to the nearest unit and uses its facilities to report through the area communications center to the authority directing the survey.

4. The survey party proceeds to the nearest area communications center and reports by available means direct to the control party.

5. The survey party physically delivers data to the control party.

c. Guidance.

More precise information on recording and reporting survey data is provided in the unit SOP or is established at the survey party briefing.

d. Security.

Radiological survey information is of intelligence value to the enemy. Proper security procedures for the reporting of these data are established by the unit SOP. For example, the unit SOP may require that location coordinates be encoded. The more detailed the briefing of the survey parties, the more easily security can be maintained.

e. Safety.

Precise information establishing turn-back dose rates and operation exposure guide is provided in the SOP or is established at the survey briefing.

7. Capability of Ground Survey Parties.

Any powered vehicle is satisfactory for conducting ground surveys. All vehicles have approximately the same area coverage capability of between 15 and 40 square kilometers per hour per vehicle, depending upon the degree of detail required, the road net, and traffic of the contaminated area. However, because of the superior shielding and cross-country characteristics, the tracked armored vehicle is preferred.

LESSON 4

PRACTICE EXERCISE

The following items will test you grasp of the material covered in this lesson. There is only one correct answer for each item. When you complete the exercise, check you answer with the answer key that follows. If you answer any item incorrectly, study again that part of the lesson which contains the portion involved.

Situation: Your unit must conduct monitoring and survey in the fallout area. You must ensure this information is accurate and provided promptly to headquarters.

1. Which RADIAC instrument is used to measure old fallout contamination, normally H+48 hours or over?

   A. AN/PDR-60
   B. AN/PDR-75
   C. AN/VDR-2
   D. IM-174

2. What is the purpose of periodic monitoring?

   A. To warn the commander of the arrival of neutron-induced radiation
   B. To assure the commander that the unit area is not contaminated
   C. To determine when fallout is completed
   D. To check the serviceability of RADIACmeters periodically

3. Units discontinue continuous monitoring when ordered by higher headquarters or when which of the following happens?

   A. Dose rate falls below 1cGy/hr
   B. Fallout has not arrived within 30 minutes of the predicted time of arrival
   C. Peak dose rate reading is less than 30 cGy/hr
   D. Unit departs that location

4. Which monitoring technique is the simplest and most precise?

   A. Continuous
   B. Direct
   C. Indirect
   D. Periodic

5. What is converted by the correlation factor?

   A. Fallout prediction dose rates to shielded dose rates
   B. Shielded dose rates to unshielded dose rates
   C. Shielded total dose to unshielded total dose
   D. Unshielded dose rates to shielded dose rates

6. The dose rate is 25 cGy/hr inside a vehicle and 125 cGy/hr outside. What is the correlation factor?

   A. 1.5
   B. 2.5
   C. 5.0
   D. 12.5

7. What is the advantage of conducting an aerial survey instead of a ground survey?

   A. Greater accuracy of readings
   B. More exposure to source of radiation
   C. More speed and flexibility
   D. Specific dose rates are available

8. Which technique is used to conduct aerial radiological surveys?

   A. Course leg
   B. Time of entry level
   C. Turn-back dose rate
   D. Zig-zag pattern

9. Which procedure determines the air-ground correlation factor?

   A. Aerial dose rate added to ground dose rate
   B. Aerial dose rate divided by ground dose rate
   C. Ground dose rate divided by aerial dose rate
   D. Ground dose rate subtracted from aerial dose rate

10. For increased plotting accuracy, at least how many readings between course leg checkpoints are desirable.

   A. 3
   B. 5
   C. 8
   D. 10

11. A survey team is conducting a ground survey using the point technique. How many meters should the monitor move from the vehicle when taking a direct ground dose rate reading?

A. 1
B. 2
C. 5
D. 10

12. Which survey technique is normally used for ground survey of old fallout contamination?

A. Route
B. Point
C. Preselected dose rate
D. Course leg

LESSON 4
PRACTICE EXERCISE

ANSWER KEY AND FEEDBACK

Item		Correct Answer and Feedback
1.	C	Part A, p. 4-1, Intro
2.	A	Part A, p. 4-2, para 1a
3.	A	Part A, p. 4-3, para 1b
4.	B	Part A, p. 4-3, para 2a
5.	B	Part A, p. 4-4, para 3
6.	C	Part A, p. 4-6, para 3b
7.	C	Part B, p. 4-7, Intro
8.	A	Part B, p. 4-9, para 3
9.	C	Part B, p. 4-13, para 6
10.	D	Part B, p. 4-16, para 11d
11.	D	Part C, p. 4-18, para 1a
12.	C	Part C, p. 4-18, para 1c

LESSON 5

RADIOLOGICAL OPERATIONS

Critical Tasks: 031-506-2047
031-506-3023
031-506-3030
031-506-3035

OVERVIEW

LESSON DESCRIPTION:

In this lesson, you will learn how to conduct radiological operations.

TERMINAL LEARNING OBJECTIVE

ACTION: Conduct radiological operations.

CONDITION: Given information about the need for radiological operations, fallout aspects, decay calculations, total dose predictions, transmission factors, crossing a fallout area, and induced radiation.

STANDARD: Demonstrate competency of the task, skills, and knowledge by responding to the multiple-choice test covering radiological operations.

REFERENCE: FM 3-3-1.

INTRODUCTION

Under the threat of or actual nuclear warfare, units in the field must continuously evaluate the impact that enemy use of nuclear weapons has on the conduct of operations. Units must be prepared for action to reduce the disruption caused by a nuclear attack. Fallout may be employed to blanket areas of poorly defined targets, create obstacles, canalize movement, disrupt operations, and force relocation of support installations. Casualty-producing levels of fallout can extend to greater distances and cover greater areas than most other nuclear weapon effects. Actions on the battlefield are influenced for a considerable period of time. Knowledge and understanding of the radiological contamination aspects will aid the commander in assessing the advantages and disadvantages of the assigned missions.

PART A - DECAY CALCULATIONS

1. Fallout.

The aftermath of a nuclear attack will present many obstacles to the continuation of effective operations within the radiologically contaminated environment. Fallout can have a major influence on tactical operations in the following ways:

- It can produce casualties within large areas outside the area of initial effects of the nuclear burst. It is potentially the most important casualty-producing effect of a nuclear weapon.

- It can restrict unprotected troops from vast areas beyond the area of initial casualty effects.

- It can increase the logistical problems of affected units. It can limit the unrestricted use of streets, roads, and communication lines for critical periods. Tremendous engineer and other service efforts are required to decontaminate fallout areas.

- It can incapacitate personnel while leaving installations intact and materiel that can be used later.

The surface burst is potentially the greatest casualty producer because of fallout. The surface burst can produce many times the number of casualties produced by other bursts based on the yield of the weapon. Whole body gamma radiation is the primary personnel hazard from the fallout. It is essential for commanders to have a means of predicting the anticipated total dose of radiation to which personnel will be exposed as they pass through or occupy the fallout area.

The radioactive material in a contaminated area is assumed to be spread evenly over the ground. An individual standing in a level portion of a contaminated area will thus be receiving radiation from all directions. However, because of absorption by the air and other factors, essentially all radiation the individual receives comes from a circular area 200 meters in radius around the location. About half the radiation the individual receives comes from a circular area 10 meters in radius.

a. The Fallout Area.

Fallout areas will be largest of the contaminated areas produced on the battlefield. An important aspect of fallout is that the direction of fallout from ground zero is based upon winds aloft, as well as upon surface winds. Thus, the actual location of fallout can differ appreciably from that which might be expected from the direction of surface winds.

b. Automatic Fallout Response.

The rapid onset of fallout, especially from small yields, within a few kilometers of ground zero of a surface burst requires quick adoption of protective measures. The time after burst before onset of fallout near ground zero will vary, depending on the yield of the nuclear detonation, weather conditions, and type of terrain. Normally, use of shelter will be automatic whenever nuclear bursts are observed, since these bursts should be assumed to be fallout producing until monitoring and the passage of time prove otherwise. During the period of uncertainty, precautionary measures consistent with the mission are instituted. See FM 3-3, FM 3-4, and FM 3-100 for information on appropriate precautionary measures.

c. Physical Recognition of Fallout.

Fallout particles are often visible during hours of daylight. The arrival and settling of dust-like particles after a nuclear burst occurs should be assumed to indicate the onset of fallout unless monitoring shows no radiation in the area.

d. The Neutron-Induced Area.

The neutron-induced area is small by comparison with the fallout area produced by the same yield nuclear weapon. It is often contained within the area of great destruction and obstacles (tree blowdown, rubble, and fire). Frequently there will be no need to enter the area. However, if friendly troops are required to pass through ground zero or occupy positions in the immediate vicinity of ground zero, induced radiation may be operationally significant. Total dose predictions are based on actual dose rates obtained from radiological surveys or from monitoring reports.

e. Rate of Decay.

The rate of decay must be known to perform meaningful dose-rate or dose calculations. This rate of decay is indicated by the decay exponent (n), which may vary with time after burst and location of the contamination within the fallout area. The true decay exponent generally will not be accurately determined until several series of dose-rate readings are available for specific locations within the contaminated area. Therefore, a decay exponent of **n equals 1.2** has been established as standard and is used by all units unless informed otherwise by higher headquarters.

f. Symbols and Terms used in Radiological Operations.

Some of the symbols used in radiological operations and the corresponding terms are as follow:

SYMBOL	TERM
CF	Correlation factor
CRF	Correction factor
D	Total dose
D_s	Calculated dose
D_t	True dose
D_{tb}	Turn back dose
GZ	Ground zero
ID	Inside dose rate; inside dose
n	Decay exponent
NBC	Nuclear, Biological, Chemical
NBC 1 Report	Used by observing unit, giving initial and subsequent data of a nuclear attack.
NBC 2 Report	Used for passing evaluated data of a nuclear attack
NBC 3 Report	Used for immediate warning of expected contamination
NBC 4 Report	Used for radiation dose rate measurements
NBC 5 Report	Used for locating areas of contamination
NF	Normalizing Factor
OCRF	Overall correction factor
OD	Outside dose rate; outside dose
R_1	Dose rate at, or reference to, 1 hour after burst (H+1)
R_{avg}	Average dose rate
R_{max}	Maximum dose rate
RS-0	Radiation Status-0
RS-1	Radiation Status-1
RS-2	Radiation Status-2
RS-3	Radiation Status-3
R_t	Dose rate at a time after burst, other than H+1
R_{tb}	Turn-back dose rate
R_{te}	Dose rate at time of entry
STANAG	Standardization agreement
T	Time
T_e	Time of entry into a contaminated area
TF	Transmission factor
T_s	Time of stay (stay time) in a contaminated area
T_x	Time of exit from a contaminated area
UTM	Universal transverse mercator (grid coordinates)

Some of the terms used in radiological operations are:

(1) Entry time.

The time, measured from the time of burst, at which personnel enter a radiation field to perform the mission. Entry time is the time at which exposure starts.

(2) Induced radiation.

Radiation near ground zero resulting from the capture of neutrons by various substances. This will be found primarily in the soil, but it may also be present in other objects.

(3) Militarily significant contamination.

Radioactive contamination capable of inflicting radiation doses which may result in a reduction in combat effectiveness.

(4) Operation exposure guide.

The maximum amount of nuclear radiation, as determined by the commander, to which troops may be exposed while performing the mission.

(5) Radiation unit of measure.

The unit of measurement of the absorbed dose of ionizing radiation represents absorption of 100 ergs of nuclear or ionizing radiation per gram of absorbing material or tissue. In conformance with the conversion to the international metric system which has been adopted by NATO, centigray should be written as cGy and pGy for microgray.

(6) Radiation dose.

The total amount of ionizing radiation absorbed by tissue or any other absorbing material as commonly measured in centigray, cGy.

(7) Radiation dose rate.

The radiation dose absorbed per unit of time, commonly measured in cGy per hour.

(8) Radiological agent.

Any of a family of radioactive substances that produce casualties by emitting radiation. Radiological agent refers to contamination other than fallout or induced radiation.

(9) Stay time.

The period during which personnel remain within a particular area of contamination or radiation hazard.

(10) Turn-back dose.

A radiation dose, determined by the command prior to a survey, at which personnel must turn back to avoid exceeding the operation exposure guidance.

(11) Turn-back dose rate.

A radiation dose rate, determined by the command prior to a survey, at which personnel will turn back to avoid undue exposure hazard.

2. Decay Nomogram.

The decrease in the radiation dose rate from a single explosion can be calculated by the use of a nomogram. The Residual Radiation Decay (Fallout) Nomogram, Figure 5-1 on page 5-9, allows the user to find the dose rate at any time if a dose rate at a known time after the burst is available.

This nomogram contains 4 lines of 2 scales each, which denote time after burst (in hours) for nonstandard decay exponents as indicated above each scale, and 1 line (the index scale) which denotes time after burst (in hours) for the **standard rate (n = 1.2) of decay**. The R_1 scale, at the right of the time scales, shows dose rates at H + 1; R_t scale, at the left of the time scales, shows dose rates at times other than H + 1. The outside left and right lines are reference lines to be used in aligning the hairline. Use of the decay nomogram, involving **standard decay**, **(1.2)**, is shown in the examples below.

Example problems. In working with nomograms, care should be taken to be as consistent as possible when joining values with the hairline. Be sure that the hairline intersects the vertical line and the interpolated value (tick mark) as closely as possible. Dose-rate values smaller or greater than those shown on the nomogram in Figure 5-1 may be reported. In the case of smaller values, multiply the dose rate by 10, proceed with the calculation, and divide the resulting dose rate by 10, see Example Problem 4. In the case of greater values, divide the dose rate by 10; proceed with the calculation, and multiply the resulting dose rate by 10. When using this process, NEVER multiply or divide a number from the time scale; multiply or divide, as appropriate, using only the dose rate values, see Example Problem 5.

Example Problem 1.

GIVEN: R_t = 200 cGyph at H + 5 hours.

FIND: R_1.

SOLUTION: Align the hairline with the 5-hour tickmark of the 1.2 (index) scale and the 200 cGyph point on the R_t scale. Read the dose rate at H + 1 as 1350 cGyph at the point of intersection of the hairline with the R_1 scale.

ANSWER: 1350 cGyph.

Example Problem 2.

GIVEN: R_1 = 1000 cGyph.

FIND: R_t at H + 6 hours.

SOLUTION: Align the hairline with the 6-hour tickmark of the index scale and the 1000 cGyph point on the R_t scale. Read R_t as 120 cGyph at the point of the intersection of the hairline with the R_t scale.

ANSWER: 120 cGyph.

Example Problem 3.

GIVEN: R_1 = 1000 cGyph.

FIND: Time when R_t = 700 cGyph.

SOLUTION: Connect 1000 cGyph on the R_1 scale and 700 cGyph on the the R_1 scale with the hairline. Read time as H + 1.4 hours at the point of intersection of the hairline and the index scale.

ANSWER: H + 1.4 hours.

Example Problem 4.

GIVEN: R_1 = 200 cGyph.

FIND: R_t at H + 25 hours.

SOLUTION: Connect 2000 cGyph (10 x 200 cGyph) on the R_1 scale and 25 on the index (time) scale with the hairline. Read R_t as 44 cGyph on the R_t scale. Divide the dose rate by 10 since the R_1 value was multiplied by 10; then, the dose rate at H + 25 hours is 4.4 cGyph.

ANSWER: 4.4 cGyph.

Example Problem 5.

GIVEN: R_1 = 200 cGyph.

FIND: Time when R_t = 4 cGyph.

SOLUTION: Since 4 cGyph cannot be found on the R_t scale, multiply both R_t and R_1 by 10, connect R_1 =2,000 cGyph and R_t = 40 cGyph with the hairline. Read t as H + 27 hours on the time scale. DO NOT divide the time by 10.

ANSWER: H + 27 hours.

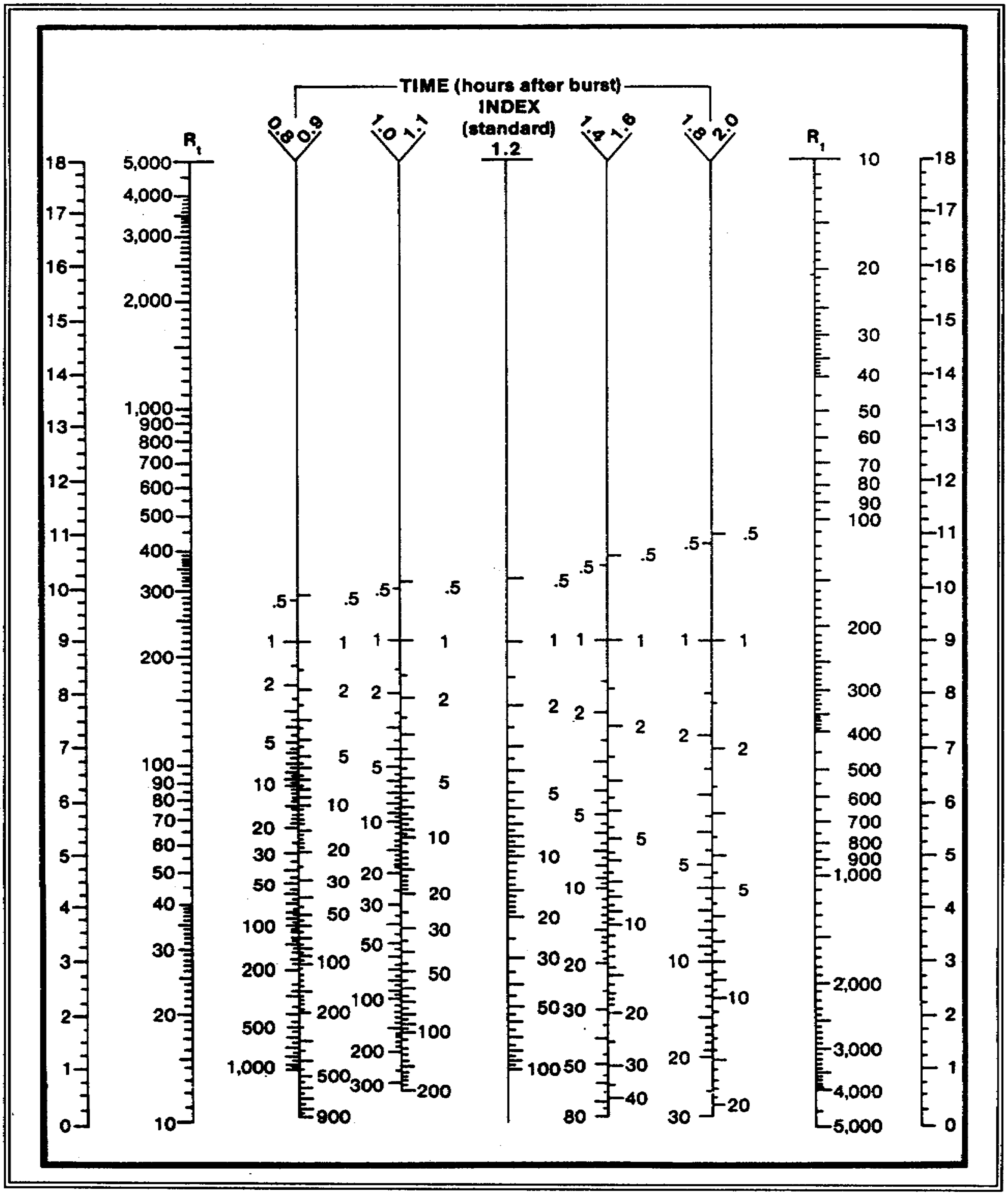

Figure 5-1. Residual Radiation Decay
(Fallout)
CAUTION: Valid for single explosions only.

PART B - TOTAL DOSE PREDICTIONS

The dose rate of radiation does not directly determine whether or not personnel become casualties. Casualties are dependent on total dose received. If the dose rate were constant, total dose would simply be the product of dose rate and time in the contaminated area, just as in a road-movement problem, rate x time = distance. But the dose rate is continually diminishing because of decay; therefore, the calculation is a little more complicated. The actual dose received is always less than the product of dose rate at time of entry and duration of stay.

1. Total Dose Calculations.

The nomogram in Figure 5-2 on page 5-12 is used for predicting total dose to be received while operating in a fallout radiation area resulting from a single explosion. This nomogram relates total dose, dose rate referenced to 1 hour after the burst, stay time, and entry time. The index scale is a pivoting line that is used as an intermediate step between D, R_1, T_s, and T_e The four values on this nomogram are defined as follows:

D = Total dose in cGy.

R_1 = Dose rate 1 hour after burst (H + 1). When using this nomogram, a dose rate referenced to 1 hour after the burst (H + 1) must ALWAYS be used; NEVER use a dose rate taken at any other time.

T_s = Stay time in hours.

T_e = Entry time (hours after burst).

Any one of these values may be determined from the nomogram if the other three values are known, as shown in examples on the next page.

2. Essential information.

If the available dose rate was taken at a time other than H+1 hour, the value of R_1 may be found by using the Residual Radiation Decay (Fallout) Nomogram, Figure 5-1, and the procedures for decay calculation in Part A.

In applying the given values, D and R_1 are used together and T_s and T_e are used together. When working with the total dose nomogram, always start the problem on the side of the nomogram for which two values are known. If D and R_1 are given, start with these two known values; if T_s and T_e are given, start with them. Never begin a problem by joining D or R_1 with either of the time values.

Example Problem 1.

GIVEN: R_1 = 200 cGyph T_s = H + 1.5 hours T_e = 1 hr.

FIND: D.

SOLUTION: On Figure 5-2, connect H + 1.5 hours on the T_e scale and 1 hour on the T_s scale with the hairline. Pivot the hairline at its point of intersection with the index scale to 200 cGyph on the dose rate (R_1) scale. Read D = 90 cGy on the total dose (D) scale.

ANSWER: 90 cGy.

Example Problem 2.

GIVEN: D = 20 cGy R_1 = 100 cGyph T_s = 1 hour.

FIND: T_e.

SOLUTION: On Figure 5-2, connect 20 cGy on the D scale and 100 cGyph on the R_1 scale with the hairline. Pivot the hairline at its point of intersection with the index scale to 1 hour on the T_s scale. Read T_e = 3.4 hours on the T_e scale.

ANSWER: H + 3.4 hours.

3. Calculations When Time of Entry is After H + 24 Hours.

By 24 hours after burst, the change in the rate of decay is so low that it is relatively insignificant. Therefore, in making estimates of the total dose to be received when entry into the contaminated area is later than H+24 hours, the total dose is obtained by multiplying the dose rate at entry time by the stay time (in hours). Symbolically, this is written--

$D = R_{Te} \times T_s$, where: D = Total dose,

R_{Te} = Dose rate at time of entry, and T_s = Time of stay.

4. Validity.

The calculations above and the nomograms in Figures 5-1 and 5-2 are valid only if the dose rate reading is made after the radioactive particles have ceased falling. For example, a dose rate reading made 1 hour after the burst while fallout is still arriving is not valid for determining what the dose rate will be at a later time, since there is no way to determine how much more fallout will arrive.

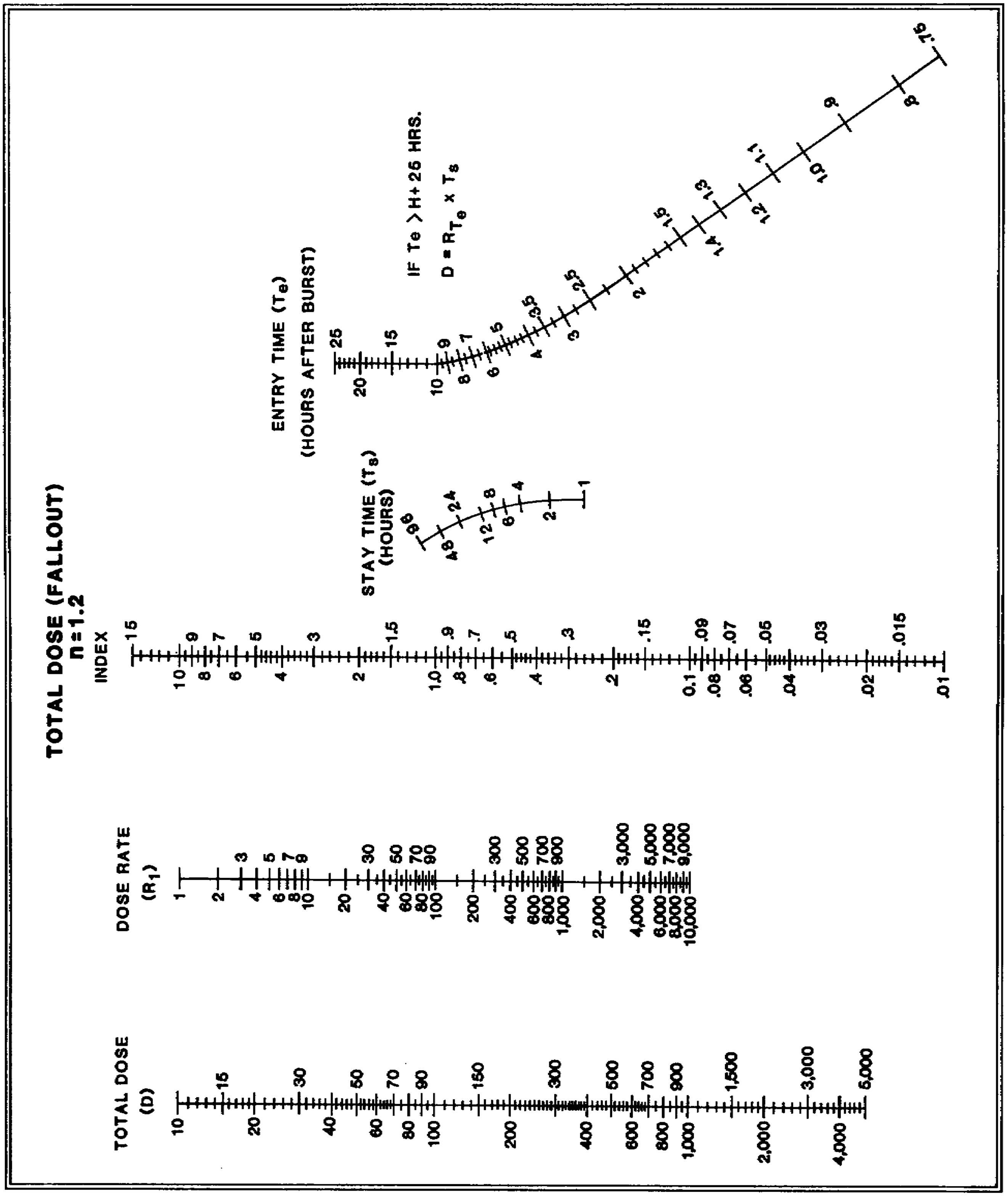

Figure 5-2. Total Dose
(Fallout)
CAUTION: Valid for single explosions only.

PART C - TRANSMISSION FACTORS

1. Ground Dose Rate.

The ground (outside) dose rate is the unshielded dose rate measured 1 meter above ground level (about waist high). This dose rate approximates the average whole body dose rate a soldier would receive if standing in the open in the contaminated area at the location of the magnitude of a contamination hazard. All dose rates mentioned in radiological intelligence are ground dose rates unless otherwise specified. All dose-rate information obtained under conditions that would modify the ground dose rate must be converted to ground dose rates for radiological intelligence purposes.

2. Factors Affecting Determinations of Ground Dose Rates.

Because some radiation is shielded out, the dose rate inside a vehicle or shelter is lower than the ground dose rate at that location. The degree of shielding depends on the type of vehicle or the construction of the shelter. Dose rates measured in an aircraft flying over a contaminated area are lower than the corresponding ground dose rates because of the shielding effect of the air and the aircraft.

3. Transmission Factors.

A transmission factor (TF) is a measure of the degree of shielding afforded by a structure, vehicle, fortification, or a set of specified shielding conditions. The transmission factor is that fraction of the outside (ground) dose or dose rate which is received inside the enclosure providing the shielding. A transmission factor (TF) is used to determine the reduction in the dose received when personnel are protected (shielded) from radiation. Transmission factors for residual radiation have been established for certain shielding environments and are given in Figure 5-3 on page 5-16. These transmission factors may be used in determination of shielded dose or total dose.

a. Determination of Transmission Factors.

Transmission factors for common types of vehicles, structures, or fortifications are contained in Figure 5-3. These transmission factors were established for a combat vehicle by determining the shielded dose or dose rate for the most exposed occupant location. For a structure or fortification, by determining the shielded dose or dose rate at approximately the center of the shielded volume. Transmission factors determined in the field require two dose rate readings taken about the same time; one will be an outside (ground) dose rate (OD) reading and the other an inside (shielded) dose rate (ID) reading.

The transmission factor can then be calculated using the formula below:

$$\text{Transmission Factor} = \frac{\text{Inside dose or dose rate}}{\text{Outside dose or dose rate}}$$

or $TF = \dfrac{ID}{OD}$; and, by mathematical rearrangement:

$$ID = TF \times OD \text{ and } OD = \frac{ID}{TF}.$$

NOTE

It is pointed out that these transmission factors are not necessarily the inverse of the correlation factors for the same vehicle listed in Table 4-3 on page 4-22. Generally, the correlation factors in Table 4-3 were calculated using the best position for the survey meter to give readings for radiological survey data. The transmission factors in Figure 5-3 were calculated to indicate the shielding afforded by vehicles to personnel in the vehicles. Also, these transmission factors may vary from other published transmission factor data for example, the data on the ABC-M1 Calculator. The transmission factors used in this manual are preferred over those on the back of the ABC-M1 Calculator.

b. Example Problem.

GIVEN: What is the calculated transmission factor of a bunker when the outside dose rate is 200 cGyph and the inside dose rate is 25 cGyph.

SOLUTION: $TF = \dfrac{ID}{OD} = \dfrac{25}{200} = 0.125.$

ANSWER: 0.125.

Once the transmission factor is determined, further inside dose rates may be converted to outside dose rates by dividing the inside dose rate by the transmission factor. Outside dose rates may be converted to inside dose rates by multiplying the outside dose rate by the transmission factor.

c. Examples.

(1) The measured outside dose (OD) is 90 cGy. The inside dose (ID) is calculated by use of a transmission factor. What dose would troops in M113 Armored Personnel Carriers receive?

The TF for an M113 Armored Personnel Carrier is 0.3 (Figure 5-3).

ID = OD x TF = 90 x 0.3 = 27 cGy.

(2) Transmission factors may also be applied to dose rates. A measured outside dose rate id 100 cGyph. The inside dose rate is calculated by use of the transmission factor. Find the dose rate inside the M113 Armored Personnel Carrier.

ID = OD x TF = 100 x 0.3 = 30 cGyph.

If possible, routes through areas of lowest dose rates should be selected. The use of tanks, armored vehicles, or sandbags on the floors and sides of cargo trucks will provide shielding and reduce the total dose received by personnel. Exposure may be minimized by staying for a short time, providing shielding, and by avoiding the contaminated area. The selection of these actions depends upon the operational situation and the extent of contamination from fallout.

ENVIRONMENTAL SHIELDING	TRANSMISSION FACTOR (TF)
VEHICLES	
M1 TANK	0.04
M48 TANK	0.02
M60 TANK	0.04
M2 IFV	0.2
M3 CFV	0.2
M113 ARMORED PERSONNEL CARRIER	0.3
M109 SPECIAL PURPOSE HOWITZER	0.2
M548 CARGO VEHICLE	0.7
M88 RECOVERY VEHICLE	0.09
M577 COMMAND POST CARRIER	0.3
M551 ARMORED RECON AIRBORNE ASSAULT VEHICLE	0.2
M728 COMBAT ENGINEER VEHICLE	0.04
HELICOPTERS	
H-58	0.8
UH-60	0.7
CH-47	0.6
TRUCKS	
HMMWV	0.6
1/4-TON	0.8
3/4-TON	0.6
CUCV	0.6
2 1/2-TON	0.6
4-TON TO 7-TON	0.5
ENGINEER EQUIPMENT	
M9 ACE	0.3
GRADER	0.8
BULLDOZER	0.5
SCRAPER	0.5
STRUCTURES	
FRAME HOUSE	0.3 - 0.6
BASEMENT	0.05 - 0.1
MULTI-STORY BUILDING (APARTMENT)	
UPPER STORY	0.01
LOWER STORY	0.1
CONCRETE BLOCK HOUSE SHELTER	
9-IN. WALLS	0.007 - 0.09
12-IN. WALLS	0.001 - 0.03
24-IN. WALLS	0.0001 - 0.0002
SHELTER, PARTLY ABOVE GRADE	
WITH 2 FT. EARTH COVER	0.005 - 0.02
WITH 3 FT. EARTH COVER	0.001 - 0.005
URBAN AREAS (IN OPEN)	0.7*
WOODS	0.8*
UNDERGROUND SHELTERS (3-FT. EARTH COVER)	0.0002
FOXHOLES	0.1

* These factors do not apply to aerial survey dose rates.

Figure 5-3. Transmission Factors for Residual Radiation

PART D - CROSSING A FALLOUT AREA

It may be necessary to cross an area in which there is residual radiation. This occasion might arise in exploitation of our own surface bursts or in retrograde or offensive operations coupled with enemy-delivered surface bursts. In nuclear warfare it is possible that extensive areas will be made residually radioactive. These areas will be habitable eventually, but operations in these areas will be complicated because of the necessity for keeping to a minimum the total dose that will be received by our troops.

1. Commander's Questions.

The problem of crossing a contaminated area, from a command point of view, is essentially, "If I cross the area, what is the risk involved?" In general, the primary objective is to accomplish the desired mission while keeping the total dose as low as possible consistent with the mission. Exposure may be minimized by keeping the stay time as short as possible, by delaying the entry time as long as possible, by providing shielding, and by avoiding the contaminated area. The selection of one of these actions, or any combination, is dependent upon the operational situation at the time, knowledge of the location, and extent of dose rate contours within the fallout area. A consideration of the radiation exposure involved will influence route selection. The shortest route, or the route that can be traversed most quickly, provides the minimum stay time. If possible, routes through areas of lowest dose rates should be selected. The use of tanks, armored vehicles, or sandbags on the floors and sides of cargo trucks will provide shielding and reduce the total dose received by personnel.

2. Average Dose Rate.

In analyzing the problem of crossing a contaminated area, it is evident that the dose rate will increase as the center of the area is approached than will decrease beyond the center of the area and as the far side is approached. When individuals or units are required to cross a contaminated area, it is necessary to determine an average dose rate to be used in predictions of total dose. The average dose rate represents a mean value to which the individual is exposed during the time of stay. A reasonable approximation of the average dose rate ($R1_{avg}$) in crossing a fallout area can be obtained by dividing the maximum dose rate ($R1_{max}$) encountered, or expected to be encountered, by two.

Symbolically, this is written as: $$R_{1avg} = \frac{R_{1max}}{2}$$

3. Procedures.

After the average dose rate has been determined, entry times that will keep the total dose below a specified maximum (operation exposure guide) can be computed on the basis of calculated stay times; or total doses can be computed for specified entry times and stay times. These calculations are made in the manner described in the following paragraphs.

4. Calculations.

In calculating the total dose to be received in crossing a fallout area, it is necessary to know the time of entry into the area, the average dose rate along the route, and the time of stay within the area. Use the total dose (fallout) nomogram in Figure 5-2 and the methods in Part B for these calculations.

In crossing, the average dose rate is equal to one-half the maximum dose rate encountered on the route. If the maximum dose rate encountered is 60 cGyph, then,

R_{1avg} = 1/2 R_{1max} = 1/2 x 60 cGyph = 30 cGyph.

In using Figure 5-2, the average dose rate must be normalized (taken back) to H + 1. Refer to pages 5-6 through 5-8 on the decay nomogram and average dose rate for determining dose rate at H + 1 and by using Figure 5-1.

In calculating the total dose to be received when crossing a fallout area, follow the procedure below.

1. Calculate the average dose rate.
   R_{1avg} = 1/2 R_{1max}.

2. Normalize R_{1avg} to H + 1, unless the dose rate data have already Eden referenced to H + 1.

3. Calculate the time required to cross the fallout area.

The length of the route within the 20 cGyph (H + 1) contour line is the distance used.

$$T_s = \frac{\text{distance}}{\text{speed}}.$$

4. Find the outside dose, using Figure 5-2 on page 5-12.

5. Calculate the inside dose (ID = OD x TF). If shielding is involved, obtain TF from Figure 5-3 on page 5-16.

5. Example Problems.

The following problems are concerned with techniques only and do not consider the impact that these doses or dose rates might have on operations in a contaminated area.

Example Problem 1.

GIVEN: Troops must cross the fallout area, shown in Figure. 5-4, at H + 3 in M113 Armored Personnel Carriers at a rate of speed of 10 kilometers per hour (kmph). The route from A to B, a distance of 5 kilometers (km), will be used.

FIND: Total dose that will be received by troops.

SOLUTION:

1. Calculate the average dose rate. R_{avg} = 1/2 R_{max} = 1/2 (300 cGyph) = 150 cGyph (at H + 1).

2. Normalize R_{avg} to H + 1. R_{avg} is already at H + 1.

3. Calculate the time of stay.

$$T_s = \frac{\text{distance}}{\text{speed}} = \frac{5 \text{ km}}{10 \text{ kmph}} = 0.5 \text{ hour.}$$

4. Find the outside dose, using Figure 5-2 on page 5-12.

R_{avg} = 150 cGyph T_e = H + 3 hours.
T_s = 0.5 hour D = 18 cGy.

5. Calculate the inside dose.

TF = 0.3 (Figure 5-3 on page 5-16).
ID = OD x TF = 18 x 0.3 = 5.4 cGy.

ANSWER: 5.4 cGy.

Example Problem 2.

GIVEN: Troops must cross the fallout area shown in Figure 5-5 at H + 3 in 2 1/2-ton trucks moving at 15 kmph, using the route A-B-C-D-E. Total distance = 7.5 km.

FIND: Total dose that will be received by troops.

SOLUTION: 1. Calculate the average dose rate.

R_{1avg} = 1/2 R_{1max} = 1/2 200 cGyph,

estimated between the 100 and 300 cGyph line = 100 cGyph (at H + 1).

2. Normalize R_{1avg} to H + 1.

R_{avg} is already at H + 1.

3. Calculate the time of stay.

$$T_s = \frac{\text{distance}}{\text{speed}} = \frac{7.5 \text{ km}}{15\text{kmph}} = 0.5 \text{ hour.}$$

4. Find the outside dose, using Figure 5-2.

R_{avg} = 100 cGyph T_e = H + 3 hours.

T_s = 0.5 hour   D = 12 cGy.

5. Calculate the inside dose.

TF = 0.6 (Figure 5-3).
ID = OD x TF = 12 x 0.6 = 7.2 cGy.

ANSWER : 7.2 cGy.

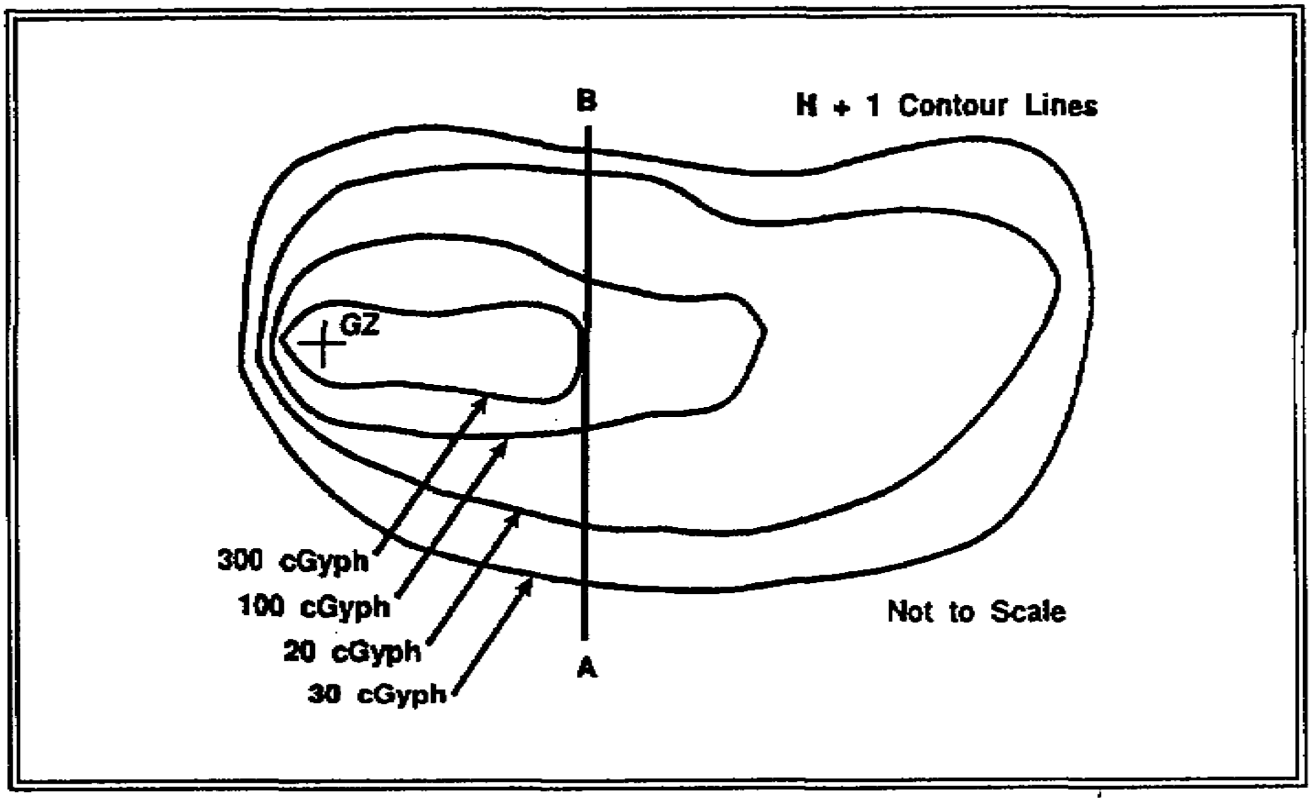

Figure 5-4. Crossing a Fallout Area

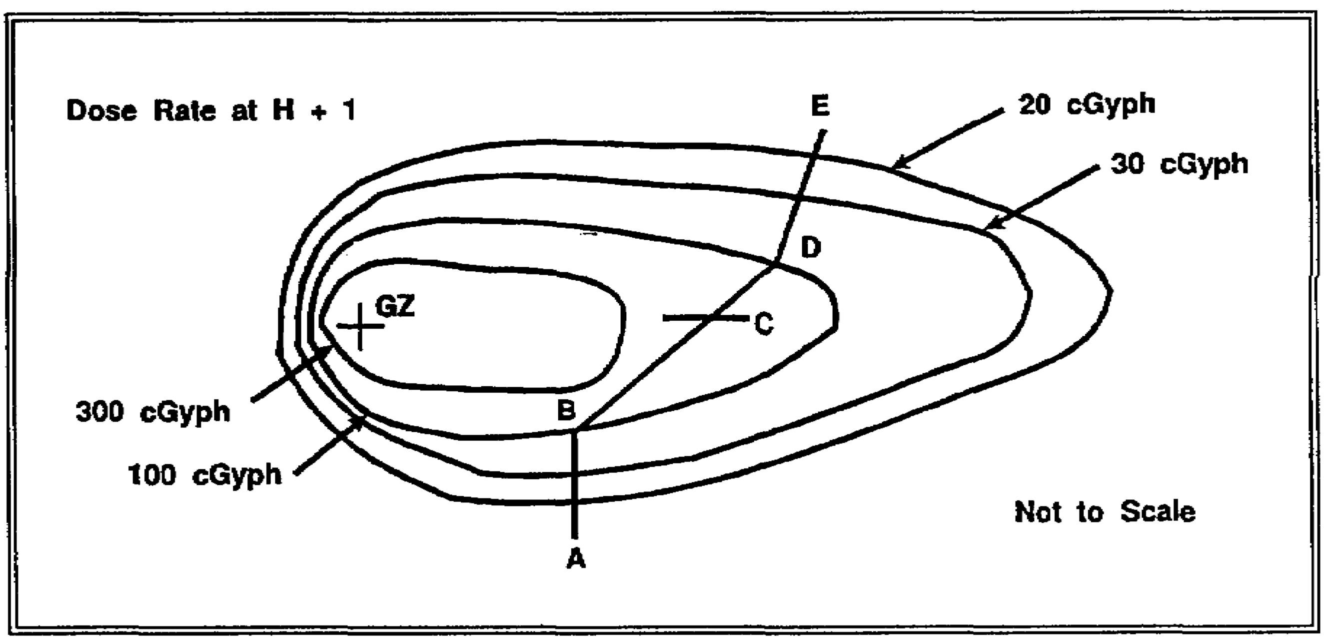

Figure 5-5. Crossing a Fallout Area

PART E -- NATURE OF INDUCED RADIATION

Neutrons are produced in all nuclear weapon detonations. Some of these neutrons may be captured by the various elements in the soil under the burst. As a result of neutron capture, some of these elements become radioactive, generally emitting beta particles and gamma radiation for an extended period following an explosion. Beta particles are a negligible hazard unless the radioactive material makes direct contact with the skin for an extended period of time. In this case, the beta particles can cause skin irritations varying from reddening to open sores. In contrast, gamma radiation readily penetrates the body and can cause radiation injury and even death. Consequently, the external military hazard of induced radiation is determined substantially through an analysis of dose rate of the emitted gamma radiation.

1. Characteristics of Induced Radiation.

The principal characteristics of induced radiation are localized symmetrical pattern, difficult to decontaminate, and persistent.

a. Localized Symmetrical Pattern.

The pattern of induced radiation is circular around ground zero. The dose rates within the pattern are highest at ground zero and decrease with distance from ground zero. The pattern is much smaller than the fallout pattern would be if the same weapon were burst on the surface. Weather conditions have no influence on the location and size of the pattern or the dose rate of induced radiation, and there is no shifting of the pattern by surface winds. The pattern, if produced, will always be located around ground zero.

b. Difficult to Decontaminate.

Since the soil in the target area is made radioactive to a depth of about 0.5 meter, decontamination is difficult, requiring the removal of the top 10 centimeters of soil where most of the radiation exists. In contrast, fallout is a deposit of radioactive dust on the surface and can be removed with somewhat more ease than induced radiation. Both types can be covered by earth.

c. Persistent.

The decay characteristics of induced radiation are considerably different from those of fallout. Fallout is a mixture of many different substances, all with different rates of decay. Induced radiation is produced primarily in aluminum, manganese, and sodium. Other elements either emit so little gamma radiation or decay so fast that they are less important. During the first one half hour after a burst, the principal contributor to induced radiation is radioactive aluminum. Almost all soils contain aluminum since it is one of the most abundant elements. Radioactive aluminum has a short half-life, so that within one-half hour after burst almost all the radioactive aluminum has decayed. Most soils also contain significant quantities of manganese which decays with a half-life of about 2.6 hours. From one-half hour until 10 to 20 hours after burst, both manganese and sodium are the principal contributors to the radiation. After 10 to 20 hours, sodium, which decays with a half-life of about 15 hours, is the principal source of radiation.

2. Considerations of the Operational Level.

A commander will desire to expose his unit to as little radiation as is compatible with the military situation. The commander may know the approximate ground zero of recent or planned nuclear detonations and will select, if possible, a course of action that will avoid the expected areas of induced radiation. However, enemy action, obstacles, or the attainment of significant tactical advantage may cause a commander to move the unit through an area of induced radiation. Also, a radiologically contaminated area may be encountered unexpectedly. The following is a discussion of aids available to the commander and some suggested courses of action.

a. Aids to the Commander.

(1) Boundary and extent of area.

The boundary of the significant area of induced activity is considered to be the distance to which a 2 cGyph dose rate 1 hour after burst will extend. The maximum horizontal radius of this dose rate contour, for yields of 1 MT or less at times later than 1 hour after burst, is about 1,400 meters; it is usually substantially less, depending on the yield and height of burst of the weapon.

(2) Indications of ground zero direction.

The circular symmetry of some types of damage such as scorching, tree blowdown, or other blast phenomena may be visible. In addition, the reverse sides of objects or shadowed objects normally will not be burned. Since the severity of these damage patterns increases in the direction of ground zero, examination of the damage may reveal the direction of ground zero.

(3) Radiological monitoring.

Radiological monitors should habitually accompany the lead elements and continuously monitor the route of advance. Information obtained by these monitors can be used to determine if radiation has been encountered, how the dose rate increases with direction of travel, and whether the maximum dose rate point has been passed for any route selected through the area of radiation.

b. Courses of Action.

(1) Selecting a route.

Any route, whether a straight line or a peripheral course, that avoids the area in the vicinity of ground zero will reduce doses below those from a route which passes through or near ground zero. However, this option as to route selection may be influenced by the terrain. Obstacles formed by tree blowdown, fires, and building collapse may limit not only the number of routes available but also whether movement is on foot or in vehicles.

(2) Mode of crossing.

If there is an option as to the method of transportation to be used in crossing an area of induced activity, it should be selected in the following priority:

1. Armored vehicles and personnel carriers.

2. Wheeled and tracked vehicles, preferably with sandbagged floors and sides.

3. On foot.

(3) Maximum Dose Rate Point.

When crossing an area of induced radiation, the commander should note the point of maximum dose rate. At this point closest to ground zero, assume that the total traversal dose will equal two times the current dosimeter reading at the point of maximum dose rate; that is, assuming the dosimeter reading was zero before entering the area. Beyond this maximum dose rate point, it will usually be just as safe to continue to advance or to move laterally away from ground zero rather than to withdraw. If the dose rate is becoming prohibitively high, causing the total dose to approach the operation exposure guide, prior to reaching this maximum dose-rate point, the commander may elect to change the route of advance or withdraw, depending upon the tactical situation.

(4) Occupancy of an Area.

Routine occupancy of an area of induced radiation is possible in from 2 to 5 days after burst. In the case of occupancy, low dose rates become of greater significance. This will be because of the accumulated dose acquired over the indefinite period of exposure. A commander should seek the least contaminated region available, consistent with the mission. During operations in a radiation field, the dosimeter should be checked frequently.

(5) Variable Decay.

The rate of decay of induced radiation is considerably different from that of fallout. The rate of decay of fallout is dependent upon the fission products produced in the burst itself and can be calculated by using the Kaufman Equation. On the other hand, soil composition is the most important factor in the decay of induced radiation. Since soil composition varies widely, even in a very localized area, the actual chemical composition of the soil must be known to be able to determine the rate of decay of induced radiation. For this reason, four types of soil have been selected to show the wide variance in the predicted dose rates and decay rates. Since the actual soil composition will not normally be known, Soil Type II has been chosen as standard for decay and total dose calculations. Soil Type II will be used for all calculations until the unit is advised to use a different soil type.

3. Decay and Dose-Rate Calculations.

Soil type is determined by using engineer soil maps or an NBC 4 Report and the Decay of Induced Radiation Nomograms (Figures 5-6 through 5-9). The method is basically a process of elimination. The dose rate and the time it was measured are applied to a Decay of Induced Radiation Nomogram. This will result in an H + 1 or R_1 dose rate. Then if the other dose rates and times from the series report result in the same R1 dose rate, that is the soil type. If not, check the other nomograms until the one used results in the same R_1.

a. Decay of Induced Radiation Nomograms.

The decrease in the dose rate must be calculated before the total dose can be found. This is done with Decay of Induced Radiation Nomograms. Use these nomograms (Figures 5-6 through 5-9) for these calculations. These nomograms allow the user to predict the dose rate at any time after the burst. Each nomogram denotes time (hours) after burst for one of the four soil types. In each nomogram, the R_1 scale is at the right. This scale shows H + 1 dose rates. The R_t scale is on the left. This scale shows dose rates at times other than H + 1.

In each nomogram, the R_1 scale is at the right. This scale shows H+1 dose rates.

The R_t scale is on the left. This scale shows dose rates at times other than H + 1.

b. Essential Information.

In working with nomograms, care should be taken to be as consistent as possible when joining values with the hairline. Be sure the hairline intersects the vertical line and the interpolated value (tick mark) as closely as possible. It is possible to find any one value on the nomogram if the other three are given, as illustrated in the example problems below.

c. Example Problems.

The following problems are concerned with technique only and do not consider the impact that these high dose rates might have on operations in the contaminated area.

Problem 1.

GIVEN: R_t = 150 cGy/hr at H + 3 hours.

FIND: R_1.

SOLUTION: Since the soil type (composition) is not known, calculations will be performed on the Soil Type II index scale (Figure 5-7). Align the hairline with the 3-hour tick mark on the Soil Type II index scale and the 150 cGyph point on the R_t scale.

Read the dose rate as 190 cGyph at the point of intersection with the R_1 scale.

ANSWER: 190 cGy/hr.

Problem 2.

GIVEN: R_1 = 300 cGyph.

FIND: R_t at H + 7 hours when the soil composition approximates Soil Type III.

SOLUTION: Align the hairline with the 7-hour tick mark on the Soil Type III scale (Figure 5-8) and equal values of the left and right reference lines. Pivot the hairline about its point of intersection with the index scale to the 300 cGyph point on the R_1 scale. Read the dose rate as 50 cGyph at the point of intersection with the R_t scale.

ANSWER: 50 cGyph.

Problem 3.

GIVEN: R_1 = 280 cGyph.

FIND : Time when R_t = 90 cGyph.

SOLUTION: Since the soil type is not indicated, Soil Type II (Figure 5-7) must be used for this calculation. Connect 280 cGyph on the R1 scale and 90 cGyph on the R_t scale. Read time as H + 15 hours on the Soil Type II (index) scale.

ANSWER: H + 15 hours.

Problem 4.

GIVEN: R_1 = 200 cGyph.

FIND: Time when R_t = 70 cGyph in Soil Type IV.

SOLUTION: Connect 200 cGyph on the R_1 scale and 70 cGyph on the R_t scale. Holding the hairline firmly at its point of intersection with the index scale, align equal values on the left and right reference lines. Read time as H + 10 hours at the point of intersection with the Soil Type IV scale (Figure 5-9).

ANSWER: H + 10 hours.

Problem 5.

GIVEN: Monitoring data from a unit occupying foxholes in an induced radiation area:

Time (hours after burst)	Ground Dose Rate (cGyph)
H + 1	40
H + 5	23
H + 6	17
H + 7	15

FIND: Soil Type in which decay approximates the data.

SOLUTION: Connect 40 cGyph on the R_1 scale and 23 cGyph on the R_t scale. Holding the hairline firmly at its point of intersection with the index scale, align equal values on the left and right reference lines. Check the intersection of the hairline with each of the four soil types to determine which is closest to H + 5; repeat this procedure, with the dose rate at H + 6 and H + 7. A review of the results will indicate that the decay of contamination from Soil Type IV (Figure 5-9) approximates the data given.

ANSWER: Soil Type IV.

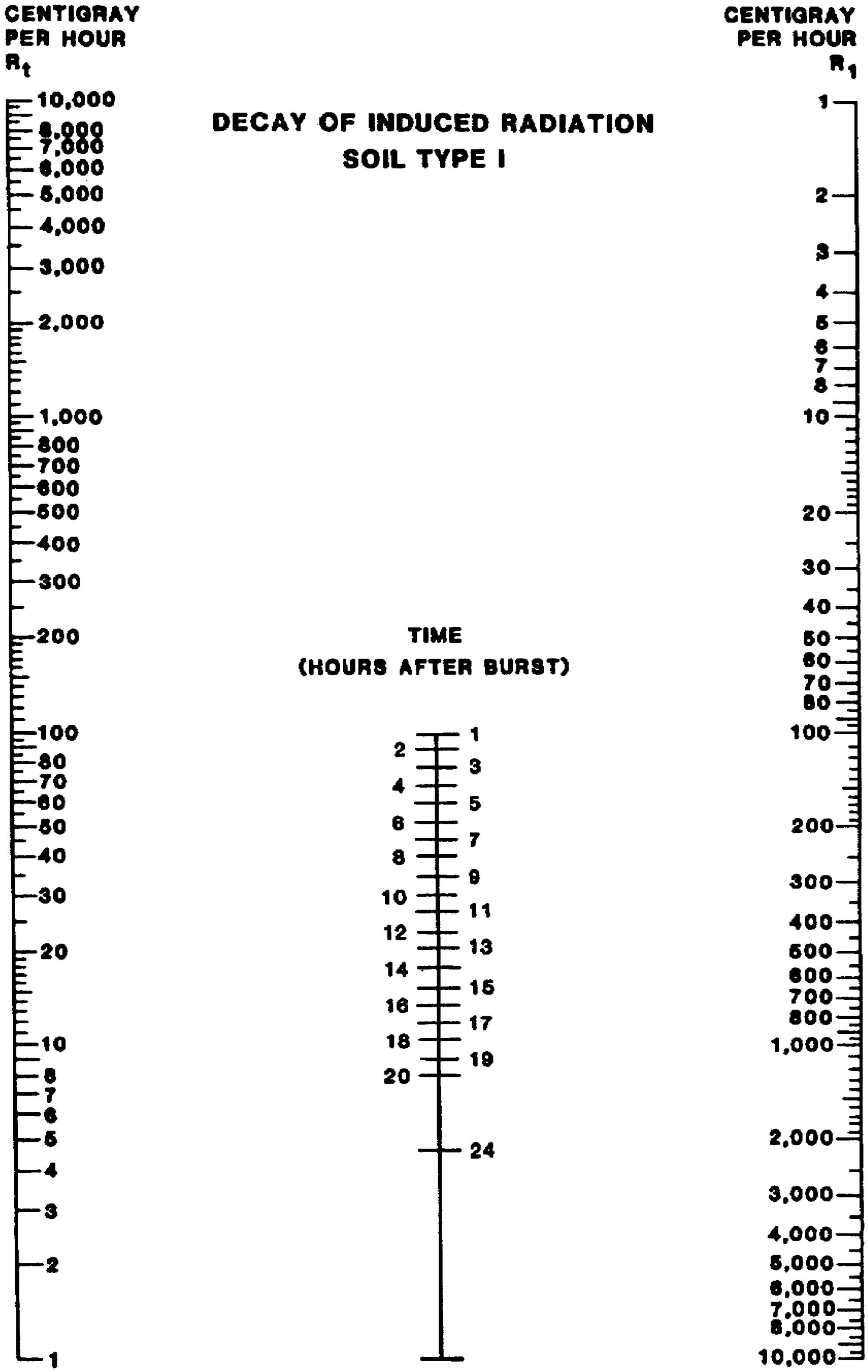

Figure 5-6. Soil Type I Nomogram

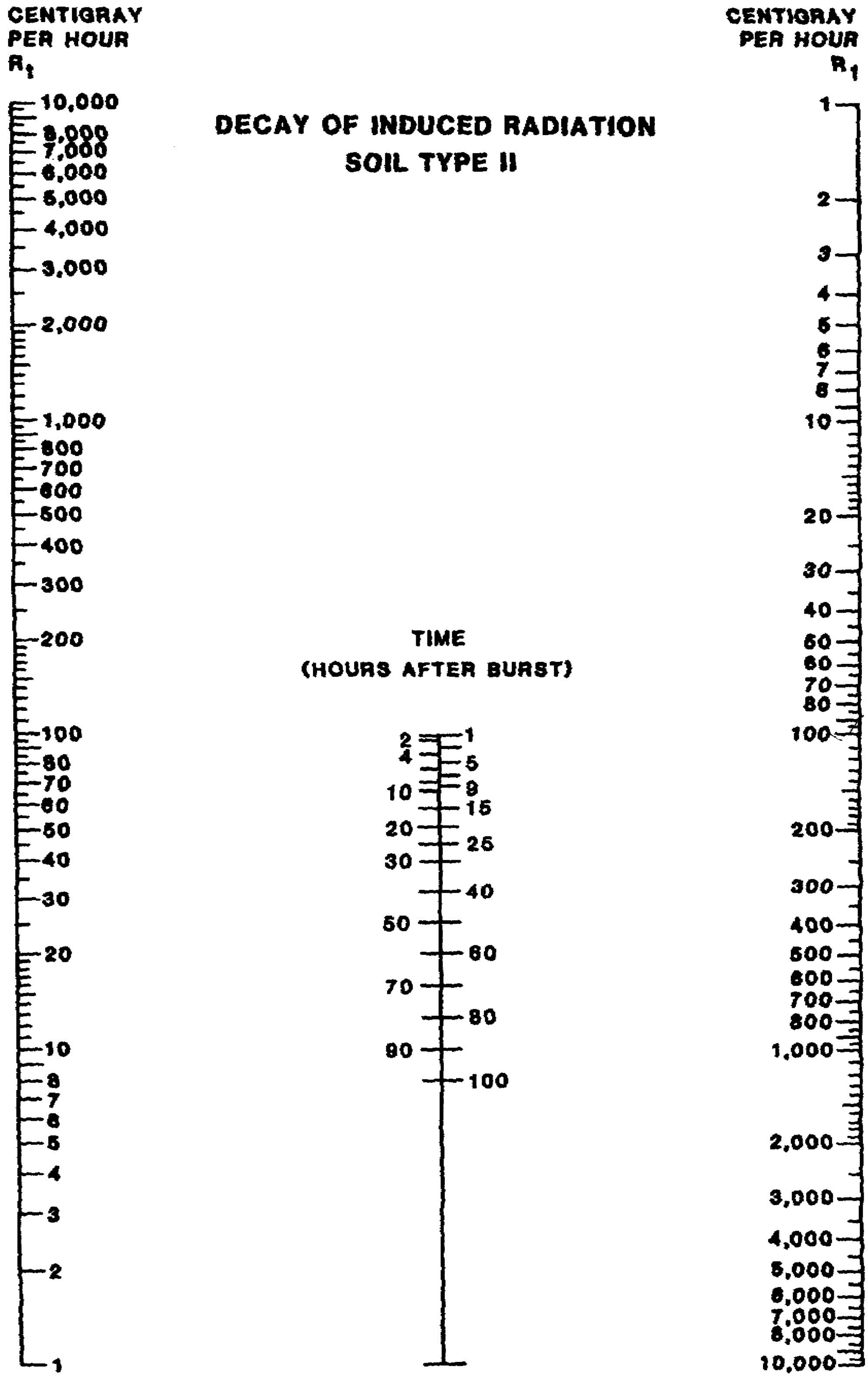

Figure 5-7. Soil Type II Nomogram

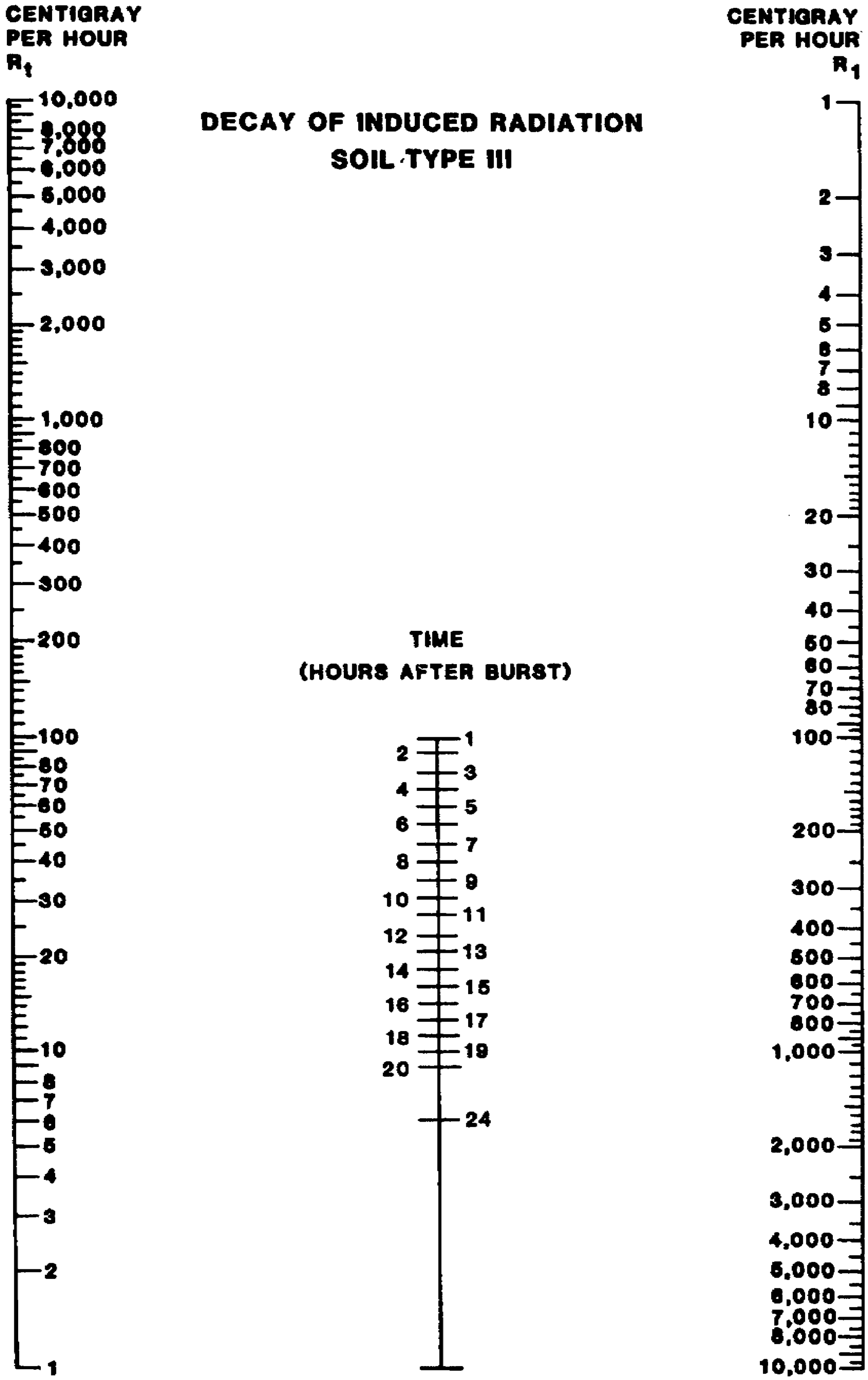

Figure 5-8. Soil Type III Nomogram

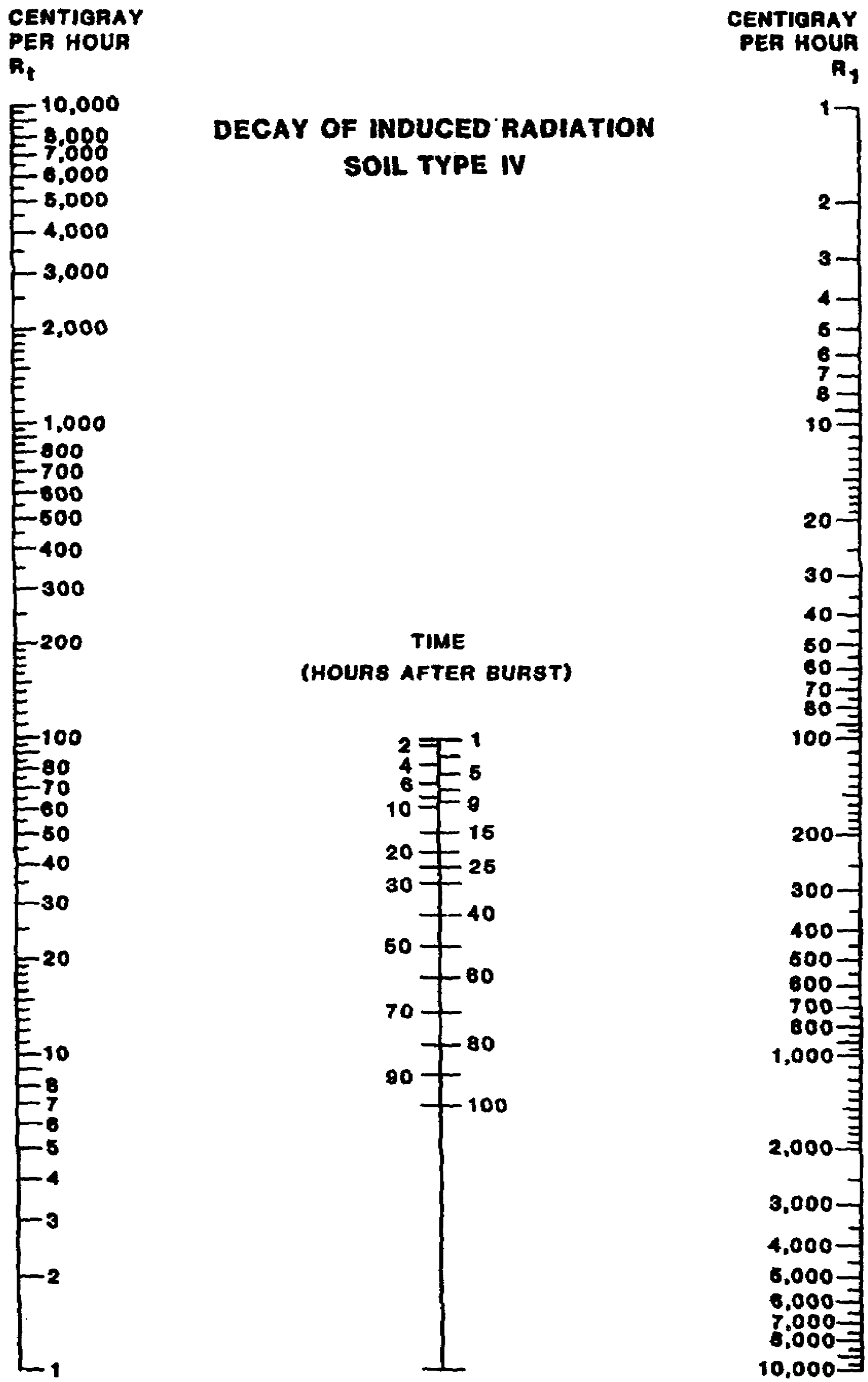

Figure 5-9. Soil Type IV Nomogram

4. Total Dose Received in an Induced Area.

The Total Dose Nomogram in Figure 5-10 is used for predicting total dose to be received while in an induced radiation area. This nomogram relates total dose (D), R_1 dose rate, stay time (T_s), and entry time (T_e). The two scales at the left show total dose and R_1 dose rate. There are two time-of-stay scales to the right of the index line. The index scale is a pivoting line which is used as an intermediate step between D and R_1 and T_s and T_e. The extreme right scale shows time of entry. The left scale is for Soil Types II and IV and the right scale is for Soil Types I and III.

a. Essential Information.

Remember the Total Dose Nomogram, Figure 5-10, is never used to find R_1. Soil Types II and IV under stay time are used for total dose calculations if the soil type is not known. If the soil type is known, the appropriate scale under stay time is used. It is possible to find any one value on the Total Dose Nomogram if the other three are given, as illustrated in the following problems.

b. Example Problems.

These problems are concerned with techniques only. They do not consider the impact the dose or dose rates might have on operations in a contaminated areas.

Problem 1.

GIVEN: R_1 = 140 cGyph T_e = H + 6 hours
T_s = 1 hour Soil Type II.

FIND: D.

SOLUTION: Since no soil type is indicated, use Soil Types II and IV scale under stay time. On the nomogram in Figure 5-10, connect H + 6 hours on the T_e scale with 1 hour on the T_s scale (Soil Types II and IV) with the hairline. Pivot the hairline at its point of intersection with the index scale to 140 cGyph on the R_1 scale. Read 72 cGy on the D scale at the point of intersection with the hairline.

ANSWER: 72 cGy.

Problem 2.

GIVEN: R_1 = 300 cGyph T_e = H + 6 hours
D = 70 cGy Soil Type III.

FIND: Ts.

SOLUTION: On Figure 5-10, connect 70 cGy on the D scale with 300 cGyph on the R_1 scale. Pin the hairline at its point of intersection with the index scale. Pivot the hairline to H + 6 hours on the T_e scale. Read 1 hour on the T_s scale (Soil Types I and III).

ANSWER: 1 hour.

Problem 3.

GIVEN: D = 25 cGy R_1 = 100 cGyph
T_s = 0.4 hour Soil Type III.

FIND: T_e.

SOLUTION: On Figure 5-10, connect 25 cGy on the D scale and 100 cGy/hr on the R_1 scale with the hairline. Pivot the hairline at its point of intersection with the index scale to 0.4 hour on the T_s scale (Soil Types I and III). Read H + 3 on the T_e scale at the point of intersection with the hairline.

ANSWER: H + 3 hours.

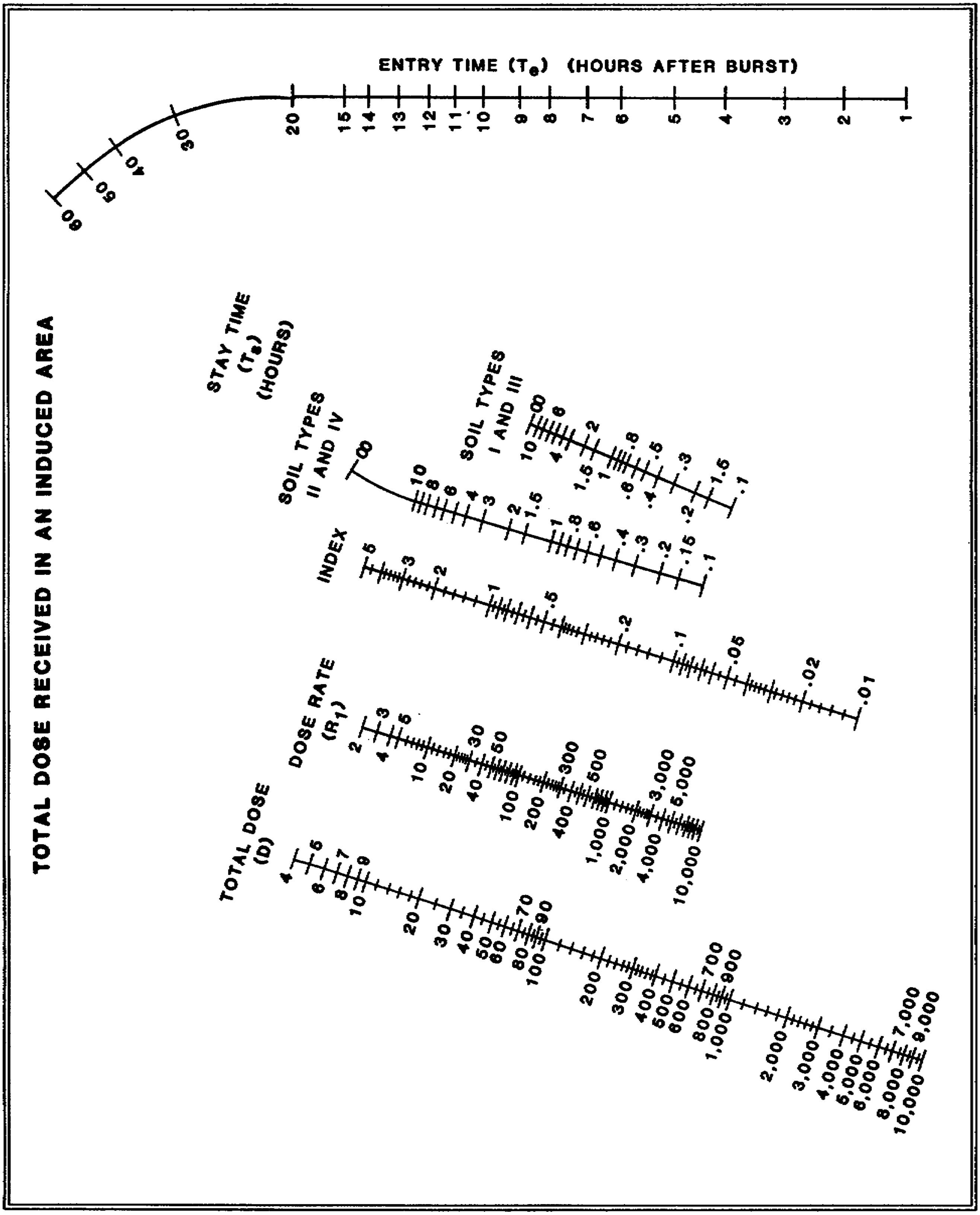

Figure 5-10. Total Dose Nomogram (Induced)

5. Crossing an Induced Radiation Area.

If an area must be crossed, select the lowest dose rate area, consistent with the mission. Route selection may be influenced by several factors. Induced radiation areas often may be avoided. However, the tactical situation may require that units cross an area in which there is induced radiation.

In calculating total dose, it is necessary to determine an average dose rate. Dose rates increase as the center of the area is approached and then decrease beyond the center of the area.

a. Average Dose Rate.

The average dose rate represents a mean value to which the individual is exposed during the time of stay. A reasonable approximation of the average dose rate can be obtained by dividing by two the maximum dose rate predicted to be encountered.

Symbolically, this is written as: $R_{1avg} = \dfrac{R_{1max}}{2}$.

b. Time of Stay.

Stay time must be calculated for crossing problems.

Use the relationship of $T_s = \dfrac{\text{distance}}{\text{speed}}$.

An example problem is given below for calculating dose when crossing an induced radiation area (Figure 5-11).

GIVEN: A crossing will take place at H + 20 hours, as shown in Figure 5-11. Distance of the route across the area is 1 kilometer; the rate of speed during the crossing, on foot, will be 5 kilometers per hour.

FIND: D.

SOLUTION:

$$R_{1avg} = \frac{R_{max}}{2} = \frac{1000 \text{ cGyph}}{2} = 500 \text{ cGyph.}$$

$$T_s = \frac{\text{distance}}{\text{speed}} = \frac{1.0 \text{ km}}{5 \text{ kmph}} = 0.2 \text{ hour.}$$

$$T_e = H + 20 \text{ hours.}$$

On Figure 5-10, connect 0.2 hours on the T_s scale (Soil Types II and IV) and 20 hours on the T_e scale with a hairline. Pivot through the point of intersection with the index scale to 500 cGyph on the R_1 scale. Read a total dose of 20 cGy on the D scale at the point of intersection with the hairline.

ANSWER: 20 cGy.

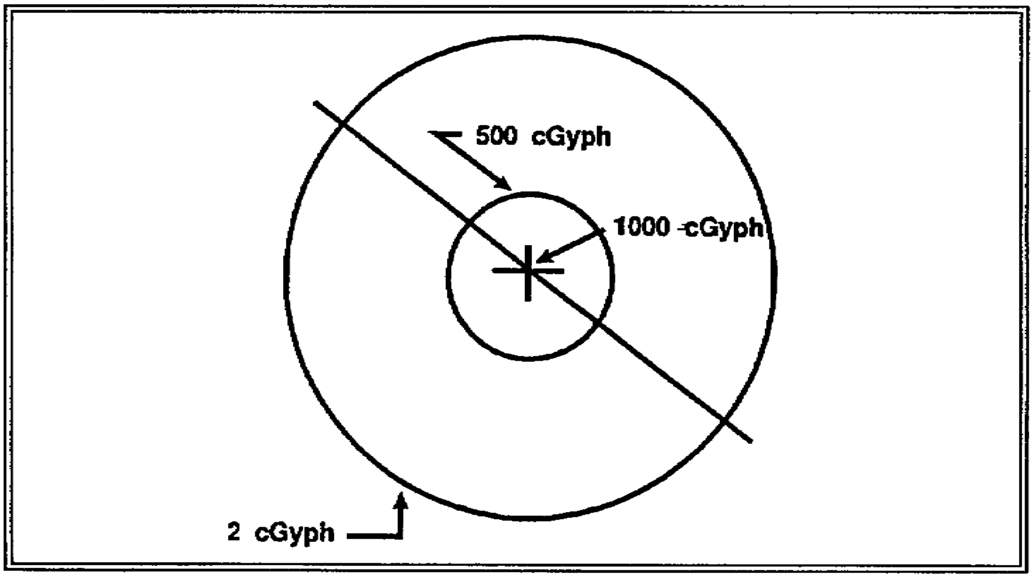

Figure 5-11. Crossing an Induced Radiation Area

LESSON 5

PRACTICE EXERCISE

The following items will test you grasp of the material covered in this lesson. There is only one correct answer for each item. When you complete the exercise, check you answer with the answer key that follows. If you answer any item incorrectly, study again that part of the lesson which contains the portion involved.

Situation: While operating in a radiologically contaminated area, your unit is required to determine dose rates and transmission factors and convert them to operational terms.

1. Before fallout begins near ground zero, which can cause the time to vary?

   A. Yield, weather, and terrain
   B. Delivery methods and amount
   C. Type of munitions
   D. Terrain and atmospheric conditions

2. In the Total Dose Nomogram, what does D equal?

   A. Dose rate before entering
   B. Total dose in rad
   C. Dose rate after fallout
   D. Total dose in cGy

3. When using the Total Dose Nomogram, always start the problem on the side for which there are how many known values?

   A. One
   B. Two
   C. Three
   D. Four

4. Which is determined by using a transmission factor?

   A. Fallout prediction dose rate
   B. Reduction in the dose received by personnel shielded from radiation
   C. Conversion from total dose to dose rate
   D. Conversion of inside dose rate to outside dose rate

5. What is the transmission factor for a 1/4-ton vehicle when the outside dose rate is 100 cGyph and the inside dose rate is 80 cGyph?

   A. 0.2
   B. 0.8
   C. 1.25
   D. 20.00

6. Why is shielding required on the nuclear battlefield?

   A. To neutralize Gamma Radiation
   B. To reduce radiation to a background level
   C. To reduce the radiation dose to an acceptable level
   D. To eliminate the possibility of radiation blindness

7. The total dose of radiation received by personnel crossing a fallout area is calculated using the Total Dose Nomogram by converting the maximum dose rate to which item?

   A. Transmission factor
   B. Average dose rate
   C. Adjusted time of stay
   D. Correlation factor

8. An armored unit equipped with M60 Tanks (TF 0.04) is located inside a radiation area with the outside dose rate at 260 cGyph. What is the inside dose rate (cGyph) ?

   A. 2.5
   B. 4.7
   C. 8.2
   D. 10.4

9. Which is the principal source of induced radiation 10 to 20 hours after burst?

   A. Sodium
   B. Manganese
   C. Zinc
   D. Aluminum

10. Which item must be determined when calculating total dose?

   A. Average dose rate
   B. Decay rate
   C. Correlation factor
   D. Dose rate

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LESSON 5

PRACTICE EXERCISE

ANSWER KEY AND FEEDBACK

Item		Correct Answer and Feedback
1	A	Yield, weather, and terrain The time . . . terrain. Part A, p. 5-3, para b
2.	D	Total dose in cGy Part B, p. 5-10, para 1, formula
3.	B	Two When working . . . known. Part B, p. 5-10, para 2
4.	B	Reduction in the dose received by personnel shielded from radiation A transmission . . . radiation. Part C, p. 5-13, para 3
5.	B	0.8 The transmission. below. Part C, p. 5-14, para a
6.	C	To reduce the radiation dose to an acceptable level The use . . . personnel. Part D, p. 5-17, para 1
7.	B	Average dose rate In crossing . . . route. Part D, p. 5-18, para 4
8.	D	10.4 Part D, p. 5-19, para 5, Example Problem 1
9.	A	Sodium After 10 . . . radiation. Part E, p. 5-21, para 1c
10.	A	Average dose rate In calculating . . . rate. Part E, p. 5-36, para 5

LESSON 6

RADIOLOGICAL DECONTAMINATION

Critical Task: 031-507-2013

OVERVIEW

LESSON DESCRIPTION:

In this lesson you will learn about the effects of radiological contamination, the priorities, uses and types of decontamination.

TERMINAL LEARNING OBJECTIVE:

ACTION: Describe radiological decontamination.

CONDITION: Given information about the effects of radiological contamination and the priorities, uses, and types of decontamination.

STANDARD: Demonstrate competency of the task, skills, and knowledge by responding correctly to a multiple-choice test covering the effects of radiological contamination and the priorities, uses, and types of decontamination.

REFERENCE: FM 3-5.

INTRODUCTION

During the past several decades, the nature of battle has changed significantly. The development and production of weapons of massive destruction have changed the complexion of the modern battlefield. With the advance of nuclear technology, many armies are able to employ nuclear weapons. These weapons and the radiological hazards resulting from their use pose tremendous challenges. The U.S. Army must be prepared to fight and win when nuclear weapons are used.

In order to win the battle, the hazards of blast effects, thermal and nuclear radiation must be reduced. NBC defense personnel and equipment must be used to reduce radiological hazards. Radiological contamination causes casualties and restricts the use of equipment, terrain, and structures. A commander has the option of avoiding contamination or moving through it. The operation exposure guide (OEG) is used to decide whether to withdraw, continue the mission, or conduct decontamination.

When decontamination is required, the resources necessary for decontamination will put a strain on the combat operations. Decontamination reduces or eliminates the hazard and permits units to continue the mission. Decontamination is done only when it is necessary to accomplish the mission.

PART A -- EFFECTS OF RADIOLOGICAL CONTAMINATION

The effects of radiological contamination range from denial of terrain, facilities, and equipment, to casualties from radiation. Heat stress, due to troops being forced to wear protective clothing, reduces combat effectiveness. Contamination will hinder operations due to losses of time spent in decontamination operations or in bypassing contaminated objects or terrain. Contamination will tax the logistics system and cause a lack of support for operations, including decontamination operations.

In a contaminated environment, special provisions will be required for eating and drinking, sleeping and attending bodily functions. For troop feeding, collective protection must be provided, or troops must be withdrawn to a safe area. Personnel must sleep in full protection and, when possible, under cover. Personnel must be taught to attend bodily functions without spreading contamination to inner clothing or their skin.

The wearing of protective clothing makes identification of personnel almost impossible without a special method of identification. Units will be required to devise expedient identification systems. Color coded tapes for subordinate unit identification with triangles or rectangles of tape to identify leaders will probably be used.

Maintenance will be more difficult in a contaminated environment. More time will be necessary for repair of equipment that has been contaminated because it must be decontaminated prior to repair. Using units are responsible for decontaminating equipment before it is turned in for maintenance. The receiving maintenance unit will check for contamination. Separate storage sites within maintenance areas will be necessary for the storage, decontamination, and disposition of equipment prior to maintenance.

Rebuilding damaged facilities is much more difficult and time-consuming when these facilities are contaminated. Restoration will not normally be undertaken unless the area affected is of vital importance and the damaged facilities cannot be established elsewhere with less effort. Consideration should be given to the use of locally available or requisitioned facilities.

The logistics system will be affected by radiological contamination Alternate supply routes and modes of transportation will be of increased importance. Traffic regulation and control measures will be necessary to prevent the use of contaminated routes. Detours and rerouting will normally extend the turn-around time of transportation vehicles and reduce the gross transportation capability. Where movement capabilities re reduced, it may be necessary to increase the storage of supplies in order to prevent shortages due to the inability to resupply. Supplies suspected of exposure to contamination will require detailed inspection, testing, and if necessary, decontamination prior to use or issue. Class I supplies and water sources suspected of contamination will demand special attention. There will be an increase in requirements for the replacement of supplies of any class that have been contaminated by enemy nuclear munitions beyond the limits of reclamation. There will also be an increase in replacement requirements because of the delay caused by decontamination.

There will be increased need for decontamination equipment and supplies, individual protective clothing, and other individual and unit protective equipment.

The main effects of a nuclear detonation are blast effects, initial and residual radiation, heat, and electromagnetic pulse (EMP). All can interfere with the mission, but decontamination is of use only for residual radiation, mainly fallout. Residual radiation consists of fallout and neutron-induced radiation. Fallout is of more concern and is a more important operational factor than induced radiation.

Fallout can produce casualties, delay movements, and deny terrain, if units are unprepared to detect residual radiation, take protective measures from the effects of it, and decontaminate as needed. When a nuclear weapon detonates at or near the surface of the earth, dust and debris which are drawn into the air fall to the ground and create areas of lethal radiation. Similar results can occur when the cloud from an air burst, at a fallout safe height, about 50 meters for a 1 KT weapon, passes through rain, which then carries radioactive particles to the earth.

The second type of residual radiation is neutron induced radiation.

Neutrons are produced in all nuclear bursts, and some are captured by certain elements in the soil under the burst. As a result, the elements become radioactive. When this happens, Beta and Gamma radiation is emitted from the radioactive soil. Neutron-induced radiation exists in a relatively small circular pattern around ground zero.

Initial radiation and residual radiation do not damage material; they damage human tissues. When radiation is absorbed by the body, it kills the cells. The unit used to measure the amount of radiation absorbed by a person is the **centigray, cGy**. How much radiation a soldier can receive and survive depends on such factors as the soldier's weight, general state of health, personal biochemistry, and whether the soldier has had previous exposure to radiation.

Figure 6-1 is a chart of symptoms caused by lower doses of radiation.

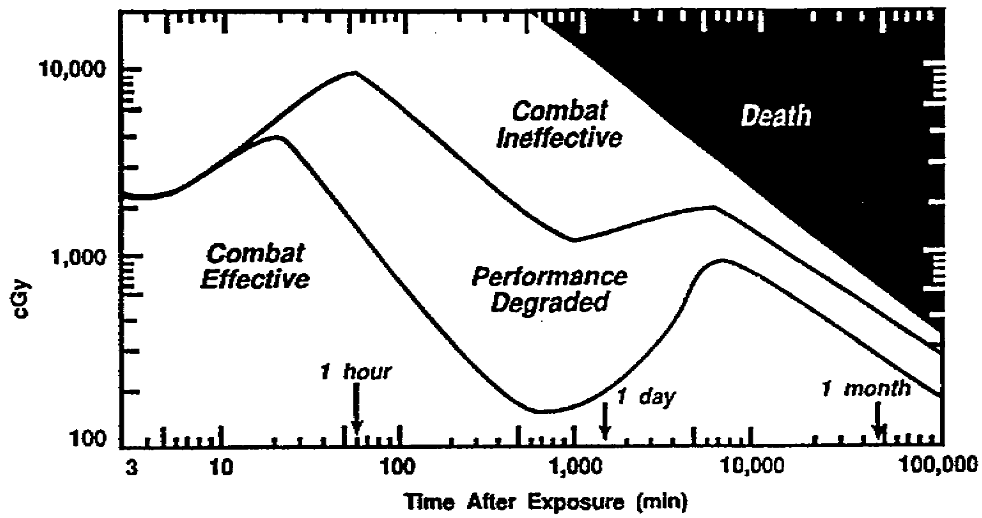
DOSE IN cGy	EARLY SYMPTOMS*	EFFECTIVENESS	FATALITIES
0 - 70	Vomiting in up to 5% exposed soldiers within 6 hours	Full	None
70 - 150	Vomiting in up to 50% soldiers, approximately 3 to 6 hours after exposure.	Reduced while vomiting. Up to 5% may be ineffective.	None
150 -450	More than 50% will vomit within 3 hours after exposure	More than 5% may be combat ineffective.	5% at lower dose to 50% at higher dose
* Symptoms include diarrhea, "dry heaving," nausea, lethargy, depression, and mental disorientation. At lower dose levels incapacitation is a simple slowing down of the performance rate due to loss of physical mobility and/or disorientation.			

Figure 6-1. Symptoms of Nuclear Radiation Exposure

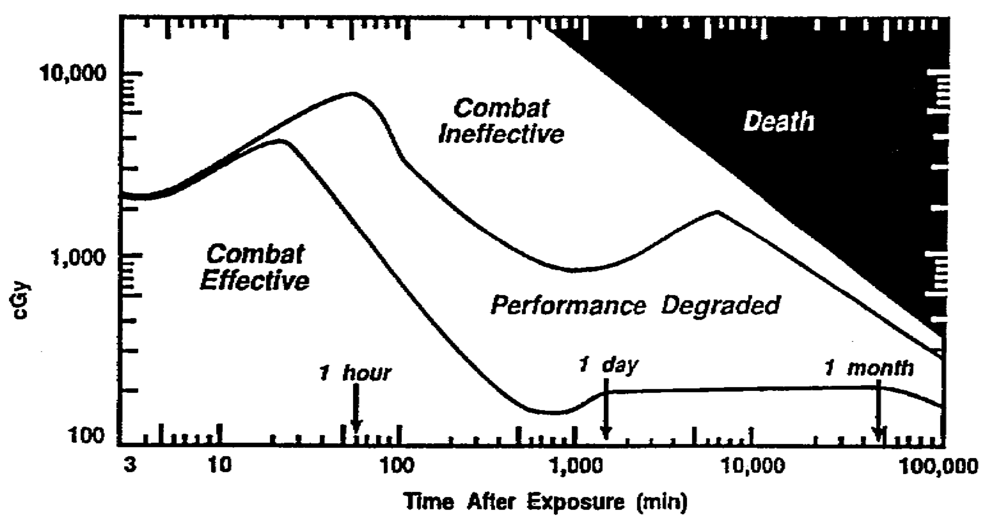
A soldier exposed to 650 cGy initially shows no symptoms, but loses some effectiveness in about 2 hours and can be expected to die within a few weeks under battlefield conditions. Exposure in the 100 cGy range usually has little effect, if there has been no prior radiation exposure. However, the effects of radiation are cumulative and commanders must maintain records of the radiation their units have received in order to control and minimize their accumulated doses.

Figure 6-2 shows how relatively high radiation doses affect personnel, based upon whether tasks are physical or nonphysical.

In general, the radiation dose which will cause immediate incapacitation is more than 8000 cGy, but an active soldier suddenly exposed to 3000 cGy will become incapacitated within 3 to 5 minutes. The soldier may recover to some degree in about 45 minutes, but due to vomiting, diarrhea, and other radiation sickness symptoms, the soldier would be only partially effective until death occurs within a week.



Combat effectiveness after exposure to radiation, nonphysical tasks



Combat effectiveness after exposure to radiation, physical tasks

Figure 6-2. Radiation Effects on Personnel Performing Nonphysical and Physical Tasks

Radiation levels of fallout are extremely high in the first few hours after a nuclear burst. Avoiding exposure is essential to avoid casualties. Exposure can be avoided by relocating units or providing shielding. Any fallout which contaminates vehicles or personnel must be removed to avoid a high radiation dose.

Personnel contaminated by fallout, neutron-induced radiation, or any radiological contamination use dosimeters and RADIACmeters to detect and measure the contamination. If detection equipment is not available, and the hazard exists, decontaminate. When contamination is removed, most of the hazard is removed.

PART B -- DECONTAMINATION PRIORITIES AND USES

The first priority for all decontamination is personnel. Personnel will decontaminate themselves and their individual equipment immediately upon contamination or as soon as the tactical situation permits. See Appendix A.

According to the priorities established by the commander, those pieces of equipment and the areas that are needed for the mission must then be decontaminated. A general guideline in establishing priorities for decontamination is that those items needed first will be decontaminated first. When individual decontamination is finished, and within priorities established by the commander, contaminated surfaces should be decontaminated as quickly as possible. Radiological contamination decays over a period of time, and decontamination of those items, that are not needed immediately, may be delayed to reduce the hazard, before beginning decontamination by other methods.

Decontamination, especially for radiological contamination, should start with the easiest method and proceed to the most difficult. In initiating an operation, the easiest job should be done first; and then the progressively harder jobs should be accomplished in order. This allows a relatively small portion of time to be spent in removing a relatively large fraction of the contamination. The dosages to which individuals are exposed are reduced as contamination is removed. The hazard from fallout will decay with time and present a lesser hazard. As a result of these two factors, when the harder, more time-consuming portions of an operation are carried out, the exposure of an individual is kept to a low level.

Following a nuclear attack or the completion of fallout in a unit area, personnel, equipment, food and water are likely to be radiologically contaminated and should be monitored.

The purpose of this monitoring is to determine decontamination requirements and also to determine decontamination requirements and also to determine if supplies of food and water must be destroyed. Acceptable or safe levels of remaining radioactive contamination should be established by the commander on the recommendations of the medical officer. In the absence of specific guidelines, a dose-rate reading as close to background, the environmental reading, as is practical will be considered acceptable.

When operational areas are contaminated, personnel monitoring stations should be established as soon as practicable at the lowest unit level having the AN/PDR-27 or AN/VDR-2 RADIAC Sets. All personnel leaving the contaminated areas should be monitored. Personnel who are contaminated will be required to decontaminate themselves, except those physically disabled. Personnel monitoring is performed to detect contamination on the body. Proper monitoring of personnel consists of complete and careful checking of those parts of the body and clothing most susceptible to contamination.

Equipment that has been exposed to radiation or has been in a contaminated area must be monitored. This should be performed at a material monitoring station as near the contaminated area as possible. Equipment that is found to be contaminated should remain within a restricted area until the contamination either is removed or has decayed to background. In general, care should be taken when monitoring equipment to pay particular attention to those surfaces where the contamination is most likely to occur, such as: wheels, tires, undersides of vehicles and aircraft; greasy surfaces, floors, and steps. Before an attempt to recover or evacuate contaminated equipment, a check should be made to determine the practicability of this action. If the contamination exceeds the capabilities of any unit to decontaminate the equipment to permit recovery and evacuation, the location should be forwarded to the next higher headquarters, so that advice and assistance on decontamination or disposal may be obtained.

The four steps for radiological decontamination are:

1. Primary wash
2. Rinse
3. Interior decontamination
4. Check

If the primary wash is not done, the equipment will have significant contamination remaining on it which will not likely be removed later. This would expose personnel to excessive levels of radiation. Rinse off the soapy water to provide an additional flushing step for removing contamination. RADIACmeters will locate radiological contamination during interior decontamination Failure to do this properly will result in contamination remaining in the interior areas. Crews will not be able to lower MOPP levels. After interior decontamination, use the AN/PDR-27 RADIACmeter to check for radiological contamination. Any vehicle retaining measurable contamination is recycled. If monitoring is not done or is done improperly, the risk of contamination is greater.

Special consideration must be given to radiological contamination hazard in aircraft. The parts of an aircraft exposed to contamination should be washed with soapy water. This reduces the exposure to radiation. All the contamination hazard may not be removed, but the aircraft can be operated if the risk is reduced. The negligible risk level is 0.33 cGy per hour measured 1 meter from the contaminated surface. Commanders may need to employ aircraft even though contamination cannot be reduced to negligible risk level. In that case, radiation exposure status (RES) of the crew and the operation exposure guide (OEG) will govern the use of the aircraft. See Appendix A.

Except in rare cases of induced radiation, rations in cans or other sealed containers are not in danger or radiological contamination. As the contamination will normally be limited to the outer surface of the sealed containers, decontamination is accomplished by removing the contamination from the outer surface. This may be done by removing outer packaging or by washing or scrubbing under running water. Under no condition should sealed containers be opened until they have been decontaminated and the effectiveness of decontamination established.

Food not protected in sealed containers must be suspected of contamination until monitored. All food should be removed from the contaminated area to a clean area. Potatoes and hard-skinned fruits and vegetables can be decontaminated by washing or scrubbing under running water, followed by the peeling or scraping and washing again. Running water, if creek or stream, should be checked for contamination, especially since the water source may be in the GZ or fallout area. All visible dirt should be brushed from meats and fish; washing is not recommended. A thin layer of meat can be removed and the food remonitored. A reduction in dose rate would indicate that the contamination was confined to the surface of the food. The cutting away process can be continued, within practical limits, until the dose-rate reading is acceptable. If the dose rate is within acceptable limits initially or after the outer layer or layers have been removed, the food can be safely consumed. As prepared food in open containers will probably be contaminated, it should be disposed of by burying or as otherwise determined by designated medical personnel. Radiologically contaminated wash water and trimmings should be similarly disposed.

Any food that has been exposed to radiological contamination must be carefully monitored before and after decontamination. Food in which radioactivity has been reduced can only be further decontaminated by aging. Careful monitoring will determine the progress of radioactive decay during aging.

Water that has been in a contaminated area or is suspected of being contaminated should be monitored and declared safe before it is used for drinking. Engineers have responsibility for decontamination of water. Determination of the potability and approval of water is a responsibility of the Surgeon for Army units. Radioactive contaminants in water are not affected by boiling or by other water treatment methods designed for chemical or biological contamination.

Spring or well water should be used in preference to surface water. If it becomes necessary to use radiologically contaminated water, for example: lakes, ponds, rivers and streams, the instructions set forth below should be followed and the water used only under these conditions.

1. If the external radiation hazard permits operations in the area around the water point without a shelter, the water is suitable for consumption for a period not exceeding 1 week, provided that normal field purification methods have been accomplished.

2. The AN/PDR-27 RADIAC Set should be used (probe open and held approximately 1 centimeter, about 1/2 inch, from the surface of the water) to give a qualitative indication of Beta-Gamma contamination. The range scale should be at the 500 scale.

IN AN EMERGENCY ONLY, water from a moving stream or similar source may be used, even though it contains radiological contamination, if it is filtered through a column of earth of at least 15 centimeters (6 inches), preferable 25 to 30 centimeters (10 to 12 inches), which must be obtained from nonradioactive sources. The column must be supported by a fine mesh material to prevent passage of earth particles. The resultant product is checked for radioactivity remaining in the filtered water. Subsequently, the water should be boiled or treated with iodine purification tablets or calcium hypochlorite to kill biological contamination.

PART C - DECONTAMINATION TYPES AND METHODS

There are three levels of decontamination: Immediate, Operational, and Thorough. Immediate Decontamination is carried out by individuals when they are contaminated. Operational Decontamination sustains operations, reduces contact hazard, and limits the spread of contamination. The aim of Thorough Decontamination is to reduce or eliminate the need for individual protective clothing.

Personnel engaged in nuclear decontamination should wear a dosimeter and be closely monitored for level of radiation exposure. The amount of radiological contamination that can be tolerated will vary depending on the operation exposure guide (OEG) and the tactical situation. See Appendix A.

Personnel contaminated with a dry contaminant, such as fallout, should shake their clothing and gear.

CAUTION

Wear a protective mask to avoid breathing contaminated dust.

Brush the dust off the load-carrying equipment and mask carrier. Wash exposed areas of the skin with soap and water. If soap and water are not available, use M258A1 Towelettes. Attention should be paid to hair and fingernails.

1. MOPP Gear Exchange.

Personnel contaminated by a wet radiological contaminant must complete a MOPP Gear Exchange as soon as possible. Brushing or shaking will not remove the hazard. Wash gloves and footwear covers if water is available. Use warm, soapy water to wipe your mask, hood, helmet and other personal equipment. If warm, soapy water is unavailable, use rags of damp paper towels. Ensure the contamination is not spread to clean areas.

MOPP Gear Exchange is accomplished as follows:

Step 1. Gear Drop.

Remove gross contamination from individual gear (weapon, helmet, load-carrying equipment, and mask carrier). Brush or wipe dust or radiological contamination from individual gear. Wash equipment with warm, soapy water, if available.

Step 2. Hood Decontamination.

Remove gross contamination from the mask and hood using the buddy system. The hood is decontaminated and rolled up and away from the back of the head.

Step 3. Remove Overgarment.

Remove contaminated overgarment and lay jacket with black side up to step on after removing boots.

Step 4. Remove Boots and Gloves.

Remove contaminated boots (footwear covers) and gloves to limit the spread of contamination. Step on the jacket as each boot is removed, then remove the gloves.

Step 5. Put on Overgarment.

The new overgarment restores protection. Remove the overgarment from the package without touching the outside of the package. Put on the trousers and jacket. Close zippers and fasten ties.

Step 6. Put on Boots and Gloves.

The boots and gloves help restore protection. Use the buddy system to remove boots from the package without touching the outside of the package. Put on boots and tie or zip them. Remove gloves from the package without touching it. Put on the gloves.

Step 7. Secure Hood.

The hood is secured to restore protective posture. Use the buddy system to close all zippers and tie the ties on the hood and overgarment.

Step 8. Secure Gear.

Secure individual gear. Put it on and move to assembly area. Use buddy system to check fit of all secured gear.

MOPP Gear provides little protection from the hazards of radiological contamination. Gamma and Beta Rays can penetrate the protective gear and the body, even though the contamination never touches the skin.

Although the effects are not immediate, the absorbed radiation may build up to dangerous levels. If your skin is contaminated, use personal wipedown and operator's spraydown to reduce the hazards in your work area.

2. Unit Sustainment and Restoration.

Set up the decontamination site near a good water source, such as a public water system, fire hydrant, river, or large pond.

Soldiers involved in washing and rinsing must wear TAP aprons to protect their overgarments. Vehicles and equipment are prepared for decontamination prior to entering the decontamination site. Exterior-mounted supplies and equipment susceptible to damage are removed and decontaminated separately. See Appendix C.

3. Natural Methods.

The most effective decontamination techniques are the natural methods. These include: Weathering, flushing, covering, clearing, and brushing. Weathering is the simplest and easiest method. It will affect radiological contamination by the rain flushing the fallout and the wind scattering the radioactive dust. Flushing uses large quantities of water. Covering does not destroy contamination, but it reduces the hazard. Clearing removes contaminated layers covering terrain. Brushing or scooping away the top inch of soil will lower the amount of hazard. See Appendix B.

A surface radiologically contaminated may be rendered less hazardous by sealing. This may be accomplished by painting a wall, plastering a surface, or by resurfacing a paved road. Sealing is of great value in reducing the amount of radiation absorbed from fallout and preventing the spread of fallout contamination.

Asphalt and concrete, three centimeters (1 inch) thick or greater, are permanent sealants applicable to decontamination of critical roadways and limited land areas. Application of these coverings requires the use of road resurfacing equipment. Spraying a surface with hot asphalt results in a semi-permanent seal that may be applied rapidly.

A half centimeter (1/4-inch) of grout, a mixture of sand, cement, and water, provides a permanent seal over contamination. Paint, varnish, and plastic coatings can be applied to wood, masonry or concrete, and metals. They should be applied by brush since spraying could scatter the contaminant.

Confining is the physical separation and isolation of the contaminant until aging or weathering reduces the hazard to an acceptable level. The time required to reduce contamination to an acceptable level by the aging method is dependent upon the decay rate of the contaminant. The confinement area should have a well-defined boundary and should be posted with contamination markers (Figure 6-3).

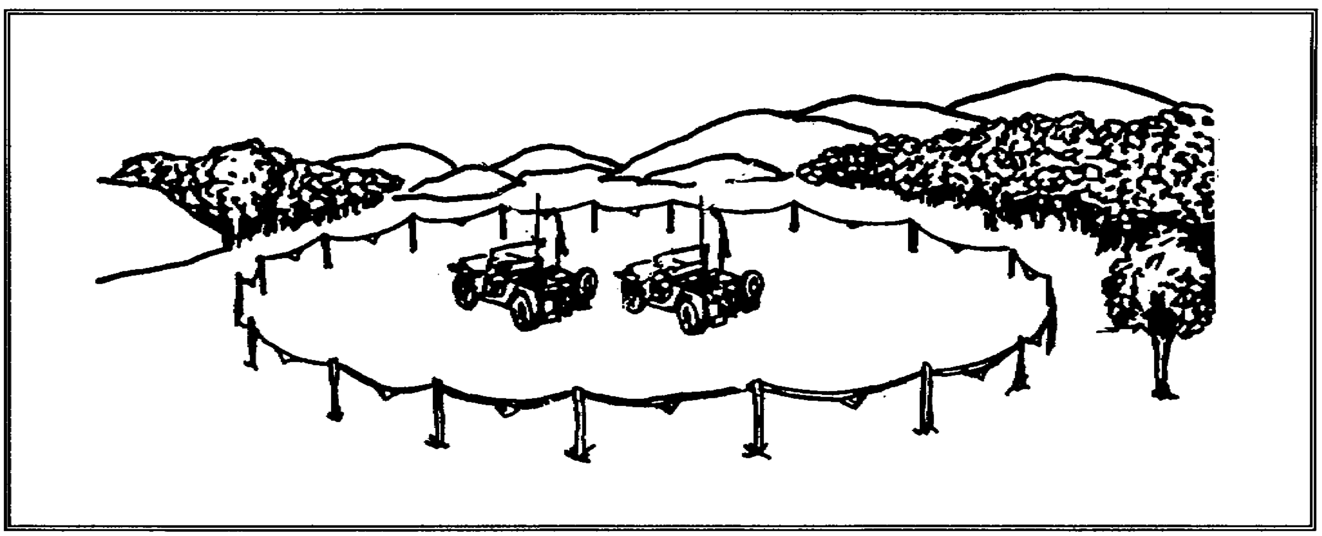


Figure 6-3. Confining Contaminated Equipment

Flushing is very effective for removing loose contamination or fallout. Water is effective for flushing away radiological contamination. Rainout can coat surfaces with a film that resists flushing. The road film on a dirty vehicle cannot be rinsed off without first being scrubbed. Film left by rainout must also be scrubbed. Any contamination removed by flushing and scrubbing will remain radioactive, so runoff must be controlled.

Covering contamination does not destroy it, but temporarily keeps the hazard away from you. Radiological contamination must be covered by thick layers of dense material, such as earth. Eight centimeters (3 inches) of earth will reduce radiation dose rates by one-half. Thirty centimeters (12 inches) is much more effective. Earth-moving equipment makes the job easier, but the equipment and operators will have to be decontaminated. Clear passageways by removing contaminated layers covering terrain. Fallout does not penetrate the top layer of soil unless it is followed by rain. It can be scraped aside. Move contaminated soil as far away as possible because the piles tend to concentrate radiation. Induced radiation may penetrate the terrain as much as 1 1/2 meters. It is impractical to decontaminate this much earth in most cases. The equipment used in decontamination operations will become contaminated and normally will be decontaminated at the completion of the operation. See Appendix C.

LESSON 6

PRACTICE EXERCISE

The following items will test you grasp of the material covered in this lesson. There is only one correct answer for each item. When you complete the exercise, check you answer with the answer key that follows. If you answer any item incorrectly, study again that part of the lesson which contains the portion involved.

Situation: While on a mission in a fallout area, you find it necessary to conduct radiological decontamination. This is essential for your survival and continuing the mission.

1. What is the purpose of radiological decontamination?

   A. To bypass the hazard
   B. To determine the amount of Beta Radiation
   C. To determine the extent of contamination
   D. To reduce or eliminate the hazard

2. Which is one principle in planning radiological decontamination operations?

   A. Complete decontamination must always be done.
   B. Decontamination is done only when necessary.
   C. Restoration decontamination must be done.
   D. The hardest items are completed first.

3. Within how many hours will personnel exposed to 650 cGy show the symptoms?

   A. 2
   B. 4
   C. 6
   D. 8

4. If there has been no prior radiation exposure, what effect will 100 cGy have?

   A. Intense effect
   B. Little effect
   C. No effect
   D. Severe effect

5. Within how much time, will an active soldier, who is suddenly exposed to 3000 cGy, become incapacitated?

   A. 3 to 5 minutes
   B. 30 to 45 minutes
   C. 6 hours
   D. 24 hours

6. When should personnel decontamination be done in a combat situation?

   A. After equipment has been decontaminated
   B. As soon as the situation permits
   C. On receipt of orders from higher headquarters
   D. When detection equipment is available

7. What must be done to all food which is exposed to radiological contamination?

   A. Bury it.
   B. Destroy it.
   C. Leave it to age.
   D. Monitor it.

8. Which item must personnel complete when contaminated by a wet radiological contaminant?

   A. MOPP Gear Exchange
   B. Neutralizing
   C. Steam cleaning
   D. Washing and drying

9. Which is a disadvantage of decontamination by removing the top layer of earth?

   A. Covering does not destroy contamination.
   B. Lack of required equipment
   C. Safety of personnel
   D. Work may begin immediately.

LESSON 6

PRACTICE EXERCISE

ANSWER KEY AND FEEDBACK

Item	**Correct Answer and Feedback**	
1.	D	To reduce or eliminate the hazard Part A, p. 6-2
2.	B	Decontamination is done only when necessary. Part A, p. 6-2
3.	A	2 Part A, p. 6-4
4.	B	Little effect Part A, p. 6-4
5.	A	3 to 5 minutes Part A, p. 6-4
6.	B	As soon as the situation permits Part B, p. 6-5
7.	D	Monitor it. Part B, p. 6-7
8.	A	MOPP Gear Exchange Part B, p. 6-9
9.	A	Covering does not destroy contamination. Part B, p. 6-12