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ABSTRACT

This student workbook includes the necessary administrative materials, briefs, exercises and answer sheets for the quizzes and final course examination as needed by the students during the conduct of the Radiological Defense Officer course. Among the briefs included are the following: (1) Reporting Forms; (2) Forecasting Dose Rates; (3) Dose Calculations; (4) Equivalent Residual Dose (ERD) Calculations; (5) Monitoring Operations; (6) Decontamination; and (7) Emergency Operations Center (EOC) Radiological Defense Functions. (LS)

SM-11.23.1
October 1972

RADIOLOGICAL DEFENSE OFFICER

STUDENT WORKBOOK

[redacted]

[redacted]

DEFENSE CIVIL PREPAREDNESS AGENCY

FOR TRAINING PURPOSES ONLY

RADIOLOGICAL DEFENSE OFFICER

STUDENT WORKBOOK

(Supersedes SM-11.23.1 dated July 1966 and reprinted July 1967)

OCTOBER 1972

DEPARTMENT OF DEFENSE

DEFENSE CIVIL PREPAREDNESS AGENCY

CONTENTS

Note to the Instructor

This Student Workbook includes the necessary administrative materials, briefs, exercises, and answer sheets for the quizzes and final course examination as needed by the students during the conduct of the Radiological Defense Officer course.

LESSON PLAN TITLES AND SCOPES

3 HOUR UNITS

RADIOLOGICAL DEFENSE OFFICER

Unit 1	Time
INTRODUCTION - Lesson Plan No. 1	:30
Welcome; description of course to include purpose, scope, procedures and standards of instruction.	
RADIOLOGICAL DEFENSE - Lesson Plan No. 2	1:30
Responsibilities, requirements and concepts of organization for radiological defense; personnel, equipment and facilities requirements; emergency staff relationships; phases of operation; a description of radiological defense as a countermeasure system.	
REPORTING PROCEDURES - Lesson Plan No. 3	1:00
Radiological defense communications and reporting system requirements; reporting frequency and techniques at the Federal, State, and local levels; message preparation.	
Unit 2	
TECHNICAL GUIDANCE FOR RADIOLOGICAL DEFENSE OPERATIONS - Lesson Plan No. 4	3:00
Review of basis for standard multiple decay exponent; forecasting dose rates under nonstandard decay conditions; computation of exposure dose based on variable decay exponents; computation of equivalent residual dose (ERD); application of ERD to operations; calculation of acceptable mission doses; entry time estimates.	
Unit 3	
QUIZ I - Lesson Plan No. 5	:20
TECHNICAL GUIDANCE FOR RADIOLOGICAL DEFENSE OPERATIONS (Concluded)	1:00

Unit 3 (Continued)	Time
PLANNING AND DIRECTING MONITORING OPERATIONS - Lesson Plan No. 6	1:40

Purpose and requirements of mobile and aerial monitoring; development of monitoring units; direction and control of monitoring activities; review of shelter and fallout station monitoring operations; practical exercise to provide experience in the maximum utilization of monitoring capabilities.

Unit 4

PLANNING AND DIRECTING MONITORING OPERATIONS (Concluded)	1:00
RADIOLOGICAL EQUIPMENT PROGRAM - Lesson Plan No. 7	1:00

Distribution programs to include equipment for monitoring stations, shelters, emergency workers, mobile monitoring, aerial monitoring and training; modifications to current equipment; status of new items; calibration and maintenance programs.

POSTATTACK RECOVERY MEASURES - Lesson Plan No. 8	1:00

Properties of fallout; criteria for exposure control; identification of postattack countermeasures to include shelter, decontamination, remedial movement, dose sharing, diking and movement of people in shelter; application of decontamination to include objective, equipment and personnel requirements, resources, planning, and estimates of efficiency; practical exercise.

Unit 5

POSTATTACK RECOVERY MEASURES (Concluded)	1:30
EOC RADEF FUNCTIONS - Lesson Plan No. 9	1:30

Readiness activities; flow and exchange of radiological data; recording of radiological intelligence; preparation of fallout forecasts, advisories, and analyses; presentation of analyses; direction and coordination of field operations; technical guidance requirements; chronological sequence of EOC activities.

Unit 6 | Time

QUIZ II - Lesson Plan No. 10 :20

RADEF STAFF OPERATIONS EXERCISE - Lesson Plan No. 11 2:40

EOC exercise including prediction of probable fallout areas; recording, analysis and evaluation of radiological intelligence; preparation and dissemination of fallout advisories on radiological conditions; experience in solving hypothetical problems in evaluation of data, reporting, staff coordination, and providing accurate and timely technical guidance.

Unit 7

RADEF STAFF OPERATIONS EXERCISE (Continued) 3:00

Unit 8

RADEF STAFF OPERATIONS EXERCISE (Concluded) 3:00

(The last half hour of the scheduled exercise time is optional to account for individual differences among the students.)

Unit 9

QUIZ III - Lesson Plan No. 12 :20

RADIOLOGICAL DEFENSE PLANNING - Lesson Plan No. 13 2:40

Principles and requirements of a radiological defense operations plan; techniques of development and evaluation; discussion of an illustrative outline for a radiological defense annex; review and evaluation of an existing radiological defense plan; criteria for revisions and modifications.

Unit 10

DEVELOPMENT OF A RADEF CAPABILITY - Lesson Plan No. 14 2:30

Number and criteria for selection of monitoring stations to include Federal installations; monitor requirements

Unit 10 (Continued) | Time

DEVELOPMENT OF A RADEF CAPABILITY (Continued)

to include number, criteria for selection, scope of training, and training resources; radef staff training requirements; decontamination training requirements; preparation of radef section of a program paper; responsibilities in peacetime nuclear incidents; methods used to achieve radiological defense operational capability; testing and exercising a radef capability; experience in solving hypothetical problem related to development of a radef capability.

COURSE REVIEW - Lesson Plan No. 15 | :30

Review of quizzes; review of course content based on student questions; clarification of concepts, principles and procedures.

Unit 11

COURSE REVIEW (Continued) | :30

(This half hour is optional.)

COURSE EXAMINATION - Lesson Plan No. 16 | 1:30

Written multiple choice and problem solving type examination covering the entire course content.

COURSE EXAMINATION REVIEW - Lesson Plan No. 17 | :30

Review of course examination to discuss specific questions and to clarify concepts.

COURSE EVALUATION - Lesson Plan No. 18 | :30

Summary of course content; evaluation of the course in terms of its objectives.

AWARDING CERTIFICATES

TOTAL (1 Hr. optional) 33:00

LESSON PLAN TITLES

2 HOUR UNITS

RADIOLOGICAL DEFENSE OFFICER

	Time
Unit 1	
INTRODUCTION - Lesson Plan No. 1	:30
RADIOLOGICAL DEFENSE - Lesson Plan No. 2	1:30
Unit 2	
REPORTING PROCEDURES - Lesson Plan No. 3	1:00
TECHNICAL GUIDANCE FOR RADIOLOGICAL DEFENSE OPERATIONS - Lesson Plan No. 4	1:00
Unit 3	
TECHNICAL GUIDANCE FOR RADIOLOGICAL DEFENSE OPERATIONS - Lesson Plan No. 4 (Continued)	2:00
Unit 4	
QUIZ I - Lesson Plan No. 5	:20
TECHNICAL GUIDANCE FOR RADIOLOGICAL DEFENSE OPERATIONS - Lesson Plan No. 4 (Concluded)	1:00
PLANNING AND DIRECTING MONITORING OPERATIONS - Lesson Plan No. 6	:40
Unit 5	
PLANNING AND DIRECTING MONITORING OPERATIONS - Lesson Plan No. 6 (Concluded)	2:00
Unit 6	
RADIOLOGICAL EQUIPMENT PROGRAM - Lesson Plan No. 7	1:00
POSTATTACK RECOVERY MEASURES - Lesson Plan No. 8	1:00

Unit 7	Time
POSTATTACK RECOVERY MEASURES - Lesson Plan No. 8 (Concluded)	1:30
EOC RADEF FUNCTIONS - Lesson Plan No. 9	:30
Unit 8	
QUIZ II - Lesson Plan No. 10	:20
EOC RADEF FUNCTIONS - Lesson Plan No. 9 (Concluded)	1:00
RADEF STAFF OPERATIONS EXERCISE - Lesson Plan No. 11	:40
Unit 9	
RADEF STAFF OPERATIONS EXERCISE - Lesson Plan No. 11 (Continued)	2:00
Unit 10	
RADEF STAFF OPERATIONS EXERCISE - Lesson Plan No. 11 (Continued)	2:00
Unit 11	
RADEF STAFF OPERATIONS EXERCISE - Lesson Plan No. 11 (Continued)	2:00
Unit 12	
QUIZ III - Lesson Plan No. 12	:20
RADEF STAFF OPERATIONS EXERCISE - Lesson Plan No. 11 (Concluded)	1:40
Unit 13	
RADIOLOGICAL DEFENSE PLANNING - Lesson Plan No. 13	2:00
Unit 14	
RADIOLOGICAL DEFENSE PLANNING - Lesson Plan No. 13 (Concluded)	:30
DEVELOPMENT OF A RADEF CAPABILITY - Lesson Plan No. 14	1:30

Unit 15	Time
DEVELOPMENT OF A RADEF CAPABILITY - Lesson Plan No. 14 (Concluded)	1:00
COURSE REVIEW - Lesson Plan No. 15	:30
COURSE EVALUATION - Lesson Plan No. 18	:30
Unit 16	
COURSE EXAMINATION - Lesson Plan No. 16	1:30
COURSE EXAMINATION REVIEW - Lesson Plan No. 17	:30
AWARDING CERTIFICATES	

RADIOLOGICAL DEFENSE OFFICER

References

The references for each unit of instruction are listed below. The student should study these references in preparation for each unit. He should read the "Remarks" section of each Brief, which indicates (a) a specific homework assignment that the student should complete prior to class, (b) a reference Brief only, or (c) a Brief which will be used during class and which should NOT be completed before class. Generally, the references in the Radiological Defense Textbook, SM-11.22.2, are background information only.

Lesson No.	Lesson Title	P&O Guide SM-11.23.2	Workbook SM-11.23.1	Textbook SM-11.22.2
1	Introduction	Preface	pp. 1 - 8	Chapters 1 and 12
2.	Radiological Defense	Introduction		
3.	Reporting Procedures	Chapter 5	Brief #1	
4.	Technical Guidance for Radiological Defense Operations	Chapters 1 and 3	Brief #2, 3, 4, 5	Chapters 6, 7, 8
5.	Quiz I		p. Q-I	
6.	Planning and Directing Monitoring Operations	Chapters 3 and 9	Brief #6	
7.	Radiological Equipment Program	Chapters 7 and 8		Chapters 4 and 5
8.	Postattack Recovery Measures	Chapters 3 and 12	Brief #7 and 8	
9.	EOC Radef Functions	Chapters 3, 5 and 6	Brief #9	
10.	Quiz II		p. Q-II	
11.	Radef Staff Operations Exercise		pp. E-1 to E-55	
12.	Quiz III		p. Q-III	
13.	Radiological Defense Planning	Chapter 2	Brief #10 and 11	Chapter 13
14.	Development of a Radef Capability	Chapters 3, 10, 11	Brief #12	Chapter 14

Lesson No.	Lesson Title	P&O Guide SM-11.23.2	Workbook SM-11.23.1	Textbook SM-11.22.1
15.	Course Review			
16.	Course Examination		p. CE-1	
17.	Course Examination Review			
18.	Course Evaluation		Course Evaluation Sheet	

TITLE: Reporting Forms

COURSE: Radiological Defense Officer

FOR USE IN THE SESSION: Reporting Procedures

REMARKS: Instructions on the preparation and use of these forms will be included in the session on Reporting Procedures.

C O N T E N T S

DEPARTMENT OF THE ARMY
OFFICE OF THE SECRETARY OF THE ARMY
OFFICE OF CIVIL DEFENSE

RADIOLOGICAL REPORTING LOG

STATION

REPORTED TO

FLASH REPORT (0.5 r/hr. or more)	1st HR THRU 12th HR[3] (Hourly on the hour)			13th HR THRU 24th HR[3] (Every 3 hours)			25th HR THRU 48th HR[3] (Every 6 hours)			AFTER 48th HR[3] ____ 1 (Daily at 0300Z)		
DATE	DATE			DATE			DATE			DATE	DOSE RATE (r/hr)	TOTAL DOSE[2] (r)
TIME		TIME	DOSE RATE (r/hr)		TIME	DOSE RATE (r/hr)		TIME	DOSE RATE (r/hr)			
DOSE RATE (r/hr)	1			1			1					
TIME SENT TO CONTROL CTR	2			2			2					
NOTE: Flash report of fallout will be made as soon as dose rate reaches 0.5 r/hr.	3			3			3					
	4			4			4					
REPORT AS FOLLOWS	5			5			TAKE OBSERVATIONS AT					
1. TIME OF OBSERVATION	6			6			0300 Z ____ 1		0900 Z ____ 1			
2. LOCATION	7			7			1500 Z ____ 1		2100 Z ____ 1			
	8			8			[2]TOTAL DOSE TO					
3. FALLOUT	9			TAKE OBSERVATIONS AT			0300 Z ____ 1		____ r			
	10			0300 Z ____ 1		0600 Z ____ 1						
	11			0900 Z ____ 1		1200 Z ____ 1						
	12			1500 Z ____ 1		1800 Z ____ 1	*If at any time following a period of decay, the dose rate increases materially, file a special report and start new program of observations.*					
				2100 Z ____ 1		2400 Z ____ 1						
	[2]TOTAL DOSE TO			[2]TOTAL DOSE TO								
	0300 Z ____ 1		____ r	0300 Z ____ 1		____ r						
REPORT DOSE RATES AS FOLLOWS	1. TIME			2. LOCATION			3. DOSE RATE			4. DOSE TO 0300 Z ____ 1		

[1]*Enter local time from reverse side.* [2]*Total dose read from dosimeter - cumulative from arrival of fallout.* [3]*After flash report.*

OCD FORM 841, MAY 64

TIME CONVERSION CHART
(For Alaska and Hawaii, see footnote)

GREENWICH MEAN TIME	ATLANTIC STANDARD OR EASTERN DAYLIGHT	EASTERN STANDARD OR CENTRAL DAYLIGHT	CENTRAL STANDARD OR MOUNTAIN DAYLIGHT	MOUNTAIN STANDARD OR PACIFIC DAYLIGHT	PACIFIC STANDARD
0100	2100*	2000*	1900*	1800*	1700*
0200	2200*	2100*	2000*	1900*	1800*
0300	2300*	2200*	2100*	2000*	1900*
0400	2400*	2300*	2200*	2100*	2000*
0500	0100	2400*	2300*	2200*	2100*
0600	0200	0100	2400*	2300*	2200*
0700	0300	0200	0100	2400*	2300*
0800	0400	0300	0200	0100	2400*
0900	0500	0400	0300	0200	0100
1000	0600	0500	0400	0300	0200
1100	0700	0600	0500	0400	0300
1200	0800	0700	0600	0500	0400
1300	0900	0800	0700	0600	0500
1400	1000	0900	0800	0700	0600
1500	1100	1000	0900	0800	0700
1600	1200	1100	1000	0900	0800
1700	1300	1200	1100	1000	0900
1800	1400	1300	1200	1100	1000
1900	1500	1400	1300	1200	1100
2000	1600	1500	1400	1300	1200
2100	1700	1600	1500	1400	1300
2200	1800	1700	1600	1500	1400
2300	1900	1800	1700	1600	1500
2400	2000	1900	1800	1700	1600

*Add one day to the local calendar date for equivalent date in GMT. Example: Observed Central Standard Time is 10:00 PM *(2200 CST)* on the 14th day of the month *(142200 CST)*. Expressed as GMT, that time would be 0400Z on the 15th day of the month *(150400Z)*.

NOTE: For central Alaska *(Anchorage)* subtract 2 hours *(0200)* from each entry in the "Pacific Standard" Column. For Hawaii subtract 2 hours and 30 minutes *(0230)* from each entry in the "Pacific Standard" Column.

RADIOLOGICAL REPORTING LOG

LOCATION DESIGNATOR	NO. OF MONITORS ON DUTY	FLASH REPORT TIME	DATE																			
			TIME																			
			r/hr or r																			

NAME OF AGENCY
(Your name, the name of the station, station designator or agency name and address)

PRECEDENCE
ACTION:
INFO.: (1)

TYPE OF MESSAGE
☐ SINGLE (2) ☐ BOOK
☐ MULTI-ADDRESS

SECURITY CLASSIFICATION
ROUTINE
UNCLASSIFIED
CONFIDENTIAL
SECRET

(Appropriate (classification (typed here and (in blank at (bottom of page

ACCOUNTING CLASSIFICATION
(Not normally used by Radef)

STANDARD FORM 14 REV. MARCH 15, 1957
GSA REGULATION 2-IX-203 04
14-303

TELEGRAPHIC MESSAGE

OFFICIAL BUSINESS
U. S. GOVERNMENT

THIS BLOCK FOR USE OF COMMUNICATIONS UNIT
(Not used by Radef)

MESSAGE TO BE TRANSMITTED (Use double spacing and all capital letters)

THIS COL. FOR AGENCY USE

START MESSAGE ADDRESS HERE

NAME AND ADDRESS IN CAPITAL LETTERS (Eliminate as much detail in the address as practical)
BLOCK STYLE
SINGLE SPACED
OPEN PUNCTUATION (Do not use suffixes with street numbers)

INFO.: (If there are information addressees, they should be listed below action addressee(s) after identifying as info addressee(s).

MESSAGE TEXT (Double spaced)

NOTES

(1) PRECEDENCE: PRECEDENCE DESIGNATIONS ARE EMPLOYED TO INDICATE THE RELATIVE ORDER IN WHICH MESSAGES ARE TO BE HANDLED. MOST RADEF MESSAGES WILL BE CLASSED AS PRIORITY. INFORMATION ADDRESSEES, I.E., PEOPLE THAT YOU WISH TO RECEIVE THE SAME INFORMATION AS THAT IN THE MESSAGE BUT WHO HAVE NO ACTION RESPONSIBILITY, MAY BE ASSIGNED THE LOWER PRECEDENCE DESIGNATOR, EITHER ROUTINE OR DEFERRED AS APPROPRIATE.

THE PRECEDENCE ASSIGNED IS WRITTEN OPPOSITE "ACTION" OR "INFO" AS APPROPRIATE.

(2) TYPE OF MESSAGE:
SINGLE: ONE MESSAGE TO ONLY ONE ADDRESSEE.
MULTI-ADDRESS: WHEN ONE OR MORE OF THE ADDRESSEES NEED TO KNOW THE OTHER RECIPIENTS, TYPE THE NAMES AND ADDRESSES ON THE FORM PRECEDING THE MESSAGE.
BOOK: WHEN SENDING AN IDENTICAL MESSAGE TO TWO OR MORE ADDRESSEES, SHOWING ONLY ONE ADDRESSEE ON THE DELIVERED MESSAGE, USE A SINGLE SHEET WHEREVER THE ADDRESSEE AND MESSAGE CAN BE TYPED ON ONE PAGE WHERE THEY CANNOT, TYPE ON THE FORM 14, "SEND THE FOLLOWING MESSAGE TO THE (NUMBER) ADDRESSEES ON THE ATTACHED PAGE(S):" FOLLOWED BY THE MESSAGE TEXT, AND ATTACH A LIST OF ADDRESSEES ON A SEPARATE SHEET(S).

(PROBABLY MESSAGES GOING UP CHANNELS WILL BE SINGLE ADDRESSEE MESSAGES AND MOST MESSAGES GOING DOWN CHANNELS WILL BE MULTI-ADDRESS MESSAGES.)

DO NOT TYPE MESSAGE BEYOND THIS LINE

PAGE NO. | NO. OF PAGES (In message)

NAME AND TITLE OF ORIGINATOR (Type)
(USUALLY THE RADEF OFFICER. USE CAPS)

ORIGINATOR'S TEL. NO.

DATE AND TIME PREPARED
(Use GMT Date and Time)

I certify that this message is official business, is not personal, and is in the interest of the Government.
(SIGNATURE OF THE ADMINISTRATIVELY RESPONSIBLE PERSON. THIS MAY BE THE DIRECTOR OR, IN SOME CASES, THE RADEF OFFICER)
(Signature)

SECURITY CLASSIFICATION
UNCLASSIFIED (Most Radef MESSAGES will be UNCLASSIFIED. This word is written here and at top of page.

BRIEF NO. 2

TITLE: Forecasting Dose Rates

COURSE: Radiological Defense Officer

FOR USE IN THE SESSION: Technical Guidance for Radiological Defense Operations

REMARKS: Requirements 1 through 3 will be completed in class. Requirements 4 through 6 are provided as practice problems for completion after the class period on Technical Guidance for Radiological Defense Operations. DO NOT complete any of these requirements before class.

The answers to each requirement are provided in Attachment D. Please do not review these answers before completing the requirements, otherwise much of the teaching value of each requirement may be lost.

CONTENTS

DISCUSSION

Each radioactive isotope has a characteristic half-life. These range from a few millionths of a second to millions of years. However, when many radioisotopes contribute to the radiation dose rate, as in the case of the fission products from a nuclear weapon, no one half-life applies for the composite. With fission products, there is a predominance of short-lived radioisotopes in the period immediately following the burst; hence, the radiation dose rate decreases very rapidly. As these short-lived radioisotopes expend themselves, the longer half-life isotopes become dominant and the decay rate of the fission products decreases.

Multiple radioactive decay of the fission products can be estimated using the general equation: $R = R_1 t^{-n}$, where R equals the dose rate at any time (t) measured from the time of burst, R_1 equals the dose rate at unit time, and n is the fallout decay exponent.

For this function, a linear plot of dose rate versus time after detonation yields a curved line which is difficult to reproduce and is of little value in forecasting dose rates. However, this same function plotted on log-log graph paper yields a straight line when n is constant. Conversely, the log-log plot is a curved line when n is <u>not</u> constant. This straight line (constant value of n) indicates an orderly and predictable decay of the radioactive fallout. This fact serves as the basis for the dose rate forecasting technique recommended for the Radef Officer.

The decay of reactor-produced fission products from the slow fission of U^{235} follows a $t^{-1.2}$ curve for about the first 100 days. This 1.2 value of n is usually used in research work, in training, and in planning when an estimate of the decrease in fallout radiation levels with time is required. "$t^{-1.2}$ decay" is so frequently used that it is referred to as "standard decay."

For planning purposes, the value of $n = 1.2$ is quite satisfactory. It also has <u>limited</u> operational use in that the doses and dose rates calculated by radiological monitors will be based on <u>standard decay</u> conditions. Since monitors will have survey meters available, they will be able to determine the current dose rate at any time. Their Nomogram calculations should not be grossly in error, if their dose rate forecasts are limited to short periods of time into the future. Thus, for short-term forecasting by the monitor, the standard decay conditions used in the Nomograms are assumed to be satisfactory. However, for longer term predictions, such as a Radef Officer would be required to make, other techniques which account for nonstandard decay conditions must be used.

The need for specific techniques for use under nonstandard decay conditions is supported by the results of investigations of the decay characteristics of actual fallout from weapons tests. Attempts to fit observed decay of the fallout with a general equation of the form, $R = R_1 t^{-n}$, have required values of "n" ranging from about 0.9 to 2.2. Therefore, attempts to forecast the decay of actual fallout fields on the basis of any particular value of "n" are almost certain to be grossly inaccurate.

The fallout decay exponent will vary with bomb design, the amount and type of neutron-induced activity, fractionation and, in a particular area, with weathering, decontamination, and the age of the fission products from multiple bursts. Since decay characteristics will be determined from measured dose rates, anything which affects the dose rate or its measurement will affect the computed value of "n" and, thus, the forecasted dose rate.

Since the decay characteristics of fallout are significantly affected by the above factors and others not mentioned, the most practical method of forecasting dose rates under these conditions is based upon the technique of plotting observed dose rates versus time after detonation on log-log graph paper and extrapolating the plotted curve. Plots of this type for two or three representative points across a community will generally be adequate.

The procedure for plotting observed dose rates is as follows. From NUDET reports, or simply from observations of the flash, the blast wave, or the cloud of the detonation, the time of burst of most weapons within a radius of 100 to 200 miles will be known. Thus, the Radef Officer will know the time of formation of most of the fission products in his immediate area and, from the current "UF" report, he will generally know which specific detonation is causing the major fallout problem in his community. The Radef Officer can then plot or direct the plotting of observed dose rates against time on log-log graph paper. Future dose rates can be estimated by projecting the curve to future times of concern. <u>However, as a practical limit, forecasts of future dose rates generally should not exceed the time period for which decreasing dose rate records are available</u>. For example, if dose rate observations have been decreasing for the preceding 12 hours, they will be plotted and, provided the plot for the last few hours approximates a straight line, the curve can be extrapolated for 12 additional hours to forecast the dose rates during that time period. Caution must be exercised in extrapolating the curve during periods of fluctuation.

If the dose rate is observed to materially increase after a period during which the logarithmic decay is approximately a straight line, this indicates the arrival of significant additional fallout. If the dose rate appears to be equal to, or less than the <u>maximum</u> dose rate from earlier fallout, continue the original plot based on the "H hour" of the original fallout. However, if considerable time has elapsed since arrival of the first fallout and the increase in dose rate equals, or exceeds the maximum dose rate from earlier fallout, plot a new graph using the estimated H hour of the latest fallout as the reference time. After the plot indicates an orderly decrease (nearly a straight line log plot), extrapolation of the curve can again provide a reasonable basis for estimating dose rates for future periods.

It should be emphasized that the actual dose rate may vary considerably from the forecast dose rate. Thus, operations likely to require high radiation exposures should be carried out on the basis of observed dose rates, <u>not</u> forecast dose rates. The forecast is simply a guide to aid the civil defense director in planning his forthcoming survival and recovery operations. A forecast dose rate could be considerably in error if additional fallout occurred after the forecast was made, or if the rate of decay changed materially from that indicated by the plots on the log-log graph. The latest fallout analysis, based upon current dose rate reports, should be the basis for current operations. Plans for future operations should be based upon the current fallout analysis, modified according to the forecast from a log-log plot.

SITUATION

The following data has been reported from monitoring station F-10. Times are given directly as "time after burst" for convenience. Normally, the monitor will report the local standard time for each dose rate observation and the Radef Officer must convert this information to "time after burst" before plotting it.

Time After Burst (hours)	Dose Rate (r/hr)	Time After Burst (hours)	Dose Rate (r/hr)
H + 3	1	H + 13	120
H + 4	6	H + 14	100
H + 5	25	H + 15	90
H + 6	80	H + 20	60
H + 7	190	H + 23	50
H + 8	200	H + 26	40
H + 9	190	H + 32	30
H + 10	170	H + 38	23
H + 11	150	H + 44	19
H + 12	130		

Requirement No. 1

a. Plot the monitoring station data on the log-log graph paper provided as Attachment A. The data is repeated on Attachment A for convenience in plotting. (NOTE: Log-log paper has no zero point).

b. Draw a smooth curve through the plotted points.

c. How far should the curve be extrapolated for forecasting dose rates? (Extrapolate the curve as a dotted line. Use a solid line for actual monitored data only.)

d. Forecast the dose rate at H + 60 __________ and H + 80 __________.

e. Plot the following additional monitored data which has been reported:

Time After Burst (hours)	Dose Rate (r/hr)	Time After Burst (hours)	Dose Rate (r/hr)
H + 50	16	H + 98	6.0
H + 74	9.0	H + 122	4.4

f. How far should the curve be extrapolated for forecasting dose rates?

g. Forecast the time when the dose rate should reach 2 r/hr. _________

h. Can dose rates be forecast beyond the limits of the general rule?

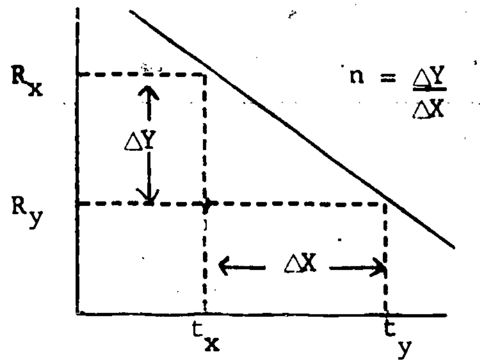
i. What should the Radef Officer do if dose rates begin to increase?

j. How could a Radef Officer forecast the dose rate at H + 50 for another location within the city, if the dose rate at H + 30 was 15 r/hr? Assume the same fallout decay characteristics at each location. What would the dose rate be at H + 50?

DISCUSSION(Continued)

Generally, only a few dose rate history curves (possibly only two or three) need to be plotted for an analysis of fallout decay characteristics. Dose rate forecasts for other locations can be estimated from a family of lines parallel to the decay curve. However, if curves for two or three locations within a community are not adequate, it may be advantageous to compute the value of the fallout decay exponent "n" and use the general equation, "$R = R_1 t^{-n}$, to predict future dose rates in areas where the decay characteristics are the same.

The fallout decay exponent "n" may be computed directly from the plotted curve. "n" is numerically equal to the slope of the curve and is, therefore, constant only when the plotted line is straight. Determine "n" from the graph by dividing the <u>measured</u> distance ΔY by the <u>measured</u> distance ΔX as indicated below.



This computed value of "n" can be used to determine the dose rate at any location where the fallout decay characteristics are the same.

Recognizing that $R = R_1 t^{-n}$ can be rewritten $R_1 = Rt^n$ and that $R_1 = R_x t_x{}^n$ and $R_1 = R_y t_y{}^n$ etc., the most useful form of the general equation will probably be $R_x t_x{}^n = R_y t_y{}^n$. "n" can be used to forecast dose rates as indicated in the following example. A table of logarithms is included as Attachment B.

The dose rate at H + 4 days is 108 r/hr; if n = 1.1, predict the dose rate at H + 8 days.

R_x = 108 r/hr $\qquad$ t_y = 8 days

t_x = 4 days $\qquad$ n = 1.1

R_y = ?

$$R_x t_x{}^n = R_y t_y{}^n$$

$$(108)\ (4)^{1.1} = (R_y)\ (8)^{1.1} \qquad \log 108 + 1.1 \log 4 = \log R_y + 1.1 \log 8$$

$$(2.0334) + 1.1\ (.6021) = \log R_y + 1.1\ (.9031)$$

$$\log R_y = 2.0334 + .6623 - .9934 = 1.7023$$

$$R_y = 50 \text{ r/hr.}$$

<u>Requirement No. 2</u>

a. Is there a difference in the fallout decay exponent "n" at H + 10, H + 40 and H + 100 for the curve in Requirement No. 1? ____________ Explain.

b. Calculate the value of "n" at H + 30 for the curve in Requirement No. 1.

c. How large should the measured distances ΔY and ΔX have been?

Requirement No. 3 (Optional - students will not be required to use this technique for forecasting dose rates during the course; only the graphing techniques will be required.)

a. The dose rate at H + 6 was 72 r/hr and decreasing. If n = 1.3, forecast the dose rate at H + 14.

Requirement No. 4 (Homework practice problem)

Repeat a through j from Requirement No. 1, using the following data for monitoring station P2. Plot the dose rates on Attachment C. The data is reproduced on Attachment C for convenience in plotting.

Time After Burst(hours)	Dose Rate (r/hr)	Time After Burst(hours)	Dose Rate (r/hr)
H + 2	1	H + 12	50
H + 3	20	H + 13	46
H + 4	80	H + 16	38
H + 5	70	H + 19	31
H + 6	60	H + 22	28
H + 7	65	H + 25	24
H + 8	70	H + 31	19
H + 9	65	H + 38	15
H + 10	60	H + 44	13
H + 11	54		

Additional reported data for item e of Requirement No. 1:

Time After Burst(hours)	Dose Rate (r/hr)	Time After Burst(hours)	Dose Rate (r/hr)
H + 54	12	H + 75	19
H + 57	13	H + 81	18
H + 60	15	H + 87	17
H + 63	18	H + 93	15
H + 66	19	H + 99	14
H + 69	20	H + 120	11
H + 72	20	H + 144	9.0

Requirement No. 5 (Homework practice problem)

Repeat Requirement No. 2, using the plotted curve from Requirement No. 4.

Requirement No. 6 (Optional homework practice problem)

The dose rate at H + 20 was 60 r/hr and decreasing. If n = 1.5, forecast the dose rate at H + 30.

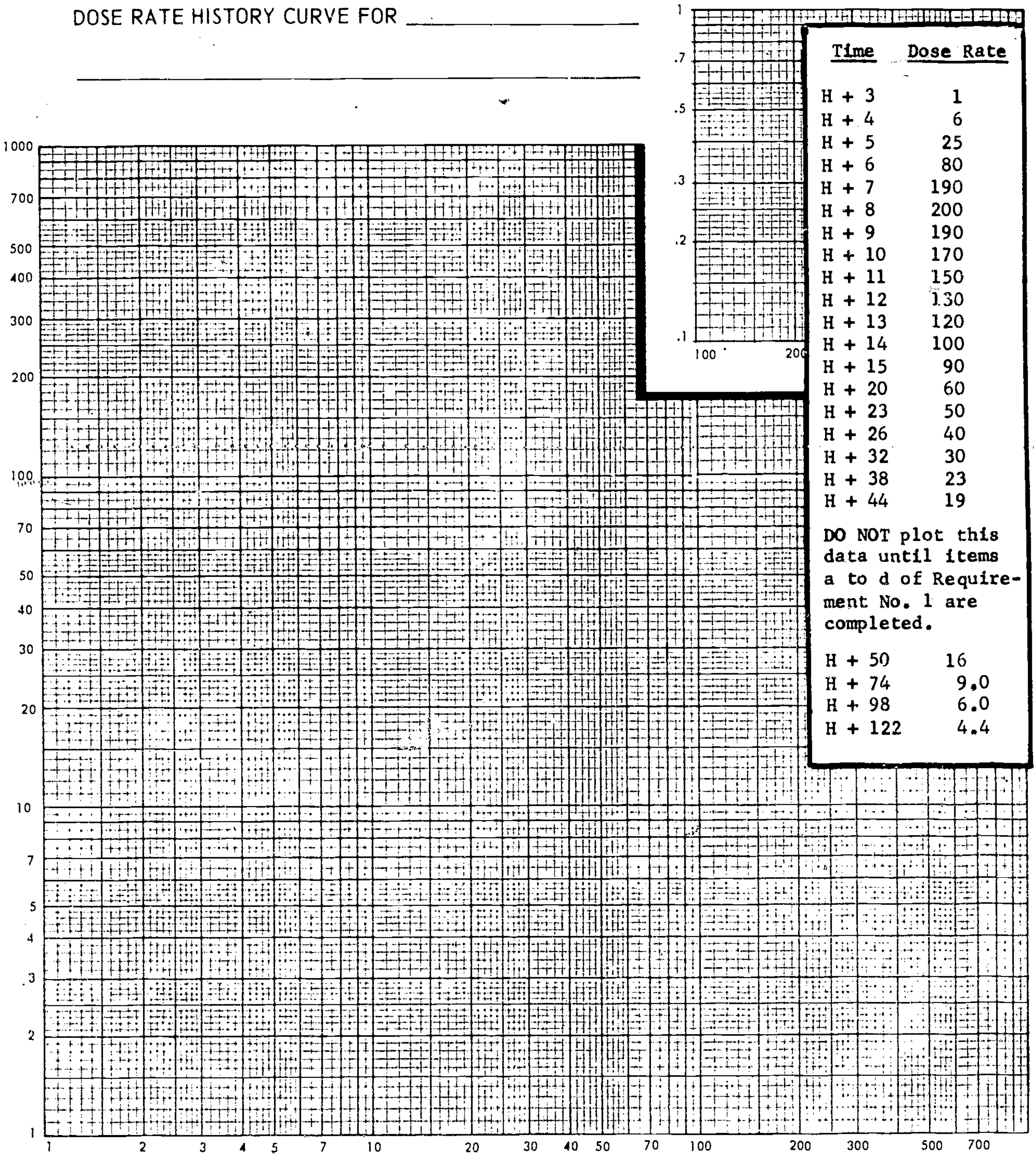
Requirement No. 7 (Homework practice problem)

Using the curve on Attachment C, assume it is now H + 30 and the remaining dose rate data is not available. When can an emergency operations crew enter this area to perform a mission if their acceptable dose has been established at 40 r and it will take them four hours to complete their work?

2-9 / 2-10

DOSE RATE HISTORY CURVE FOR ______________________

____



Time	Dose Rate
H + 3	1
H + 4	6
H + 5	25
H + 6	80
H + 7	190
H + 8	200
H + 9	190
H + 10	170
H + 11	150
H + 12	130
H + 13	120
H + 14	100
H + 15	90
H + 20	60
H + 23	50
H + 26	40
H + 32	30
H + 38	23
H + 44	19

DO NOT plot this data until items a to d of Requirement No. 1 are completed.

Time	Dose Rate
H + 50	16
H + 74	9.0
H + 98	6.0
H + 122	4.4

ATTACHMENT B

COMMON LOGARITHMS

N	0	1	2	3	4	5	6	7	8	9
10	0000	0043	0086	0128	0170	0212	0253	0294	0334	0374
11	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755
12	0792	0828	0864	0899	0934	0969	1004	1038	1072	1106
13	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430
14	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732
15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014
16	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279
17	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529
18	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765
19	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989
20	3010	3032	3054	3075	3096	3118	3139	3160	3181	3201
21	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404
22	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598
23	3617	3636	3655	3674	3692	3711	3729	3747	3766	3784
24	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962
25	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133
26	4150	4166	4183	4200	4216	4232	4249	4265	4281	4298
27	4314	4330	4346	4362	4378	4393	4409	4425	4440	4456
28	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609
29	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757
30	4771	4786	4800	4814	4829	4843	4857	4871	4886	4900
31	4914	4928	4942	4955	4969	4983	4997	5011	5024	5038
32	5051	5065	5079	5092	5105	5119	5132	5145	5159	5172
33	5185	5198	5211	5224	5237	5250	5263	5276	5289	5302
34	5315	5328	5340	5353	5366	5378	5391	5403	5416	5428
35	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551
36	5563	5575	5587	5599	5611	5623	5635	5647	5658	5670
37	5682	5694	5705	5717	5729	5740	5752	5763	5775	5786
38	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899
39	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010
40	6021	6031	6042	6053	6064	6075	6085	6096	6107	6117
41	6128	6138	6149	6160	6170	6180	6191	6201	6212	6222
42	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325
43	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425
44	6435	6444	6454	6464	6474	6484	6493	6503	6513	6522
45	6532	6542	6551	6561	6571	6580	6590	6599	6609	6618
46	6628	6637	6646	6656	6665	6675	6684	6693	6702	6712
47	6721	6730	6739	6749	6758	6767	6776	6785	6694	6803
48	6812	6821	6830	6839	6848	6857	6866	6875	6884	6893
49	6902	6911	6920	6928	6937	6946	6955	6964	6972	6981
50	6990	6998	7007	7016	7024	7033	7042	7050	7059	7067
51	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152
52	7160	7168	7177	7185	7193	7202	7210	7218	7226	7235
53	7243	7251	7259	7267	7275	7284	7292	7300	7308	7316
54	7324	7332	7340	7348	7356	7364	7372	7380	7388	7396

N	0	1	2	3	4	5	6	7	8	9
55	7404	7412	7419	7427	7435	7443	7451	7459	7466	7474
56	7482	7490	7497	7505	7513	7520	7528	7536	7543	7551
57	7559	7566	7574	7582	7589	7597	7604	7612	7619	7627
58	7634	7642	7649	7657	7664	7672	7679	7686	7694	7701
59	7709	7716	7723	7731	7738	7745	7752	7760	7767	7774
60	7782	7789	7796	7803	7810	7818	7825	7832	7839	7846
61	7853	7860	7868	7875	7882	7889	7896	7903	7910	7917
62	7924	7931	7938	7945	7952	7959	7966	7973	7980	7987
63	7993	8000	8007	8014	8021	8028	8035	8041	8048	8055
64	8062	8069	8075	8082	8089	8096	8102	8109	8116	8122
65	8129	8136	8142	8149	8156	8162	8169	8176	8182	8189
66	8195	8202	8209	8215	8222	8228	8235	8241	8248	8254
67	8261	8267	8274	8280	8287	8293	8299	8306	8312	8319
68	8325	8331	8338	8344	8351	8357	8363	8370	8376	8382
69	8388	8395	8401	8407	8414	8420	8426	8432	8439	8445
70	8451	8457	8463	8470	8476	8482	8488	8494	8500	8506
71	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567
72	8573	8579	8585	8591	8597	8603	8609	8615	8621	8627
73	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686
74	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745
75	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802
76	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859
77	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915
78	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971
79	8976	8982	8987	8993	8998	9004	9009	9015	9020	9025
80	9031	9036	9042	9047	9053	9058	9063	9069	9074	9079
81	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133
82	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186
83	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238
84	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289
85	9294	9299	9304	9309	9315	9320	9325	9330	9335	9340
86	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390
87	9395	9400	9405	9410	9415	9420	9425	9430	9435	9440
88	9445	9450	9455	9460	9465	9469	9474	9479	9484	8489
89	9494	9499	9504	9509	9513	9518	9523	9528	9533	9538
90	9542	9547	9552	9557	9562	9566	9571	9576	9581	9586
91	9590	9595	9600	9605	9609	9614	9619	9624	9628	9633
92	9638	9643	9647	9652	9657	9661	9666	9671	9675	9680
93	9685	9689	9694	9699	9703	9708	9713	9717	9722	9727
94	9731	9736	9741	9745	9750	9754	9759	9763	9768	9773
95	9777	9782	9786	9791	9795	9800	9805	9809	9814	9818
96	9823	9827	9832	9836	9841	9845	9850	9854	9859	9863
97	9868	9872	9877	9881	9886	9890	9894	9899	9903	9908
98	9912	9917	9921	9926	9930	9934	9939	9943	9948	9952
99	9956	9961	9965	9969	9974	9978	9983	9987	9991	9996

ATTACHMENT C

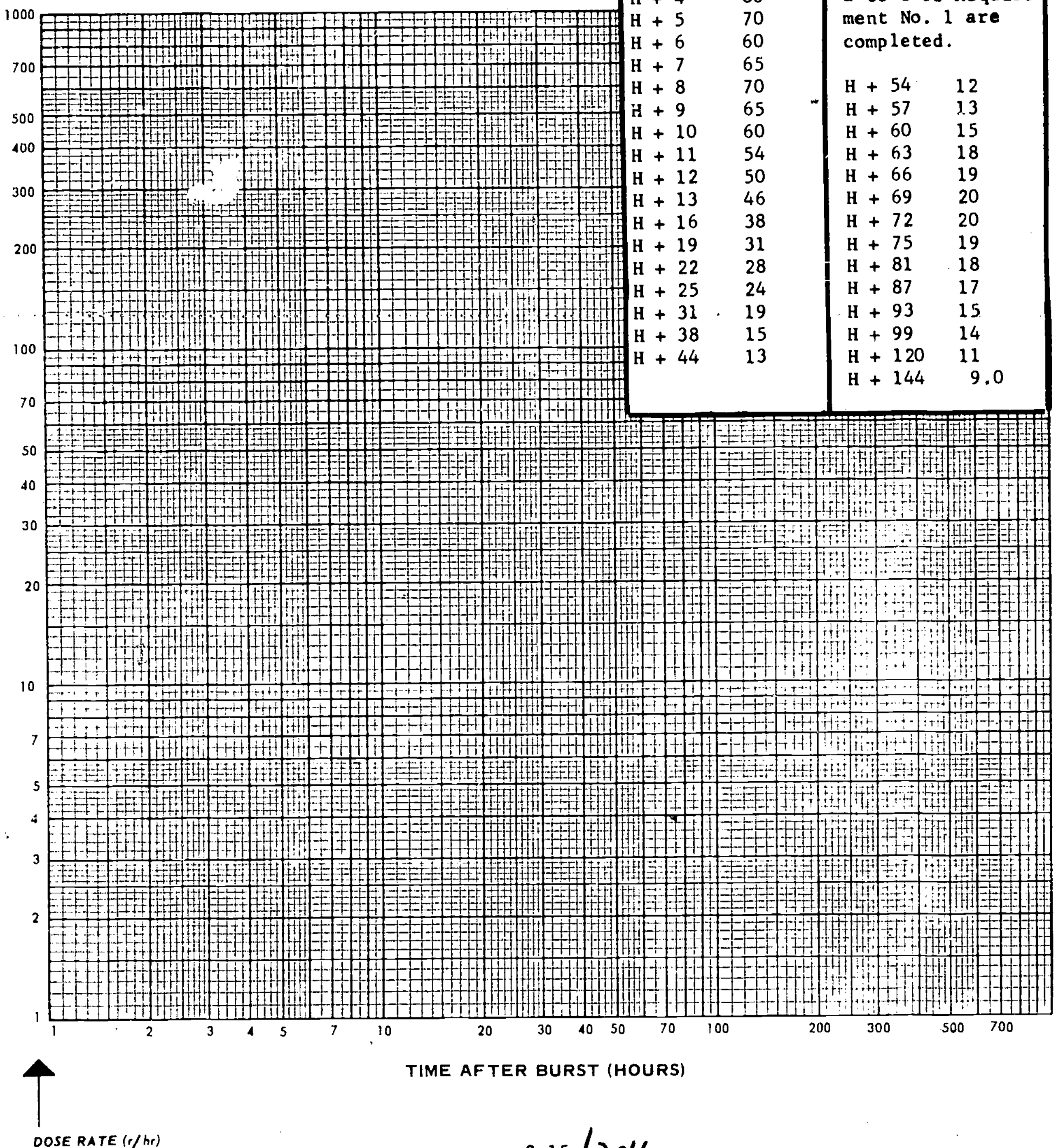
DOSE RATE HISTORY CURVE FOR ______________________

____

Time	Dose Rate
H + 2	1
H + 3	20
H + 4	80
H + 5	70
H + 6	60
H + 7	65
H + 8	70
H + 9	65
H + 10	60
H + 11	54
H + 12	50
H + 13	46
H + 16	38
H + 19	31
H + 22	28
H + 25	24
H + 31	19
H + 38	15
H + 44	13

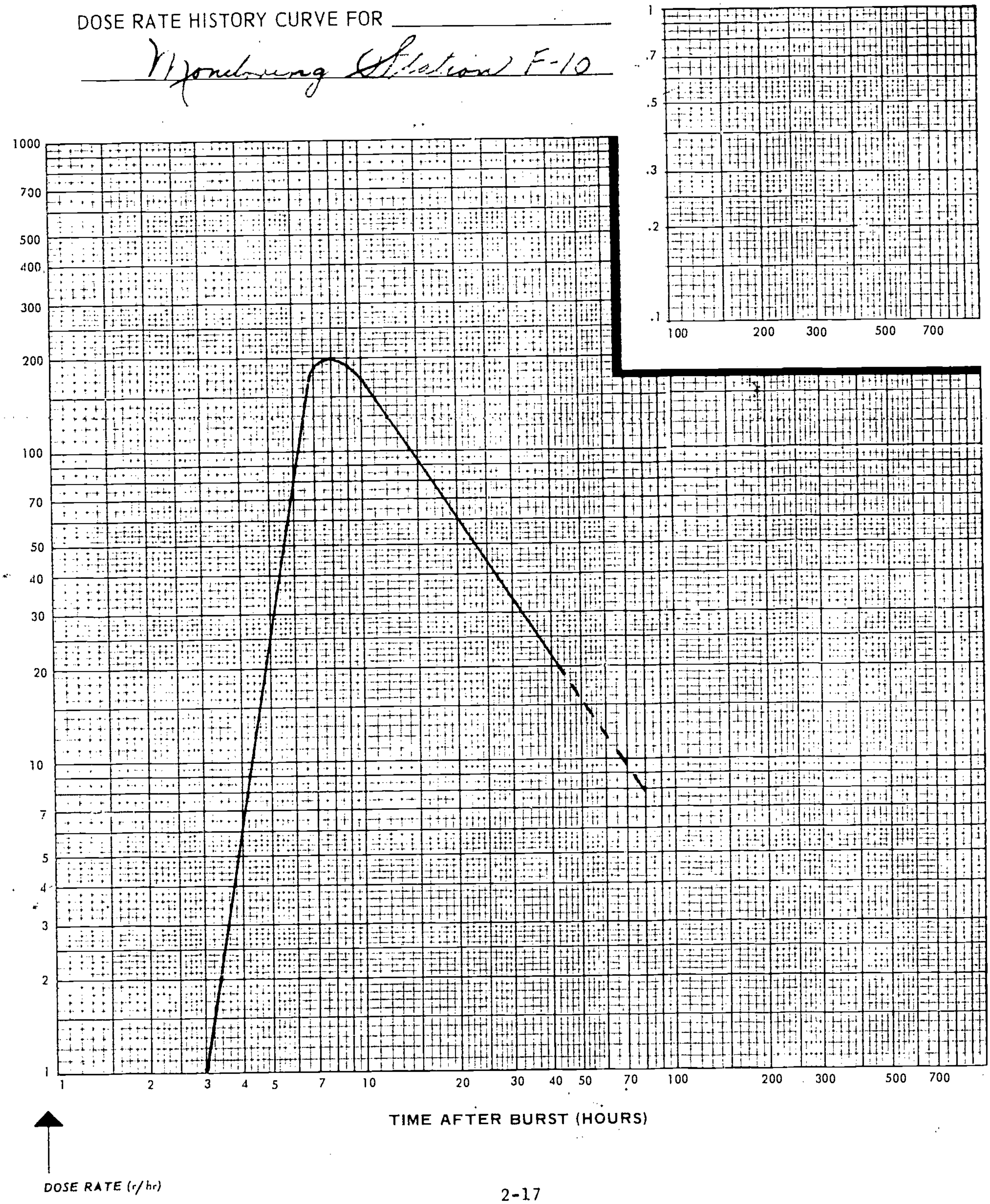
DO NOT plot this data until items a to d of Requirement No. 1 are completed.

Time	Dose Rate
H + 54	12
H + 57	13
H + 60	15
H + 63	18
H + 66	19
H + 69	20
H + 72	20
H + 75	19
H + 81	18
H + 87	17
H + 93	15
H + 99	14
H + 120	11
H + 144	9.0



ANSWER TO Requirement No. 1 ATTACHMENT D

DOSE RATE HISTORY CURVE FOR Monitoring Station F-10



2-17

ANSWER to <u>Requirement No. 1</u>

a. See graph for station F-10.
b. See graph for station F-10.
c. Through about H + 80.
d. 12 r/hr; 8 r/hr.
e. Additional data is not plotted, but the curve continues straight through H + 122.
f. Through about H + 240 (H + 10 days).
g. About H + 200 to H + 210.
h. Yes, but with less validity.
i. Modify actions taken, or recommendations made on the basis of the extrapolated curve.
j. Position a straightedge at 15 r/hr at H + 30, and align it parallel with the plotted curve. Read a forecasted dose rate of about 7 r/hr at H + 50.

ANSWER to <u>Requirement No. 2</u>

a. No. The decay curve has the same slope at each point.
b. "n" = about 1.45 to 1.50.
c. To minimize error, ΔY should have been at least four inches or larger. Thus, ΔX would have been larger than 2.5 inches. Distances will be different for different curves, but remember that the curve can be extrapolated as far as desirable <u>for determining "n"</u>.

ANSWER to <u>Requirement No. 3</u>

$R_x = 72$ r/hr $\qquad t_y = 14$

$t_x = 6$ hours $\qquad n = 1.3$

$R_y = ?$

$R_x t_x^{\,n} = R_y t_y^{\,n} \qquad (72\ (6)^{1.3} = R_y(14)^{1.3}$

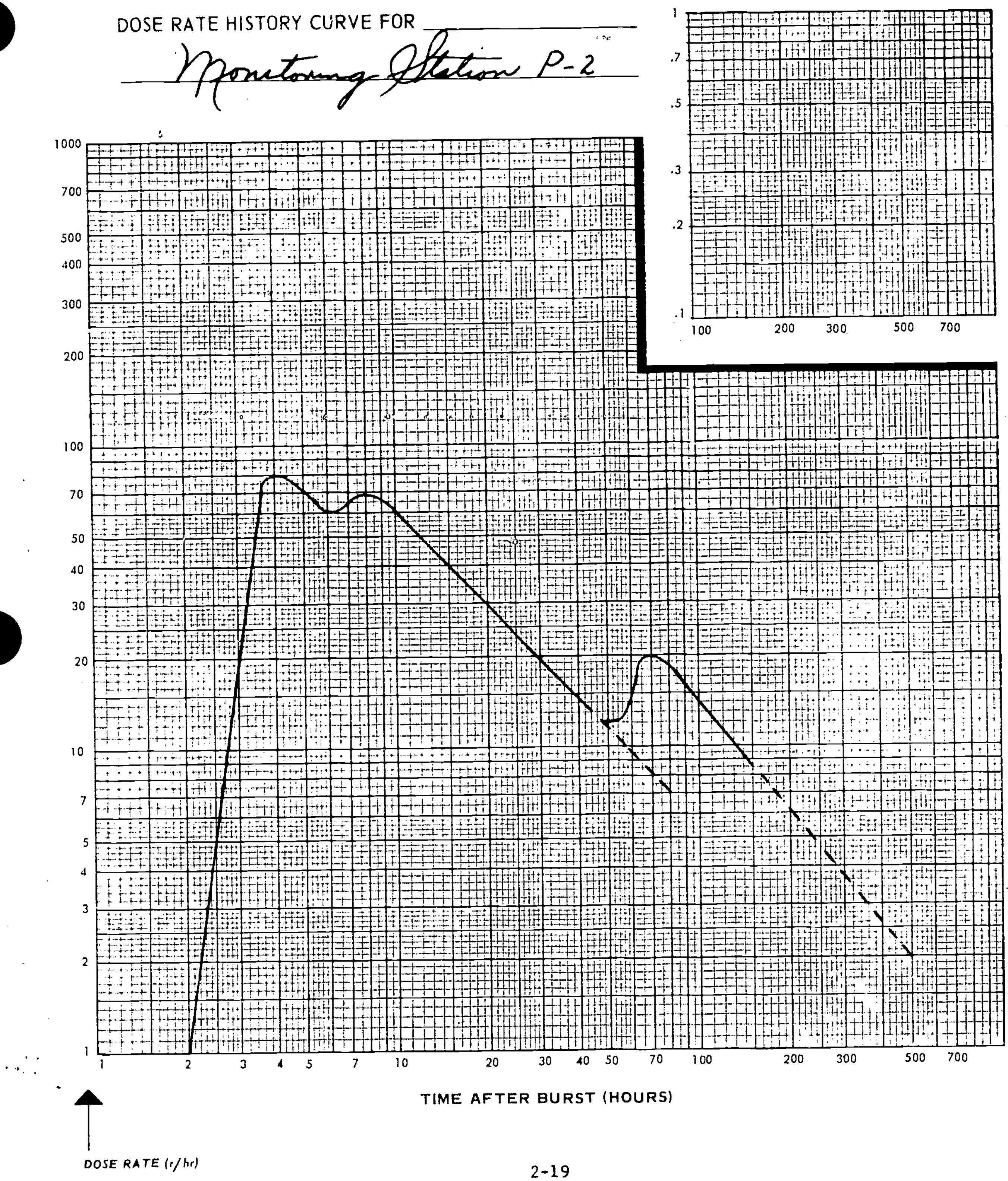
$\log 72 + 1.3 \log 6 = \log R_y + 1.3 \log 14$

$1.8573 + 1.3(.7782) = \log R_y + 1.3(1.1461)$

$\log R_y = 1.8573 + 1.0117 - 1.4899 = 1.3791$

$R_y = 24$ r/hr

DOSE RATE HISTORY CURVE FOR Monitoring Station P-2



ANSWER to Requirement No. 4

a. See graph for station P-2.
b. See graph for station P-2.
c. Through about H + 80.
d. 9.5 r/hr; 7 r/hr.
e. See graph for station P-2.
f. Through about H + 200. The curve is extended beyond this to meet the requirements of item g.
g. About H + 500 (21 days). (This is beyond the limits of the general rule, but it is the best estimate available.)
h. Yes, but as in g, above, the results are less valid.
i. Since the dose rates did increase after the first forecast, the Radef Officer may need to modify actions taken or recommendations made on the basis of the forecast made at H + 44.
j. Position a straightedge at 15 r/hr at H + 30 and align it parallel with the plotted curve. Read a forecasted dose rate of about 9 r/hr at H + 50.

ANSWER to Requirement No. 5

a. Yes, the slope of the curve at H + 100 is different than at H + 10 and H + 40.
b. "n" = about 1.0 to 1.05.
c. At least greater than 2 inches.

ANSWER to Requirement No. 6

$R_x = 60$ r/hr $\quad\quad t_y = 30$ hours

$t_x = 20$ hours $\quad\quad n = 1.5$

$R_y = ?$

$$R_x t_x^{\,n} = R_y t_y^{\,n} \qquad (60)(20)^{1.5} = R_y(30)^{1.5}$$

$$\log 60 + 1.5 \log 20 = \log R_y + 1.5 \log 30$$

$$1.7782 + 1.5(1.301) = \log R_y + 1.5(1.4771)$$

$$\log R_y = 1.7782 + 1.9515 - 2.2157 = 1.5140$$

$R_y = 33$ r/hr.

ANSWER to Requirement No. 7

Average dose rate during exposure period = 40 r ÷ 4 hrs. = 10 r/hr
Enter curve at 10 r/hr and find midpoint of exposure period = H + 58
Entry time = H + 58 minus 2 hrs. (one-half of exposure period) = H + 56

TITLE: Dose Calculations

COURSE: Radiological Defense Officer

FOR USE IN THE SESSION: Technical Guidance for Radiological Defense Operations

REMARKS: Requirement No. 1a and b, and Requirement No. 2 will be completed in class. Requirement No. 1c and d, and Requirement No. 3 are provided as practice problems for completion after the class period on Technical Guidance for Radiological Defense Operations. DO NOT complete any of the requirements before class.

The answers to each requirement are provided in Attachment B. Please do NOT review these answers before completing the requirements, otherwise much of the teaching value of each requirement may be lost.

CONTENTS

DISCUSSION

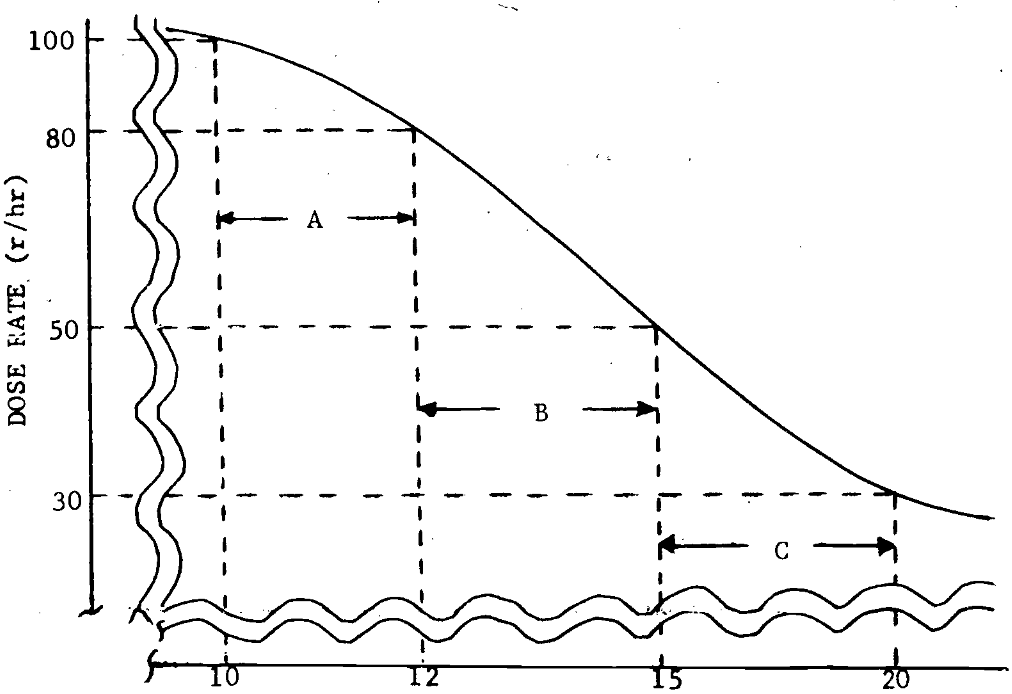
Dosimeters integrate exposure doses over a period of time and account directly for variations in dose rates due to decay or to movement into areas of higher or lower radiation levels. Dosimeters thus provide the simplest and most direct method of measuring personnel exposure doses. However, there may be instances when the Radef Officer must estimate exposures based on a series of dose rate measurements. In these instances, it is relatively simple to forecast dose rates and, consequently, total exposure doses of individuals when the fallout decay exponent remains constant over long periods of time. However, if we are concerned with estimating the total exposure dose for the periods (1) of fallout deposition, (2) when the value of the fallout decay exponent is changing rapidly, or (3) when fallout from several detonations contributes to the dose rate, calculation of these estimates becomes more complex.

A satisfactory estimate of total exposure doses can be obtained by plotting dose rates versus time after detonation and determining the doses from the graph. To do this, first divide the exposure period into small increments. When the slope of the curve is changing rapidly, the increments should be small. When the slope is relatively straight over the exposure period, the increments may be larger. The increments need not be equal in size. (See the illustration on the following page.)

As a general rule, an increment should not exceed one-half of the time from detonation to the beginning of the increment. For example, if the increment begins at H + 10, it should not be larger than 5 hours. However, if the slope of the curve changes appreciably during this time, it may be necessary to use even smaller increments. During the initial periods of fallout deposition, the increments should be no larger than one hour. This technique for computing the dose under the curve is limited by these general rules, because the technique is applicable only to linear graph paper and is not applicable to log-log paper. However, within the limitations of the general rules, the technique does provide a sufficiently close approximation.

After the exposure period is divided into increments, determine the average dose rate within each increment and multiply this by the elapsed time. Total the exposures in each increment to find the estimated exposure between the times of interest.

<u>Sample Problem</u> Find the exposure dose between H + 10 and H + 20 from the following curve.



Time After Burst (Hours)

Increment	Average dose rate X elapsed time	=	incremental dose
A	$\left(\frac{100 + 80}{2}\right) \times 2 = 90 \times 2$	=	180
B	$\left(\frac{80 + 50}{2}\right) \times 3 = 65 \times 3$	=	195
C	$\left(\frac{50 + 30}{2}\right) \times 5 = 40 \times 5$	=	200
	Total		575 r

SITUATION

Attachment A is a dose rate history curve for Monitoring Station F-2.

Requirement No. 1

Determine the total doses for the following periods:

a. H + 7 to H + 15

Increment	Average dose rate X elapsed time	=	incremental dose

b. H + 15 to H + 40

Increment Average dose rate X elapsed time = incremental dose

c. H + 40 to H + 90 (Homework Practice Problem)

Increment Average dose rate X elapsed time = incremental dose

d. H + 90 to H + 600 (Homework Practice Problem)

Increment Average dose rate X elapsed time = incremental dose

If persons are not exposed to the outside dose rate, but are in shelter for all or part of the exposure period, a correction can be made for this protection in computing their exposure dose. Before this correction is considered, an understanding of the term, "Protection Factor" is required.

Protection Factor, as used in the National Fallout Shelter Survey, is defined as the expected radiation level in the location of interest (shelter) compared to the level that would exist three feet above a smooth, infinite plane contaminated with the same amount of fallout per unit area. Thus, the protection factor is related to a hypothetical situation and not to a real situation.

Technically, the PF is not simply the ratio of the expected outside to inside radiation levels. This is because the outside reading is not observed over a uniformly contaminated, smooth plane but is measured over a real location where ground roughness, buildings, lakes and other characteristics of the environment provide some reduction in the radiation level (protection). Thus, the outside PF -- defined as the ratio of the radiation level that would occur three feet above a very large surface of ideal smoothness compared to the level that would occur with the same amount and distribution of fallout three feet above the ground outside -- may be some value like 1.5. In this case, if a shelter had a protection factor of 100, the outside to inside ratio of the radiation level would be 100 ÷ 1.5, or 67.

In general, protection factors are useful preattack for planning shelter utilization, damage assessment of hypothetical attacks, etc. However, for postattack operations, the concept of PF is of little value. Instrument readings would provide real information about the radiation hazard in shelter, outside, or at other places of interest. Thus, if the radiological situation becomes critical, the problem is <u>not</u> to find a location with a better PF but to find a place where the radiation hazard is less, or to determine if there is anything else that would reduce the expected radiation exposure.

In some cases, an actual measurement of the outside to inside radiation levels may provide useful information when combined with the information from dose rate history curves. Care must be exercised in determining this ratio to assure that the outside dose rate is, in fact, representative of the radiation field outside the sheltered location. Expected exposure doses within these locations can then be <u>estimated</u> by dividing the computed dose from a dose rate history curve by the measured ratio.

In order to provide experience in solving typical problems based on hypothetical postattack data, it is necessary to use some number, which is representative of the degree of protection afforded by shelters, as a measure of the reduction in radiation levels in the shelters. <u>For the purposes of this course, in the absence of actual measurements of shelter effectiveness, and with full recognition of the limited postattack application of National Fallout Shelter Survey (NFSS) protection factors, the concept of PF will be used as a measure of the outside to inside radiation levels for a particular shelter.</u>

Many times personnel will occupy more than one shelter, or will spend part time in shelter and part time outside. To simplify the calculations in these situations, a combined or equivalent PF can be estimated using the following formula.

a. To determine an equivalent daily PF:

$$\frac{1}{PF_e} = \frac{1}{24}\left(\frac{t_1}{PF_1} + \frac{t_2}{PF_2} \cdots\right)$$

where t_1 is the time in hours in shelter with PF_1 and t_2 is the time in shelter with PF_2, etc. PF_e is the equivalent protection factor.

b. To determine an equivalent PF during a month:

$$\frac{1}{PF_e} = \frac{1}{30}\left(\frac{t_1}{PF_1} + \frac{t_2}{PF_2} \cdots\right)$$

where t_1 is the time in days in shelter with PF_1 and t_2 is the time in shelter with PF_2, etc.

c. For the purposes of this course, assume a PF of 1 for outside work. This value is probably low for any real situation, since outside PF's are more like 1.25 to 1.5, but this assumption makes the mathematics easier.

d. What is the equivalent daily PF if 8 hours each day are spent sleeping in a shelter with PF 100, 8 hours are spent outside of the shelter area where the PF is 10, and 8 hours are spent outside where the PF is 1?

e. SOLUTION:

$$\frac{1}{PF_e} = \frac{1}{24}\left(\frac{t_1}{PF_1} + \frac{t_2}{PF_2} + \frac{t_3}{PF_3}\right) = \frac{1}{24}\left(\frac{8}{100} + \frac{8}{10} + \frac{8}{1}\right) =$$

$$\frac{1}{24}\left(\frac{8}{100} + \frac{80}{100} + \frac{800}{100}\right) = \frac{1}{24}\left(\frac{888}{100}\right) = \frac{888}{2400}$$

$$PF_e = \frac{2400}{888} = \text{about } 3$$

Requirement No. 2 (Use the curve in Attachment A)

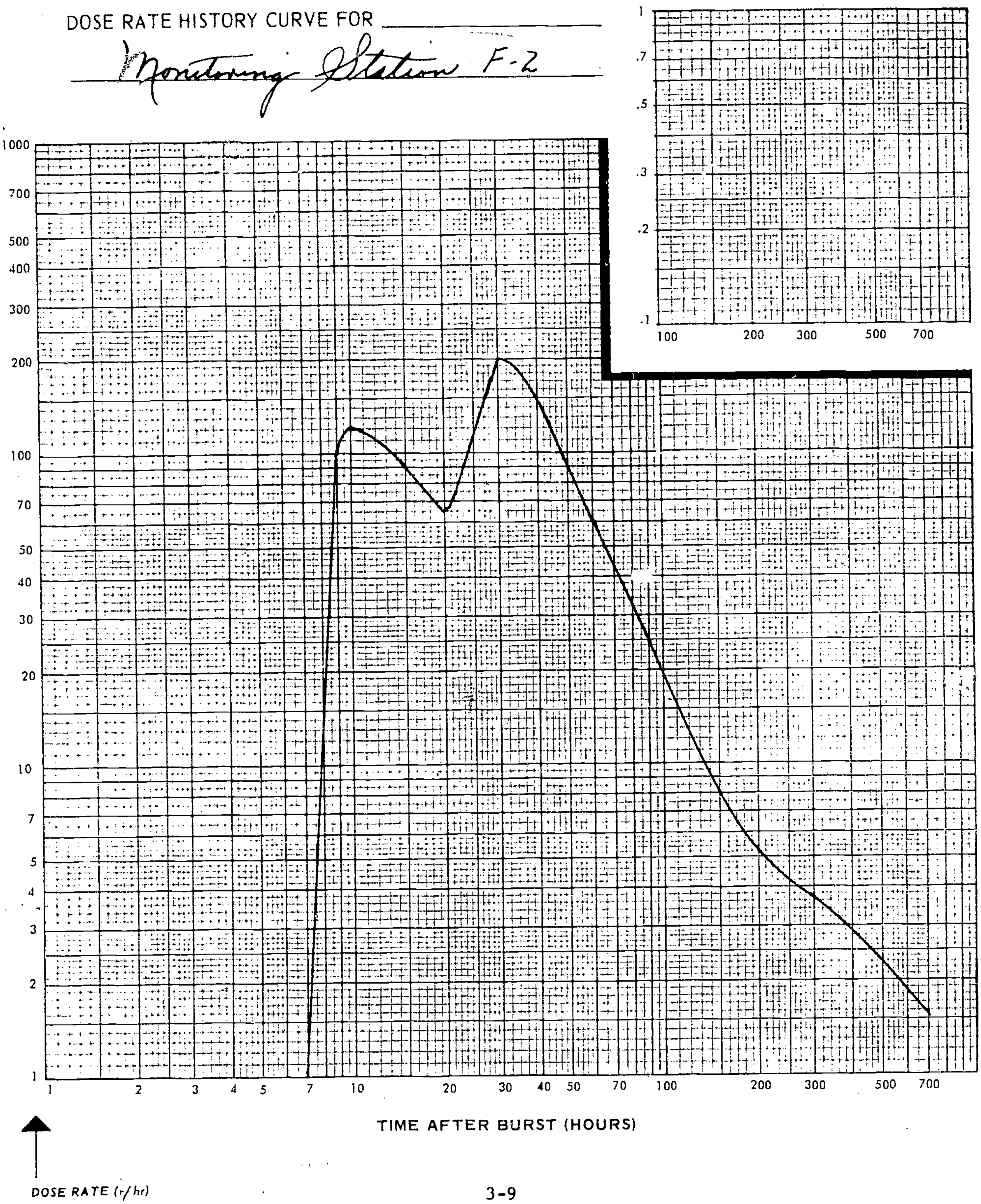
Assume that a group of people were in a shelter with a PF of 20 from fallout arrival through H + 15, at which time they transferred to a shelter with a PF of 100. What would be their exposure dose through H + 40, if it took them ten minutes to transfer shelters and their exposure during transfer was 15 r? Use computed answers from Requirement No. 1a and b.

Requirement No. 3 (Homework Practice Problem - Use the curve in Attachment A)

Between H + 90 and H + 600 a group of workers were in shelter with a PF of 200 for ten hours a day, in a facility with a PF of 40 for twelve hours a day, and outside for the remaining two hours. Using the computed answer from Requirement No. 1d, estimate the exposure of these workers from H + 90 to H + 600.

ATTACHMENT A

DOSE RATE HISTORY CURVE FOR Monitoring Station F-2



ANSWER to Requirement No. 1

a. Dose from H + 7 to H + 15

Increment	Average dose rate X elapsed time	=	incremental dose
H + 7 to 8	$\left(\frac{1 + 25}{2}\right) X\ 1 = 13 X 1$	=	13
H + 8 to 9	$\left(\frac{25 + 100}{2}\right) X\ 1 = 63 X 1$	=	63
H + 9 to 10	$\left(\frac{100 + 120}{2}\right) X\ 1 = 110 X 1$	=	110
H + 10 to 15	$\left(\frac{120 + 90}{2}\right) X\ 5 = 105 X 5$	=	525
	TOTAL		711 or 710 r

b. Dose from H + 15 to H + 40

Increment	Average dose rate X elapsed time	=	incremental dose
H + 15 to 20	$\left(\frac{90 + 65}{2}\right) X\ 5 = 78 X 5$	=	390
H + 20 to 30	$\left(\frac{65 + 200}{2}\right) X\ 10 = 133 X 10$	=	1330
H + 30 to 40	$\left(\frac{200 + 150}{2}\right) X\ 10 = 175 X 10$	=	1750
	TOTAL		3470 or 3500 r

c. Dose from H + 40 to H + 90

Increment	Average dose rate X elapsed time	=	incremental dose
H + 40 to 60	$\left(\frac{150 + 60}{2}\right) X\ 20 = 105 X 20$	=	2100
H + 60 to 90	$\left(\frac{60 + 25}{2}\right) X\ 30 = 43 X 30$	=	1290
	TOTAL		3390 or 3400 r

d. Dose from H + 90 to H + 600

Increment	Average dose rate X elapsed time	=	incremental dose
H + 90 to H + 140	$\left(\frac{25 + 9}{2}\right) X\ 50 = 17\ X\ 50$	=	850
H + 140 to H + 200	$\left(\frac{9 + 5.2}{2}\right) X\ 60 = 7.1\ X\ 60$	=	426
H + 200 to H + 300	$\left(\frac{5.2 + 3.7}{2}\right) X\ 100 = 4.5\ X\ 100$	=	450
H + 300 to H + 400	$\left(\frac{3.7 + 2.9}{2}\right) X\ 100 = 3.3\ X\ 100$	=	330
H + 400 to H + 600	$\left(\frac{2.9 + 1.9}{2}\right) X\ 200 = 2.4\ X\ 200$	=	480
	TOTAL		2536 or 2500 r

ANSWER to Requirement No. 2

Dose in initial shelter (H + 7 to H + 15) = 710 r ÷ 20 = 36 r

Dose during transfer = 15 r

Dose in final shelter (H + 15 to H + 40) = 3500 ÷ 100 = 35 r

TOTAL 86 r

ANSWER to Requirement No. 3

$$\frac{1}{PF_e} = \frac{1}{24}\left(\frac{10}{200} + \frac{12}{40} + \frac{2}{1}\right) = \frac{1}{24}\left(\frac{10}{200} + \frac{60}{200} + \frac{400}{200}\right)$$

$$= \frac{1}{24}\left(\frac{470}{200}\right) = \frac{470}{4800}$$

$$PF_e = \frac{4800}{470} = 10$$

Unsheltered dose from H + 90 to H + 600 = 2500 r

Dose to workers from H + 90 to H + 600 = 2500 r ÷ 10 = 250 r

TITLE: ERD Calculations

BRIEF NO. 4

COURSE: Radiological Defense Officer

FOR USE IN THE SESSION: Technical Guidance for Radiological Defense Operations

REMARKS: The abbreviated and Nomogram methods for calculating ERD will be taught during class. The problems in Attachment A are provided as practice problems for completion after the class period on Technical Guidance for Radiological Defense Operations. They will not be worked in class. The answers are provided in Attachment C. The ERD Nomogram is included as the last attachment (D) for easy removal during class.

C O N T E N T S

DISCUSSION

The problems of controlling exposure to radiation in a nuclear war are inordinately complex, and their solution is not susceptible to rules of thumb, or to principles of radiation protection based on past experience. It is not possible, for example, to assign values for "permissible dose." In the first place, it is realistic to expect that during the attack phase many people will receive doses in excess of the amount that a committee might stipulate for the highest-priority task. What does the civil defense commander do when his key personnel have already received the "permissible dose" and there is still important work to be done? Further, it seems obvious that the privileges of a civil defense commander and a military commander should be similar with respect to decisions involving the risk to subordinates of injury or death. Who would accept an assignment as the commander of a fortress or of a warship if his actions were limited in advance by rules prescribed by a committee which did not have the authority to appoint him and was not responsible for the manner in which he discharged his duties?

The alternative to prescribing permissible doses for specific tasks or for specific groups of people is to prepare guidelines describing the consequences of exposure to the amounts of radiation that might be encountered. The commander then becomes the decision-maker with respect to the people for whom he is responsible. Of course, his decisions should be based on the recommendations of his staff, including the Radef Officer and the Medical Officer.

In making decisions regarding radiation exposure, survival is paramount, for without it there is no need to be concerned about late somatic and genetic effects of radiation. In the event of a nationwide attack, there may be a tendency to think only of survival and disregard entirely the possibility that late somatic and genetic effects could impair the health of the people. Such an attitude, if allowed to dominate decision making, may be shortsighted, although it should be realized that measures adopted to insure survival with the fewest possible casualties will be the same as measures effective in reducing late effects. Consequently, early command decisions based on survival alone are not likely, in general, to be in serious conflict with more leisurely made judgments in which late effects are carefully considered.

When circumstances permit, it is desirable to give preferential consideration to personnel who will be required to perform early outside activities and to children and adults still capable of procreation, since these are the ones through whom the genetic effects of radiation will have the most adverse influence on the future population.

In dealing with radiation exposure and its measurement, numerous physical quantities and units are necessary for proper description and understanding of the phenomena involved. Included are such terms as absorbed dose (rad), exposure dose (roentgen), and RBE dose (rem). Conceptually, these are all different and in some cases apply only to specific radiations. However, in consideration of all the uncertainties and inaccuracies involved, the various terms can be considered as numerically about the same. Hence, the term "roentgen" will be considered as synonymous for all the terms cited above.

When dosimeters are worn by personnel to measure their exposure, the reading of the dosimeter gives the dose in roentgens, or milliroentgens, for the period worn. It is convenient to assume that the accumulated exposure dose and the dose received--or absorbed--by the individual are identical; but, strictly speaking, such is not the case. In an emergency situation, it is not practical to make the measurements and calculations that are needed to convert exposure dose (in roentgens) into absorbed--or tissue--dose (in rads).

For emergency conditions, an exposure that ranges in duration from a few seconds to 4 days is termed brief. When the period of continuous or intermittent exposure is longer than 4 days, it is termed protracted. These terms, applied to dose or exposure dose, are more appropriate than acute or chronic, respectively, which are used conventionally to describe the severity and duration of an illness or an injury.

It is assumed that in the case of a brief exposure to radiation lasting up to 4 days, the extent of the radiation injury is more dependent on the total dose than when exposure is protracted beyond 4 days. In the latter case, recovery from the injury leads to an increasing disproportion between the size of the accumulated dose and the extent of the observable symptoms of radiation injury. In this situation, the equivalent residual dose (ERD) is more useful than the accumulated dose for predicting the resultant illness and the chances of survival.

Thus, ERD is a concept that permits a more reliable prediction of the biological and medical consequences of exposure to radiation than is possible on the basis of the accumulated dose alone. By definition, ERD is the accumulated dose corrected for such recovery as has occurred at a specific time. It is presumed that a person who has received a particular ERD--expressed in r--will display approximately the same signs and symptoms of radiation injury as would be anticipated following a brief dose of the same size.

The decision to use ERD to evaluate radiation exposure in an emergency is based on the following considerations: (1) it is not possible to predict the immediate effect of any amount of radiation unless one knows the manner and the duration of the exposure; (2) the body can repair a substantial fraction of the injury responsible for such immediate effects as acute radiation sickness; (3) required recovery time; and (4) what injury cannot be repaired persists, and successive increments of the irreparable injury are cumulative.

Because quantitative information on the rate or the extent of recovery in man is limited, it is necessary to make certain assumptions on the basis of experiments with animals in order to evaluate the effects of large protracted exposures such as may occur in an emergency. Therefore, the following assumptions are made:

a. Ten percent of the injury is irreparable and may cause late effects.

b. The body recovers from the reparable 90 percent of the injury in such a fashion that about half the recovery has occurred in 1 month and nearly all possible recovery has occurred after 3 months.

c. The process of recovery is continuous in the case of protracted exposure.

d. Since there are no proper units to describe radiation injury, it is convenient to consider that a brief dose and the injury that it causes are proportional in magnitude.

Thus, radiation injury equivalent to 100 r (for example) is sustained by a person who received a brief dose of 100 r. Likewise, the radiation injury expected as a result of an ERD of 100 r should be equivalent to that expected following the brief dose of the same size. With the passage of time after the onset of exposure, the occurrence of recovery has the effect of canceling, or subtracting, an appropriate fraction of the accumulated dose. The amount of dose canceled varies with time after the onset of exposure but may never exceed 90 percent. At any time, the dose that has not been canceled represents the injury inflicted by radiation and is reported as the equivalent residual dose (ERD).

The concept of ERD should be used only to predict immediate effects, such as radiation injury or acute radiation sickness of the kind expected following brief doses in the range below 300 r. Although it may seem practical to use ERD to predict that additional protracted exposure may be fatal, it is not recommended. Similarly, there is no reason to suppose that ERD is a reliable predictor of any of the late somatic effects of radiation or of the genetic effects.

The principal advantage to be gained from using ERD is to evaluate the combination of brief and protracted exposures that can be expected in most radiation emergencies. The dose already received and the protracted exposure anticipated in the future can be combined readily to obtain an ERD, except that it is not recommended to extend the calculations beyond one year after the onset of the emergency.

During postattack recovery, the ERD should be particularly helpful in controlling protracted exposure by adjusting the time permitted outside shelter.

In calculating the ERD at any time, the previous assumptions can be restated as follows:

a. 10% of the radiation injury is irreparable,

b. 90% of the radiation injury is repaired at the rate of 2.5% per day,

c. repair begins 4 days after the start of a brief exposure, and

d. recovery is continuous during a protracted (longer than 4 days) exposure.

The ERD can be expressed mathematically as: $ERD = 0.1D + 0.9D\ (0.975)^{t-4}$ where D is the dose in a single day and t is the number of days from the time of exposure to the time at which the ERD is to be computed. For example, assume that a group of emergency workers has been exposed as indicated below (exposure determined by dosimeter readings). Total exposure was 200 r. About two weeks after the first day of exposure, this group is needed to carry out another emergency mission in a fallout area, and the Radef Officer must compute their ERD at the end of fourteen days to determine whether they can be used without risk of serious radiation sickness. Assuming the exposures after the seventh day are negligible, the computation is as follows:

Daily Exposure	t-4	Value of $(0.975)^{t-4}$	0.9D	Not Yet Recovered	0.1D
95 r	10	0.776	85.5	66.4	9.5
15 r	9	0.796	13.5	11.7	1.5
50 r	8	0.816	45.0	36.7	5.0
22 r	7	0.837	19.8	16.6	2.2
10 r	6	0.859	9.0	7.7	1.0
5 r	5	0.881	4.5	4.0	0.5
3 r	4	0.904	2.7	2.4	0.3
200 r			180.0	145.5	20.0

ERD at 14 days after start of exposure is 145.5 + 20 = 165.5, or 166 r. (See Attachment B for Powers of 0.975).

On the basis of this calculation, it is apparent that, if essential, an additional dose of approximately 34 r might be tolerated on the fifteenth day. However, since the exposure of this group has been rather large, it might be preferable to assign the task to another group with less exposure or, if possible, to postpone the operation for a while. This will take advantage of further radiation decay as well as additional biological repair.

When workloads make detailed calculations impractical, the abbreviated method can be used for close approximations. When considering doses received over a several days period, assume a single dose equal to the total and received at the time that about one-half of the total dose was received. In the previous example, half of the 200 r exposure occurred on the 2nd day. Thus, there was only an average of 8 days ($t-4 = (14 - 2) - 4 = 8$) for biological repair to occur. Applying the formula, the ERD is:

$$\begin{aligned}
ERD &= .1D + .9D\,(0.975)^{t-4} \\
ERD &= .1(200) + .9(200)\,(0.975)^{14-2-4} \\
ERD &= 20 + 180\,(0.816) \\
ERD &= 20 + 146.8\text{ r} = 166.8\text{, or }167\text{ r}
\end{aligned}$$

While not exactly equal to the 166 r dose from the first example, the percentage of error is small. Therefore, the abbreviated method may be applied to exposures spread over about one week. When daily exposures over a two or three week period must be accounted for, two or three applications of the abbreviated method must be used. It should also be noted that these ERD calculations are based upon dosimeter measurements and are, therefore, independent of the age of the fallout comprising the situation and the rate of delivery of exposure.

If it should be necessary to estimate how much time must elapse before an additional specific dose could be reasonably accepted over a period of a few days, the calculation can be made. Assume that an emergency operation requiring less than one day must be performed in a fallout area and the anticipated exposure is 100 r. Also assume the group from the previous examples are to be used, and that the total ERD cannot exceed 200 r.

The ERD at the end of the new mission will consist of the following parts:

irreparable dose	20 r
new dose	100 r
not yet recovered dose	X
maximum ERD	200 r

X must be equal to 200 - (100 + 20) = 80 r before the new dose of 100 r can be accepted during the new mission and not exceed an ERD of 200 r. The 180 r repairable portion of the initial dose must be reduced by a factor of 80 ÷ 180, or .444 before the mission can be performed. Thus, $(0.975)^y = .444$ where y is the average number of days for biological repair to occur. Referring to Attachment B, it is found that y must equal 32 days.

To find the elapsed time before the new mission can begin, add the number of days on which no biological repair was assumed to the number of days biological repair did occur. Thus, 2 + 4 + 32, or 38 days after the start of the first exposure, an additional dose of 100 r could be accepted by the group and not exceed an ERD of 200 r.

Attachment D is a Nomogram, which is also an effective tool for rapid computation of ERD. The scale at the bottom expresses the time in days after exposure. The scale at the right side expresses the brief dose (shock dose, or dose spread over one to four days). The scale on the left expresses equal daily exposures subsequent to the initial dose. The curved, quasi-horizontal lines represent the equivalent residual dose.

To use the Nomogram, align a straightedge with the brief dose on the right column and with the daily dose on the left. Enter the Nomogram at the appropriate time measured from the start of exposure and read the ERD at the intersection of the straightedge and curve.

If an additional shock dose (unusually large dose received because of some activity, such as performing an emergency mission) is received at some time after the start of exposure, it can be accounted for by adding it directly to the calculated ERD at that time. The straightedge is then aligned with this new ERD on the appropriate time line and with the daily dose on the left column. The ERD can then be found for any later time at the intersection of the straightedge and the appropriate time line.

Many additional types of information can be found with the aid of the Nomograms as illustrated by the following problems.

What is the ERD on the 30th day, if a brief dose of 40 r is received and the exposure is controlled to 4 r/day thereafter?

SOLUTION: Align 40 r on the right axis with 4 r/day on the left. Enter the family of curves on the 30th day and read about 95 r.

What is the ERD on the 20th day after a brief dose of 150 r, assuming no interim exposures?

SOLUTION: Align 150 r on the right axis with 0 on the left. Enter the family of curves on the 20th day and read about 105 r.

What is the ERD on the 40th day, if the exposure is controlled to about 5 r/day after a brief dose of 20 r?

SOLUTION: Align 20 r on the right axis with 5 r/day on the left. Enter the family of curves on the 40th day and read about 125 r.

What is the ERD on the 60th day after a brief exposure of 30 r, if the daily dose was controlled to about 5 r/day through the 20th day at which time an additional dose of 30 r was received and the daily dose thereafter was controlled to about 3 r/day?

SOLUTION: Align 30 r on the right axis with 5 on the left. Enter the family of curves on the 20th day and read about 82 r. Add 30 r and align 112 r on the 20th day with 3 on the left axis. Enter the family of curves on the 60th day and read an answer of about 125 r.

What additional exposure can a crew accept on the 40th day, if their maximum ERD has been set at 150 r and they received a brief dose of 60 r after which their exposure was controlled to about 4 r/day?

SOLUTION: Align 60 r on the right axis with 4 on the left. Enter the family of curves at 40 days and read 118 r. Subtract 118 r from 150 r to find an answer of 32 r.

Any decisions involving the controllable exposure of an individual to radiation under emergency conditions is intimately related to many factors involving human judgment made under stress. Unfortunately, any decision involving radiation exposure is irrevocable, once the exposure is received. It must be assumed that, while most radiation effects are partially reparable, some may be completely irreversible. Hence, in a given emergency situation, <u>if</u> it is possible to choose between different courses of action--one involving a large exposure and the other a smaller one--the only wise course is to select the one involving the lesser exposure. The acceptance of any radiation exposure is warranted <u>only</u> when there is no practical or reasonable alternative way to achieve the required goal.

The following is a summary of the guidelines of the National Committee on Radiation Protection and Measurement for making decisions in a radiation emergency:

1. General Principles:

   a. The objective of all radiation protection is to minimize injuries.

   b. In war emergencies, the objectives are: first, the fewest deaths; second, the fewest requiring medical care; third, the smallest amount of genetic injury; and fourth, the least probability of late somatic effects.

   c. For practical purposes, assume that the entire population is equally susceptible to the effects of radiation.

   d. People should remain in whatever shelters are immediately available until the radiological situation is evaluated.

   e. Casualties due to radiation are the same, administratively, as casualties due to blast, fire, toxic chemicals, etc.

2. System for Predicting Immediate Outcome of Exposure:

   a. Make no allowance for recovery during the first 4 days, but take the accumulated total dose as equivalent to a single dose of equal size.

   b. Use the equivalent residual dose (ERD) for exposure protracted beyond 4 days.

   c. When neither the brief dose nor the ERD exceeds 200 r, the majority of people will not require medical care.

   d. When either the brief dose or the ERD is between 200 and 600 r, the majority will require medical care and about half may die eventually.

   e. When the dose is more than 600 r, the majority will die.

   f. The median lethal gamma dose (brief exposure or single dose) for man is 450 r.

   g. The reliability of any prediction of radiation injury cannot be any greater than the reliability of the estimate of dose.

   h. Any prediction of the number of casualties may be incorrect by as much as ± 25 percent.

   i. The possibility of genetic injury and of late effects of radiation should not be the principal determining factor when making decisions during an emergency.

   j. Decisions regarding work capacity should be based on medical evidence of fitness and not on estimates of exposure dose.

3. Reliability of Physical Estimates of Dose Under Emergency Conditions:

The effect of an actual dose to an individual depends on many biological factors that cannot be precisely evaluated and must, of necessity, be disregarded or the planning problem becomes unmanageable. For practical purposes, the accuracy of estimates of dose should be considered to be the same as the accuracy of the instrumental measurement under the following conditions:

a. When dose is measured by personal dosimeters, the error, even under ideal conditions, may be as great as ± 25 percent of the true value.

b. When dose is calculated from dose rate measured by survey meters, the error may be as great as ± 35 percent.

c. When dose is calculated on the basis of area dose rates by means of a map on which isodose lines have been drawn, the error may be as great as ± 50 percent.

d. When dose in the non-lethal range is estimated on the basis of the severity of radiation sickness, the error may be at least ± 25 percent.

ERD PROBLEMS

Use abbreviated method:

1. The daily doses of an emergency operational group, as measured by dosimeters, were: 40 r, 10 r, 60 r, 15 r, 20 r, 30 r, and 25 r. What is the ERD of this group 24 days after the start of exposure?

2. When could the emergency operational group in problem 1 be exposed to an additional 125 r exposure? Assume the mission is absolutely required, and the ERD is not to exceed 200 r.

3. The daily exposures of an emergency operational group, as measured by dosimeters, were: 20 r, 6 r, 25 r, 8 r, 40 r, 16 r, and 8 r. What is the ERD of this group 20 days and 50 days after start of exposure?

4. The daily exposures of an emergency operational group, as measured by dosimeters, were: 35 r, 5 r, 12 r, 8 r, 40 r, 15 r, 10 r, 8 r, 12 r, and 15 r. What is the ERD of this group at the end of the 30th day?

5. The daily exposures of an emergency operational group, as measured by dosimeters, were: 10 r, 8 r, 5 r, 20 r, 10 r, 40 r, and 7 r. Their exposures were regulated for the next three weeks to about 5 r/day. What is the ERD of this group at the end of the 28th day?

6. The daily doses of an emergency operational group, as measured by dosimeters, were: 23 r, 31 r, 14 r, 21 r, 8 r, 6 r, and 14 r. What additional exposure could be accepted by this group 30 days after start of exposure and not exceed an ERD of 100 r?

7. How long would it be after the additional exposure on the 30th day before the group in problem 6 could accept another exposure of 30 r and not exceed an ERD of 100 r?

Use Nomogram:

8. What is the ERD on the 20th day, if a brief dose of 80 r is received and the exposure is controlled to 2 r/day thereafter?

9. What is the ERD on the 25th day after a brief dose of 200 r, assuming no interim exposures?

10. What is the ERD on the 50th day, if the exposure is controlled to about 4 r/day after a brief dose of 30 r?

11. What is the ERD on the 40th day after a brief exposure of 40 r, if the daily dose was controlled to about 4 r/day through the 15th day at which time an additional dose of 20 r was received and the daily dose thereafter was controlled to about 2 r/day?

12. What additional exposure can a crew accept on the 30th day, if their maximum ERD has been set at 200 r and they have received a brief dose of 80 r after which their exposure was controlled to 3 r/day?

13. A group of workers with a critical skill were exposed to a brief dose of 200 r. What additional daily exposure could they receive and not exceed a maximum ERD of 200 r? How long could they receive this additional daily exposure before it would have to be changed?

14. What is the ERD of a group of emergency workers on the 50th day after a brief exposure of 40 r and the following exposure schedule? The daily dose was controlled to 2 r/day through the 14th day at which time a new dose of 50 r was received. The daily dose was then controlled to 4 r/day through the 30th day at which time an additional dose of 30 r was received. Thereafter the daily exposure was again controlled to 2 r/day.

For additional practice with the Nomogram, the student is encouraged to work problems 1 through 7. Remember that the correction for the lack of repair during the first 4 days is built into the Nomogram, but the correction for the assumption in the abbreviated method is not. Also, the family of curves represents the ERD at a given time, i.e. the sum of the irreparable and "not yet recovered" parts of any exposure.

ATTACHMENT B

Powers of 0.975 (100%-2.5%)

For Use in Solution of the Equation

$$ERD = .1D + .9D\,(0.975)^{t-4}$$

Power	Value	Power	Value
1	0.975	22	.573
2	.951	24	.544
3	.927	26	.517
4	.904	28	.492
5	.881	30	.468
6	.859	32	.444
7	.837	34	.422
8	.816	36	.401
9	.796	38	.382
10	.776	40	.363
11	.757	45	.320
12	.738	50	.282
13	.719	55	.248
14	.701	60	.218
15	.684	65	.193
16	.667	70	.170
17	.650	80	.132
18	.634	90	.102
19	.618	100	.079
20	.602	110	.061
		120	.048

ANSWERS FOR ERD PROBLEMS

Problem 1

$40 + 10 + 60 + 15 + 20 + 30 + 25 = 200$ r

Since half of the exposure occurred on the third day, assume a 200 r exposure on the third day.

$$ERD = .1\ D + .9\ D\ (0.975)^{t-4} = .1(200) + .9(200)(0.975)^{24-3-4}$$

$$= 20 + 180(.650) = 20 + 117 = 137 \text{ r}$$

Problem 2

Irreparable dose	20 r	
New dose	125 r	
Not yet recovered dose	X	$= 200 - 145 = 55$ r
ERD	200 r	

Not yet recovered dose must be reduced by a factor of $55 \div 180 = .305$

$(0.975)^y = .305$ $\qquad$ $y = 47$ days

Days after start of first exposure before an additional 125 r exposure could be accepted $= 47 + 3 + 4 = 54$ days.

Problem 3

$20 + 6 + 25 + 8 + 40 + 16 + 8 = 123$ r

Since half the exposure occurred on the 5th day, assume a 123 r exposure on the 5th day.

$$ERD\ 20 = .1D + .9D\ (0.975)^{t-4} = 0.1(123) + .9(123)(0.975)^{20-5-4}$$

$$= 12.3 + 110.7\ (.757) = 12.3 + 84 = 96.3 \text{ or } 97 \text{ r}$$

$$ERD\ 50 = .1D + .9D\ (0.975)^{t-4} = .1(123) + .9(123)(.975)^{50-5-4}$$

$$= 12.3 + 110.7\ (.354) = 12.3 + 39.3 = 51.6 \text{ or } 52 \text{ r}$$

Problem 4

Use two successive applications of the abbreviated method.

Step 1: $35 + 5 + 12 + 8 + 40 = 100$ r (assume 100 r on 3rd day)

$$\text{ERD} = .1(100) + .9(100)(0.975)^{30-3-4}$$

$$= 10 + 90\ (.559) = 10 + 50.3 = 60.3 \text{ r}$$

Step 2: 15, 10, 8, 12, 15 = 60 r (assume 60 r exposure on the 8th day)

$$\text{ERD} = .1(60) + .9(60)(0.975)^{30-8-4}$$

$$= 6 + 54\ (.634) = 6 + 34.2 = 40.2 \text{ r}$$

Total ERD on 30th day = 60.3 + 40.2 = 100.5 or 101 r

Problem 5

Compute the ERD on the 28th day in four steps:

Step 1: $10 + 8 + 5 + 20 + 10 + 40 + 7 = 100$ r (assume 100 r on 5th day)

$$\text{ERD} = .1D + .9D\ (0.975)^{t-4} = .1(100) + .9(100)(0.975)^{28-5-4}$$

$$= 10 + 90\ (.618) = 10 + 55.6 = 65.6 \text{ r}$$

Step 2: exposure during 2nd week = 7 X 5 = 35 r
assume 35 r exposure at midweek, or on 11th day

$$\text{ERD} = .1(35) + .9(35)(0.975)^{28-11-4}$$

$$= 3.5 + 31.5(.719) = 3.5 + 22.6 = 26.1 \text{ r}$$

Step 3: exposure during 3rd week = 7 X 5 = 35 r
assume 35 r exposure at midweek, or on 18th day

$$\text{ERD} = .1(35) + .9(35)(0.975)^{28-18-4}$$

$$= 3.5 + 31.5(.859) = 3.5 + 27 = 30.5 \text{ r}$$

Step 4: exposure during 4th week = 7 X 5 = 35 r
assume 35 r exposure at midweek, or on 25th day

Since 28-25-4 = -1, no repair occurs and ERD = 35 r

Total ERD = 65.6 + 26.1 + 30.5 + 35 = 157.2, or 158 r

Problem 6

$23 + 31 + 14 + 21 + 8 + 6 + 14 = 117$ r

Assume 117 r exposure on the 3rd day.

Compute ERD at the end of the 29th day.

$$\text{ERD} = .1D + .9D(0.975)^{t-4} = .1(117) + .9(117)(0.975)^{29-3-4}$$

$$= 11.7 + 105.3(.573) = 11.7 + 60.7 = 72.4 \text{ or } 73 \text{ r}$$

New dose on 30th day = 100 - 73 = 27 r

Problem 7

Total dose has been 117 r from initial exposure, plus 27 r exposure on 30th day, or 144 r

Irreparable dose = 11.7 + 2.7	=	14.4	
New dose	=	30.0	
Not yet recovered dose	=	X	= 100 - 44.4 = 55.6 r
	ERD	100 r	

Since no repair of the second exposure will occur until on the 34th day after the first exposure, compute the additional repair for the first exposure through the 33rd day.

First exposure 117 r (See Problem 6)
not yet recovered dose on 33rd day =
$60.7(0.975)^4 = 60.7(.904) = 54.8$
Second exposure 27 r (See Problem 6)
not yet recovered dose 24.3

Total dose not yet recovered on 33rd day 79.1 r

Not yet recovered dose must be reduced by a factor of $\frac{55.6}{79.1} = .703$

$(0.975)^y = .703$ $y = 14$ days

Days after start of first exposure before a 3rd exposure of 30 r could be accepted = 33 + 14 = 47 days.

Problem 8

Align 80 r on the right axis with 2 r/day on the left. Enter the family of curves on the 20th day and read 80 r.

Problem 9

Align 200 r on the right axis with 0 on the left. Enter the family of curves on the 25th day and read 130 r.

Problem 10

Align 30 r on the right axis with 4 r/day on the left. Enter the family of curves on the 50th day and read 115 r.

Problem 11

Align 40 r on the right axis with 4 on the left. Enter the family of curves on the 15th day and read 67 r. Add 20 r and align 87 r on the 15th day with 2 on the left axis. Enter the family of curves on the 40th day and read an answer of 85 r.

Problem 12

Align 80 r on the right axis with 3 on the left. Enter the family of curves at 30 days and read 100 r. Subtract 100 r from 200 r to find an answer of 100 r.

Problem 13

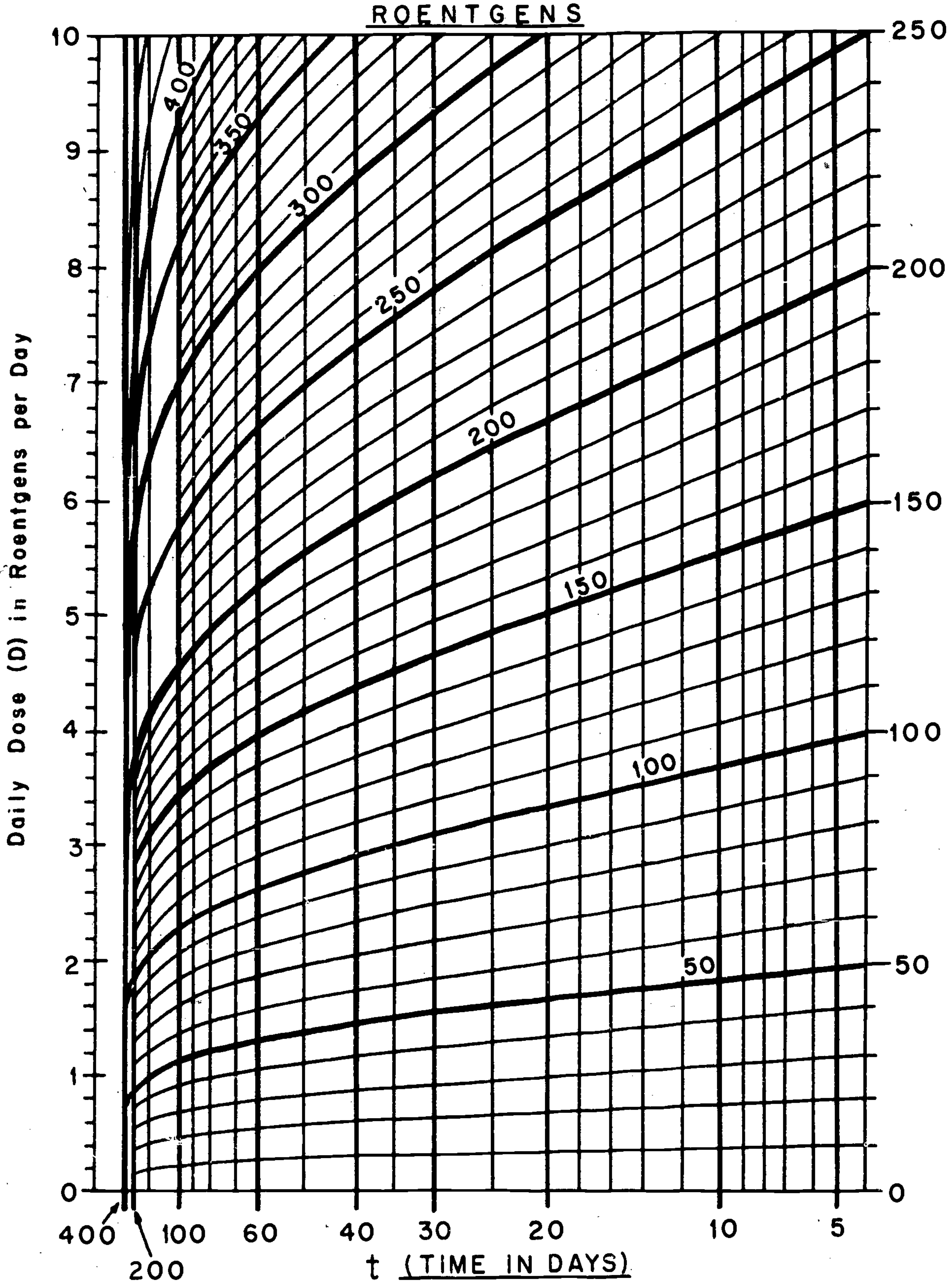
Position the straightedge at 200 r on the right axis. Align it with the 200 r ERD curve and read a daily dose of 4.8 to 5 r/day on the left axis. Assuming 4.8 r/day, the daily dose would have to be changed after the 40th day. (Since it would be impractical to read 5 r/day on a CD V-742 dosimeter, this daily criteria should probably be converted to a criteria of 20 r/4 days or 35 r/week.)

Problem 14

Align 40 r on the right axis with 2 on the left. Enter the family of curves on the 14th day and read 50 r. Add 50 r and align 100 r on the 14th day with 4 on the left axis. Enter the curves on the 30th day and read 120 r. Add 30 r and align 150 r on the 30th day with 2 on the left. Enter the curves on the 50th day and read an answer of 130 r.

ATTACHMENT D

EQUIVALENT RESIDUAL DOSE



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TITLE: Entry Time Estimates

COURSE: Radiological Defense Officer

FOR USE IN THE SESSION: Technical Guidance for Radiological Defense Operations

REMARKS: Requirements 1 through 3 will be completed in class. Requirements 4 through 7 are provided as practice problems for completion after the class period on Technical Guidance for Radiological Defense Operations. DO NOT complete any of these requirements before class.

The answers to each requirement are provided in Attachment G. Please do not review these answers before completing the requirements, otherwise much of the teaching value of each requirement may be lost.

CONTENTS

DISCUSSION

Much of the success of civil defense operations is dependent upon the accurate preparation of analytical calculations. These calculations regulate the acceptable mission dose for emergency personnel and determine the timetable for emergency operations. One of the primary types of analytical calculations which the Radef Officer will be required to make is an estimate of entry times into contaminated areas. This area of guidance is broad enough to include not only the estimation of the earliest time when emergency activities, such as decontamination and reactivation of essential facilities, can begin, but also the estimation of the time when people can emerge from shelter for short periods of time, or return to their homes.

In this course, estimating forms will be used in the calculation of entry times and in the calculation of acceptable mission doses, which must be determined before entry times can be calculated. These forms are intended only as an aid in organizing the approach to the solution of complex problems. They are NOT intended to substitute for good judgment or to reduce the calculations to a "cookbook" or a "fill-in-the-blank" procedure. The forms are not infallible.

The technique for calculating acceptable mission dose is based on the ERD concept and the use of a dose rate history curve. Because of the many parameters which influence these calculations, several of the variables must be held constant in order to make a first "rough cut" approximation of the permissible dose. For example, early entry estimates will be based on expected exposure doses computed through the first month (30 days) post-attack. Calculation of entry times beyond the first month will be delayed until dosimeter measurements of actual exposures and dependable evaluations of radiation decay characteristics permit more reliable estimates.

After the acceptable mission dose has been found, entry times are calculated using the "rough cut" approximation of the doses.

The last, but equally important step is to recalculate the dose (based on the expected exposure schedule as determined by the entry time estimate) to assure that the acceptable limits are not exceeded. At this point, minor adjustments in entry times are frequently required.

An Estimating Form for the calculation of acceptable mission doses is included as Attachment B. Directions for completing each item on the form are as follows:

FOR — Identify the personnel for whom the calculation is being made.

Item 1 — List the protection factor (PF) of the shelter occupied by the mission personnel. If the mission personnel occupy more than one shelter during the first month, the equivalent protection factor can be estimated as follows:

$$\frac{1}{PF_e} = \frac{1}{30} \times \left(\frac{t_1}{PF_1} + \frac{t_2}{PF_2} \cdots \right)$$

where t_1 is the time in days in shelter with PF_1, and t_2 is the time in shelter with PF_2. In a real situation, the ratio of outside to inside dose rates should be used instead of the protection factor.

<u>Item 2</u> After an orderly decrease in the unsheltered dose rate history curve occurs, extend the curve through the first month. Determine the exposure dose through the first month.

<u>Item 3</u> Determine the expected shelter dose during the first month by dividing Item 2 by Item 1.

<u>Item 4</u> The acceptable ERD dose will be a command decision. <u>For purposes of the Radiological Defense Officer course</u>, assume an acceptable ERD dose to the general population of 100 r, and an acceptable ERD dose for emergency operational personnel of 200 r, unless otherwise indicated.

<u>Item 5</u> Since the ERD is corrected for biological repair, the total exposure dose during the first month can be larger than the acceptable ERD. If the exposure rate over the first month is relatively constant, the total exposure dose is about 1.5 times the ERD dose. As large exposures tend to occur toward the end of the first month period, fewer days are available within the month for biological repair of these exposures and the 1.5 value becomes less realistic. As an <u>initial rough estimate</u> for the relationship between exposure dose and ERD, use a ratio of 1.25. In a real situation, there is a requirement for a continual observation of personnel exposure records and periodic recalculation of ERD from these records to assure that acceptable levels are not exceeded.

<u>Item 6</u> The total mission dose for the first month is determined by subtracting the shelter dose (Item 3) from the total exposure dose (Item 5).

<u>Item 7</u> The Radef Officer will probably spread the total mission dose during the first month over several separate missions. The sum of these separate mission doses should not exceed Item 6.

<u>Item 8</u> After the entry time into a contaminated area has been calculated based on Item 6 or 7, above, recalculate the ERD based on the expected exposure schedule as determined by the entry time estimate to assure that the acceptable limits are not exceeded. Remember Item 8 cannot be completed until after the entry time is determined.

SITUATION A

The electrical power company (PF = 5) must be reactivated as soon as practicable. The Radef Officer is considering the use of decontamination in order to permit earlier reactivation. He estimates it will require six hours to complete the decon with an over-all efficiency of .2; i.e., DF = .2. The revised protection factor after decon would then be 5 ÷ .2 = 25. (This revised PF should not imply any permanent change in the PF of the facility. It is merely a convenient way to express the reduction in exposure after decontamination.)

Personnel within six blocks of the power company and located in Category 3 (PF 70 - 99) shelter will man the facility continuously. Each shift will work eight hours/day and 7 days/week. Non-working time will be spent in the original shelter. The ERD for emergency operations personnel, including the power company and decon personnel, has been established at 150 r.

A dose rate history curve for monitoring station No. 7, located near the power company, is provided as Attachment A. The incremental doses under the curve are given in order to minimize the dose calculations.

Requirement No. 1

It is now H + 24. Calculate the acceptable mission dose for the power company personnel. An Estimating Form is provided as Attachment B.

DISCUSSION (Continued)

Entry times based on the calculated acceptable mission doses can be estimated from a dose rate history curve. Again, an estimating form can be used as a guide to organize these calculations. Directions for completing each item on the form (Attachment C) are as follows:

FOR — Identify the personnel for whom the calculation is being made.

Item 1 — Frequently, in considering the possible application of specific countermeasures, the Radef Officer will be concerned with estimating entry times both with and without employing specific countermeasures. Indicate this in Item 1.

Item 2 — Enter the acceptable mission dose from the Estimating Form used for its calculation.

Item 3 — Enter the degree of protection afforded by the facility or shelter where people will be located. For purposes of the Radiological Defense Officer course, this should be the protection factor. In a real situation, this should be the ratio of outside to inside dose rates. This protection factor could also be 1, if the work is to be accomplished outside. This value is probably low for any real situation, since outside PF's are more like 1.25 to 1.5. However, for purposes of this course, use a PF of 1. This makes the mathematics easier.

Item 3a is a measure of the protection without the countermeasure, and 3b is a measure of the protection with it. For example, if people were to work in a facility with a PF of 20 and this facility was to be decontaminated with an expected over-all decon factor of .05, 20 should be entered in Item 3a, and 20 X 1/.05, or 400 should be entered in Item 3b.

If the protection factor of a shelter is not specified exactly, such as Category 3 shelter (PF = 70 - 99), use the lowest value of the PF as the controlling condition.

Item 4 Determine the total length of time personnel will actually be in the facility or shelter area during the first 30 days. For example, decon workers, or workers at a vital facility, may work in an area 12 hours/day for three days, or a total of 36 hours. If the exposure time is not for a specified number of days but is to continue, as in the case of estimating the earliest time for reactivation of an industrial facility, use an exposure time estimate of 2 weeks. Thus, if people were to work 8-hour shifts, 7 days a week, 112 hours should be entered in Item 4 (8 hrs/day X 7 days/week X 2 weeks).

Item 5 Determine the total elapsed time during the exposure period. The total exposure time for the example in Item 4, above, would be 24 hrs/day X 7 days/week X 2 weeks, or a total of 336 hours.

Item 6 Determine the ratio of total elapsed time to personnel exposure time by dividing Item 5 by Item 4. This ratio will be used to convert the exposure during the nonconsecutive working shifts to an equivalent exposure during the total elapsed time. Such conversion is necessary in order to use a dose rate history curve.

Item 7 Complete 7a or 7b. (7a) Determine the total acceptable unsheltered dose during the total elapsed time, assuming no countermeasure, by multiplying Item 2 X Item 3a X Item 6. (7b) Determine the unsheltered dose with the countermeasure by multiplying Item 2 X Item 3b X Item 6.

Item 8 The average dose rate during the exposure period, which is equal to the dose rate at the midpoint of the period, is determined by dividing the acceptable unsheltered dose by the total elapsed time. Divide 7a, or 7b, by Item 5.

Item 9 Identify the time on the dose rate history curve when the average dose rate occurs. This represents the midpoint of the exposure period.

Item 10 Find the first estimate of entry time by subtracting one-half of the total elapsed time (Item 5) from the time for the average (midpoint) dose rate (Item 9). Frequently, Item 5 will be expressed in hours and Item 9 will be expressed in days. Remember to express the time in the same units.

Item 11 If the first estimate of the entry time is beyond 30 days, enter the figure from Item 10 directly into Item 16. Any estimates beyond 30 days, based on early data only, are likely to be too unreliable to extend the calculations beyond this point. However, such a calculated entry time does provide an "order of magnitude" estimate. Refinements of this calculated entry time should be postponed until more reliable estimates can be made, based on further evaluation of the radiation decay characteristics.

If the entry time is within the first thirty days, calculate the unsheltered dose from the dose rate history curve from the estimated entry time through H + 30 days.

Item 12 Complete 12a or 12b. (12a) Determine the dose to personnel without the countermeasure by dividing Item 11 by Items 3a and 6. (12b) Determine the dose to personnel with the countermeasure by dividing Item 11 by Items 3b and 6.

Item 13 Compare Item 12a or 12b to Item 2. Revise the entry time, if necessary. There are no simple rules for judging the revision, but usually a second estimate will cause the dose to be sufficiently close to the established limits.

Item 14 Repeat Item 11.

Item 15 Repeat Item 12.

Item 16 Enter the final entry time estimate. It may be necessary in some instances to revise the entry time estimate a second time. If so, repeat Items 13 through 15.

Requirement No. 2

Calculate the entry time for the power company personnel in Situation A, assuming no decontamination. Use the acceptable mission dose calculated in Requirement No. 1. An estimating form is provided as Attachment C.

DISCUSSION (Continued)

To assure that the acceptable exposure limits are not exceeded, the maximum ERD should be calculated, based on the expected exposure schedule as determined by the estimated entry time.

Requirement No. 3

Calculate the maximum ERD which the power company personnel will receive if they begin work at H + 19 days. Make these calculations under Item 8 of Attachment B. Use the reverse side of the Attachment form, if necessary. An ERD Nomogram is provided as Attachment H.

DISCUSSION (Continued)

In some cases, the use of the estimating forms may unnecessarily complicate the calculation of entry times or acceptable mission doses. After the solution of several problems, students should understand the steps in the technique and may be able to quickly estimate acceptable answers. Students are encouraged to make quick approximations, since in a real situation there may be insufficient time for detailed time-consuming calculations.

Requirement No. 4 (Homework practice problem)

Calculate the entry time for the power company personnel in Situation A if the facility is decontaminated. Use the acceptable mission dose calculated in Requirement No. 1. An estimating form is provided as Attachment D.

Requirement No. 5 (Homework practice problem)

If the decontamination personnel in Situation A are in Category 6 (PF = 250 - 499) shelter near monitoring station No. 7 and their ERD has been set at 150 r, calculate their acceptable mission dose for the decon of the power company. An estimating form is provided as Attachment E.

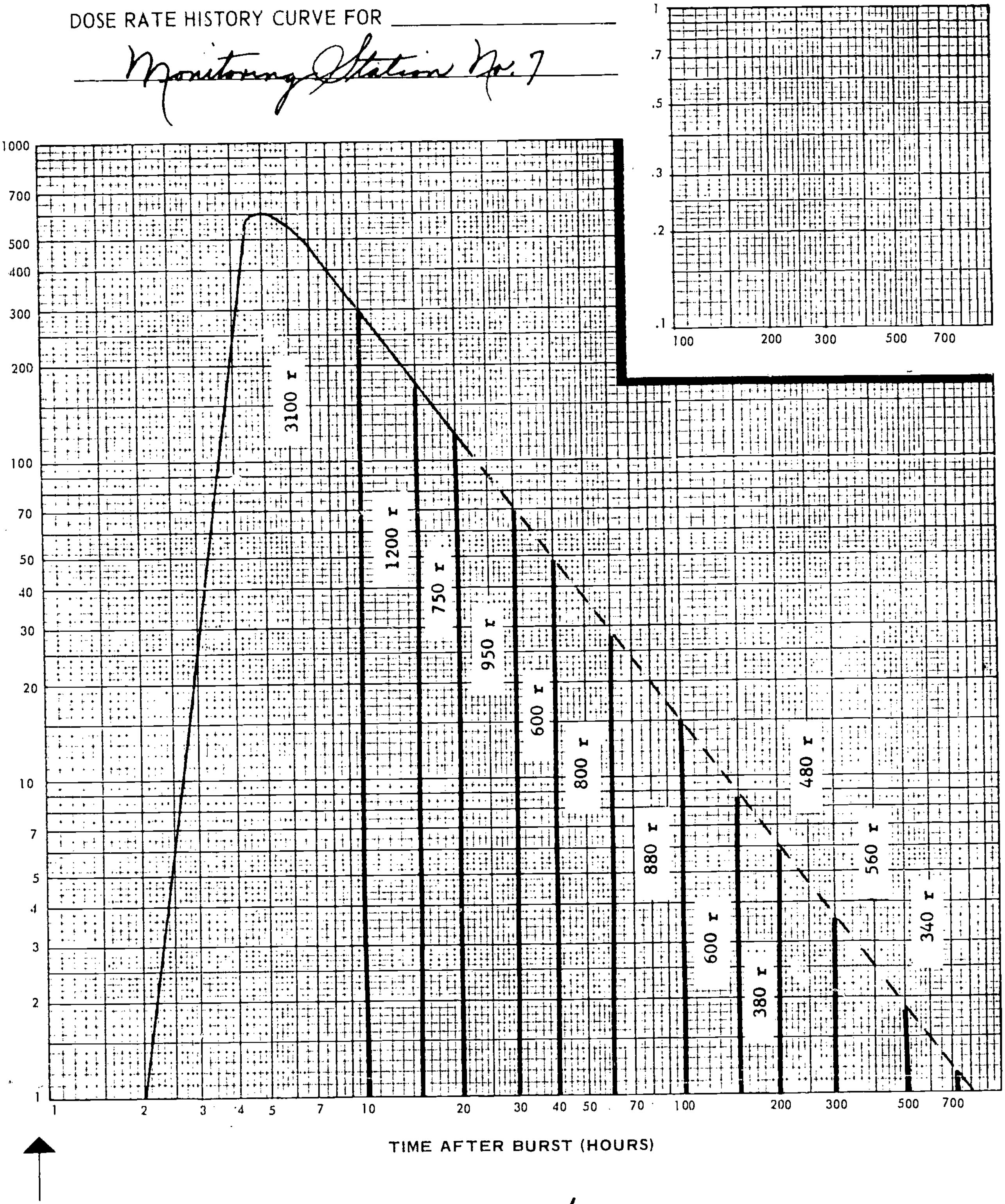
Requirement No. 6 (Homework practice problem)

Calculate the entry time for the decon personnel in Situation A. Use the acceptable mission dose calculated in Requirement No. 5. Remember Item 1a will be checked, Item 3a will be 1 (outside PF = 1), and it requires six hours to complete the decon task. An estimating form is provided as Attachment F.

Requirement No. 7 (Homework practice problem)

Calculate the maximum ERD of the decon personnel if they begin work at the time calculated in Requirement No. 6. Make these calculations under Item 8 of Attachment E. Use the reverse side of the Attachment form, if necessary.

DOSE RATE HISTORY CURVE FOR Monitoring Station No. 7



5-9 /5-10

CALCULATION OF ACCEPTABLE MISSION DOSE
(Estimating Form)

FOR ______________________________

1. Protection factor of shelter ______

2. Unsheltered dose during first month (estimated from dose rate history curve). ______

3. Shelter dose during first month (Item 2 ÷ Item 1). ______

4. Acceptable ERD dose during first month (command decision) ______

5. Total exposure dose during first month (1.25 X Item 4). ______

6. Total mission dose for first month (Item 5 - Item 3). ______

7. Separate mission doses

   a. ______ d. ______

   b. ______ e. ______

   c. ______ f. ______

   g. Total (not to exceed Item 6) ______

8. Calculation of ERD based on the expected exposure schedule (to be completed after an estimate of the entry time is made).

ATTACHMENT C

CALCULATION OF ENTRY TIME
(Estimating Form)

FOR ______________________________

1. Estimate of entry time:
   a. /_/ without countermeasure
   b. /_/ with countermeasure

2. Acceptable mission dose ______

3. Protection of working area
   a. Without countermeasure ______
   b. With countermeasure ______

4. Personnel exposure time ______

5. Total elapsed time during exposure period ______

6. Ratio of total elapsed time to personnel exposure time(5÷4) ______

7. Acceptable unsheltered dose during total elapsed time

   a. Without countermeasure (2 X 3a X 6) ______

   b. With countermeasure (2 X 3b X 6) ______

8. Average (midpoint) dose rate during exposure period (7a or 7b ÷ 5) ______

9. H-time at midpoint of exposure period (enter dose rate history curve at 8) ______

10. First estimate of entry time (9 - 1/2 of 5) ______

11. Estimated unsheltered dose for exposure period (from dose rate history curve) ______

12. Dose during exposure period

    a. Without countermeasure (11 ÷ 3a ÷ 6) ______

    b. With countermeasure (11 ÷ 3b ÷ 6) ______

13. Revised entry time ______

14. Revised unsheltered dose for exposure period (repeat 11) ______

15. Revised dose to personnel during exposure period (repeat 12) ______

16. Final estimate of entry time ______

CALCULATION OF ENTRY TIME
(Estimating Form)

FOR ______________________________

1. Estimate of entry time:
   a. /_/ without countermeasure
   b. /_/ with countermeasure

2. Acceptable mission dose ______

3. Protection of working area
   a. Without countermeasure ______
   b. With countermeasure ______

4. Personnel exposure time ______

5. Total elapsed time during exposure period ______

6. Ratio of total elapsed time to personnel exposure time (5÷4) ______

7. Acceptable unsheltered dose during total elapsed time

   a. Without countermeasure (2 X 3a X 6) ______

   b. With countermeasure (2 X 3b X 6) ______

8. Average (midpoint) dose rate during exposure period (7a or 7b ÷ 5) ______

9. H-time at midpoint of exposure period (enter dose rate history curve at 8) ______

10. First estimate of entry time (9 - 1/2 of 5) ______

11. Estimated unsheltered dose for exposure period (from dose rate history curve) ______

12. Dose during exposure period

   a. Without countermeasure (11 ÷ 3a ÷ 6) ______

   b. With countermeasure (11 ÷ 3b ÷ 6) ______

13. Revised entry time ______

14. Revised unsheltered dose for exposure period (repeat 11) ______

15. Revised dose to personnel during exposure period (repeat 12) ______

16. Final estimate of entry time ______

ATTACHMENT E

CALCULATION OF ACCEPTABLE MISSION DOSE
(Estimating Form)

FOR ____

1. Protection factor of shelter ______________

2. Unsheltered dose during first month (estimated from dose rate history curve). ______________

3. Shelter dose during first month (Item 2 ÷ Item 1). ______________

4. Acceptable ERD dose during first month (command decision) ______________

5. Total exposure dose during first month (1.25 X Item 4). ______________

6. Total mission dose for first month (Item 5 - Item 3). ______________

7. Separate mission doses

   a. ____________ d. ____________

   b. ____________ e. ____________

   c. ____________ f. ____________

   g. Total (not to exceed Item 6) ____________

8. Calculation of ERD based on the expected exposure schedule (to be completed after an estimate of the entry time is made).

CALCULATION OF ENTRY TIME
(Estimating Form)

FOR ______________________________

1. Estimate of entry time:
   a. /__/ without countermeasure
   b. /__/ with countermeasure

2. Acceptable mission dose ______

3. Protection of working area
   a. Without countermeasure ______
   b. With countermeasure ______

4. Personnel exposure time ______

5. Total elapsed time during exposure period ______

6. Ratio of total elapsed time to personnel exposure time (5÷4) ______

7. Acceptable unsheltered dose during total elapsed time

   a. Without countermeasure (2 X 3a X 6) ______

   b. With countermeasure (2 X 3b X 6) ______

8. Average (midpoint) dose rate during exposure period (7a or 7b ÷ 5) ______

9. H-time at midpoint of exposure period (enter dose rate history curve at 8) ______

10. First estimate of entry time (9 - 1/2 of 5) ______

11. Estimated unsheltered dose for exposure period (from dose rate history curve) ______

12. Dose during exposure period

    a. Without countermeasure (11 ÷ 3a ÷ 6) ______

    b. With countermeasure (11 ÷ 3b ÷ 6) ______

13. Revised entry time ______

14. Revised unsheltered dose for exposure period (repeat 11) ______

15. Revised dose to personnel during exposure period (repeat 12) ______

16. Final estimate of entry time ______

ANSWERS TO REQUIREMENTS NO. 1 TO 7

ANSWERS to Requirement No. 1

FOR	Power Company personnel
Item 1	70
Item 2	10,700 r
Item 3	153 r
Item 4	150 r
Item 5	188 r
Item 6	35 r

ANSWERS to Requirement No. 2

FOR	Power company personnel
Item 1	Check "a"
Item 2	35 r
Item 3a	5
Item 3b	25
Item 4	112 hrs. (8 hrs/day X 7 days/week X 2 weeks)
Item 5	336 hrs. (24 hrs/day X 7 days X 2 weeks)
Item 6	3
Item 7a	525 r
Item 8	1.6 r/hr
Item 9	H + 560
Item 10	H + 392, or about H + 16.3 days
Item 11	580 r
Item 12a	39 r
Item 13	H + 18 days
Item 14	510 r
Item 15	34 r
Item 16	H + 18 days

ANSWERS to Requirement No. 3 (Item 8 - Acceptable Mission Dose form)

(a) Brief dose through H + 100 (about 4 days) = 8280 ÷ 70 = 118 r

(b) From H + 5 days to H + 19 days (H + 456) the <u>daily dose</u> varies from about 13 X 24 ÷ 70 = 4.5 r/day to about 2.2 X 24 ÷ 70 = .8 r/day, which averages about 2.7 r/day. Using the ERD Nomogram and aligning 118 r on the right with 2.7 r/day on the left, the ERD at 19 days is about 115 r.

(c) From H + 19 days (H + 456) to H + 33 days (H + 792) the equivalent PF for the facility personnel is:

$$\frac{1}{PF_e} = \frac{1}{24}\left(\frac{16}{70} + \frac{8}{5}\right) = \frac{1}{24}\left(\frac{16}{70} + \frac{112}{70}\right) = \frac{1}{24}\left(\frac{128}{70}\right) = \frac{128}{1680}$$

$$PF_e = \frac{1680}{128} = 13$$

(d) From H + 19 days (H + 456) to H + 33 days (H + 792) the <u>daily dose</u> varies from about 2.2 X 24 ÷ 13 = 4 r/day to 1 X 24 ÷ 13 = 1.9 r/day, which averages about 3 r/day. Using the ERD Nomogram and aligning 115 r at H + 19 days with 3 r/day on the left, the ERD at H + 33 days is about 120 r.

(e) By an inspection of the relationship between the straightedge and the family of ERD curves, the maximum ERD can be determined. For Requirement No. 3, the ERD would not have exceeded 125 r at the most. Thus, the entry time could have been revised to permit a 2- or 3-day earlier entry time. The exact time could be determined by an examination of the ERD Nomogram and the dose rate history curve.

(f) Generally, the calculation of the maximum ERD need not be this detailed. The detail was included in "a" through "e," above, for clarity.

ANSWERS to Requirement No. 4

FOR	Power Company personnel	Item 9	H + 165
Item 1	Check "b"	Item 10	H - 3 (a negative answer means entry can be made when decon is completed)
Item 2	35 r	Item 11	3000 r
Item 3a	5	Item 12b	40 r
Item 3b	25	Item 13	H + 3 days
Item 4	112 hrs.	Item 14	2300 r
Item 5	336 hrs.	Item 15	31 r
Item 6	3	Item 16	About H + 2.5 days
Item 7b	2625 r		
Item 8	7.8 r/hr		

ANSWERS to Requirement No. 5

FOR	Decon personnel	Item 5	188 r
Item 1	250	Item 6	145 r
Item 2	10,700 r	Item 7	
Item 3	43 r	Item 8	
Item 4	150 r		

ANSWERS to Requirement No. 6

FOR	Decon personnel		
Item 1	Check "a"	Item 9	H + 70
Item 2	145 r	Item 10	H + 67
Item 3a	1	Item 11	144 r
Item 4	6	Item 12a	144 r
Item 5	6	Item 13	-
Item 6	1	Item 14	
Item 7a	145 r	Item 15	
Item 8	24 r/hr	Item 16	H + 67

ANSWERS to Requirement No. 7 (Item 8 - Acceptable Mission Dose form)

(a) Dose through H + 67 = 7600 ÷ 250 = 30 r

(b) Dose from H + 67 to H + 73 = 145 r

(c) Dose from H + 73 to H + 96 (H + 4 days) = 460 ÷ 250 = about 2 r

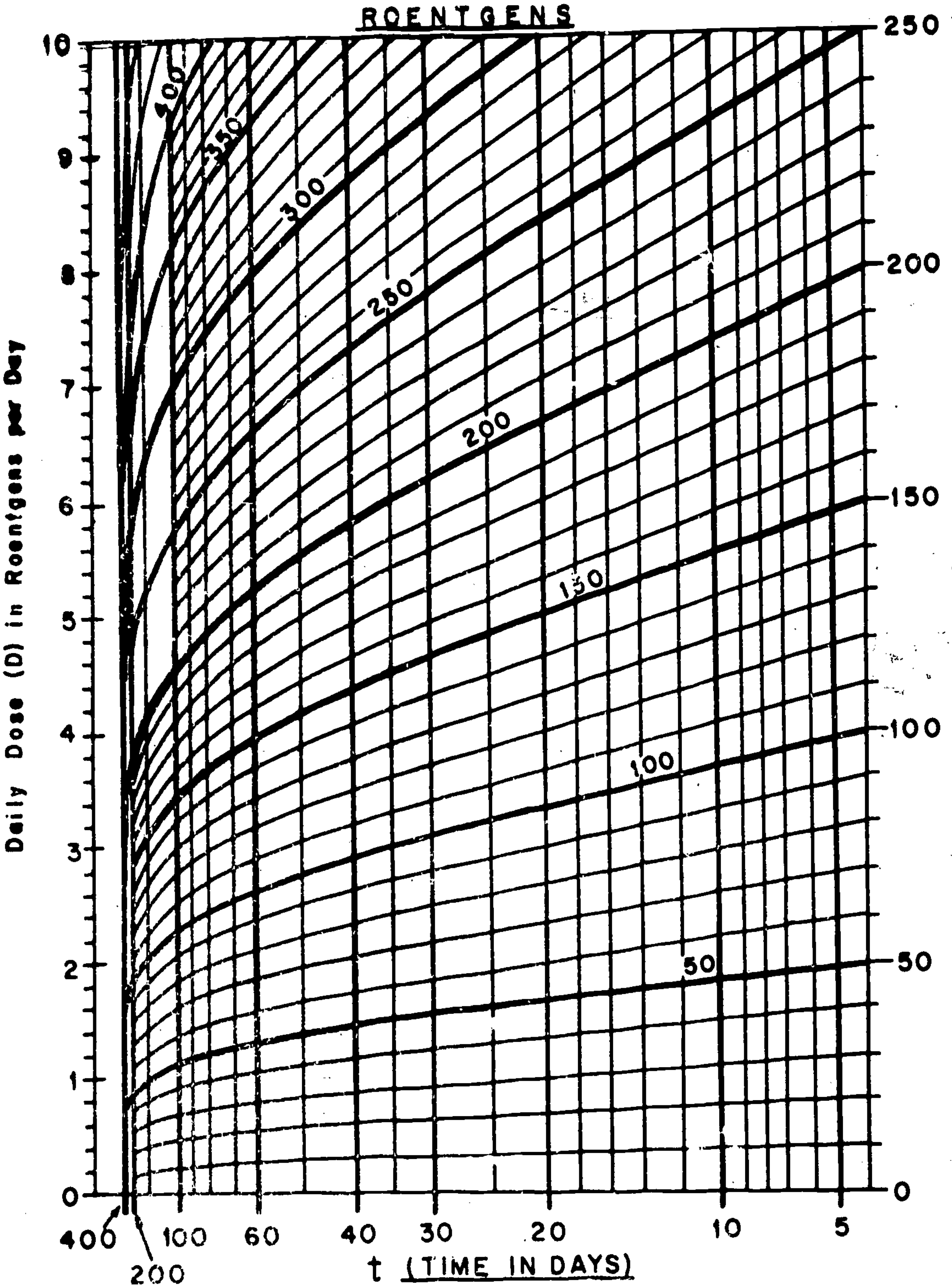
(d) Brief dose through H + 4 days = 30 + 145 + 2 = 177 r

(e) Since there is no biological repair during the first four days, this dose obviously exceeds the acceptable limit of 150 r.

(f) Without conducting the decontamination, the brief dose at H + 4 days is 8280 ÷ 250 = 33 r. It can be seen from the Nomogram that it would take about 100 days to repair the 33 r exposure to an ERD of 5 r (150 r - 145 r) even if the daily dose was zero. Since the daily dose at H + 4 days is about 13 X 24 ÷ 250 = 1.3 r/day, no decon can begin during the first month, unless the exposure criteria is changed.

(g) However, since the exposure is less than 200 r at H + 4 days (actually 177 r), it would not be unreasonable to allow the decon at about H + 3 days to H + 4 days.

EQUIVALENT RESIDUAL DOSE



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TITLE: Monitoring Operations

COURSE: Radiological Defense Officer

FOR USE IN THE SESSION: Planning and Directing Monitoring Operations

REMARKS: Study this Brief and be prepared to present your recommendations for each requirement to a discussion group of about four people. Each group will be responsible for completing all requirements and reporting on at least one requirement to the rest of the class.

It is important that you complete your recommendations before class. Class time for the individual group discussions will be limited to resolving differences in student recommendations. There will not be sufficient time for lengthy consideration of each requirement.

CONTENTS

SITUATION

The people in City KXE have taken shelter after a nuclear attack on a city to the west. Seventy percent of the fallout monitoring stations in the city are operating with communications and control from the Emergency Operating Center located in the basement of the City Hall. All monitoring stations are manned by at least three men and have a minimum protection factor of 100. Ninety percent of the population is in community shelters (PF = 40 - 500). The remaining people are in home basements having protection factors of only about 10. The employees of the United Manufacturing Company are not located in any special shelter. They live in areas randomly scattered throughout the city.

You are the Radef Officer for the community and have been informed by the civil defense director that it is necessary to reactivate the United Manufacturing Company plant (Avg. PF = 30) as soon as possible. Three semi-trucks from the motor freight terminals (Avg. PF = 5) will be used to transport urgently needed products from the United Manufacturing Company plant to City KUE. He has also requested that people be allowed to return home as soon as practicable.

On the map of City KXE, community shelters are identified by the numbers 10 through 25. Operating monitoring stations are lettered A through X, and are also established at public shelters 10, 16, 18, 19, and 23. On the sub-state area map, airports are located in cities KWP and KUE. The Civil Air Patrol has developed an aerial monitoring capability at each of these airports. State police posts are located at KWP, KXE, 1KXT, and KUE. The State police post in City KXE (monitoring station T) is part of the State radiological monitoring net.

Requirement No. 1

It is now H + 3 days. The average accumulated unsheltered dose on the east side of KXE is about 4000 r, and on the west side about 4500 r. A dose rate history curve for fallout monitoring station 18K indicates the current dose rate at that station is 17 r/hr.

Outline your actions to provide for all of the monitoring required to support reactivation of the United Manufacturing Company and the shipment of products from KXE to KUE. Make any additional assumptions not given in the general situation to meet this requirement. Your outline should include the types of monitoring to be used; the number and source of monitors; where monitoring is required; when it should begin; exposure criteria; and transporting vehicles and reassignment of monitors from one station or shelter to another, if required. You are not required to plan the reactivation of the plant. You are only required to plan the monitoring necessary to support the reactivation. Draft typical messages required to implement your plan

NOTE: The real urgency for the recovery of the United Manufacturing Company cannot be determined until postattack. Thus, it is difficult to establish exposure criteria for this problem. However, one of the important elements in the exercise is to identify some exposure criteria and schedule activities consistent with this criteria.

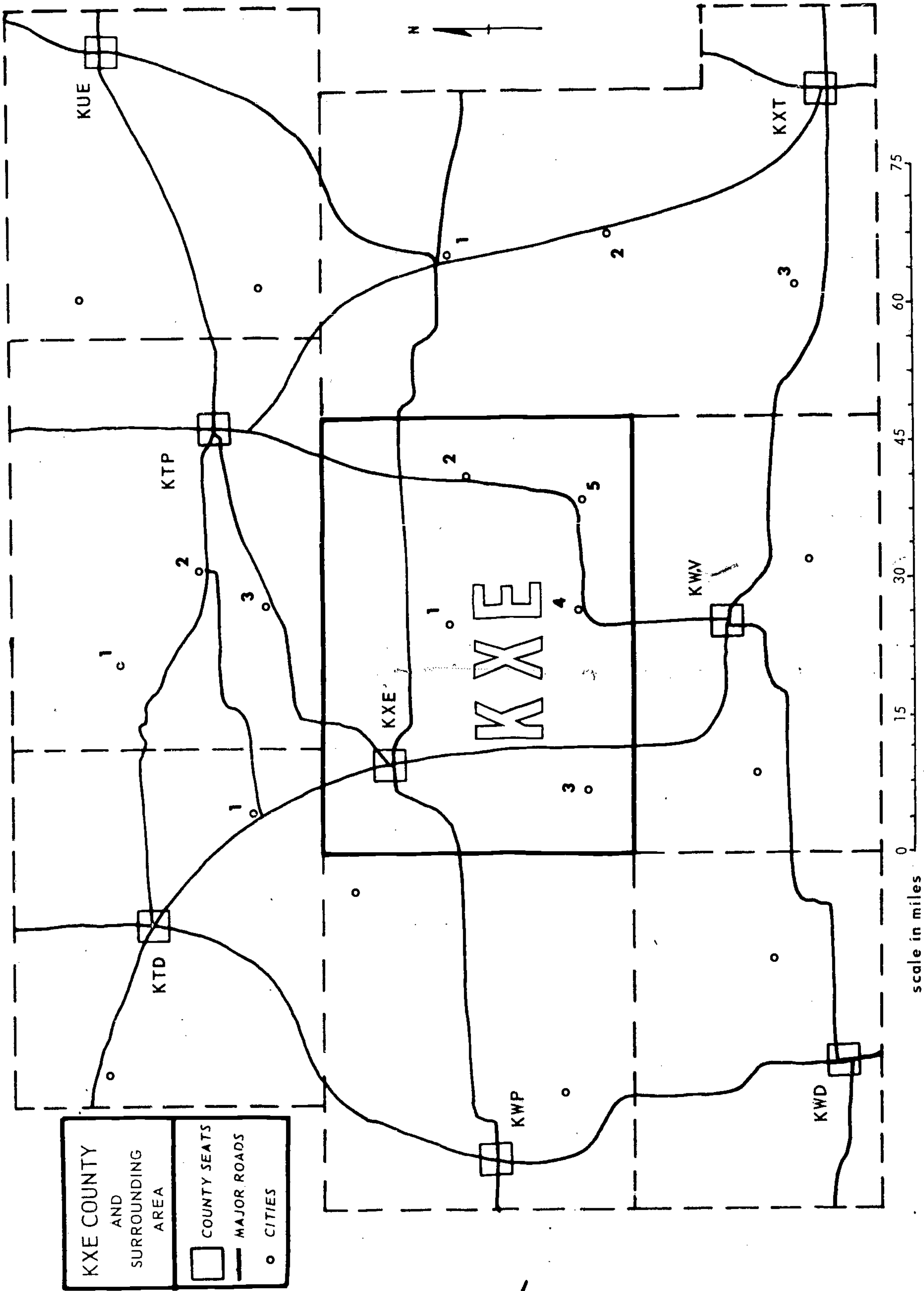
Requirement No. 2

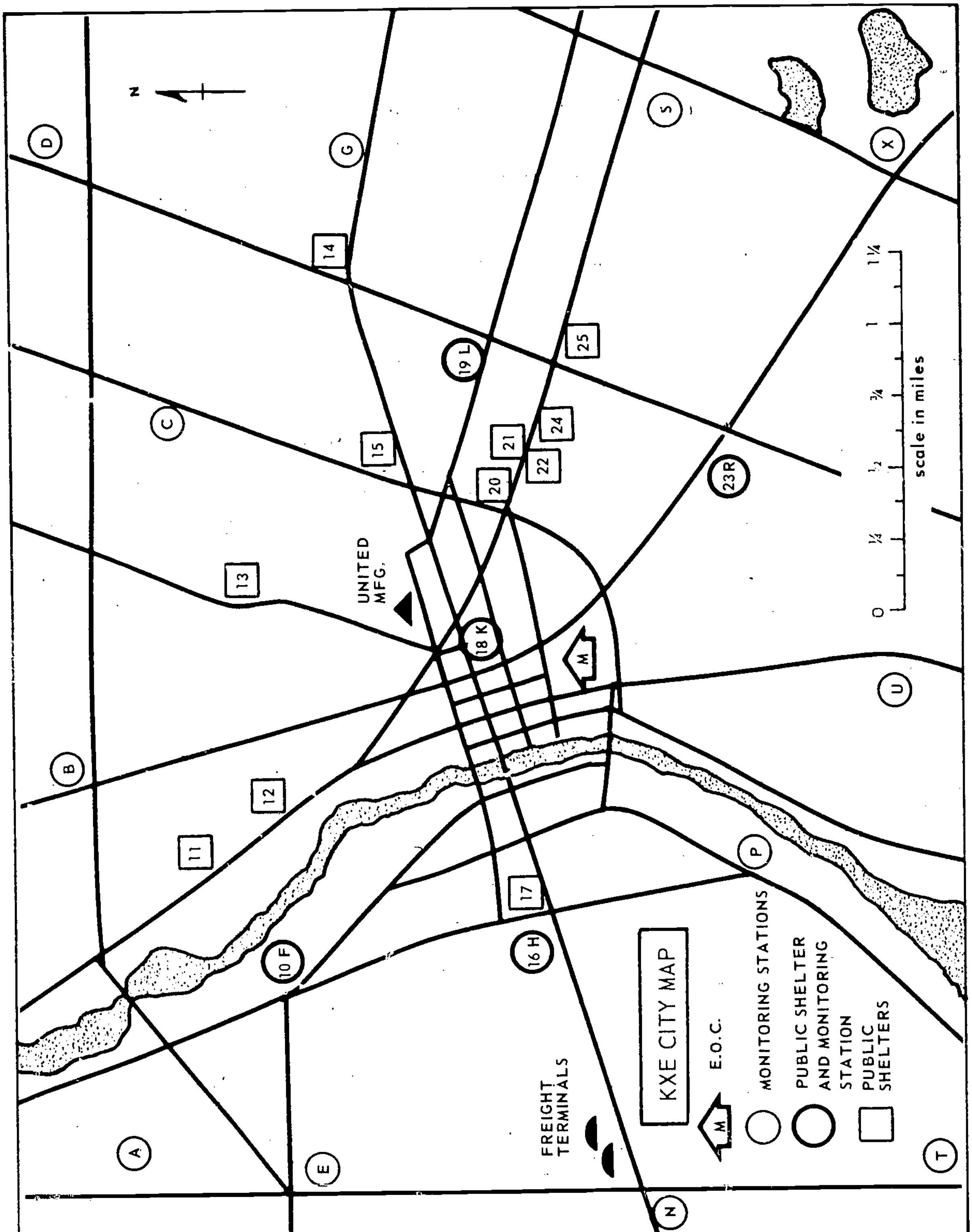
It is now H + 4 days. All counties in the area, except counties KWV and KXT, have been operating with 60% - 80% of their planned monitoring capability. County KWV has only 10% of its monitoring system in operation, and county KXT has virtually no monitoring capability. Your civil defense director has been requested by State civil defense to arrange for and coordinate an aerial survey of counties KWV and KXT to determine the extent of the fallout hazard in these counties. Outline the required activities for conducting an aerial survey of the two counties. Draft typical messages required to implement the aerial survey.

Requirement No. 3

It is now H + 7 days. No new fallout has occurred. Dose rates have continued to decrease at the same rate. Outline a plan for any necessary monitoring of City KXE in preparation for additional recovery activities, and for the return of the population to their homes as soon as possible.

ATTACHMENT A




KXE CITY MAP
E.O.C.
MONITORING STATIONS
PUBLIC SHELTER AND MONITORING STATION
PUBLIC SHELTERS
FREIGHT TERMINALS
UNITED MFG.
N
scale in miles
0
1/4
1/2
3/4
1
1 1/4
A
B
C
D
E
G
N
P
S
T
U
X
10 F
16 H
18 K
19 L
23R
M
11
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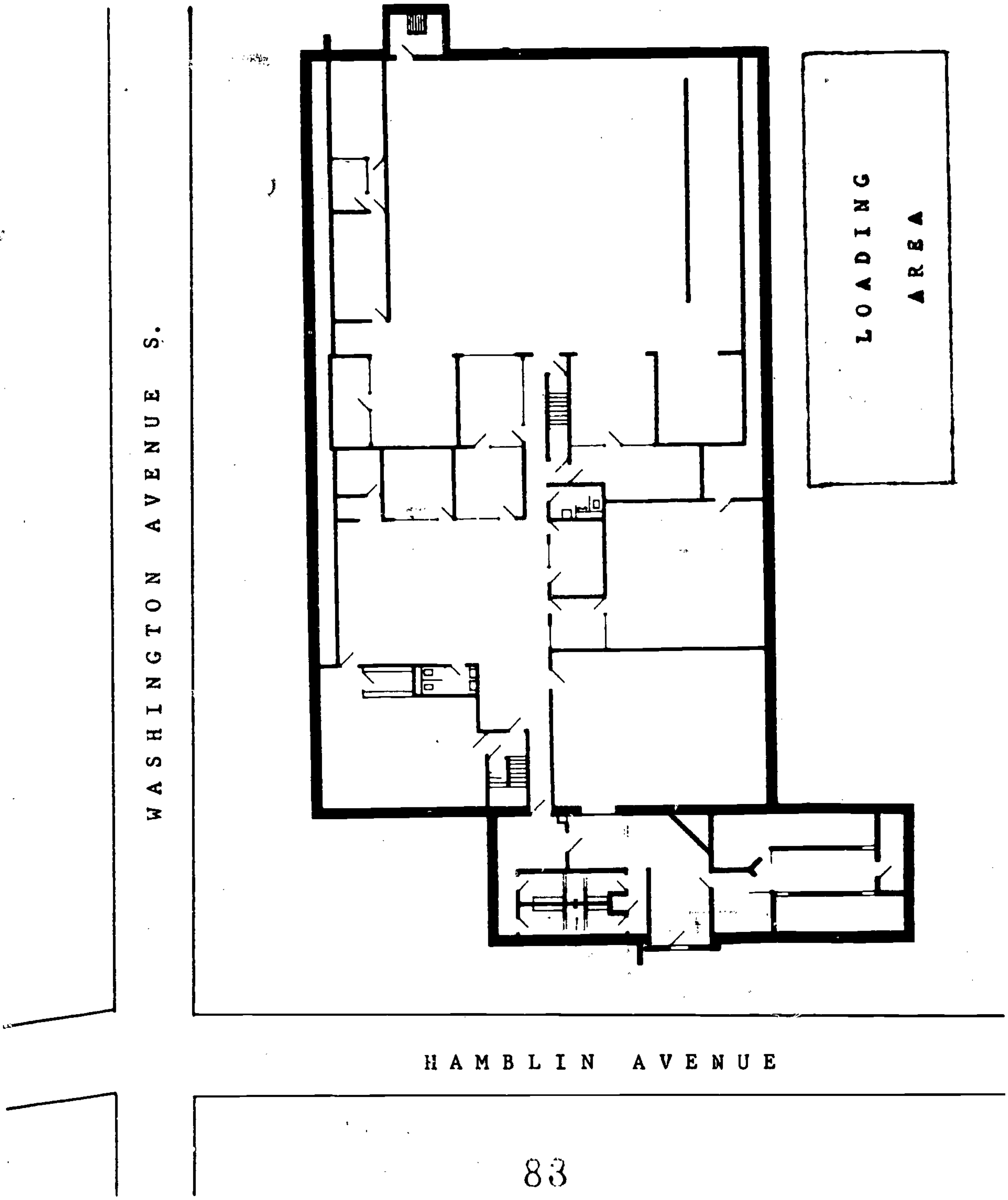
6-7/6-8

ATTACHMENT C

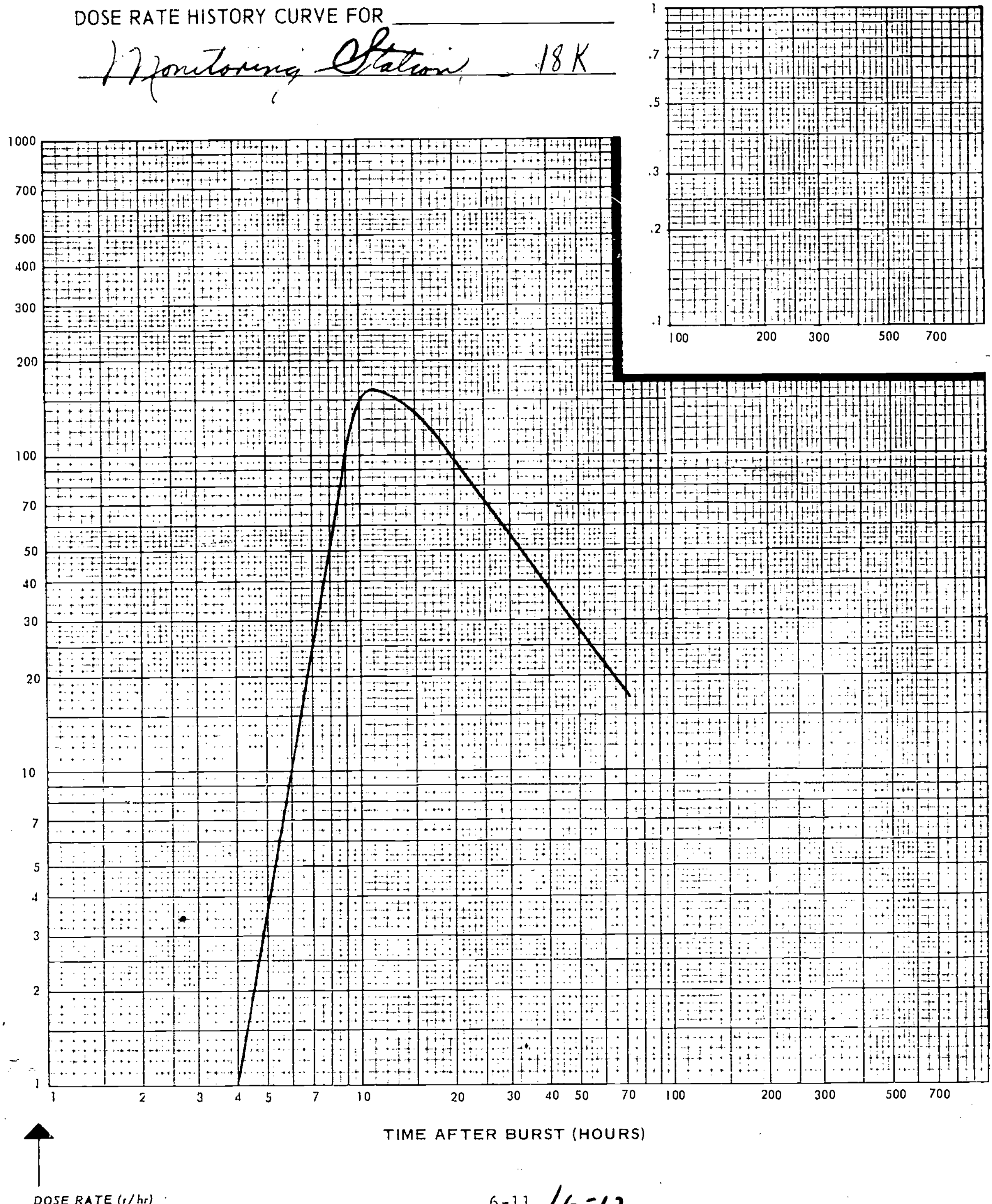
Sketch of

UNITED MANUFACTURING COMPANY

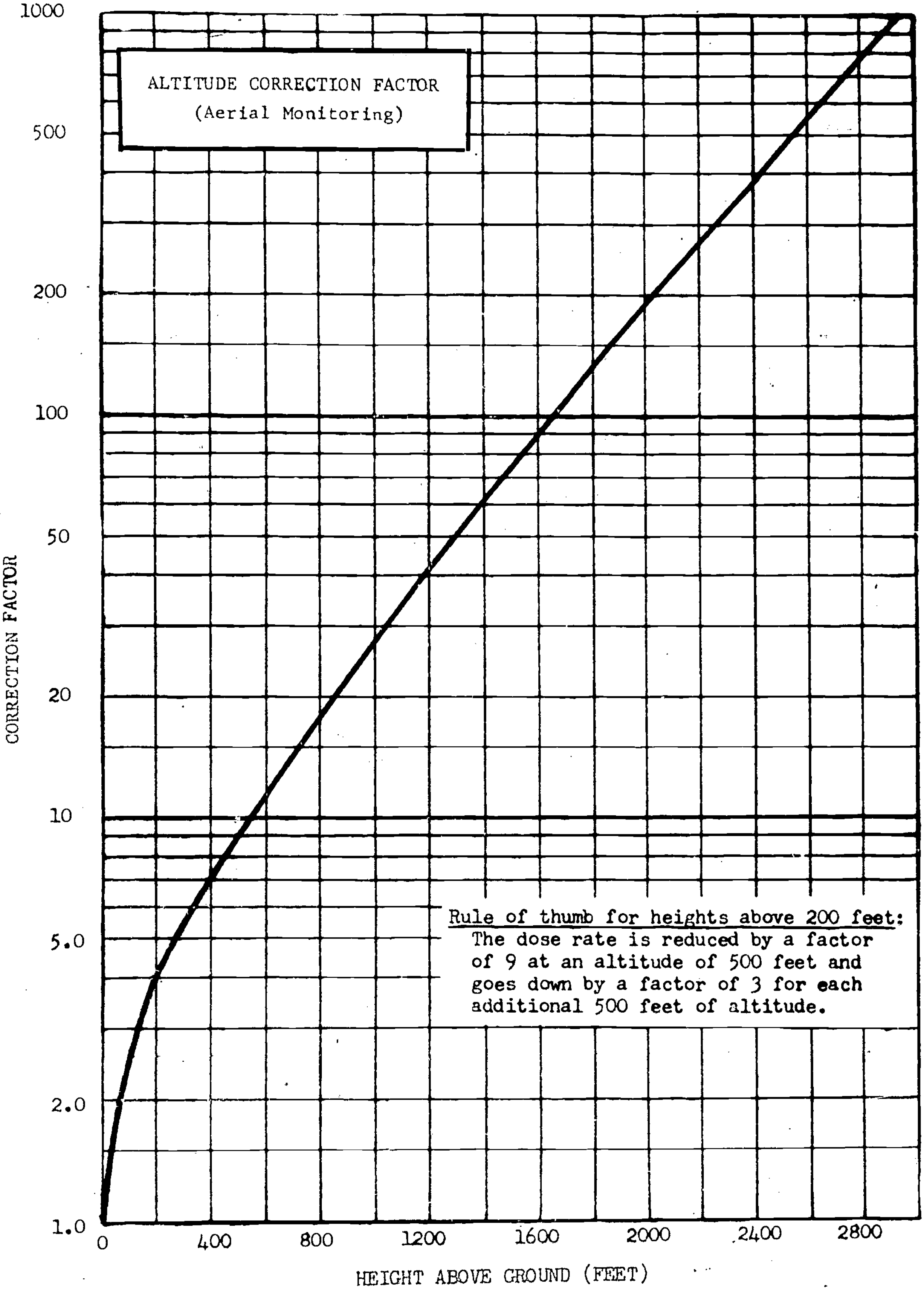


ATTACHMENT D

DOSE RATE HISTORY CURVE FOR Monitoring Station 18K



6-11 /6-12


ALTITUDE CORRECTION FACTOR
(Aerial Monitoring)
1000
500
200
100
50
20
10
5.0
2.0
1.0
CORRECTION FACTOR
0
400
800
1200
1600
2000
2400
2800
HEIGHT ABOVE GROUND (FEET)
Rule of thumb for heights above 200 feet:
The dose rate is reduced by a factor of 9 at an altitude of 500 feet and goes down by a factor of 3 for each additional 500 feet of altitude.

TITLE: Decontamination

COURSE: Radiological Defense Officer

FOR USE IN THE SESSION: Postattack Recovery Measures

REMARKS: Requirements No. 1, 2, 4 and 5 will be completed in class. Requirements No. 3 and 6 are provided as practice problems for completion after the class period on Postattack Recovery Measures. DO NOT complete any of the requirements before class.

The answers to each requirement are provided in Attachment E. Please do NOT review these answers before completing the requirements, otherwise much of the teaching value of each requirement may be lost.

C O N T E N T S

DISCUSSION

Radiological decontamination is the central countermeasure of the operational recovery period. It is defined as the reduction or removal of contaminating radioactive material from a structure, area, object, or person. Radioactivity cannot be destroyed, but in the event of nuclear attack, the fallout radiation hazard could be reduced (a) by removing radioactive particles from a contaminated surface and safely disposing of them, (b) by covering the contaminated surface with shielding material, such as earth, or (c) by isolating a contaminated object and waiting for the radiation from it to decrease through the process of radioactive decay.

Decontamination may be partial or complete. Partial decontamination usually involves the rapid, partial removal or covering of contamination to reduce the radiation dose rate as quickly as practicable and to a point where priority work can be accomplished with reasonable safety. Complete decontamination would be accomplished subsequently as required to further reduce the radiation hazard.

Decontamination is a recovery countermeasure to be used postattack. It is not a substitute for adequate fallout shelters. Generally, decontamination would be used on vital areas and facilities to allow early availability and utilization of important survival resources, such as public utilities (i.e., electric power, water, gas and communications); food distribution and processing facilities; medical facilities and distribution points; vital industries; and to allow earlier emergence from shelter. The area or facility must be essential to some function that is vital in the postattack period, and must be necessary at a time after attack when serious contamination would result in unacceptable radiation exposures.

It would be impossible to accomplish all the decontamination that might be desired in a postattack situation. Personnel responsible for shelter operation, public services, health, welfare, transportation, food distribution, food processing, key industrial production, etc., would all present heavy demands for decontamination services. The total demand would probably far exceed the capability.

It is, therefore, necessary that there be a practical system for (a) preattack evaluation of potential decontamination requirements, (b) estimation of the resultant demands for equipment, skilled operators, general labor, water, fuel for motorized equipment, etc., (c) estimation of the probable postattack availability of equipment, manpower, water, fuel, etc., (d) evaluation of the potential over-all effectiveness by various decontamination methods, (e) evaluation of the feasibility of employing other countermeasures to meet some requirements, and (f) establishment of orders of priority for decontamination.

In order to develop this decontamination capability, it is necessary that the Radef Officer be aware of (a) the methods of decontamination and the factors influencing their application, (b) the preattack planning requirements, and (c) the concept of postattack operations.

Decontamination Methods and Equipment The types of equipment and skills required for radiological decontamination are not new. Ordinary equipment now available, such as firehoses, street sweepers, and bulldozers, and the skills normally used in operating this equipment are the basic requirements for decontamination. The choice of method will depend upon the type and extent of contamination, type of surface contaminated, the weather, and the availability of personnel, material and equipment.

The efficiency of each method is expressed as a decontamination factor (DF), which is defined as the decimal fraction of the contaminant, or the radiation from it, that remains after decontamination. The more effective the decontamination, the smaller the DF. Thus, whereas, the protection afforded by a shelter increases as the protection factor increases, the advantages of decontamination increase as the decontamination factor decreases.

Because part of the radiation contribution to the dose rate at a given location comes from beyond a given distance, the dose rate will normally not decrease in direct proportion to the decontamination factor. For example, if a DF of .1 is realized in decontaminating a 50 ft. circle, the dose rate would be reduced to 50% + (.1 X 50%) = 55% of the initial value.

Because of the contributions from great distances, buffer zones are usually required when decontaminating a facility for the purpose of reducing the gamma dose rate entering the working area from the surrounding unreclaimed area. A typical buffer zone distance may be about 200 ft., although this distance may vary considerably as combinations of alternatives (e.g., earth dikes) are used.

Tables 1 through 4, in Attachment A, indicate the effectiveness of various decontamination methods applied to specific surfaces. The effectiveness is expressed in terms of a "decontamination factor" (DF). These DF's are based on data compiled from field tests, performed by military organizations under contracts for the Office of Civil Defense.

Where sufficient data are available, the efficiencies for various rates of operation are provided. The tables show the effort in terms of man-hours per 1000 sq. ft.; the decontamination factor (the fraction remaining); and rate in terms of area decontaminated per team hour. Where efficiencies for various rates of operation are shown, any lower rates would not materially increase the decontamination factors, and any higher rates would decrease the DF's rapidly. The tables make some allowance for normal equipment set-up time and for short rest periods. Time required to move equipment and personnel from one decontamination site to the next is not included. Travel time to and from the dump sites when the method requires removal of soil is not included in the data. Tables 5 and 6 are provided as guides for the selection of various decontamination methods.

Preattack Planning Preattack planning and preparation are required in order that decontamination operations can be carried out quickly and effectively, with minimum exposure to decontamination personnel. In preattack planning, plans for government and private organizations should be coordinated with the State and local civil defense plans. Decontamination workers, such as firemen, sanitation and construction workers, and their augmented forces should be trained and assigned to perform the basic decontamination functions. The personnel should be organized so that there will be a capability for any type of decontamination likely to be needed within areas of potential need. Personnel should know the safety rules and procedures so that they will avoid needless entry into hazardous areas.

A means of measuring radiation dose rates and accumulated doses should be provided, and individual radiation exposures should be recorded. Personnel should be instructed concerning the wearing and reading of dosimeters, the allowable dose for the mission, and reporting of the mission dose. The person in direct charge of a decontamination operation should examine the exposure records of the decontamination personnel to assure that the calculated mission dose will not cause any individual to receive a total dose in excess of established standards.

Local officials are responsible for suitable recovery plans based upon a detailed analysis and evaluation of their area situations. The preparation of such plans will require the following: (a) a list, in the order of recovery priority, of structures and areas likely to require decontamination, (b) a list of available equipment, manpower and supplies required for decontamination, and (c) the preparation of recovery plans for each area or structure.

In developing a list of structures and areas which are likely to require decontamination, the following criteria should be considered: (a) the structure or area must be essential to some function that is vital in the postattack period, and (b) the function must be necessary at a time when decontamination can be beneficial. Vital areas or facilities which may require decontamination are public utilities, i.e., electric power, water, gas and communications; food distribution and processing facilities, medical facilities and supply warehouses; and fuel supplies within the area. Important access roads that might require decontamination should be listed.

A survey should be made of the equipment that will be available for decontamination operations. This should include municipally owned and privately owned equipment. Each type of equipment should be tabulated, such as bulldozers, trucks, street sweepers, street flushers, etc. The general location of this equipment should be recorded. In addition, a survey of experienced equipment operators within a municipality should be accomplished. The Corps of Engineers is conducting a nationwide survey of the availability of heavy equipment and this information will be made available in the near future.

Recovery plans should be prepared for each area or structure and staging areas that will be used as a basis for recovery operations. Such information would include (a) details of the facility including the size of the structure and type of roof surface, (b) the type of surfaces, or existing buildings surrounding the area or facility, (c) the radiation sources contributing to the area of concern in the facility, (d) the most effective and feasible decontamination methods to be applied to the roof of the structure and surrounding areas of the facility, (e) an estimate of the reduction factor to the area of concern in the facility, upon completion of decontamination of the various surfaces, and (f) the logistics required for the decontamination of areas to be decontaminated, i.e., equipment, man-hours, fuel, water, etc.

In making plans to decontaminate a vital facility or area, consideration should be given to (a) a suitable staging area, (b) availability of water near the facility for decontamination and the proper drainage of water from the area, and (c) the proper disposal of radioactive waste.

The term "staging area" is any area serving as a base for decontamination operations. When an area is heavily contaminated and recovery is to be accomplished from outside the area, the term may apply to an extensive temporary base of operations close enough for effective operations. When decontamination is to be effected from within a contaminated area, the term "staging area" may apply to a single site within the area, the vital facility itself, or to a combination of several sites such as fire stations, city garages and street and road maintenance depots.

The services required for decontamination of the facility should be checked. Fire hydrants located near the facility, capacity of the water main, and the pressure should also be checked. Proper drainage of water from the roof of the vital facility and from the paved areas surrounding the facility should be checked for adequacy of the large quantities of water to be used. Since firehosing and flushing are methods used in decontamination of structures and paved areas, proper drainage will reduce the amount of time required for application of these methods.

Access to the roof of the critical facility should be checked if decontamination is to be accomplished with personnel on the roof. In case roofs are so steep that it is dangerous or difficult for personnel to work on them, the feasibility of decontaminating these roofs by the "lobbing" technique should be considered. This technique involves lobbing the water onto the roof from the ground.

Some land areas will be unpaved. Low areas that will create puddles should be avoided since wet soil will hinder earthmoving equipment or the plowing of the unpaved areas. Provisions should be made for the proper drainage of water from all areas surrounding the facility.

Provision should be made for the disposal of radioactive waste. Waste material carried by hosing or flushing procedures usually will be drained by existing storm sewers. Where storm sewers do not exist, the area should be drained into large natural or man-made sumps. These sumps should be far enough away from essential facilities so that they will not create a radiation hazard. If the sumps are dug with earthmoving equipment, the earth material should be kept close by so that the sump can be backfilled upon completion of decontamination. These sumps should then be checked and appropriate radiological contamination markers posted.

In decontaminating unpaved land areas when scraping is to be used, appropriate dump sites should be selected for dumping the contaminated material. The contaminated material should be deposited in a dump site 100 feet or more beyond the scraped area. At a later period, the contaminated material should be stabilized to prevent scattering due to weather. Appropriate radiological safety signs should be posted around such areas.

<u>Postattack Operations</u> The decision to recover specific facilities will be the responsibility of the civil defense director. He will be assisted by his staff, including the Radef Officer, in making such decisions. Priorities must be established since it is unlikely that all of the decontamination that may be desired can be accomplished. The Radef Officer will reevaluate the validity of planned operations for each facility. He will determine when operations at each facility can begin under the existing radiation conditions without the employment of countermeasures, and again with specific countermeasures. If decontamination is appropriate, he will determine when decontamination can begin under the prevailing conditions. The Radef Officer will determine the specific decontamination methods to be used and the personnel, equipment and resources required.

Emergency service personnel, such as public works personnel, firemen, sanitation and construction workers, industrial services and their augmenting forces, and the necessary equipment and resources will be committed by the civil defense director. These personnel will have been drilled in the utilization of their specialized skills and equipment in decontamination operations.

The emergency service personnel will be under the direct supervision of their normal field supervisors, who in turn will take direction from the chiefs of their respective services. It will be desirable, when several services are jointly decontaminating a facility, to designate one individual as a field supervisor to coordinate all on-site activities. The Radef Officer will coordinate decontamination requirements and operations among the service chiefs. He will also provide technical direction for field operations, and guidance and direction in the control of radiation exposures of field personnel.

<u>Decon Calculations</u> The degree of protection afforded by a facility is expressed as a protection factor (PF). For convenience of calculation, the reciprocal of the PF, called the "reduction factor," is used. Reduction factors, expressed as decimals, can be added when combining roof and ground contributions to the dose rate at a particular location as follows:

a.	Roof contribution	=	.015
b.	Ground contribution	=	.010
c.	Total reduction factor	=	.025
d.	Protection factor	=	1 + .025 = 40

Roof and ground contributions for buildings included in the National Fallout Shelter Survey (NFSS) are given in the Phase I printouts. This data is in the possession of the local civil defense director. A sample Phase I Printout is included as Attachment B. For each story of a surveyed facility, the printout provides the roof contribution (CL), the contribution for each side (A, B, C, D, lettered clockwise from the address side of the facility) and the total contribution. A decimal point and a zero have been dropped from the printout, thus, 04 represents a reduction factor of .004. Sometimes the total contribution is different than the sum of the individual contributions because the computer carries one more significant figure than is included on the printout.

The printout figures are useful in the decon analysis of a particular facility in that they identify the main sources of radiation contribution. For example, if the reduction factors are 00 01 06 00 04, the greatest benefit will be derived from decontaminating the area opposite side C and decontaminating the roof. It does no good to decontaminate a given surface area, unless the ground contribution through the given wall is significant relative to the other walls and the ceiling.

If a particular facility was not included in the NFSS, other sources of reduction factors are available. A facility may be eligible for inclusion in the National Survey Updating Program. If this is not practicable, rosters of architects and engineers trained in shielding analysis techniques are available either from the local or the State civil defense office. It may be possible to make arrangements for a special analysis by one of these persons.

Decontamination factors can be used in conjunction with reduction factors for determining revised protection factors after decontamination. Roof decontamination might revise the PF as follows:

a.	Ground contribution	=	.010
b.	Roof contribution	=	.015
c.	DF for roof decon	=	.04
d.	Revised roof contribution	=	.04 X .015 = .0006
e.	Revised total reduction factor	=	.010 + .0006 = .0106
f.	Revised protection factor(PF)	=	1 ÷ .0106 = 95

Before ground contributions can be revised to reflect the decon of surface areas, it is necessary to now know the percentage of radiation contribution from various distances around a facility. Attachment D shows the reduction in dose rate versus the radius of a decontaminated circle. From the graph it can be seen that the reduction in dose rate three feet above the center of a completely decontaminated 200 ft. circle is about .25. This means that 25% of the radiation contribution comes from beyond 200 ft., while 75% comes from within 200 ft. These values are for an infinitely contaminated smooth plane. As the surface becomes less smooth, a greater percentage of the radiation contribution comes from within a given distance.

Decontamination factors can be used in conjunction with reduction factors for determining ground contribution as follows:

a.	Roof contribution	=	.015
b.	Ground contribution	=	.010
c.	Contribution from contamination beyond 200 ft. (See Attachment D)	=	0.25

d. DF for decon of surface out to 200 ft. = 0.1
e. New ground contribution within 200 ft. = .010 X 0.1 X 0.75 = .00075
f. Ground contribution beyond 200 ft. = .010 X .25 = .0025
g. New total ground contribution = .00075 + .0025 = .0033
h. Revised total reduction factor = .003 + .015 = .0183
i. Revised protection factor = 1 + .0183 = 55

If several decon methods are used on surfaces around a facility, a "weighted DF" should be used in Item 8d, above. This weighted DF is determined by multiplying each DF by the ratio of its area to the total buffer zone area and summing these products.

The reduction in roof and ground contribution can be determined from the revised reduction factors as follows: (Continuing with problem from 6 and 8, above)

a. New roof contribution = .0006
b. New ground contribution = .0033
c. Revised total reduction factor = .0006 + .0033 = .0039
d. Revised protection factor = 1 ÷ .0039 = 250

It should be recognized that the ground contribution of .010 in the above examples is the total of the contributions through each wall; i.e., the total of the A, B, C, D contributions in the Phase I printout. The calculations in 8, above, are valid only if the contribution through each wall is about the same and the decon factor used is appropriate for the decontamination opposite each wall. Such calculations are of a general simplified nature and provide order of magnitude estimates only. More detailed calculations are required to correct individual side contributions for different decon methods. These calculations are beyond the scope of this course. Guidance for such calculations will be published in the future in FG-E-7.2.

<u>Requirement No. 1</u>

From an inspection of the site plans and NFSS Phase I Printout data, in Attachment C, determine for each story the major source(s) of the radiation contribution. For each story determine the areas where decontamination would be most beneficial.

Requirement No. 2

The roof contribution for a particular building is .020 and the total ground contribution is .030. If a 100 ft. buffer zone is decontaminated with a DF of .2, and the roof is decontaminated with a DF of .05, what is the revised protection factor of the facility?

a. Roof contribution =

b. Ground contribution =

c. Total contribution (reduction factor) =

d. PF =

e. DF for roof decon =

f. DF for ground decon =

g. Contribution from contamination beyond_______ft. =

h. Revised roof contribution =

i. Revised ground contribution within _______ft. =

j. Ground contribution beyond ________ ft. =

k. Revised total ground contribution =

l. Revised total contribution (reduction factor) =

m. Revised PF =

Requirement No. 3 (Homework practice problem)

The Phase I Printout data for a facility is as follows:

STORY	A	B	C	D	CL	TOT
1	11	09	11	09	22	62

If the composition shingle roof is firehosed at a rate of 12,000 sq. ft./hr. and a buffer zone of 150 ft. width is scraped at a rate of 9000 sq. ft./hr., what is the revised PF of the facility? (See Attachment A for expected DF's).

a. Roof contribution =

b. Ground contribution =

c. Total contribution (reduction factor) =

d. PF =

e. DF for roof decon =

f. DF for ground decon =

g. Contribution from contamination beyond ________ ft. =

h. Revised roof contribution =

i. Revised ground contribution within ________ft. =

j. Ground contribution beyond ________ ft. =

k. Revised total ground contribution =

l. Revised total contribution (reduction factor) =

m. Revised PF =

Requirement No. 4

Using Attachment A, determine how many men are needed on a firehose team (1) for decontamination of pavements, and (2) for decontamination of tar and gravel roofs. How many men are required for mechanical street sweeping decon operations?

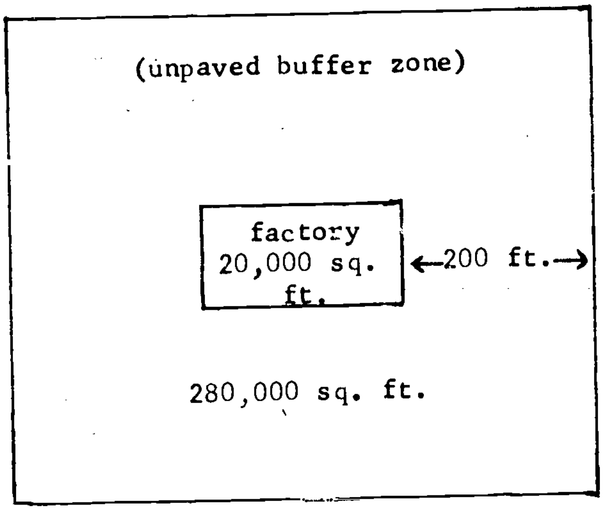
a. Firehose team (pavements)

b. Firehose team (tar and gravel roofs)

c. Street sweeping team

Requirement No. 5

The Radef Officer is considering the use of decontamination in order to reactivate the Baker Manufacturing Company (PF = 20) as soon as possible. This will require firehosing the 20,000 sq. ft. tar and gravel roof and plowing a 200 ft. wide buffer zone around the factory. One firehose team and two operators with tractors and plows are available. A sketch of the area follows:



Determine the manpower requirements for the decon of the facility. Determine how long it will take to decon the facility with the equipment available. Of what value is the manpower requirement figure?

a. Roof decon

1. Method =

2. Rate =

3. Time =

4. Manpower requirements =

b. Ground decon

1. Method =

2. Rate =

3. Time =

4. Manpower requirements =

c. Total decon effort

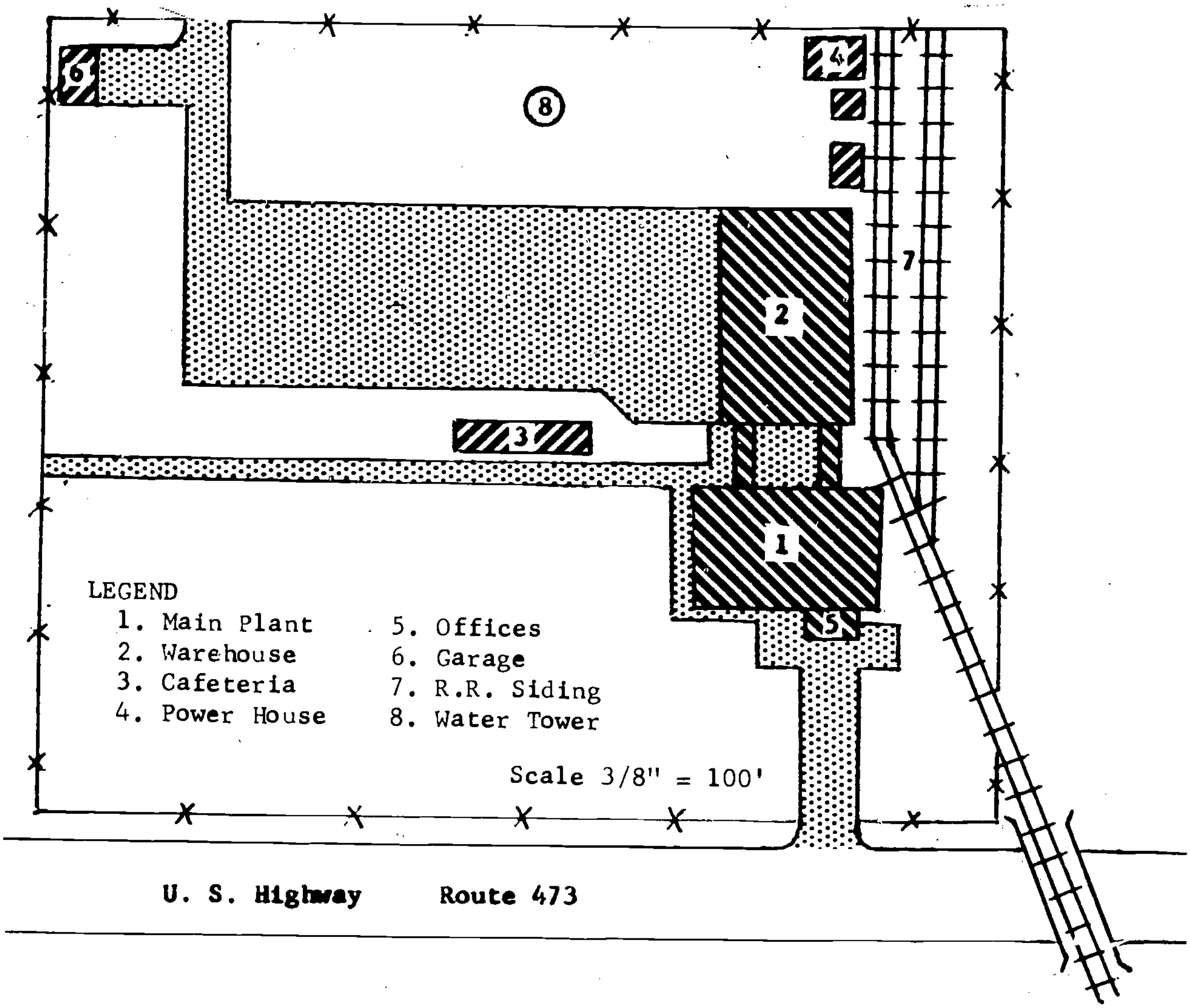
1. Manpower requirements =

2. Time =

d. Value of manpower requirements figure:

Requirement No. 6 (Homework practice problem)

The Continental Manufacturing Company is considered a vital facility. A sketch of the facility follows:



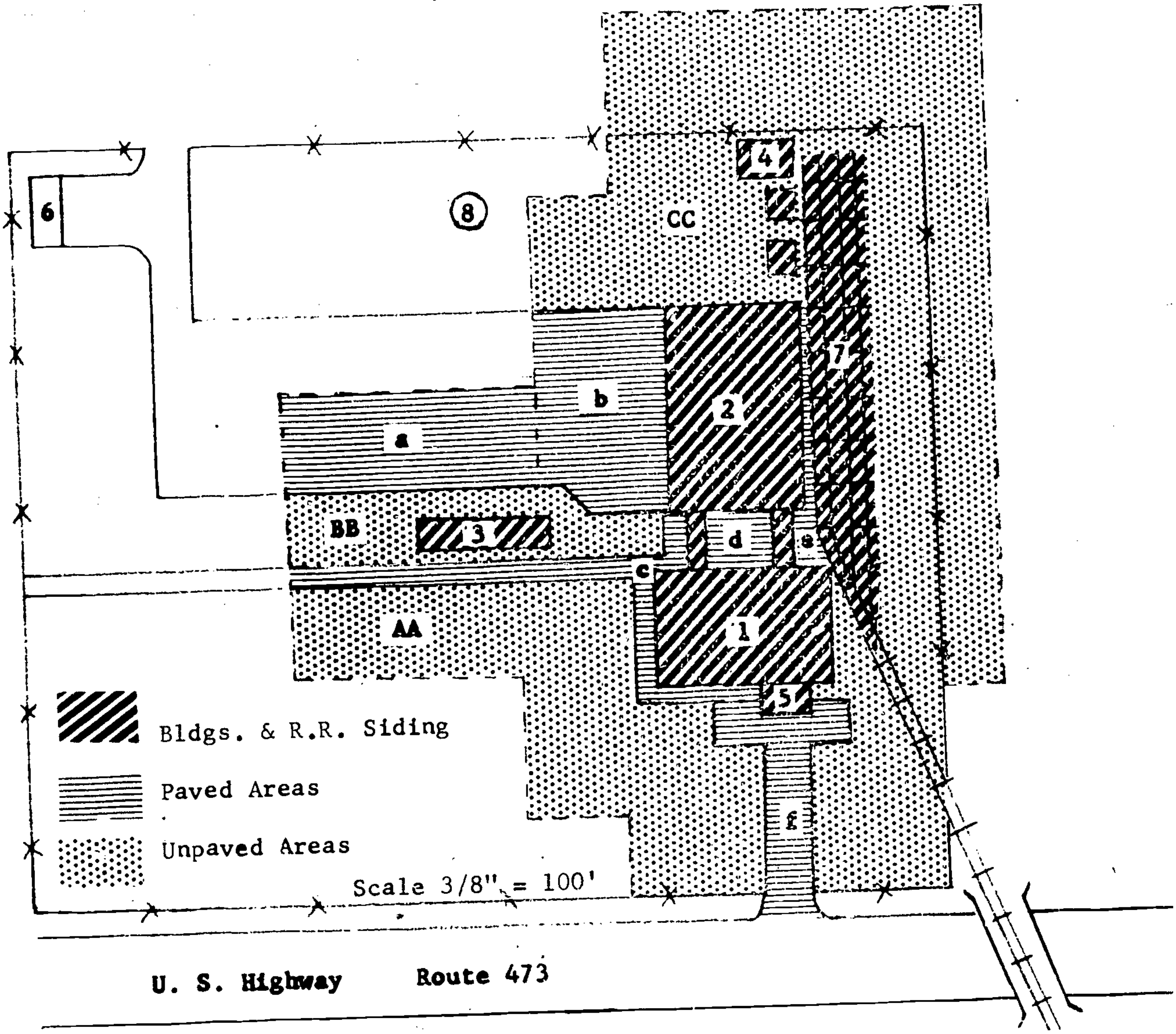
The equipment available for decon includes 2 motorized scrapers, 2 plows and tractors, 1 mechanical street sweeper, and 2 units of firehose equipment. The buildings have tar and gravel roofs. Twelve men are available with an operations capability for all equipment. Outline a plan for the decon of the facility, and determine how long it will require to complete the task. The following sketch outlines a buffer zone of 200 ft. surrounding the vital facility. The sizes of the areas in square feet are:

1. Roofs

(1)	Main Plant	46,800
(2)	Warehouse	63,400
(3)	Cafeteria	5,000
(4)	Power House	4,800
(5)	Offices	3,200
(6&8)	2 small bldgs.	5,000
		128,200 sq.ft.

2. Railroad Siding (7) 70,000 sq.ft.

3. Paved areas		4. Unpaved areas	
(a)	58,800	(AA)	171,300
(b)	62,000		
(c)	33,500	(BB)	40,800
(d)	8,500		
(e)	3,300	(CC)	425,500
(f)	31,600		637,600 sq.ft.
	197,700 sq.ft.		



a. Decon plan

b. Roof decon
   1. Method =
   2. Rate =
   3. Time =
   4. Manpower requirements =

c. Paved area decon
   1. Method =
   2. Rate =
   3. Time =
   4. Manpower requirements =

d. Unpaved area decon
   1. Method =
   2. Rate =
   3. Time =
   4. Manpower requirements =

e. Railroad Siding decon
   1. Method =
   2. Rate =
   3. Time =
   4. Manpower requirements =

f. Total decon effort
   1. Manpower requirements =
   2. Time =

ATTACHMENT A

TABLE 1
DECONTAMINATION OF PAVEMENTS

Method	Man-hours per 1000 Sq. Ft.	Rate Sq. Ft./hr.	DF
Regular Street Sweepers	0.04	25,000	0.04
	0.02	50,000	0.06
	0.015	75,000	0.09
	0.01	100,000	0.15
Vacuumized Sweepers	0.04	25,000	0.02
	0.02	50,000	0.09
	0.01	100,000	0.25
Motorized Flusher	0.01	100,000	0.02
	0.004	300,000	0.04
Firehosing	1.0	5,000	0.02
	0.5	10,000	0.03
	0.2	25,000	0.07

TABLE 2
DECONTAMINATION OF ROOFS

Method	Man-hours per 1000 Sq. Ft.	Rate Sq. Ft./hr.	DF
Firehosing Tar and Gravel Roofs	1.0	7,000	0.01
	0.5	14,000	0.03
	0.3	23,000	0.07
	0.2	35,000	0.12
Firehosing Composition Shingle	0.45	12,000	0.03
	0.2	30,000	0.05
	0.1	60,000	0.08
Firehosing plus Scrubbing			
Composition Shingle	2.0	5,000	0.02
Corrugated Sheet Metal	2.0	5,000	0.01
Wood Shingle	2.0	5,000	0.08
Tar and Gravel	2.0	5,000	0.02

TABLE 3
DECONTAMINATION OF UNPAVED LAND AREAS

Method	Man-hours per 1000 Sq. Ft.	Rate Sq. Ft./hr.	DF
Scraping	0.11	9,000	0.02
Filling			
6 inch Fill	0.25	4,000	0.15
12 inch Fill	0.50	2,000	0.02
Plowing	0.04	25,000	0.20
Grading	0.016	60,000	0.07
Bulldozing	0.12	8,500	0.07
Grader and Scraper	0.23	9,000	0.07
Hand Shoveling with Wheelbarrow	4.5	225	0.12

TABLE 4
DECONTAMINATION METHODS FOR COLD-WEATHER CONDITIONS

Method	Man-hours per 1000 Sq. Ft.	Rate Sq. Ft./hr.	DF
BARE FROZEN GROUND			
Mechanical Sweeping	0.027	37,000	0.1
Vacuum Sweeping	0.027	37,000	0.1
Firehosing	0.27	20,000	0.50
BARE CONCRETE			
Mechanical Sweeping	0.015	65,000	0.06
Firehosing (near $0^{o}F$)	0.27	20,000	0.04
PACKED SNOW			
Mechanical Sweeping (below $20^{o}F$)	0.017	60,000	0.017
Vacuum Sweeping ($10^{o}F$ to $30^{o}F$)	0.033	30,000	0.2
Firehosing $30^{o}F$	0.45	13,000	0.05
$15^{o}F$	0.45	13,000	0.12
$0^{o}F$	0.45	13,000	0.20
Grader ($0^{o}F$ to $30^{o}F$)	0.055	18,000	0.03
UNDISTURBED SNOW			
Snow Plow (Blade)	0.003	330,000	0.03
Snow Plow (Rotary)	0.019	53,000	0.10
Grader	0.033	30,000	0.35
Scraper	0.014	72,000	0.04

TABLE 4 (Cont'd)
DECONTAMINATION METHODS FOR COLD-WEATHER CONDITIONS

Method	Man-hours per 1000 Sq. Ft.	Rate Sq. Ft./hr.	DF
BARE-SLOPED ASPHALT SHINGLES			
Fire Hose			
$0^{o}F$ - Lobbing	0.5	8,000	0.55
$25^{o}F$ - Lobbing	0.5	8,000	0.33
Hand Sweeping	1.0	1,000	0.12

TABLE 5
SELECTION OF DECONTAMINATION METHODS

A - Applicable to areas where there is enough space.
B - Recommended for pavements less than 70 feet in width.
C - Recommended for smaller areas or when motorized equipment is not available.
D - Applicable, but not recommended.
E - Applicable where little or no earth cover exists.
*A - Applicable, but dependent on slope.
N/A - Not applicable.
N/R - Not recommended.

PAVED AREAS

Type of Surface	Mechanical Sweeper	Vacuum Sweeper	Street Flusher	Firehose
All paved & hard surfaces	A	A	B	C

ROOF AREAS

	Firehosing	Lobbing	Firehosing plus scrubbing (not applicable to tar & gravel)
Flat Roof	A	N/A	A
Low Slope	A	*A	*A
Steep Slope	N/A	A	N/A

UNPAVED AREAS

	Motor Scraper	Motor Grader	Bull-dozing	Plowing	Filling	Hand Shoveling	Fire-hosing
Noncohesive Soils	A	D	D	A	N/R	D	N/A
Cohesive Soils and Lawns	A	A	A	A	N/R	A	N/A
Soils Containing Boulders	A	N/R	A	N/R	D	D	N/A
Exposed Rock Formations	N/A	N/A	N/A	N/A	A	N/R	E

TABLE 5 (Cont'd)

Variations in earth composition are quite common even within a small area. For purposes of this document, earth composition will be broken down into four categories: (1) noncohesive soils, (2) cohesive soils and lawns, (3) soils containing boulders, and (4) exposed rock formations with little or no earth cover.

Noncohesive Soils Noncohesive soils, when in a moistened condition, lack the ability to be deformed and remolded in the hand without disintegration. Gravel, sand, and silty sands are examples of this class. Because they lack cohesion, they tend to slide off the blade of a grader or bulldozer. The most effective methods of decontamination are picking the surface up, turning the surface under, or covering the surface with fill.

Cohesive Soils Cohesive soils, when in a moistened condition, can be deformed and remolded in the hand without disintegration. Clays, silty clays and sand clays are examples of this class. Their inherent plasticity causes them to stay in a single mass even though they are pushed about or turned over. While soil on which a lawn is growing is not necessarily cohesive, the root system of the lawn holds the soil together causing a reaction to being worked similar to that of cohesive soils. The most effective methods of decontamination are picking up the surface, pushing the surface, and turning the surface over.

Soils Containing Boulders Soils containing boulders may be either cohesive or noncohesive. Boulders are considered as any rock, regardless of origin, having a dimension more than eight inches. The presence of boulders eliminates the use of plows and graders. Boulders which do not extend more than four or five inches below the surface can be easily picked up, or pushed. Larger ones often extend 12 inches or more below the surface with their tops exposed causing the equipment either to skip over them, or requiring that they be dug out resulting in lost time and additional volumes of soil to be removed. Bulldozers and scrapers have the weight and power required to remove most boulders. The method of clean, earth fill cover can also be used.

Exposed Rock Formations Exposed rock formation can be either totally void of earth cover or can have varying degrees of both exposure and depth of cover. The surface can neither be picked up, pushed away, nor turned under by any of the equipment discussed in this brief. Two methods may be used although both are quite costly in terms of time, manpower, and equipment. If the area has little or no earth cover, firehosing with the assistance of hand shoveling and wheelbarrows is possible. It should be noted, however, that exposed rock formations are normally quite weathered, giving them a rough-surface with a great number of fissures into which the contaminant will collect. The second method is that of covering over with clean earth fill. In this case, the availability of clean soil, equipment, and time should be considered and, in addition, the site should be accessible to the equipment chosen.

TABLE 6
SELECTION OF DECONTAMINATION METHODS

COLD WEATHER

	Condition 1	Condition 2	Condition 3	Condition 4	Condition 5
Mechanical Sweeper	good	N/A	good, after initial removal of deep snow cover, or where snow layer is less than 2 inches thick.	N/A	applicable, if depth of snow is less than 2 inches and snow is dry.
Vacuum Sweeper	good	N/A	fair, after initial removal of deep snow cover or where snow layer is less than 2 inches.	N/A	applicable, if depth of snow is less than 2 inches and snow is dry.
Motor Grader	N/A	N/A	applicable only for removal of snow cover exposing fallout particles.	applicable for removal of snow cover exposing ice layer.	fair
Firehosing	fair-good	may be used if ice layer is thin. Salt may be used to assist melting.	fair to good, after initial removal of deep snow cover, or where snow layer is less than 2 inches.	may be used where ice layer is thin after initial removal of snow cover. Salt may be used to assist melting.	good, if snow depth is less than 2 or 3 inches.
Blade Snowplow	N/A	N/A	applicable, only for removal of snow cover exposing fallout particles.	applicable for removal of snow cover exposing ice layer.	good
Motor Scraper	N/A	N/A	applicable only for removal of snow cover exposing fallout particles.	applicable for removal of snow cover exposing ice layer.	good
Hand-broom	good	N/A	good, after initial removal of deep snow cover, or where snow layer is less than 2".	N/A	good, if snow depth is less than 2 or 3 inches.

TABLE 6 (Cont'd)

The many combinations of time of fallout arrival, time of precipitation, and temperature variation are unknown variables during the preattack planning phase which greatly affect the effectiveness of the plan. These combinations can be categorized into approximately five conditions.

Condition 1 - Loose Fallout Lying on a Hard Frozen Surface This condition may result from the occurrence of the fallout event following a dry, cold period where all the surfaces are frozen, but clean. It may also result from the deposit of fallout on packed snow or ice. In all cases in Condition 1, no precipitation follows the fallout event, and the temperature remains below freezing throughout the period.

The choice of decontamination method must be guided by the fact that the frozen surface is extremely hard, thus eliminating the use of bulldozers or other equipment that pick up or push away the surface. In addition, methods utilizing water may not be effective since the surface temperature may freeze the runoff water and fallout particles before they reach the drainage points.

Mechanical sweepers, vacuum sweepers, and manual sweeping methods are not seriously affected by the low temperature.

Condition 2 - Fallout Encased in a Layer of Ice This condition can result if fallout is followed by a freezing rain, or if the fallout particles fall on an iced surface which subsequently melts and re-freezes. The major problem is that the fallout particle is encased in the ice. In order to remove the particles, the ice must be removed also.

At the present time the methods available for removing ice-entrapped fallout are extremely limited in application. It is possible that, if the ice layer is thin, and with good slope and drainage, the firehose may melt the ice and remove the particles. The slope required for fast drainage will present a hazard to the operations of the decontamination team. Salt may be spread to assist in melting the ice so that firehosing is more easily accomplished.

The problem of removing ice layers from the roofs of buildings can be reduced if the internal heating system is used to raise the temperature inside the building to a point where it will melt the ice.

Another method, which can be used, is manual ice chopping. The method is extremely slow and should be used on small areas where other methods are not available. Ice choppers should not be used on roof surfaces since damage to the roofing material can result in leakage of water and fallout particles into the building.

Condition 3 - Loose Fallout on a Hard Frozen Surface, Covered by a Layer of Snow This condition is similar to Condition 1, except that in addition to removing the fallout particles, the snow layer must also be removed. It may result from the accumulation of fallout particles on frozen ground, packed snow or ice followed by a snowfall; the temperature throughout the entire period remaining below freezing.

The choice of decontamination method is dependent upon the depth of snow cover. If the depth is less than three inches, it may be possible to hose, if sufficient slope and drainage are available to carry the volume of runoff without the occurrence of re-freezing.

Mechanical sweepers and vacuum sweepers may also be used, but the depth of snow will determine the rate of filling the hopper. Manual sweeping is also possible, but it may be necessary to remove the snow accumulation ahead of the sweeper with hand shovels. Sweeping will be most effective where the depth is shallow and the snow is dry.

Snowplows, motor graders, motor scrapers, and other equipment that scrape or pick up the snow from the surface cannot lower their blades enough to remove the fallout particles. This equipment may be useful when the loose fallout particles are covered by deep snow. The plows can remove the bulk of the snow, exposing the fallout particles so that firehosing and sweeping methods can be employed.

Condition 4 - Fallout Particles Entrapped in Ice, Covered by a Layer of Snow
This is a combination of Conditions 2 and 3 which further complicates the problem of decontamination. It may result if fallout is followed by a freezing rain which, in turn, is followed by snow or if the fallout particles fall on an iced surface which subsequently melts and re-freezes and then receives a snowfall.

If the ice layer is thin and the snow cover shallow, firehosing may be useful as a decontamination method. In this situation, the problem of roof decontamination may be alleviated by raising the internal temperature of the building to assist in melting the ice and snow on the roof.

If the ice layer is covered by deep snow, it will first be necessary to remove the snow prior to decontaminating the iced surface. Snow removal may be effected by snowplows, motor scrapers, hand shoveling, etc., in accordance with the size of the area and the equipment available. Once the ice layer has been exposed, the decontamination of the surface can be accomplished by salting the surfaces, firehosing, ice chopping or, in the case of roofs, elevating the internal building temperature. A more detailed description of the removal of ice entrapped fallout particles is given under Condition 2.

Condition 5 - Fallout Particles Intermixed with Snow This condition may result from fallout commencing at any time during or after a snowfall. The fallout can be intermixed throughout the entire depth, or occur at any level within the depth, or it could lie entirely on the top surface.

The major problems of decontaminating areas upon which fallout intermixed with snow has fallen are (a) the depth of the snowfall, and (b) the location of the fallout particles within the depth. As the depth of snow increases, the volume of snow that must be removed increases, resulting in additional man and equipment hours. If methods involving picking up the snow and hauling it to dump sites are used, as the depth of snow increases, the number of trips to the dump site increases.

The location of the fallout particles within the layer of snow also affects the effort expenditure. If the fallout is located on the top surface of the snow, skimming the upper few inches can remove the fallout particles without the need for removal of excessive amounts of snow. As the depth of the fallout particles below the surface increases, the depth of cut must likewise increase requiring that greater volumes of snow be removed.

The choice of decontamination methods for depths less than three inches can be considered independently of the location of the fallout particles. Firehosing may be used to wash the snow and fallout particles away provided that sufficient slope and drainage are available to carry the volume of runoff without the occurrence of re-freezing.

Mechanical sweepers, vacuum sweepers, or manual sweeping are also effective, especially when the depth of snow is shallow and the snow is dry.

As the depth of snow increases, the location of the fallout particles within the snow layer becomes more important. Snowplows, motor graders, motor scrapers, and other equipment that scrape or pick up the snow from the surface are effective as long as the particle location is more than a few inches above the bottom surface so that the blade can cut below them. As the depth of particles below the top surface decreases, the depth of cut decreases, resulting in the removal of less snow and greater equipment speeds.

A DECIMAL POINT AND A ZERO HAVE NOT BEEN INCLUDED FOR EACH REDUCTION FACTOR LISTED ON THE PHASE ONE PRINTOUTS. THUS, A SIDE "A" REDUCTION FACTOR OF 04 SHOULD BE READ AS A SIDE "A" GROUND CONTRIBUTION OF .004. THE CODE FOR THE ADDITIONAL INFORMATION IN THIS SAMPLE IS INCLUDED IN THE DIRECTIONS FOR USE OF THE PHASE ONE PRINTOUTS. ADDITIONAL INFORMATION IS NOT NEEDED FOR DECON ANALYSIS.

PF Category	PF Range
8	over 1000
7	500 - 1000
6	250 - 499
5	150 - 249
4	100 - 149
3	70 - 99
2	40 - 69
1	20 - 39

ATTACHMENT B

SAMPLE NFSS PHASE I PRINTOUT

FAC=01003 PT=01 OF 01 REV=0 ST=05 WEST HALL IU BLOOMINGTON IND PARK ST AT TENTH
USE=23 OWN=2 PV=57 YEAR=1938 SM=5

STORY	A	B	C	D	CL	TOT	PF	FLOOR	S-AREA	CORE	VOLUME	PEOPLE
0	01	00	00	00	01	02	6	4653	4653		46535	93
1	00	01	06	00	01	08	4	9307	2792		27920	279

FAC=01024 PT=03 OF 04 REV=0 ST=08 UNION BLDG UNIT 3 IU BLOOMINGTON
USE=11 OWN=2 PV=43 YEAR=1956 SM=6

STORY	A	B	C	D	CL	TOT	PF	FLOOR	S-AREA	CORE	VOLUME	PEOPLE
1	00	00	04	03	01	07	4	19116	5734		6[illegible]082	573
2	00	00	02	01	02	06	5	18036	12625		151502	1262
3	02	00	10	01	04	17	2	18036	9018			901*
4	03	00	09	01	05	18	2	18036	9018			901*
5	02	02	09	01	10	24	2	12446	6223			622*
6	02	01	08	01	22	35	1	10486	5243			524*

FAC=01024 PT=04 OF 04 REV=0 ST=05 UNION BLDG UNIT 4 IU BLOOMINGTON
USE=11 OWN=2 PV=32 YEAR=1956 SM=6

STORY	A	B	C	D	CL	TOT	PF	FLOOR	S-AREA	CORE	VOLUME	PEOPLE
1	00	00	05	00	05	10	4	37440	11231		123551	1123
2	00	00	02	00	09	12	3	37440	18720		243360	1872*
3	00	00	02	00	19	21	2	37440	18720			1872*

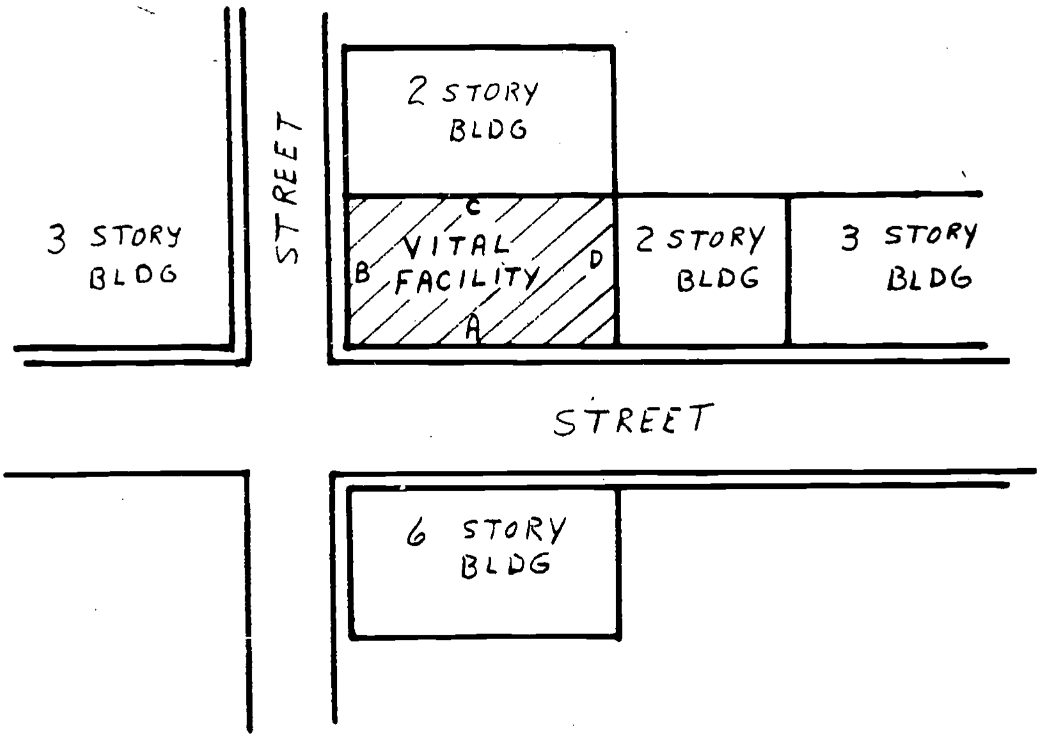
FAC=01045 PT=01 OF 01 REV=0 ST=02 MAXWELL HALL IU BLOOMINGTON INDIANA
USE=23 OWN=2 PV=36 YEAR=1890 SM=6

STORY	A	B	C	D	CL	TOT	PF	FLOOR	S-AREA	CORE	VOLUME	PEOPLE
0	01	00	00	00	26	27	1	7167	3583		35839	71*

SITE PLANS AND NFSS DATA
FOR THREE VITAL FACILITIES

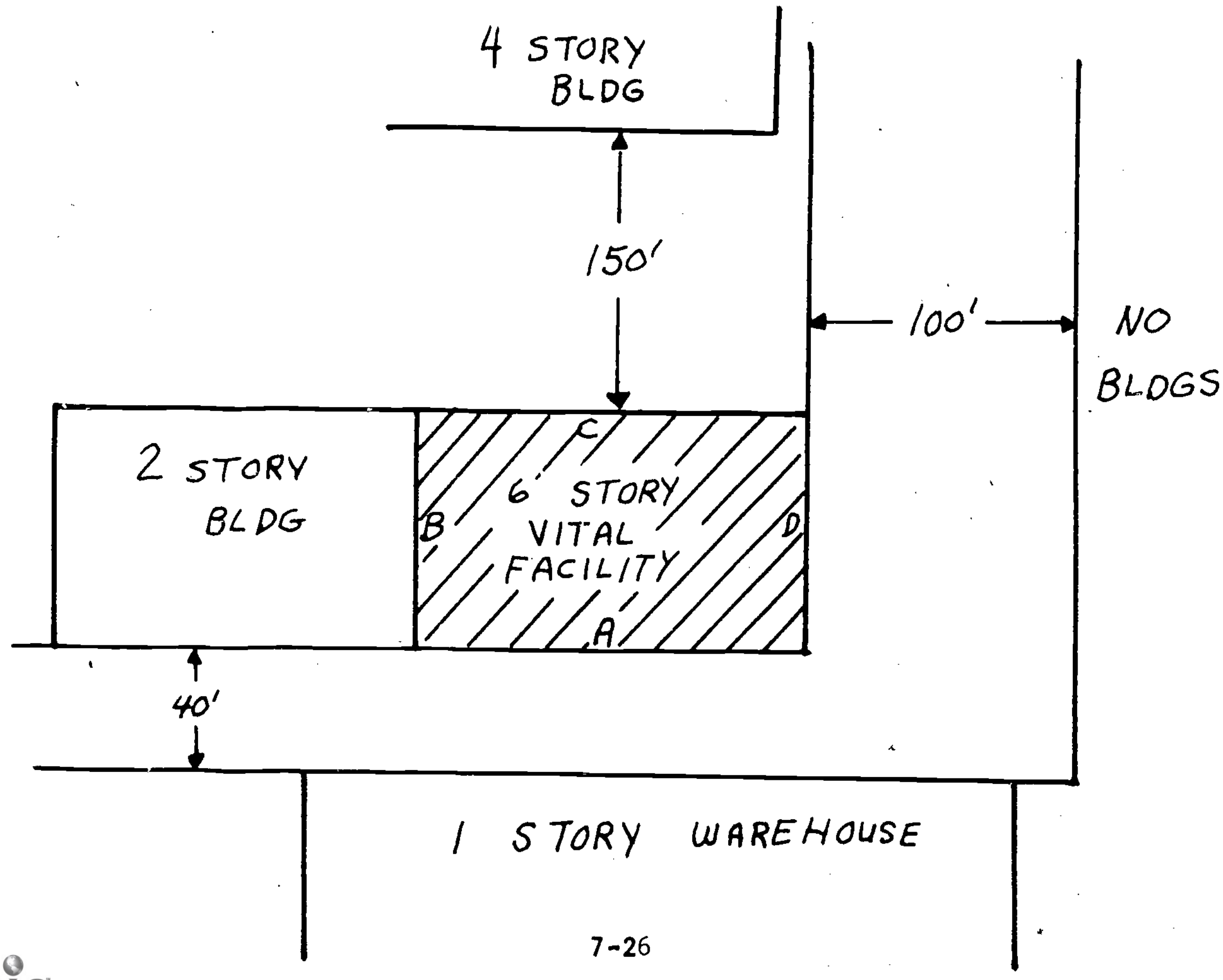
Site Plan 1

STORY	A	B	C	D	CL	TOT
0	00	00	00	00	00	00
1	16	18	00	00	00	35
2	03	09	18	10	00	41
3	02	10	11	13	00	35
4	01	06	07	07	00	21
5	00	04	05	05	01	16
6	11	03	04	03	04	25
7	07	02	03	02	20	34



Site Plan 2

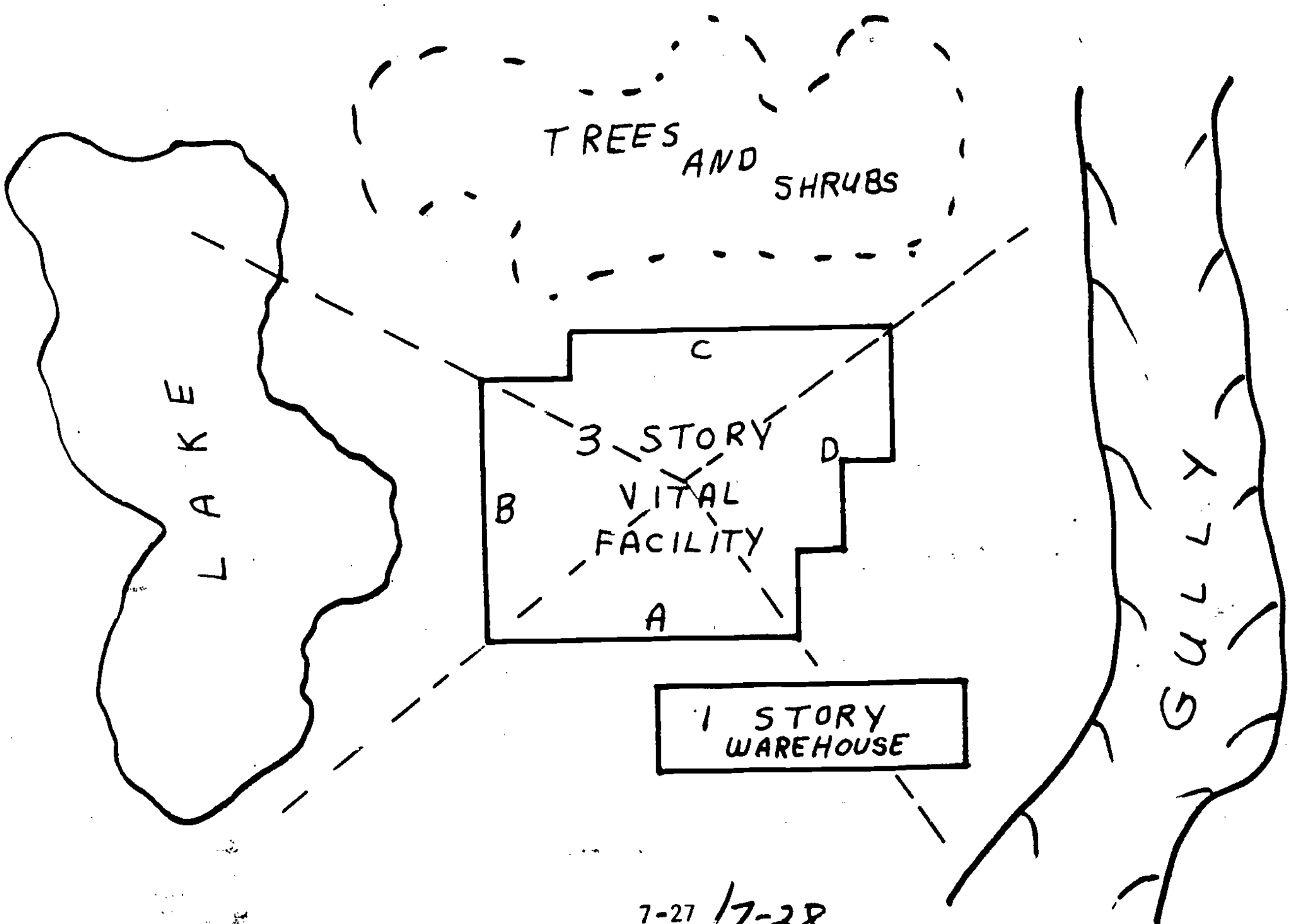
STORY	A	B	C	D	CL	TOT
0	00	00	01	00	00	01
1	10	00	17	15	00	42
2	10	10	09	09	00	38
3	04	14	02	03	00	23
4	01	03	02	01	01	08
5	00	01	00	00	12	13
6	00	00	00	00	21	21



ATTACHMENT C
(Continued)

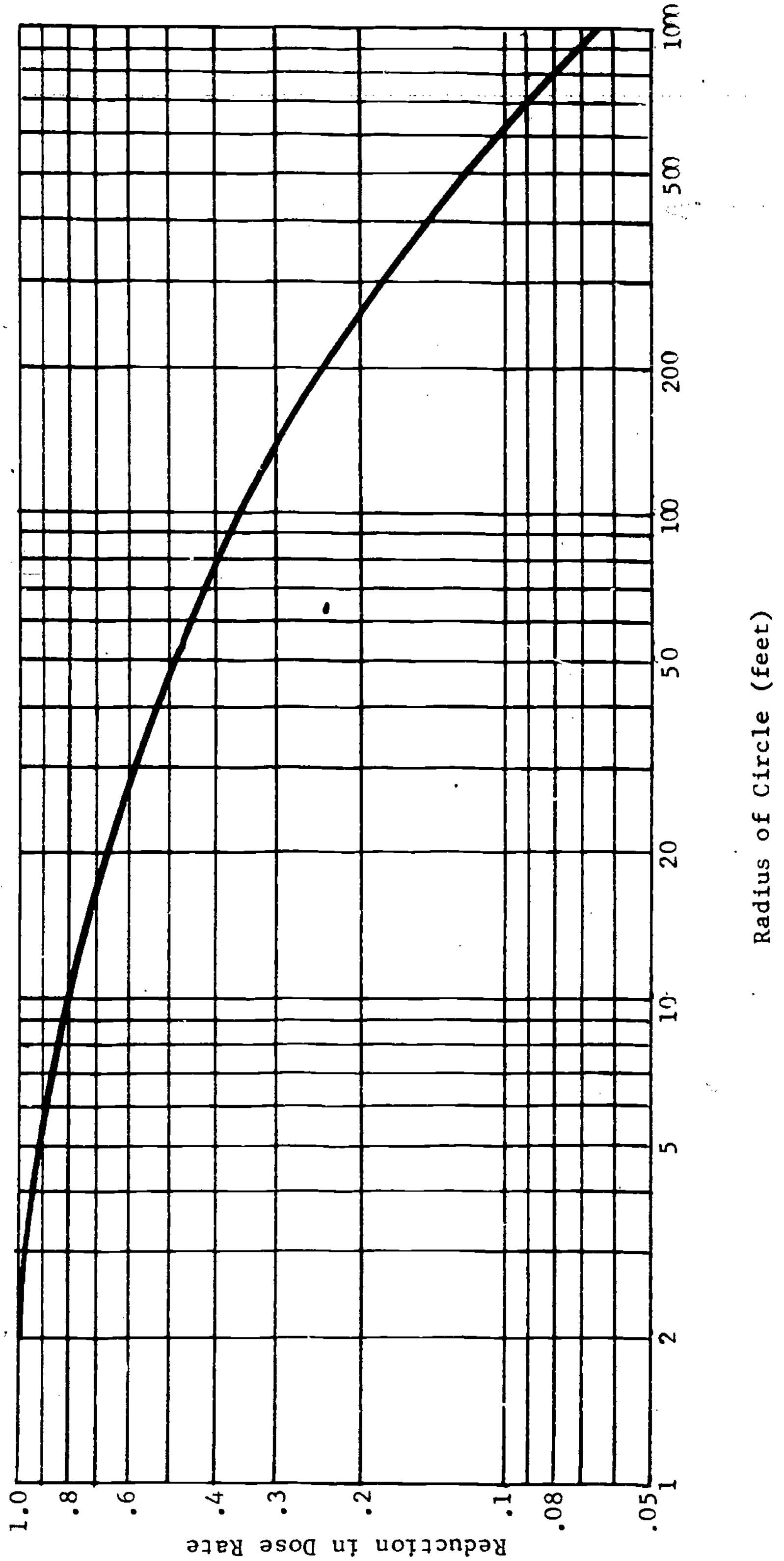
Site Plan 3

STORY	A	B	C	D	CL	TOT
0	01	00	01	01	00	03
1	10	04	13	13	02	44
2	10	01	10	08	08	28
3	06	00	02	01	16	25



ATTACHMENT D

REDUCTION IN DOSE RATE VERSUS
RADIUS OF DECONTAMINATED CIRCLE
(Infinite contaminated plane)



ANSWERS TO REQUIREMENTS NO. 1 TO 6

ANSWERS to Requirement No. 1

Only the areas with the highest contributions have been indicated. In some cases, contributions other than those indicated are almost as important.

Site Plan	Story	Sources of Major Contribution	Areas to be Decontaminated
1	0	-	-
	1	A and B	Streets
	2	C	Roof of 2-story building
	3	D	Roofs of 2- and 3-story bldgs.
	4	C and D	Roofs of 2- and 3-story bldgs.
	5	C and D	Roofs of 2- and 3-story bldgs.
	6	A	Roof of 6-story building
	7	Roof	Roof
2	0	C	Area opposite Side C
	1	C	Area opposite Side C
	2	All sides about equal	Areas opposite Sides C, D and A, and roof of 2-story bldg.
	3	B	Roof of 2-story bldg.
	4	B	Roof of 2-story bldg.
	5	Roof	Roof
	6	Roof	Roof
3	0	A, C and D	Areas opposite Sides A, C and D
	1	C and D	Areas opposite Sides C and D
	2	A and C	Areas opposite Sides A and C, and roof of warehouse
	3	Roof	Roof

ANSWERS to Requirement No. 2

1. Roof contribution = .020
2. Ground contribution = .030
3. Total contribution (reduction factor) = .050
4. PF = 1 ÷ .05 = 20
5. DF for roof decon = .05
6. DF for ground decon = .2
7. Contribution from contamination beyond 100 ft. = .35

8. Revised roof contribution = .020 X .05 = .001

9. Revised ground contribution within 100 ft. = .030 X .65 X .2 = .0039

10. Ground contribution beyond 100 ft. = .030 X .35 = .0105

11. Revised total ground contribution = .0039 + .0105 = .0144

12. Revised total contribution (reduction factor) = .001 + .0144 = .0154

13. Revised PF = 1 + .0154 = 65

ANSWERS to Requirement No. 3

1. Roof contribution = .022

2. Ground contribution = .040

3. Total contribution (reduction factor) = .062

4. PF = 1 ÷ .062 = 16

5. DF for roof decon = .03

6. DF for ground decon = .02

7. Contribution from contamination beyond 150 ft. = .3

8. Revised roof contribution = .022 X .03 = .00066

9. Revised ground contribution within 150 ft. = .040 X .7 X .02 = .00056

10. Ground contribution beyond 150 ft. = .040 X .3 = .012

11. Revised total ground contribution = .00056 + .012 = .01256

12. Revised total contribution (reduction factor) = .00066 + .01256 = .01322

13. Revised PF = 1 ÷ .01322 = 76

ANSWERS to Requirement No. 4

1. Firehose team (pavements) = 5,000 sq.ft/hr X 1.0 man-hour/1000 sq.ft. = 5 men

2. Firehose team (tar & gravel roofs) = 7,000 sq.ft/hr X 1.0 man-hour/1000 sq.ft. = 7 men

3. Street sweeping team = 25,000 sq.ft/hr X .04 man-hours/1000 sq.ft. = 1 man

ANSWERS to Requirement No. 5

1. Roof decon
   a. method = firehosing
   b. rate = 7000 sq. ft./hr.
   c. time = 20,000 sq. ft. ÷ 7000 sq. ft./hr. = 2.9 hours
   d. manpower requirements = 20,000 sq. ft. X 1 man-hour/1000 sq. ft = 20 man-hours

2. Ground decon
   a. method = plowing
   b. rate = 25,000 sq. ft./hr.
   c. time = 280,000 sq. ft. ÷ 25,000 sq. ft./hr. = 11.2 hours
   d. manpower requirements = 280,000 sq. ft. X .04 man-hours/1000 sq. ft. = 11.2 man-hours

3. Total decon effort
   a. manpower requirements = 20 + 11.2 = 31.2 man-hours
   b. time - (1) roofs = 2.9 hours ÷ 1 team = 2.9 hours
      (2) ground = 11.2 hours ÷ 2 teams = 5.6 hours
      (3) ground decon is the controlling operation, so it will require 5.6 hours to decon the facility.

4. Value of manpower requirements figure: It allows a quick estimate of the decon time requirements, depending on the number of men available.

ANSWERS to Requirement No. 6 (This is only one solution, others may be equally acceptable)

1. Decon Plan
   a. firehose all roofs
   b. sweep all paved areas
   c. plow unpaved areas
   d. fill railroad siding with scraper to 6" depth.

2. Roof decon
   a. method = firehose
   b. rate = 7000 sq. ft./hr.
   c. time = 128,200 sq. ft. ÷ 7000 sq. ft./hr. = 18.3 hours
   d. manpower requirements = 128,200 sq. ft. X 1 man-hour/1000 sq. ft. = 128.2 man-hours

3. Paved area decon
   a. method = sweep
   b. rate = 25,000 sq. ft./hr.
   c. time = 197,700 sq. ft. ÷ 25,000 sq. ft./hr = 7.9 hours
   d. manpower requirements = 197,700 sq. ft. X .04 man-hours/1000 sq. ft. = 7.9 man-hours

4. Unpaved area decon
   a. method = plowing
   b. rate = 25,000 sq. ft./hr.
   c. time = 637,600 sq. ft. ÷ 25,000 sq. ft/hr. = 25.5 hours
   d. manpower requirements = 637,600 sq.ft. X .04 man-hours/1000 sq. ft.= 25.5 man-hours

5. Railroad siding decon
   a. method = fill to 6" depth with scraper
   b. rate = 4000 sq. ft./hr.
   c. time = 70,000 sq. ft. ÷ 4000 sq. ft./hr. = 17.5 hours
   d. manpower requirements = 70,000 sq. ft. X .25 man-hours/1000 sq. ft. = 17.5 man-hours

6. Total decon effort

   a. manpower requirements = 128.2 + 7.9 + 25.5 + 17.5 = 179.1 man-hours

      (will commit 7 men (1 team) to firehosing, 2 men to plowing, 2 men to filling, and 1 man to sweeping).

   b. time - (1) roof = 18.3 hrs. ÷ 1 team = 18.3 hours
      (2) paved areas = 7.9 hrs. ÷ 1 team = 7.9 hours
      (3) unpaved areas = 25.5 hours ÷ 2 teams = 12.8 hours
      (4) railroad siding = 17.5 hours ÷ 2 teams = 8.8 hours
      (5) roof decon is the controlling operation, so it will require 18.3 hours to decon the facility. However, all men will not be required for the full time.

TITLE: Remedial Movement

COURSE: Radiological Defense Officer

FOR USE IN THE SESSION: Postattack Recovery Measures

REMARKS: The problems in Attachment A will not be solved in class. They are intended as homework practice problems for completion after the session on Postattack Recovery Measures. The answers are provided in Attachment B.

CONTENTS

DISCUSSION

Remedial movement is defined as the movement of people (a) from an area highly contaminated by fallout to one with less or no contamination, or (b) from a poor shelter to a better one.

In planning to use remedial movement as an appropriate countermeasure, the problem should be thoroughly examined by the civil defense director in conjunction with his Radef Officer, Medical Officer, and welfare and transportation officials. Movement to any great distance not only may take people from their homes and communities, in which they have a relative degree of comfort and sense of security, but it may require mass transportation across fallout areas, the establishment of reception and care centers, and the subsequent transportation of food and other required survival items. Various types of shelter regimentation should be considered alternatively to remedial movement. However, if relatively poor fallout protection is all that is available in much of a community, such movement may be the only solution.

In general, people should not be moved from a shelter location because of high radiation levels in the first few hours, or the first day or so, following fallout arrival. There are two important reasons for this: first, they might receive excessive exposures during the movement period; and second, some time may be required to identify the location of safer areas and whether or not the areas have space available and are habitable. For these reasons, it is expected that remedial movement would be used mostly during the period of days to weeks postattack.

The Radef Officer should recognize that, for a nuclear attack lasting a day or two, the equivalent residual dose (ERD) will generally reach a maximum during the first seven to ten days postattack. Thus, if people cannot be moved during this period, they might just as well be kept in whatever shelters they have available until a more orderly movement can be planned and carried out. If such people have not been exposed to a sickness dose during the first seven to ten days, they will probably not be exposed to a sickness dose thereafter as long as they remain in that shelter. If a nuclear attack continues for several days the maximum ERD may not be reached for some time after the "first seven to ten day period."

The exposure dose to people to be moved consists of (a) the dose received in the initial shelter, (b) the dose received during transfer, and (c) the dose received at the final shelter. Generally, the problem of transferring from one shelter to another is to choose a time when the sum of these exposures is minimized. This is referred to as the optimum transfer time. It is a rather complex problem to identify the optimum transfer time under a variety of radiological conditions. But generally, it is a matter of selecting an arbitrary transfer time based on an educated guess and calculating the separate exposures identified in a to c, above. By repeating the calculations for two or three times, the optimum transfer time can be bracketed.

There are two rules of thumb to provide a minimum of guidance to the Radef Officer in determining the optimum time to carry out postattack remedial movement operations. These rules of thumb should also serve as rough guides in making calculations for conditions other than those specified.

For movement requiring but a short time to move from low grade shelter to a shelter with at least ten times better protection and located in an area having about the same dose rate, the rule of thumb is:

THE OPTIMUM TRANSFER TIME (IN HOURS) IS EQUAL TO THE PROTECTION FACTOR OF THE INITIAL SHELTER TIMES THE NUMBER OF HOURS IT WILL TAKE TO GET TO THE BETTER SHELTER.

For example, if people are located in a heavy fallout area in a structure with a protection factor of 10 and they could be moved to a shelter with a protection factor of 100 or better in one-half hour, the optimum time for moving would be 1/2 X 10, or 5 hours after detonation. Movement of this type to better shelter would generally be advisable before fallout arrival. It should <u>not</u> be accomplished while significant amounts of fallout particles are still in the air.

There is a similar rule of thumb for determining the optimum time to leave shelter for an area with little or no fallout. This is:

THE OPTIMUM TRANSFER TIME (IN HOURS) IS EQUAL TO 3/5 OF THE SHELTER PROTECTION FACTOR TIMES THE NUMBER OF HOURS IT WILL TAKE TO GET TO THE RADIATION FREE AREA.

For example, if people were in a structure with a protection factor of 20 and they could move to an area relatively free of fallout in 6 hours, the optimum transfer time would be 3/5 X 20 X 6, or 72 hours after detonation.

These rules of thumb predict optimum times to leave shelter, but they do not indicate how long the individual must stay in the improved shelter to more than offset the additional dose (penalty dose) he received during transfer over what he would have received had he stayed in his original shelter. Generally, this time falls between 2.5 and 3 times the optimum time to transfer shelters. Thus, if the optimum transfer time is H + 2 days, people will not realize any advantage (reduction in their total exposure) from the move until about H + 5 to H + 6 days.

If the Radef Officer is not sure of his estimate of the protection factor for either the initial or final shelter, or of his estimate of the time required to transfer shelters, he should advise the civil defense director that shelter occupants should stay later (up to a factor of 2) than the predicted optimum transfer time in order to keep the probable penalty dose as low as possible.

As a peripheral countermeasure, remedial movement is technically feasible in a variety of radiological situations. If it is initiated at or near to optimum transfer time, it will result in a lower dose than would be received by arbitrarily remaining in the initial shelter a given period.

It appears that the maximum payoff is related to situations involving low protection factors; i.e., less than 10, and to situations involving fallout arrival times earlier than 11 hours.

Problems

1. People must be moved to higher grade shelter. Their current shelter has a protection factor of 15, and the new shelter will have a protection factor of 250. When should these people transfer shelter, if it requires 40 minutes transfer time?

2. How long will it be before the additional dose (penalty dose), received by the people in Problem 1 during transfer, is offset?

3. The Civil Defense Director has decided to move people from their current shelters (PF = 30) to an area where the dose rate is less than 1 r/hr at H + 4, and decreasing. When should these people move, if it will require 2.5 hours transfer time?

4. How long will it be before the additional dose (penalty dose), received by the people in Problem 3 during transfer, is offset?

5. City X has received fallout from two weapons detonated 1 hour apart. The Civil Defense Director is considering remedial movement. He has asked the Radef Officer for guidance on the best time to transfer people from a shelter with a protection factor of 50 to an area relatively free of fallout. If it will require ten hours to move to this new area, what should the Radef Officer recommend?

ATTACHMENT B

Answers

1. 15 X 2/3 = 10 hours after detonation (assuming fallout is complete).

2. 10 X (2.5 to 3) = 25 to 30 hours after detonation, or about 15 to 20 hours after arrival at the new shelter.

3. 3/5 X 30 X 2.5 = 45 hours after detonation.

4. 45 X (2.5 to 3) = 113 to 135 hours after detonation, or about 65 to 88 hours after arrival at the new shelter.

5. The equivalent residual dose of these people will not be reduced by moving them to a new area. The maximum ERD of these people, from the single wave attack, will be reached at H + 7 days to H + 10 days. Since the optimum transfer time is 3/5 X 50 X 10 = 300 hours (H + 12.5 days), these people should remain in their current shelter, unless another factor besides minimizing their ERD requires their transfer.

TITLE: Emergency Operations Center Radef Functions — Brief No. 9

COURSE: Radiological Defense Officer

FOR USE IN THE SESSION: Emergency Operations Center Radef Functions

REMARKS: The student should read and be familiar with the contents of this brief prior to the class session. The requirements will be completed and discussed during the class session.

CONTENTS

SITUATION A

In determining the Representative Dose Rate for the city, local monitoring Stations 4, 7, 13, 19, and 24 have been selected. On the last reporting cycle, the dose rates reported from the selected stations were as follows:

Stations	Dose Rates
4	230 r/hr
7	250 r/hr
13	120 r/hr
19	220 r/hr
24	230 r/hr

Requirement No. 1 What Representative Dose Rate for the city should be reported to the county EOC?

SITUATION B

The State EOC receives dose rate reports from the State monitoring net and Representative Dose Rate reports from the counties through the substate EOC.

Requirement No. 2

In what ways are the reports alike?

In what ways are the reports different?

SITUATION C

You are the RADEF Officer at City KXE in the State of Kent (see map, Attachment A). The Nation has received warning of possible attack and the EOC is manned for emergency operations. The civil defense director has requested a fallout forecast analysis for the potential targets KPE, KPI, KPM, KSX, KUH, KWG, KWH and KYH. The latest DF data is as follows:

DF 150000

ABC	0713	0913	1109
DEF	0713	0813	1109
GHI	0614	0814	1010

Requirement No. 3 For each target, indicate the DF data point(s) that should be used for making a fallout forecast.

Requirement No. 4 Which target, or targets, should be plotted to forecast expected fallout on City KXE?

Requirement No. 5 How long will it take for fallout to arrive at City KXE from a surface burst on KWG at 1600 hours? Do not construct a plot. Determine the answer by inspection of the data. You may use a ruler.

SITUATION D

Dose rates are reported by the local monitoring stations to the city EOC. The city EOC then transmits dose rate information to the county EOC. The county in turn reports dose rate information to the substate or State EOC.

Requirement No. 6

Describe the nature of the dose rate information received by the city EOC.

Describe the nature of the dose rate information received by the county EOC.

Describe the nature of the dose rate information received by the State EOC.

SITUATION E

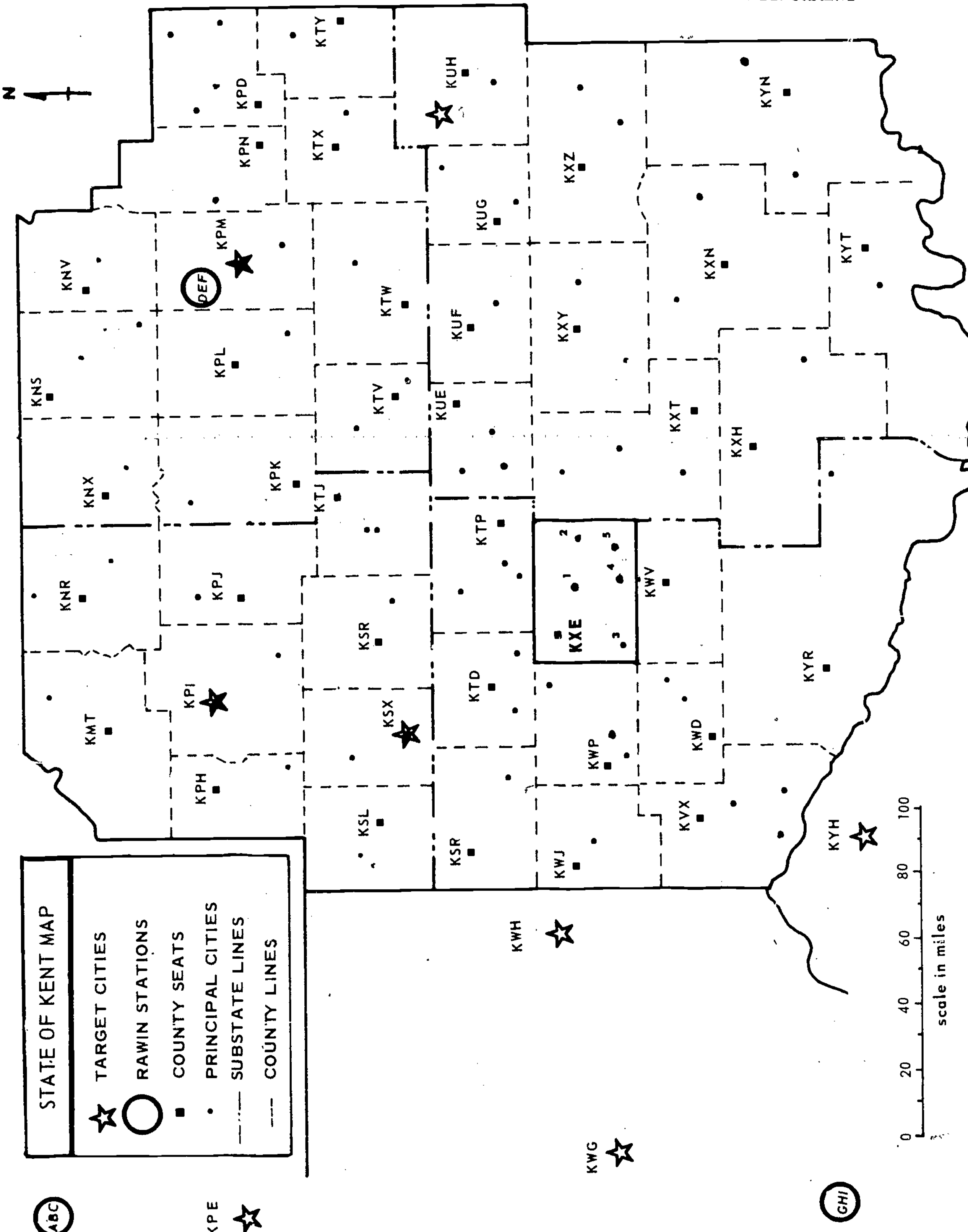
The nation has received warning of possible nuclear attack. The monitoring stations and EOC are manned for emergency operations.

Requirement No. 7 What is the nature of the first report from the monitoring stations to the EOC? Succeeding reports?

SITUATION F

A fallout forecast has been prepared which indicates that fallout is likely to occur in City X. A NUDET report has just been received confirming a reported nuclear detonation on City Y 100 miles to the west. At the request of the civil defense director, an advisory is being prepared for issuance to the people of City X.

Requirement No. 8 What items of information should be included in the advisory?


STATE OF KENT MAP
TARGET CITIES
RAWIN STATIONS
COUNTY SEATS
PRINCIPAL CITIES
SUBSTATE LINES
COUNTY LINES
scale in miles
0
20
40
60
80
100
ABC
DEF
GHI
KPE
KWG
KWH
KYH
KXE
1
2
3
4
5
KNV
KNS
KNX
KNR
KMT
KPD
KPN
KPM
KPL
KPK
KPJ
KPI
KPH
KTY
KTX
KTW
KTV
KTJ
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KSX
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KUH
KUG
KUF
KUE
KTP
KTD
KSR
KXZ
KXY
KXT
KWV
KWP
KWD
KWJ
KVX
KYN
KXN
KYT
KXH
KYR

TITLE: Operations Planning

COURSE: Radiological Defense Officer

FOR USE IN THE SESSION: Radiological Defense Planning

REMARKS: The student should read this Brief prior to the session and be familiar with it.

CONTENTS

INTRODUCTION

Primary responsibility for attainment of civil defense objectives rests with government at all levels. The means available for the accomplishment of these objectives are materials and manpower. These must be organized as a team -- beginning with existing units of government and supplemented, as necessary, with other organizations and individuals -- with established channels for direction, utilization, and coordination of trained manpower, conditioned and maintained in a state of operational readiness.

To create and maintain an operational capability for disaster situations, planning on a continuous basis is essential. As a part of disaster preparations, the development of an Emergency Operations Plan, if properly prepared through education and training, will enable responsible officials to apply resources at the times and places of need without delay and in the most effective manner.

The purpose of this Brief is to develop a better understanding of the concepts, principles and processes involved in developing an operations plan.

DEFINITIONS

Planning, in relation to emergency situations, may be defined as the process of anticipating the need for application of resources and determining the methods of obtaining and committing those resources to the operations plan. To do this effectively, responsible officials must have a knowledge of conditions -- conditions which are determined through the process of intelligence -- in order to project their thinking into the future and prepare for operations.

Operations is the process of applying resources to events to achieve specific objectives. In reality, this is a continuation of the planning process.

The Operations Plan is a description of actions to be taken in the face of an anticipated situation and the method, or scheme, for taking coordinated actions to meet the needs of that situation. It describes the actions to be taken (who, what, where, when) on the basis of assumptions, objectives, and capabilities.

NEED FOR OPERATIONS PLANNING

Evaluate Areas of Responsibility The processes required in developing an operations plan provide education and training for responsible officials, and force them to preview and evaluate their areas of responsibility in terms of operational readiness in the event of disasters.

Identify and Anticipate Problems The development of an operations plan (as indicated in the above definition of planning) enables responsible officials to identify and anticipate the types of problems that may arise in the event of a disaster and, thus, assist those officials in assigning specific duties to disaster operating forces for the common good of all concerned.

Information The processes involved in operations planning require the gathering of a great deal of information which is basic to the development of an operations plan. When the capabilities of the enemy are known, when the effects of his weapons have been analyzed, and when our own situation is known in terms of resources (manpower and materials) and the characteristics of the area or community, then, and only then, can operations planning be done effectively.

Coordinated Action Planning, as indicated by the above definition of operations, will permit taking directed and coordinated actions to utilize resources in the most favorable manner and location. For example, during a public alert, action may be taken to increase the food stocks and comfort items, or to increase the shielding in a shelter area; thereby increasing the potential for saving life and property. The philosophy - "Any action that may accomplish the objective is a valid action" - is only partly true and can be dangerous. Reliance on this idea leaves the outcome to chance. Planning, on the other hand, permits the sound applicatin of capabilities on a coordinated and effective basis.

BASES OF AN OPERATIONS PLAN

Assumptions The following questions relating to assumptions are suggestive and are not exhaustive. List any assumptions upon which planned actions are to be based.

1. Threat - Who or what is the threat? (Effects of weapons, natural disasters).

2. Threatening force - What are the capabilities of the threatening force? (This may include natural disasters).

3. Warning time - How much warning time may be expected?

4. Fallout probability - Is there a good possibility of this area being fallout free?

Objectives of Government What are the primary objectives of the unit of government, or responsible agency? (State, Federal, county, city, rural community).

Objectives of Civil Defense Public Law 920 states that one of the objectives of civil defense is to save life and property. To accomplish this goal, many specific tasks must be accomplished. One objective of any community, large or small, is self-protection. In addition, the primary mission may be that of fixed support (care of evacuees), mutual aid, or a combination of these.

Capabilities of the Threatening Force What are the capabilities of the threatening force? (Related to assumptions).

Capabilities in Specific Areas What are the capabilities of the specific area or unit of government concerned in terms of the assumptions, objectives, and resources as related to the characteristics of the area and the threatening force?

REQUIREMENTS OF A PLAN

Provide for Automatic Response In the transition period, the operations plan should provide for procedures to be taken during the transition from a peacetime posture to that of an emergency posture.

Reaction to emergency situations, as prescribed by the operations plan, should place the planning agency (unit of government) in the best possible position to meet a general type of emergency, the exact details of which may be unknown. Familiarity with the plan and the basic concept of operations is essential to the conduct of operations during emergency phases so that responsible people can carry out a coordinated plan of action toward a common objective without reference to the planning document itself.

Describe Actions to be Taken These are based on assumptions, objectives, and capabilities, and were discussed in the previous section.

Establish Command and Control The plan establishes a definite command and control structure.

Assign Authority The plan fixes the limit of authority of subordinates and establishes measures for insuring compliance with the imposed limitations.

Assign Duties The plan assigns specific tasks to be performed by each element of the organization, and provides the resources necessary for performance of assigned tasks. (Who, what, when, where).

Define Channels The plan defines channels for requesting supplies and additional resources that may be required.

Delegate Authority The plan provides authority commensurate with responsibility.

Detail The basic plan provides sufficient detail, based on assumptions, to make definite assignments but not in such detail that the plan becomes obsolete each time one assumption proves invalid.

DEVELOPMENT OF THE OPERATIONS PLAN

An Operations Plan is the end product of considerable effort, which develops generally as follows:

1. Estimate of the situation. (Analysis)
2. Decision-making and development of a concept of operations.
3. Basic operations plan.
4. Supporting annexes.
5. Test, revision, and rehearsal.

Estimate of the Situation The estimate of the situation is a systematic process for anticipating requirements, determining resources, and determining methods of applying resources to accomplish objectives.

Civil defense urban analysis may be used as a guide for estimates of the situation. Data obtained from this orderly process are used for:

1. Making target analyses.
2. Assuming hypothetical attacks.
3. Estimating extent of potential damage.
4. Organizing emergency forces.
5. Considering and comparing possible courses of civil defense action.

Suggested format for the estimate of the situation:

Classification

Name of Agency
Address
Date

1. Mission - (A brief statement of the emergency mission as it pertains to the unit of government, agency, area, or locality being considered.)

2. Considerations affecting possible courses of emergency action - (All factors which can affect planning.)

   a. Characteristics of the area to be considered in the operations plan - (All physical characteristics of the area should be itemized. Weather, terrain, location and characteristics of built-up areas, location and densities of population centers are all considerations which will affect the various possible courses of action--our own courses of action and those of the threatening forces.)

   b. Attack effects - (An estimate of the probable effects of an enemy attack--a hypothetical attack and the resulting effects. This is not the selection of probable targets, but a listing of the general and specific effects which must be considered in determining the best courses of action.)

   c. Available resources - (A detailed listing of available resources by type, location, status, and disposition.)

3. Enemy capabilities - (Based on planning assumptions as applied to the specific locality or community being considered. Attack capabilities and probable attack patterns are developed by target analysis. What is the probable warning time? What is the relative criticality of your city as a target when compared with other cities in the area or the nation? What size bomb, or bombs, would be used as a planning criterion? What are the logical targets in your city or area? CAUTION: Logical courses of enemy action are not the only possible courses.)

4. Alternative methods of accomplishing objectives - (Every practicable course of action should be listed. Consider actions to be taken under various conditions of warning as well as different courses of action for command, control, communications, etc.)

5. Analysis of alternative methods of accomplishing objectives - (List each alternative that has been selected as practicable and weigh it against the full range, best to worst, of probable operational situations in order to determine which alternative can accomplish the mission without undue reliance upon specific enemy action. In comparing mobile versus fixed control points, the factors developed in paragraph 2, above, should be considered. Do terrain and shelter locations favor fixed installations? Are suitable communications available? Do costs of mobile units exceed financial resources?)

6. Comparison of alternative methods - (Weigh advantages and disadvantages of each alternative to determine relative probability of success. For example, if alternatives of establishing mobile or fixed control points are being considered, probable warning time, size of bombs, probable targets, possible target error, and so on, should be considered in selecting the most profitable action.)

7. Decision - ("Who, what, where, when" are basic elements of decision. "How" is the concept of operations.) The decision should be tested by these questions:

   a. Does it require more resources than can be expected to be available?

   b. Does it leave any essential element to chance?

   c. Does any part of it depend upon a single personality?

   d. Does it consider time and space factors?

Planning Directive Having organized the ground for operations and the services for operational readiness, the responsible official is now ready to develop the over-all operations plan. To insure coordination in the development of an operations plan, a planning directive should be issued. This directive should be addressed to chiefs of services, units of government, units within government, and other staff members responsible for preparing parts of the plan. It should be signed by the appropriate officials, preferably the official having the highest authority over all of those participating in the civil defense effort. For example, the mayor or the governor. In preparing the directive, the directing authority should consult with his staff and the civil defense advisory committee on the following:

1. The general hazards for his jurisdiction.

2. The unit's role in State and regional planning.

3. Civil defense analysis - (NOTE: The planning directive should not be delayed, however, pending completion of a formal analysis. Information readily available should be utilized in determining the general elements of the directive.)

4. Support and assistance which may be available from other units of government or other agencies.

5. Time factors, insofar as they are known. For example, estimates of the time available for organizing and planning; time that would be available before fallout arrival because of the geographic location of the city or community and the characteristics of the area.

6. Security requirements, if any. (Keep to minimum.)

A planning directive translates a decision into the action of making a plan. The following outline for a planning directive is intended as a guide rather than as a set form:

Headquarters
Location
Date

1. Purpose and authority - (State the purpose of the directive, the requirements that a plan be made, and the legal authority for the directions.)

2. Time elements - (Target date for completion, and any intermediate phase dates.)

3. Objective of the plan - (State what the plan is to accomplish, the anticipated situation for which it is to be made, and the assumptions which the planners are to use. Be sure all elements of the decisions which the plan should carry out are included.)

4. Assignment of plan responsibility - (Say who is to be responsible for preparing each plan element, at each level of authority.)

5. Supply of materials - (If such materials as maps, stencils for mimeographing, and so on, are involved, indicate where to get them.)

6. Directions as to form - (Specify what the finished plan is to look like. Give all details: size of paper, whether the plan is to be single or double spaced, directions for punching, binding, stitching, numbering system for sections or pages, number of copies required, and distribution. Care here can save much effort later.)

7. Review and approval - (State the procedures for review and approval at each level of planning.)

   NOTE: A shelter assignment plan requires integration of the operations plan of the city proper and those of the surrounding communities. This coordination should be accomplished by the planning committee consisting of representatives of each political jurisdiction within the area. Operations planning involves close interrelations at all levels. A decision at one level includes specific assignment or responsibilities for operational units at the next lower level and these, in turn, form a basis for that level's operations planning. Each level should submit its plan to the next higher authority for review and approval in order to insure coordination. Subsequently, plans should be rehearsed and tested; first, within each individual service or department, and progressively, in widening areas of defense responsibility. Thus, impracticalities may be eliminated early. As an alternative to the successive review and approval procedure, concurrent planning may be undertaken at all levels and coordination effected later.

8. Security - (Give the provisions for security with specifications for classification or custody.)

9. References - (List all references to other plans, maps, legal authorities, civil defense analyses, studies, applicable manuals, and other source material, especially those cited in the plan.)

10. Special instructions - (Add any instructions which may be applicable, generally, to two or more units. The requirement that mobilization procedures are to be included in each service annex is an example of such special instructions.)

11. Signature and authentication.

Documentation The plan itself should be documented. It may be entirely written or partially expressed in graphic form. The basic plan is comparatively brief and general; the complete plan with all annexes may be voluminous. Its parts may be tested and perfected piecemeal, then joined to plans with other units of government, and finally tested and perfected as a whole.

It will be helpful if uniform specifications for the identification of parts, size, and binding are included in the planning directive. Distribution of the plan and for each part of the plan should be indicated on each plan, or parts thereof.

The following is a suggested outline for the operations plan. Many modifications may grow out of the actual planning process when applied to a given area. This outline is intended to be a guide.

Classification

Name of Organization
Address
Date

PLAN PREFACE

Authority This section should contain a list of the specific documents, laws, regulations, etc., which give the plan legality.

Example: Public Law 920, and changes thereto
State Civil Defense Act
Civil Defense Ordinance

Purpose This section should contain a brief paragraph stating precisely why the plan was written.

Example: To provide, in cooperation with the State and Federal governments, a workable plan for River City, designed to develop and maintain an emergency operational capability to prevent, minimize and/or overcome the effects of the threat (enemy weapons and/or natural disasters).

BASIC PLAN

Mission:

1. State the task to be accomplished (what -- why). Example: To shelter and care for River City inhabitants· to provide operational support to Lake City and Central City on a priority basis, and to other areas in the State on a directed basis.

2. Before writing this part of the plan, examine the State Operations Plan and consult with State authorities to make certain of your community's role in the over-all plan for the State.

Situation and Assumptions:

1. General Situation. Include such things as:

   a. Enemy capabilities (weapons and means of delivery and/or attack, attack effects due to other target areas).

   b. Information on available resources that are not under the control of your city; pertinent information regarding aid and support which may have a bearing on the decision of a subordinate. (Detailed aid and support actions should be described in appropriate annexes.)

   c. Information on your city (or State) as to its characteristics and geographical location (terrain, weather, industry, rail and road systems, rivers, lakes, land use, military installations, etc.). Maps should be used to simplify and clarify much of this information.

   d. Emergency Powers to meet emergency - when and by whom invoked.

2. Assumptions. List all assumptions upon which planned actions are based. The following are suggestive, not exhaustive:

   a. Warning time - how much?

   b. Equipment and supplies - where located, how maintained, control, and issue?

   c. Weapons - type and effects?

   d. Variations in shelter capability - location of shelter in relation to population distribution, seasonal population changes (convention population), use of shelter, weather.

   e. Support - when, how much, where?

   f. Trained personnel.

OVER-ALL GENERAL PLAN

State the general concept of operations. Include preattack ground organization and an organizational chart. A statement on procedure in organizing the ground postattack would be in order here. Automatic actions to be taken upon receipt of warning by operating personnel. Automatic actions to be taken by operating personnel and the general public upon sounding of alerts.

State the general concept of assignment, movement, or use of shelter. This part of the plan should describe the over-all operations as they appear to the responsible official (mayor, governor, director). The paragraph on Task Assignments, below, indicates details in carrying out this broad concept. Separate paragraphs may be used to describe action and activities under varying time phases, such as strategic and tactical warning, transattack and postattack periods.

Examples of items to consider in this part of the plan are maps showing preattack ground organization; organization chart; alerting actions and/or procedures; checking equipment and communications systems; establishing contact with higher, adjacent and lower units or levels of governments; activating control center; continuity of government activities; dispersal of operating forces and equipment; public information announcements; economic controls and management of resources; check weather intelligence.

1. Task Assignments In separate lettered subparagraphs, state the specific tasks of each element of the organization charged with the execution of duties. This paragraph defines the role of each subordinate element in the over-all concept described above. Example: police - maintain law and order, control traffic and protect life and property.

2. Supply and Transportation Broad instructions concerning supply and transportation for the conduct of the operation. Details should be

included in one or more annexes (a separate annex for each department or service concerned).

3. Command, Control and Communications State the communications facilities and systems to use, time zone to use, the location of operating center and alternates. Command relationships are defined in this paragraph. If complex, command relationships may be described in a separate annex. (Maps and charts are appropriate here.)

4. Charts and Maps Some parts of the operations plan lend themselves to graphic presentation on maps and overlays. Examples are: fallout forecasting; shelter assignment and movement plans; plans for damage control and damage reconnaissance teams; highways to be kept open, etc. The preparation and use of such operations maps, upon which instructions may be given or amplified in working out an operations plan, are recommended and encouraged.

5. Signature and Authentication

6. Distribution

7. List of Annexes

OPERATIONS PLAN ANNEXES

Annexes are parts of the plan which expand in detail general provisions of the operations plan. They are generally of the following types:

1. Intelligence Annex The details of the civil defense analysis, target analysis, and hypothetical attack are important to the preparation of supporting service annexes. These details may be included in the intelligence annex. As a minimum, the intelligence annex should include:

   a. The essential elements of information.

   b. Instructions for collecting and reporting intelligence information.

   c. Plan for dissemination of intelligence.

2. Service Annexes The basic assumptions for the development of the operations plan are made by the responsible official and his staff during the study in which the civil defense analysis, target analysis, hypothetical attack, and over-all damage assessment are made.

   The individual services should base their plans on the over-all assumptions given to them as a result of the study made by the civil defense staff, the general concept of operations, the specific responsibilities assigned to their service, and the administrative and command portions of the basic plan.

The outline for development of the various annexes may be the same or very similar to the over-all outline for the operations plan given above, or they may differ. Appropriate headings should be established, according to the service. Certain differences may be desirable in the development of service annexes. It will be necessary to include, in addition to the statements involving communications and coordination, detailed functions as follows:

a. Dispersal plan, if any.
b. Rendezvous areas, where applicable.
c. Assembly plans.
d. Specific actions to be taken at significant time periods.
e. Intra-service communication and reporting instructions.
f. Arrangements for command and coordination.
g. Administrative details.
h. Protective measures for personnel.
i. A broad statement of instructions to next lower level of organization (if applicable).

3. Administrative and Facility Annexes General plans for administrative functions, such as communications, may appear in the basic plan with details of such plans spelled out in the appropriate annexes. One of these details should specify the radio or telephone alerting procedure by which the warning signals are disseminated to key personnel not otherwise alerted by the warning signal.

4. Aid and Support Annexes These annexes should specify manpower and equipment requirements in terms of service units when possible. They should be realistic in consideration of competitive demands on personnel and equipment.

   Where local organizations (civic or veterans organizations, taxi companies, Boy Scouts) have accepted specific emergency responsibilities, their plans should be integrated with that of the local unit of government through appropriate annexes.

5. Task Organization Annexes This annex should outline the chain of command and control. Agencies, services or units (except staff agencies) reporting directly to the issuing agency are listed as major paragraph headings. The principal subordinate agencies or units of these major agencies may be listed in subparagraphs under the appropriate major heading.

An annex describing the general plan for a class, group or service, may have appendices giving amplified and detailed plans for individuals or units within that group or service.

In order to develop a service annex for operation purposes, it is desirable that a table of organization and equipment be developed. This table would describe the normal mission, organizational structure, personnel and equipment, and capabilities for an organized defense unit. During a disaster, many emergency operations will require the combined efforts of a group of defense workers. Therefore, it is deemed advisable to organize these individuals into units or teams. A unit for defense purposes consists of a group of workers organized to perform a specific emergency operation. Thus, it will be seen that, whereas the over-all plan is primarily directive, the service annexes are largely quantitative, containing numerical estimates (by type) of the manpower and material requirements to support the operations plan.

Although it is recognized that some services (e.g., transportation) may not be able to develop a precise table of organizational units and capabilities, generally the information furnished for each table of organization and equipment is as follows:

1. Function or mission.
2. Organizational structure.
3. Personnel.
4. Equipment.
5. Capability.
6. Remarks.

Security Certain parts of an operations plan may involve information (communication arrangements or vital facilities) which might be of value to a potential enemy. The originating official should be responsible for determining the information which should be classified. A relatively small amount of operations plan material will need to be classified. Unnecessary classification should be carefully avoided so that ordinary instructions and information can flow freely. Classified parts will have to be omitted in unclassified directives and referred to only in separate directives. The number of copies of classified parts of an operations plan should be kept to a minimum to avoid the risk of their falling into unauthorized hands.

Testing and Revising the Operations Plan No operations plan, however sound in concept and completeness of detail, is of much value if it is untested or untried. To be useful, an operations plan should be capable of implementation. Planners should be realistic in their consideration of the possible total number of casualties and damage, including possible losses to the operating forces. They must determine the resources, both in manpower and materials, that will be required in support of the objectives. The plans should be such that the capacity of the emergency organization is commensurate with the problem posed by the total casualties and damage.

A good plan should require change only when circumstances challenge major assumptions. Some of the factors that may affect planning assumptions are changes in international relationships, weapons, weapons delivery systems, defense techniques, and within the community. Responsible officials at all levels of government should review and revise their own plans in the light of such factors.

SUMMARY

An operations plan converts the leader's (director's) decisions into a plan of action and contains such details as are necessary to insure coordinated action by the entire organization. In the preparation of the operations plan, a thorough visualization of the plan of action and a clear understanding of what is required of each element involved in operations is essential. Specifically, what is each expected to accomplish and how does it contribute to the success of the over-all mission?

Planning is a natural and definite process which will increase the chance for success. Through planning, problems are identified. This, in turn, enables the planning officials to place resources in the most advantageous position to create the greatest potential for saving life and property, and in the conduct of operations. It cannot be assumed that emergency preparedness will be sufficient to the need in times of disaster, unless plans are made now to organize, train, equip and condition. It cannot be assumed, even in the face of the most modern weapons, that this Nation cannot override the damage they can cause. Either of these assumptions could lead to national suicide. A strong military defense allied with a strong civil defense increases our total defense posture as a Nation. As it has been well said, "It is far better to have a plan and not need it, than to need a plan and not have it."

TITLE: Radiological Service Plan BRIEF NO. 11

COURSE: Radiological Defense Officer

FOR USE IN THE SESSION: Radiological Defense Planning

REMARKS: (Homework assignment) Study this brief before the Radiological Defense Planning session. Be prepared to present and defend recommendations on the Illustrative Outline for the following:

a. Additions or deletions to the plan format as outlined in the contents below.
b. Changes in the mission statement.
c. Modifications to the Table of Organization.
d. Modifications to the Execution and Operational Responsibilities section.

If no changes or modifications are recommended be prepared to defend the outline as presented.

CONTENTS

LOCAL RADIOLOGICAL SERVICE PLAN

Illustrative Outline

NOTE: It is not intended that this outline serve as "copy" for a local radef annex. For clarity, most of the major topics include more detail than would appear in the basic annex. The statements in the basic annex should be broad enough to include required concepts but need not, and should not, include distracting details that can appropriately be presented as attachments detailing specific topics, or as SOP's which describe detailed operations of the respective subgroups of the Radiological Service.

MISSION

To provide capability for radiological monitoring and reporting; analysis, presentation, and evaluation of data; and technical staff support as a basis for (a) the control of radiation exposures of persons performing civil defense operations, and (b) the direction of activities of the populace to minimize fallout radiation hazards resulting from nuclear weapons attack.

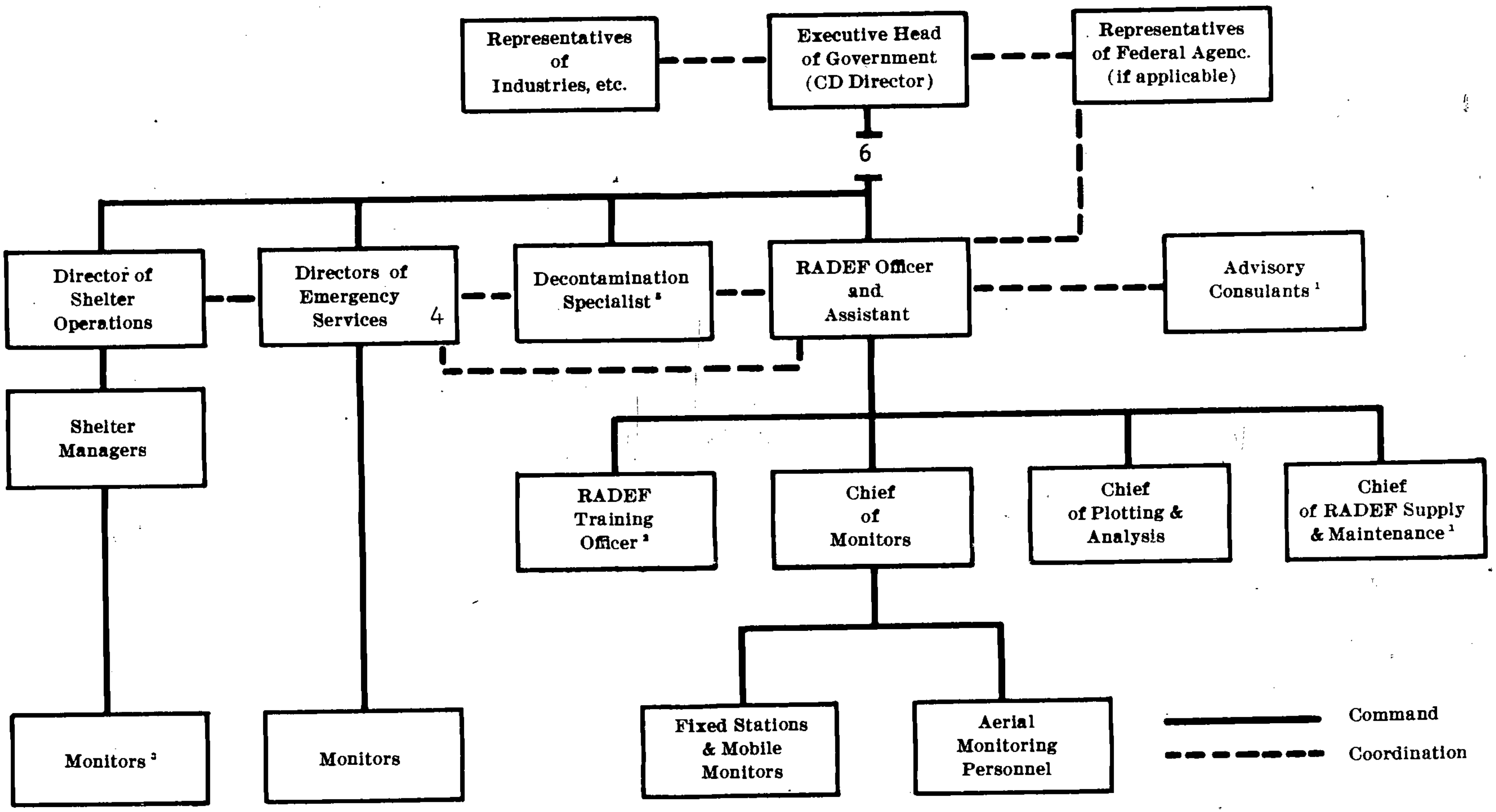
ORGANIZATION

The "Table of Organization, Local Radef Operations" is presented on the following page. It shows chain of command and indicates the important coordination with other services necessarily performing limited radiological service functions. Recommended radef staffing at emergency operating centers for several sizes of communities is:

Radef Officer

1. Appointed by Civil Defense Director.
2. Reports to and supplies staff support to the Civil Defense Director.
3. Responsible for:
    a. Planning
    b. Personnel:
        (1) Recruits and appoints with approval of director.
        (2) Directs activities.
        (3) Determines line of succession of staff.
    c. Determining local aspects of training and evaluating effectiveness of training programs.
    d. Liaison with local civil defense services.
    e. Preparation of radiological information for release to the public through appropriate channels.
    f. Preparation of reports to appropriate higher authority.
    g. Coordination of radef functions of other services within the local jurisdiction.
    h. Coordination of operational plans with local representatives of Federal and State governments.
    i. Emergency radef operations.

TABLE OF ORGANIZATION LOCAL RADEF OPERATIONS



[1] Should have operational assignments, and where feasible, should include a meteorologist.
[2] May be Assistant Radef Officer.
[3] Subject to reassignment to mobile monitoring at conclusion of shelter period.
[4] Includes Public Health, Welfare, Police, Fire, Public Works, P.I. Officer, etc.
[5] Under direction of Radef Officer when required by local plan
[6] Could be intermediate executive Officers, e.g. Operations Officer.

Advisory Consultants

1. Nature of personnel:
   a. Physicists and chemists
   b. Radiologist
   c. Meteorologist
   d. Professional engineers
2. Duties:
   a. Promote the recruitment of technically competent personnel for the Radef Service.
   b. Provide technically accurate advice and guidance to the Radef Service during implementation of programs and postattack.
   c. Perform radef operational functions as appropriate.

Staff

1. Assistant Radef Officer
   a. Assists the Radef Officer and acts for him in his absence.
2. Radef Training Officer
   a. Adapts Federal training materials and guidance to lesson plans which satisfy local training requirements in:
      (1) EOC operational procedures.
      (2) Orientation for executives.
      (3) Monitoring and reporting techniques and operations.
      (4) Decontamination (when assigned to Radiological Services by the basic civil defense plan).
   b. Provides for elements of the training program, including:
      (1) Specialized training of key personnel (at OCD schools, etc.).
      (2) Schedules of local courses:
         (a) Initial training
         (b) Refresher training
      (3) Operational tests, exercises, evaluation, and remedial training.
      (4) Provisions for facilities, equipment and training aids.
   c. Maintains roster of trained personnel and recommends assignments.
3. Chief of plotting and analysis
   a. Provides for:
      (1) Necessary maps, materials and plotting equipment.
      (2) Receipt of upper fallout (UF) wind data.
      (3) Continuing training of his staff.
   b. Directs his staff in preparation or maintenance of:
      (1) UF wind vector plots.
      (2) Fallout forecasts.
      (3) Message and reporting logs.
      (4) Dose and dose rate plots and analysis.
      (5) Reports to higher heads of government.
   c. Assists the Radef Officer in preparation of advisories.
   d. Assists in the planning of mobile and aerial monitoring missions.
4. Chief of monitoring:
   a. Assists in training of monitors and, in coordination with the training officer, recommends assignment of monitoring personnel.

b. Maintains current roster of monitoring stations and teams.
c. Directs monitor personnel relative to:
   (1) Monitoring procedure.
   (2) Reporting.
   (3) Mobile and aerial monitoring missions.
   (4) Postattack redistribution (reassignment) of monitors.
d. Maintains radiation dose records of monitors when operationally feasible.

5. Decontamination specialist (where in organization):
   a. Plans and develops decontamination capability, including:
      (1) Assessment of existing suitable equipment and operators, and maintenance of current lists.
      (2) Studies of the feasibility of decontaminating vital areas and facilities.
      (3) Assures assignment of trainees through coordination with emergency services, industries, contractors, etc.
      (4) Assists in training personnel to apply existing skills in decontamination operations.
   b. Provides staff support concerning:
      (1) Time phase feasibilities of decontamination.
      (2) Methods to be employed.
   c. Provides for field operations
      (1) Technical direction and coordination.
      (2) Evaluation of effectiveness.
6. Chief of radef supply and maintenance
   a. Requests radiological equipment.
   b. Assures appropriate storage at designated dispersed locations.
   c. Distributes and maintains custody records of operational and training equipment.
   d. Provides for scheduled operability checks and local aspects of maintenance and calibration of radiological equipment.
   e. Coordinates transportation of personnel and equipment.
   f. Trains for and performs postattack functions as assigned.

EXECUTION AND OPERATIONAL RESPONSIBILITIES

Readiness Development Period

1. Organize and staff the emergency radef service at the EOC.
2. Develop the planned operational capability through:
   a. Recruitment and training of personnel.
   b. Requests for radiological equipment.
   c. Maintenance of personnel rosters.
   d. Liaison with other civil defense elements.
3. Establish monitoring capability at selected locations.
4. Coordinate training and operational capability of other civil defense services performing monitoring functions.
5. Evaluate and perfect capability through tests and exercises by the various elements of government.
6. Provide authoritative public information to PIO on hazards of nuclear attack and protective measures.

7. In coordination with communications, provide for adequate communications for all radef functions.
8. Prepare SOP's for:
   a. Supply and local aspects of instrument maintenance and calibration programs.
   b. EOC radiological service staff procedures. (See "Checklist for Preparation of EOC Radiological Operations SOP").
   c. Decontamination procedures (where the responsibility of the Radef Service).
   d. Fixed monitoring station procedures to include mobile monitoring (See page 11-10 for illustrative SOP).
   e. Community shelter monitoring procedures.
   f. Aerial monitoring and survey procedures.

Period of Extreme International Tension

Perform the following functions in accordance with the corresponding SOP's.

1. Place personnel on alert.
2. Perform operational check and users' maintenance of equipment.
3. Disperse equipment not previously distributed for operational purposes.
4. Activate Radef Service at EOC with key personnel.
5. Maintain and plot UF data on current basis.
6. Supply UF wind vector plots for use by the EOC staff.
7. Check Radef Service supplies.
8. Check communication capabilities specifically assigned to radef.
9. Prepare public information material for release through established channels.

At Warning that Attack Is Imminent or Has Begun

1. Complete staffing of all radiological defense installations in accordance with directives based on civil defense plan, or take protective action and report to duty stations in accordance with the local plan.
2. Complete actions listed under "Period of Extreme International Tension," if required.
3. If no such warning was received give the following priority:
   a. Alert personnel
   b. Staff Radef Service at EOC
   c. Prepare UF wind vector plots

Postattack Period - In Accordance with SOP's for:

1. Period of high radiation hazard:
   a. If required by basic plan, observe and report strike time and weapon effects for evaluation of location and yield of explosion (SOP).
   b. Prepare fallout forecasts for the civil defense director and his staff.

c. Prepare public warnings and directives for release through authorized channels.
d. Receive from higher echelons selected flash reports of fallout arrival at other locations and apply for forecasting arrival time of fallout.
e. Receive high priority or flash reports of arrival of local fallout and report to next higher echelon.
f. Receive, plot and analyze radiological reports.
g. Prepare scheduled radiological reports for transmission to the next higher echelon.
h. Continually evaluate the radiological situation for use in issuing public guidance and in planning and directing emergency operation.
i. Receive, plot and display radef information from higher echelons for use by the EOC staff.
j. Give technical assistance to civil defense director and staff.

2. Operational recovery period:
   a. Continue to receive, plot, analyze and display local radiological information.
   b. Prepare and transmit in accordance with established reporting procedures, radiological information required by the next higher echelon.
   c. Perform detailed mobile and aerial monitoring or surveys as required.
   d. Continue to assess radiation exposure of emergency personnel as a basis for reassignment, replacement and rehabilitation.
   e. Evaluate radiological decay characteristics and predict future dose rates and doses (SOP).
   f. Estimate the dose to populace having various degrees of radiation protection and the feasibility of remedial movement when required.
   g. Prepare appropriate public information releases.
   h. Perform other duties as directed.
3. Transition to near-normal operations:
   a. Continue operational recovery activities.
   b. Restaff and train radef personnel as required.
   c. Maintain instruments and equipment.
   d. Assist other civil defense services in assessing the radiation hazards.
   e. Assist public health and agricultural officials in evaluating the radiological contamination of food and water.
   f. Advise other services on decontamination and waste disposal operations as required.

APPROVED:

Chief executive of local government	Date

EOC RADIOLOGICAL OPERATIONS SOP

Checklist for Preparation

The SOP should provide specific detail concerning WHO (by title), WHEN, WHERE and HOW for the following functions, as applicable.

Functions

1. Alerting of personnel (example Personnel Roster, page 11-9).
2. Preparation for operations (rearrangement of space, setting out special equipment, maps, etc.)
3. Delineation of communications channels and procedures (in consonance with local civil defense plan).
4. Schedules for reports from monitors.
5. Receipt of UF data, preparation of wind vector plots and fallout forecasts.
6. Reporting to other elements of government.
7. Presentation and display of radiological information to EOC staff.
8. Training in EOC operations, if required postattack to fill position vacancies or augment staff.
9. Coordination with other services.
10. Message and data handling.
11. Plotting and analysis.
12. Preparation of advisories.
13. Radiological calculations in support of evaluation (item 15, below).
    a. Decay characteristics.
    b. Estimation of future dose rates and doses.
14. Control and direction of monitoring operations:
    a. Scheduled onstation monitoring and reporting.
    b. Coordination of monitoring by various services recognizing changing radiological and operational situations.
    c. Reassignment of shelter monitors in support of recovery operations.
    d. Radiation exposure control for monitors.
    e. Planning and assignment of mobile (surface and/or aerial) monitoring and survey missions and associated reporting systems and procedures.
15. Evaluation and staff support, concerning:
    a. Relative hazards in various types of shelter.
    b. Need for and feasibility of decontamination and/or remedial movement.
    c. Shelter stay time.
    d. Hazards associated with emergency operations (proposed and in progress).

(EXAMPLE)

ROSTER

RADEF OPERATION PERSONNEL

November 16, 1962

Name	Address	Phone		
		Home	Business	
Richardson, M. C.	227 North Rampark	MO6634	MA3215	RADEF officer.[1]
Miller, C. S.	2064 McElvertt St.	SE8436	BL1968	Assistant RADEF and training officer.[2]
Turner, L. A.	9063 Grover Ave.	NO1106	OX7111	Chief, plotting and analysis.[1]
Mann, Z. F.	4110 Lewis Place	BL5437	MA9934	Plotter.[2]
Smith, D. A.	3364 Wilson St.	LO3004	MA70 3	Plotter.[1]
Bigger, M. V.	217 Dupoint Ave.	DL9786	PL0775	Senior analyst.[2]
Callahan, B. H.	5502 McDill Ave.	MO7681	OX2444	Analyst.[1]
Wright, C. M.	694 McElvertt St.	SE8486	MA2926	Chief monitor.[1]
Weinthrub, G. N.	7854 Gross St.	NO6229	OX3468	Assistant monitor Chief.[2]
Hiscox, I. J.	4710 Mt. Pleasant	DE4442	PL1367	Chief supply and maintenance.[1]
Little, V. C.	116 Nelvin Ave.	BL5753	BL6879	Assistant supply and maintenance.[2]
Curruth, Y. T.	2674 Rosson St.	LO3207	BL4030	Assistant supply and maintenance.[1]
Matt, V. O.	69 Royal Place	NO4997	MO7345	Assistant supply and maintenance.[2]
Bryant, L. D.	3219 Hinds Park	SE1117	PL6011	Assistant supply and maintenance [2]

[1] 1st Shift (subject to postattack revision)
[2] 2nd Shift

Order of Succession

RADEF officer	Richardson, M. C.
Assistant RADEF officer	Miller, C. S.
Chief plotting and analysis	Turner, L. A.
Senior analyst	Bigger, M. V.

SOP FOR FIXED FALLOUT MONITORING STATION XYZ
AND
EMERGENCY MONITORING OPERATIONS IN AREA 27A

CITY STREET DEPARTMENT
(Illustrative Example)

References

1. Local radiological service plan.
2. City street department emergency operations plan.
3. Handbook for Radiological Monitors, OCD, April 1963.

General The primary functions of monitoring teams are to provide timely and accurate information to the Radef Service required for proper analysis and evaluation of fallout in their designated area of responsibility and to give monitoring capability to the city street department during emergency operations. (See Tables 1 and 2)

Organization

1. Fixed Monitoring Station XYZ is located in Room B-26, Baker Building and is manned by personnel of the city street department.
2. Monitoring personnel will consist of a Senior Monitor (monitor in charge) and three monitors. (See Table 3)
3. The monitoring operations during the shelter period will be conducted under the direct supervision of the Radef Officer.
4. During emergency field operations the team will render monitoring support to the city street department in coordination with the Radef Service.

Equipment and Supplies

1. Monitoring instruments. The monitoring equipment will be stored in Room B-26, Baker Building. Two sets of serviceable batteries will be maintained on hand; however, the batteries will not be inserted in the instruments during storage. (See Table 4 for inventory of radiological instruments.)
2. Administrative supplies and forms. An adequate supply of administrative supplies such as paper, pencils, etc., and forms will be maintained in the monitoring station. Forms will consist of the following:
   a. Radiation Exposure Record
   b. Inspection, Maintenance and Calibration Log for Radiological Instruments
   c. Radiological Reporting Log
3. Vehicles. As assigned by Transportation, utility pickup trucks CSD 337 and CSD 360 will be made available by the dispatcher for use by monitoring teams for emergency operations. These vehicles

will come under the control of the Senior Monitor upon an attack, or warning of an attack, and will be housed, when not is use, in designated location in city street department maintenance building number 2. (See Table 1)

Communications Telephone will be used in reporting radiological information to the EOC during period of in-shelter monitoring. The city street department radio net may be utilized for this purpose in the event of telephone communications disruptions. During emergency operations monitoring the department's radio net may be used for high priority reporting to EOC. The call sign designation is listed on the card attached to each radio of the department.

Monitoring Operations Radiological monitors will perform functions as outlined in this section. Any departure from these procedures must be approved by the Radef Officer and the department's civil defense coordinator.

1. Readiness operations. During peacetime, monitoring personnel will take the following actions under the supervision of the Senior Monitor.
   a. Perform operational check on all survey meters and rezero all dosimeters on or about the 20th of March, May, July, September, November, and January.
   b. Record the results on the inspection, maintenance, and calibration log.
   c. Initiate action for the repair or replacement of inoperable instruments through the department's civil defense coordinator.
   d. Make instruments available to the radef supply and maintenance officer for calibration on or about the 20th of March and September in conformance with his specific request.
   e. Replace batteries on or about the 20th of March or sooner if necessary.
   f. Participate in refresher training exercises and tests as requested by the training officer through the civil defense coordinator for the city street department.
   g. Maintain current sketches of area of responsibility shown in Tables 1 and 2, indicating monitoring station, in-shelter monitoring point, unsheltered monitoring point, and preselected monitoring points within area of responsibility.
2. Shelter operations
   a. Readiness action
      (1) Reporting for duty. All team members will report to Station XYZ with the least possible delay following warning that attack on the nation is likely to occur, or has occurred.
      (2) Instrument operability check. The first monitor arriving at the station will perform an operational check on all survey meters and charge dosimeters.
      (3) Operational readiness report. A report will be made to the EOC that "Station XYZ is operational." When time permits, attempts will be made to contact missing team members by telephone.

(4) Station safety. Check to see that doors, windows, or other openings are securely closed during fallout deposition.

(5) Place one CD V-730 dosimeter and one CD V-742 dosimeter, after being properly zeroed, in the rack on the table provided as the in-shelter monitoring point. (See Table 1)

(6) Place second CD V-742 dosimeter in a plastic container and place on the stake provided at the unsheltered monitoring point.

3. Fallout monitoring station operations.

a. Flash reports. A flash report is a "one-time," high-priority, unscheduled report. Begin outside surface monitoring to determine the time of fallout arrival. When outside dose rate exceeds 0.5 r/hr make FLASH REPORT to the EOC using the following format: Example: This is Monitoring Station XYZ. Dose rate exceeded 0.5 r/hr at 1000 hours.

b. Monitoring times and reporting schedules. All reports will utilize local time (Eastern Standard Time or Eastern Daylight Time) and will conform to the reporting schedule shown on the Radiological Reporting Log. (See Handbook for Radiological Monitors). Reporting times indicated on the Radiological Reporting Log will be converted to local time using the time conversion chart on the reverse side of the log. These conversions will be entered in spaces provided above Greenwich Meridian times on the log.

c. Dose rate reports. Except as provided in e, below, the scheduled unsheltered dose rates will be measured and recorded. Upon call for report from the Radef Officer, the report will be rendered in the format as indicated below:

Example: This is Station XYZ. 2200 hour dose rate 57 r/hr.

d. Dose measurement report. The accumulated dose measurements will be reported as a part of, and immediately following, the 2200 hour (2300 hours daylight time) report using the below format:

Example: Measured dose at 2200 hours 720 roentgens.

e. Discontinuance of unsheltered monitoring. When the unsheltered dose rate reaches or exceeds approximately 100 r/hr, they will be calculated from sheltered dose rates. (See Handbook for Radiological Monitors).

f. Resumption of outside monitoring. Resume outside monitoring after the unsheltered dose rate has decreased to 25 r/hr.

Monitoring in Support of Emergency Operations When it has been determined, in coordination with the EOC, that radiation levels have decreased sufficiently to permit high-priority street maintenance operations and later, as operational recovery activities including decontamination of streets and structures in the area of responsibility are initiated, the monitoring team will be required to provide radiological monitoring support to these operations as a primary mission. At this time, reporting of radiological information will become a secondary mission.

1. Except where radiological coordination has been effected through the department representative at the EOC, the Senior Monitor will obtain the following information from the EOC and furnish it to the coordinator of operations of the city street department:
   a. The time when personnel of the department may leave shelter to perform specific missions.
   b. The allowable dose for the complete mission from time of departure until return to shelter.
   c. The dose rate to be expected in the area of the mission.
   d. Procedure and schedule for reporting radiological information to the EOC.
2. When the Senior Monitor has assigned a monitor to accompany an emergency operational mission, the monitor will:
   a. Advise on protective measures to be taken by members of the group to prevent the contamination of their bodies. (See Handbook for Radiological Monitors.)
   b. Read his instrument frequently during each operation and advise the individual in charge of the mission on the necessary radiological protective measures and when the radiation exposure is approaching the planned maximum mission dose.
   c. Determine the effectiveness of decontamination measures when supporting decontamination operations.
   d. Monitor personnel and equipment on return to shelter or base of operation to determine the decontamination requirements.
   e. Direct decontamination of personnel and equipment, in coordination with person in charge and assure that the decontamination is effective.
   f. Record monitored information on sheets attached to the Radiological Reporting Log in format appropriate to the mission. Report data to EOC, if required in mission directive.
   g. Assist in recording exposure doses of Emergency Team members on individual Radiological Exposure Records.
3. Obtain monitoring readings at Preselected Monitoring Points designated in Table 2, when directed.

Table 1 Diagram of Monitoring Station XYZ
Table 2 Area of Emergency Operations
Table 3 Roster of Monitors
Table 4 Status of Monitoring Instruments

APPROVED:

Radef Officer	Date
Director of City Street Department	Date

TABLE 1

City Street Department SOP Fixed Fallout Monitoring Station XYZ
and
Emergency Monitoring Operations in Area 27a

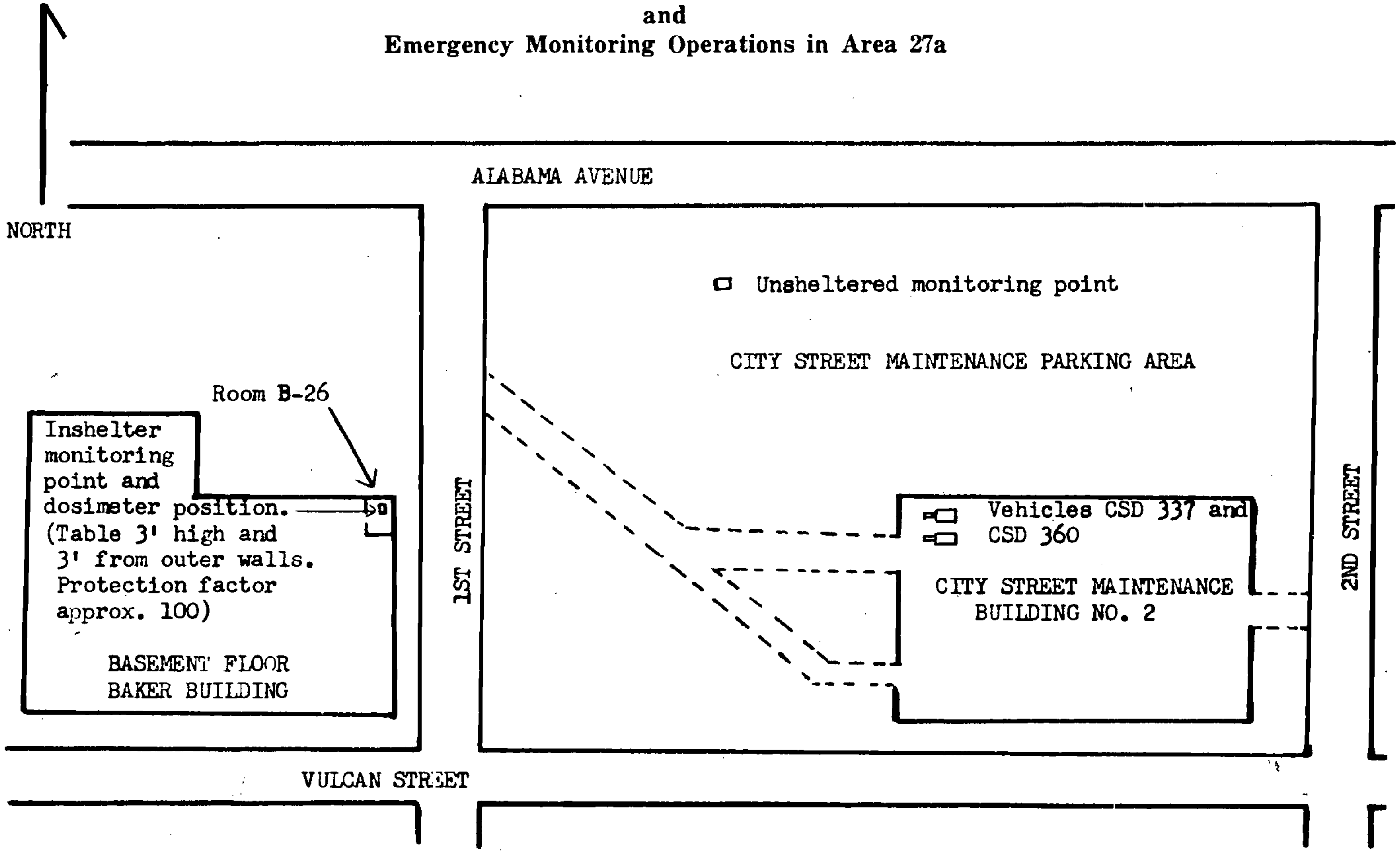
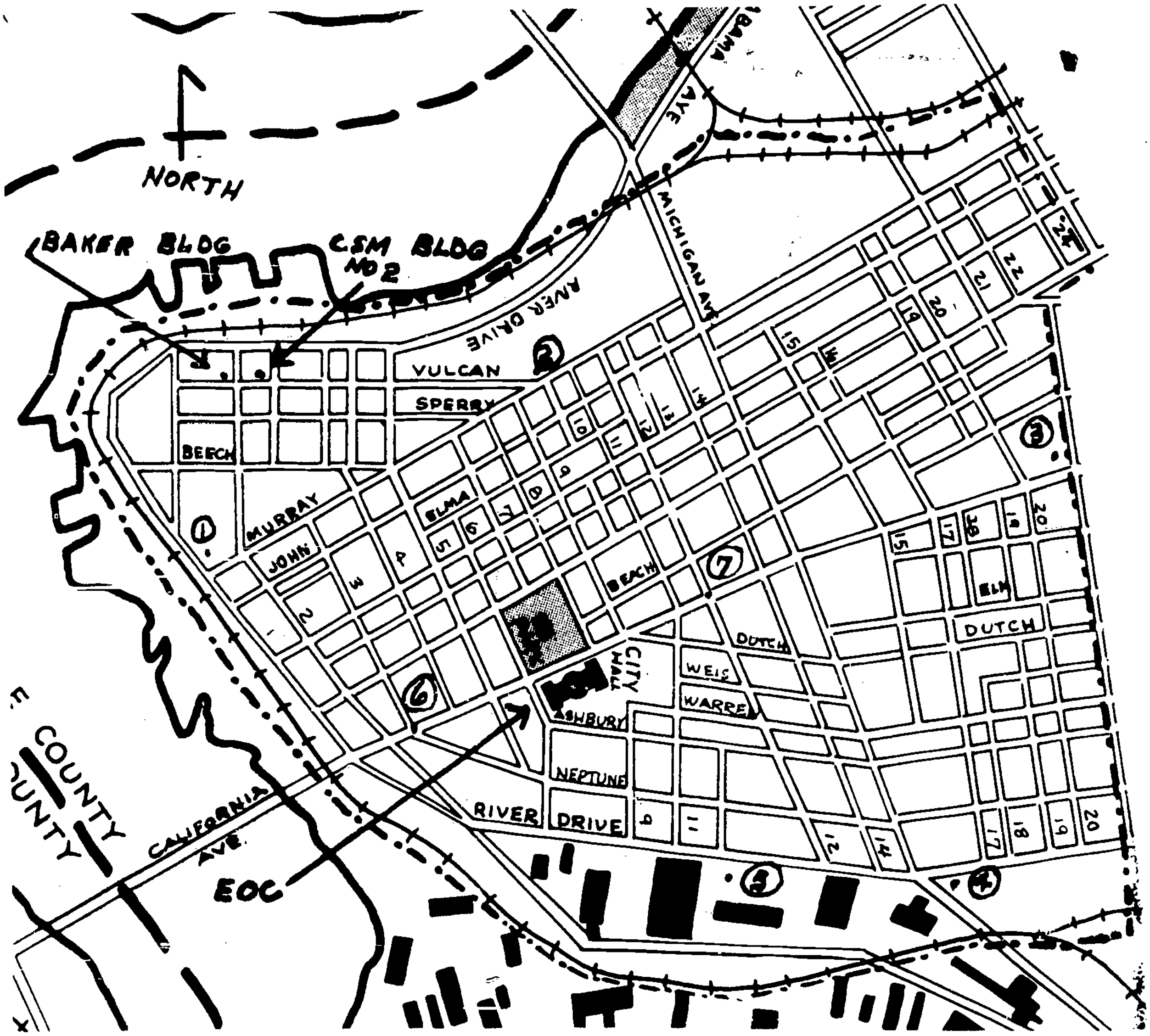


TABLE 2

City Street Department SOP Fixed Fallout Monitoring Station XYZ
and
Emergency Monitoring Operations in Area 27A



— · — · — · Boundary Area 27a

① Etc. Preselected monitoring points

TABLE 3

ROSTER OF MONITORS

MONITORING STATION XYZ AND AREA 27A

Name	Division	Home address and phone	
Daniels, L. C [1]	Street maintenance	1542 Elm Ave	MO62371
McCue, O. B	do	402 S. 20th St	LO34536
Johnson, W. D	do	118 N. 15th St	NE21161
Leary, B. F	do	521 N. 19th St	NE21885

[1] Senior monitor.

Roster is listed in succession of command.

EMERGENCY TELEPHONE NUMBERS

RADEF officer	McLaughlin, G. H	OX71163
RADEF supply and maintenance officer	Williams, E. C	OX74110
EOC location	Room B–117, City Hall	OX74100, OX74101

TABLE 4

RADIOLOGICAL INSTRUMENTS

MONITORING STATION XYZ AND AREA 27A

Operational Monitoring Kits, CD V777, 2 each consisting of the following:

Number	*Item*	*Quantity*
CD V–700	Geiger counter (0–50 mr/hr)	2
CD V–710	Survey meter (0–50 r/hr)	1
CD V–715	Survey meter (0–500 r/hr)	2
CD V–720	Dosimeter (0–500 r/hr)	1
CD V–730	Dosimeter (0–20 r)	1
CD V–740	Dosimeter (0–100 r)	1
CD V–742	Dosimeter (0–200 r)	2
CD V–750	Dosimeter charger	2

INSTRUMENTS REQUISITION PENDING

CD V–742	Dosimeter (0–200 r)	20

COORDINATED FUNCTIONS
COUNTY RADEF-REPRESENTATIVES OF USDA

General The States and their political subdivision have broad responsibility for developing radiological service capabilities throughout their areas. The USDA is assigned certain responsibilities for radiological defense as it affects agriculture and agricultural resources. These include developing plans and furnishing technical guidance covering protective measures, treatment and handling of livestock, including poultry; agricultural commodities on farms or ranches; agricultural lands; forest lands; and water for agricultural purposes, any of which have been exposed to or affected by radiation. It also includes activities to assure the safety and wholesomeness and minimize losses from radiological effects, and other emergency hazards of livestock, meat and meat products, poultry and poultry products in establishments under the continuous inspection of the U.S. Department of Agriculture, and agricultural commodities and products owned by the Commodity Credit Corporation or by the Secretary of Agriculture. In order to avoid duplication of equipment, training, and personnel requirements, the following division of responsibilities should be observed.

Responsibilities

1. Local government.
   a. Establish local procedures for the monitoring and reporting necessary for the evaluation and control of radiation exposure of the (rural) population, livestock, and poultry.
   b. In conjunction with representatives of USDA, establish local procedures for the radiological monitoring and reporting (or mapping) of contamination of privately owned farmland and agricultural commodities.
   c. Establish monitoring and reporting systems to supply the intelligence necessary for the short- and long-range protection of the lives and property of (rural) people. Appropriate monitoring information should be made available respectively to the local government and to USDA representative(s).
   d. Perform other appropriate radiological defense functions as directed in the Federal Civil Defense Guide.
2. The Department of Agriculture (local representatives)
   a. In conjunction with the local civil defense office, establish local procedures for the radiological monitoring and reporting (or mapping) of contamination of privately owned (1) farmland and (2) agricultural commodities (stored or harvestable).
   b. Based upon local monitoring information and USDA guidance, recommend appropriate (1) use of agricultural lands, (2) use or disposition of agricultural commodities, and (3) care or disposition of livestock.
   c. In conjunction with the local civil defense, advise the farm population on precautions to take to minimize radiation exposures associated with important farm work, i.e., denial time, stay time, shielding required, etc.
   d. Perform other radiological defense functions in consonance with Executive Order 10998 and official OCD guidance.

Organization The organization of local government varies significantly from State to State. However, in most States the element of government most active in administering local aspects of USDA programs is the county. For that reason it is expected that a major part of the radiological defense for agricultural areas will be organized and administered primarily from the seat of county government.

1. Coordinating personnel. The following personnel will be among those concerned with the joint responsibility for local agricultural radiological defense:
   a. County Civil Defense Director (policy)
   b. County Radiological Defense Officer
   c. Chairman, USDA County Defense Board
   d. Local representative of the Agricultural Marketing Service, Agricultural Research Service, Forest Service, or Soil Conservation Service, having radiological defense responsibilities.

Operational Plans (Joint USDA and Local Functions) Since farm size, land use, terrain, road systems, and communications requirements will vary greatly from area to area, detailed plans will vary and must reflect local conditions. The following are general recommendations of items for such a detailed plan.

1. USDA (local representative) will recommend guides and procedures for that part of the monitoring required for evaluation of (a) acceptable land and farm water use; (b) the degree of contamination of agricultural commodities, stored or harvestable on farms, ranches, and at bin sites; forest products; and (c) the probable effects on livestock and poultry.
   a. For land use, except national forest lands, Soil Conservation Service, USDA, will recommend:
      (1) The spacing of the monitoring grid (at section line corners, etc.), and/or aerial monitoring flight patterns. This item of the plan should be subject to postattack revision for those areas where fallout deposition is quite irregular. Early monitoring performed for the safety of people and property should indicate whether or not deposition was markedly irregular.
      (2) Methods of reporting, plotting, and mapping the radiological defense (radef) situation as it affects agricultural operations.
      (3) In conjunction with the county Radiological Defense Officer, recommend when monitoring for land or water use evaluation should be undertaken.
         (a) Dose rates decayed to intensity low enough to present acceptable hazard to monitors.
         (b) Dose rates high enough for surface or aerial measurement with OCD survey instruments.
   b. For specialized monitoring directly assigned to USDA, the agencies made responsible for the functions will plan the extent and methods of carrying out the assignments.

c. The Department of Health, Education, and Welfare, in cooperation with their State and local government counterparts, has certain responsibilities for monitoring food for radiological contamination with the exception of food and related items assigned to USDA.

2. In an emergency, the USDA County Defense Board will apply USDA criteria in recommending:
   a. Disposition to be made of commodities, livestock and poultry.
   b. Utilization of land.
   c. Other disposition relating to agricultural commodities and agriculture, and forest lands within the county.

3. The county civil defense is responsible for performing radiological defense functions in conformance with Federal and State plans. Those functions include the development of monitoring and reporting capability in support of USDA requirement.

TITLE: Development of a Radef Capability | Brief No. 12

COURSE: Radiological Defense Officer

FOR USE IN THE SESSION: Development of a Radef Capability

REMARKS: Study each requirement. Outline your answers to each in the space provided. Your outline should be in sufficient detail for you to provide a comprehensive, yet concise, answer during the class discussion of this exercise.

CONTENTS

SITUATION A

The State Civil Defense Plan calls for a civil defense system composed of State, substate, county and local organizational elements. Among the many guidelines furnished by the State Office for the organization of its political subdivisions, the recommendation dealing with radiological defense calls for establishing radiological defense staff elements at each organizational level. Although the State plan does not specify the exact composition of a radef staff, it does suggest that staffing follow the Office of Civil Defense recommendations based on population density, size of the political jurisdiction, nature of the services required, and similar factors. The plan was originally prepared about seven years ago. Comprehensive review and revision is needed.

During the past year under new leadership, the State legislature did appropriate funds for civil defense personnel and administration beyond what had normally been voted in the past. In addition to providing for radef positions at State and substate level, sufficient funds are available for staffing at the county level with one full-time Radef Officer and for clerical assistance in addition to the county civil defense director.

Because of (1) prior interest in radef, (2) attendance at the Radiological Defense Officer and Radiological Monitoring for Instructors courses, and (3) a limited amount of monitor training which you had conducted on a voluntary basis for one of the local health organizations in City X, the county seat, you have been approached by the county commission to accept a full-time position as county Radef Officer. You accept.

The Radef Officer position had previously been filled by a volunteer who recently moved to another city because of a job transfer. Although he has done a good job, most of your predecessor's efforts have been devoted to determining county radef station requirements. From your review of this work, it is evident that the operational requirements for monitoring stations are divided among the two major cities in your County, City X and City Y, and the county at large. Among the major requirements is one which indicates a minimum requirement for a total of 45 monitoring stations, 20 for City X, 10 for City Y and 15 for the remainder of the county. Currently there is a total of 33 public shelters in the county that will require assignment of trained monitors; 21 in City X, 8 in City Y and 4 in the remainder of the county. Eleven of the public shelters will serve as monitoring stations; 5 in City X, 2 in City Y and all four of those in the remainder of the county.

Both cities rely on the services of volunteer Radef Officers; the one in City X being a high school science teacher who has graduated from the OCD Monitor Instructor course and who has been planning sporadically for the last two years. The other Radef Officer is an electronics engineer for a local electrical equipment manufacturing firm who just recently volunteered to assume the job of Radef Officer for City Y. Although he has a general knowledge of the problems of fallout and radiological instrumentation, he has never completed any formal radef training.

Requirement No. 1 Assuming that the existing over-all civil defense operations plan needs considerable updating, outline the principal actions that you would take or cause others to take to insure action on the over-all plan, as well as on the radiological defense annex and its appendices. Indicate those actions which would be most important to the final operational effectiveness of the plan.

Requirement No. 2 How many monitors should be trained to achieve a maximum radef capability?

Requirement No. 3 What actions should the county Radef Officer request of the city Radef Officer in developing a countywide radef training program?

SITUATION B

Besides yourself and the Radef Officer in City X, no other personnel to your knowledge have Atomic Energy Commission licenses to use OCD Source Sets for monitor training nor have any other personnel completed the OCD Monitor Instructor course. Since your job for the most part precludes your being able to conduct any more than a minimum of monitor training because of other duties, the problem of having a sufficient instructional staff is critical.

Requirement No. 4 What actions can you take to increase monitor training in the county?

Requirement No. 5 What will you recommend to a person who indicates an ~~interest~~ in conducting monitor training but who cannot meet AEC licensing requirements?

SITUATION C

City X and City Y currently have only one Radef Officer on their civil defense staffs. You recommend that each obtain an assistant, which is done. However, both individuals are untrained, although they do possess good backgrounds in the physical sciences.

Requirement No. 6 What training program will you suggest for these new assistants?

SITUATION D

You have established a training program and are making good progress. Most of the assigned monitors received their basic monitor training at least six months ago.

Requirement No. 7

What should be included in a refresher training period for the monitors?

How often should it be conducted?

How long should it be?

Requirement No. 8 What can you do to reduce attrition in the monitoring force?

Requirement No. 9 What do you consider to be your major problems in establishing a radef capability during the next year?

R A D I O L O G I C A L   D E F E N S E   O F F I C E R

RADEF STAFF OPERATIONS EXERCISE

In preparation for completion of this Exercise in class, the student should study the Introduction, pages E-2 through E-8. For the purpose of familiarization, the student may read the Exercise, beginning on page E-9, however, he SHOULD NOT complete any of the specified requirements.

INTRODUCTION

The purpose of this exercise is to provide experience in the procedures of collecting, assembling, analyzing, evaluating, coordinating and disseminating radiological intelligence. It also requires the solution of practical problems designed to develop a capability for providing accurate and timely technical guidance.

Each group participating in this exercise will function as a Radef staff located in a city/county Emergency Operating Center (EOC). Many EOC's may serve only a city or a county rather than both. However, to better understand the functions of each and the lateral as well as vertical operational relationships, the two levels of government have been combined in this exercise into the one facility.

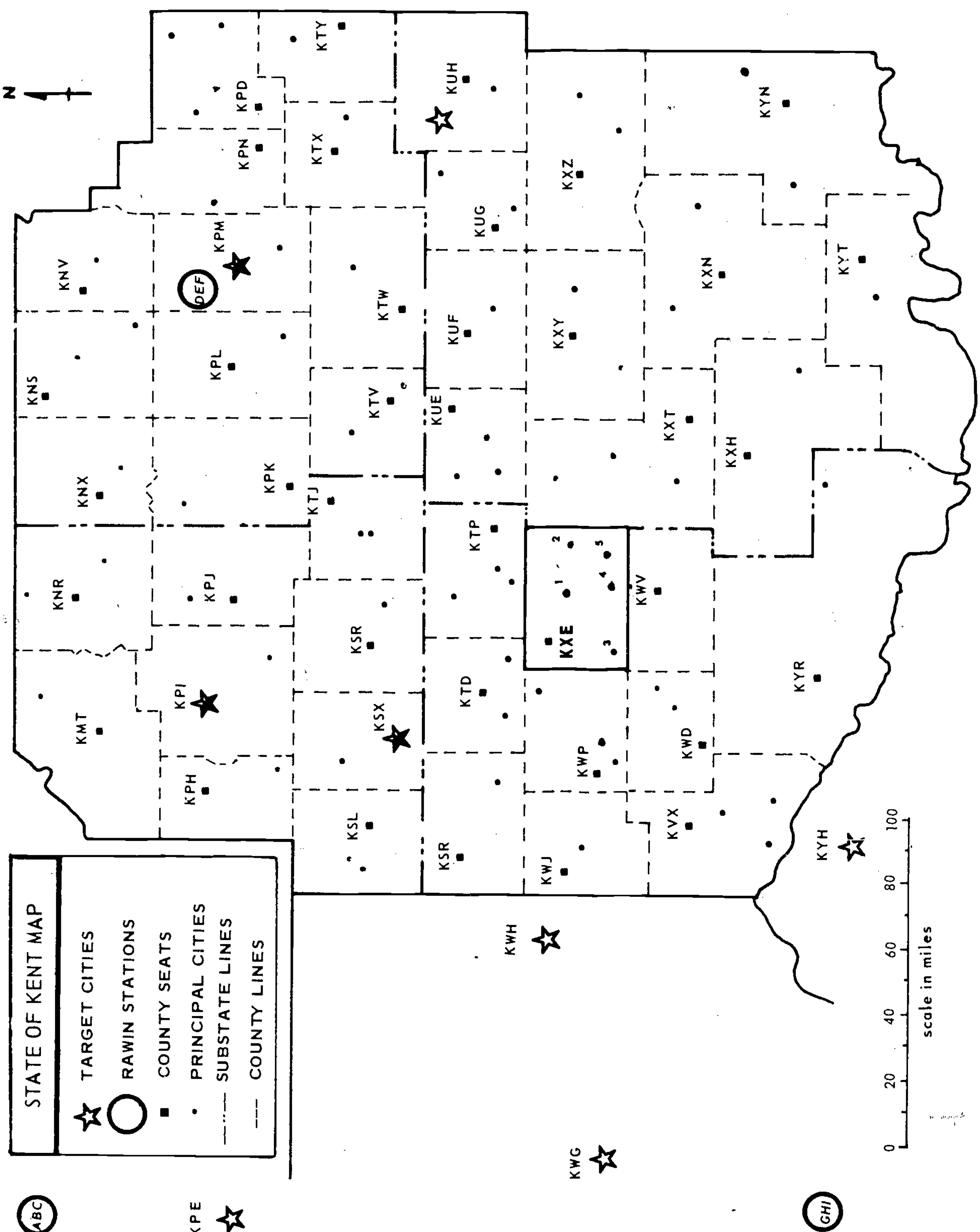
<u>Geography</u> KXE represents a city of 60,000 population, and it is also the county seat. The other cities in the county are represented by 1KXE, 2KXE, etc. Each county is identified by the three-letter designator assigned to its county seat.

City KXE is located in the northwest corner of KXE County, in the State of Kent. The Radef Officer has selected three maps for operational use (see maps on the following pages): (1) a county outline map of the State of Kent, including county seat designators, RAWIN stations, and eight target cities in and near the State; (2) a county area map of KXE and adjacent counties; and (3) a city map of KXE showing monitoring station locations.

<u>The State Plan</u> The Kent State plan calls for warning counties and large cities of approaching fallout by issuing selected flash reports from substate EOC's. Kent has been divided into four substate areas as illustrated on the State map. The State receives flash reports directly from monitoring stations in the State net, which is comprised of 10% of the fallout monitoring stations throughout the State. These stations, generally, are located in 24-hour manned installations, such as police or fire stations.

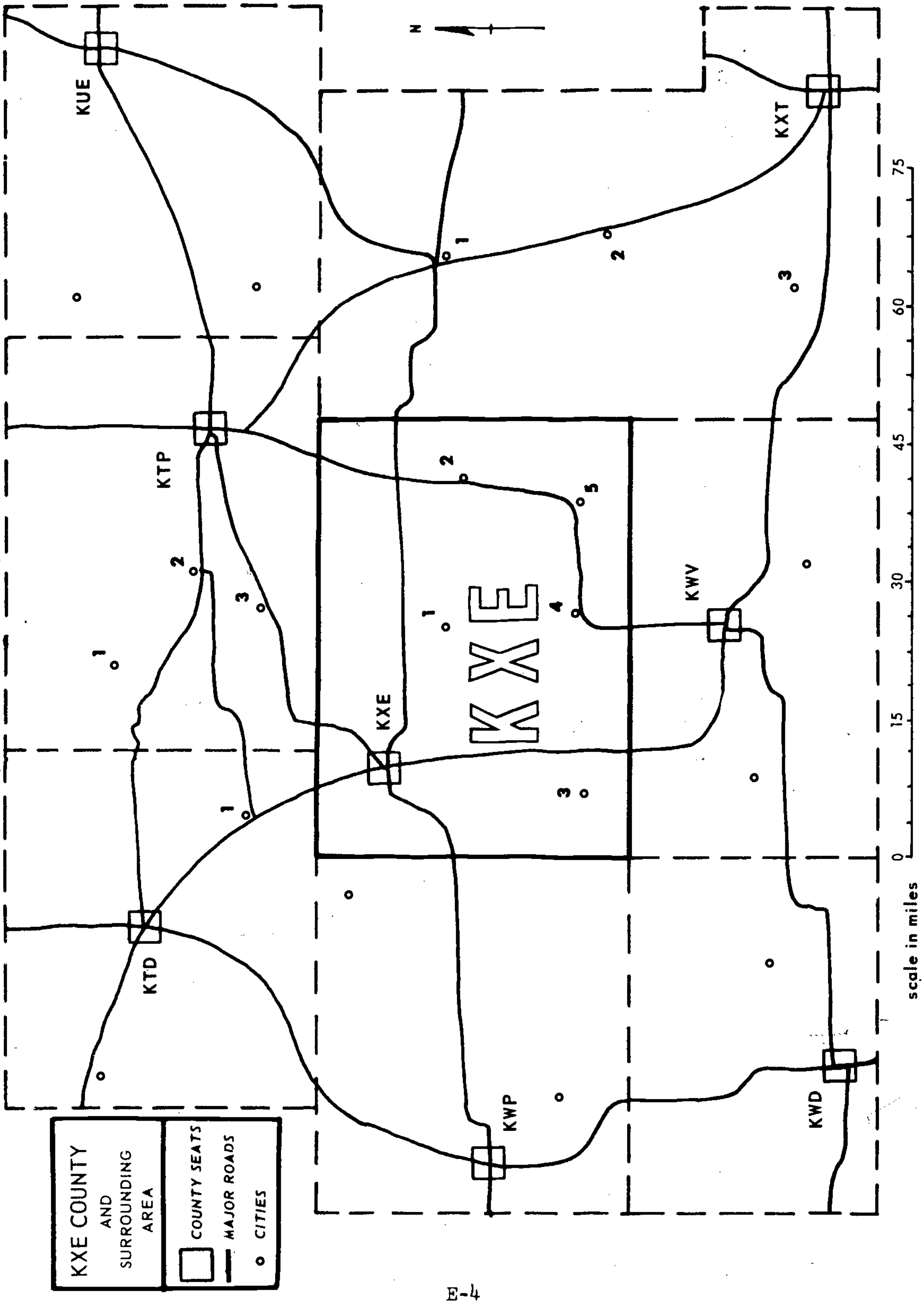
<u>The County Plan</u> The KXE County plan calls for a combined city/county EOC with subcounty EOC's located at 1KXE, 2KXE, 3KXE, 4KXE, and 5KXE. It also provides for exchange of data with neighboring counties.

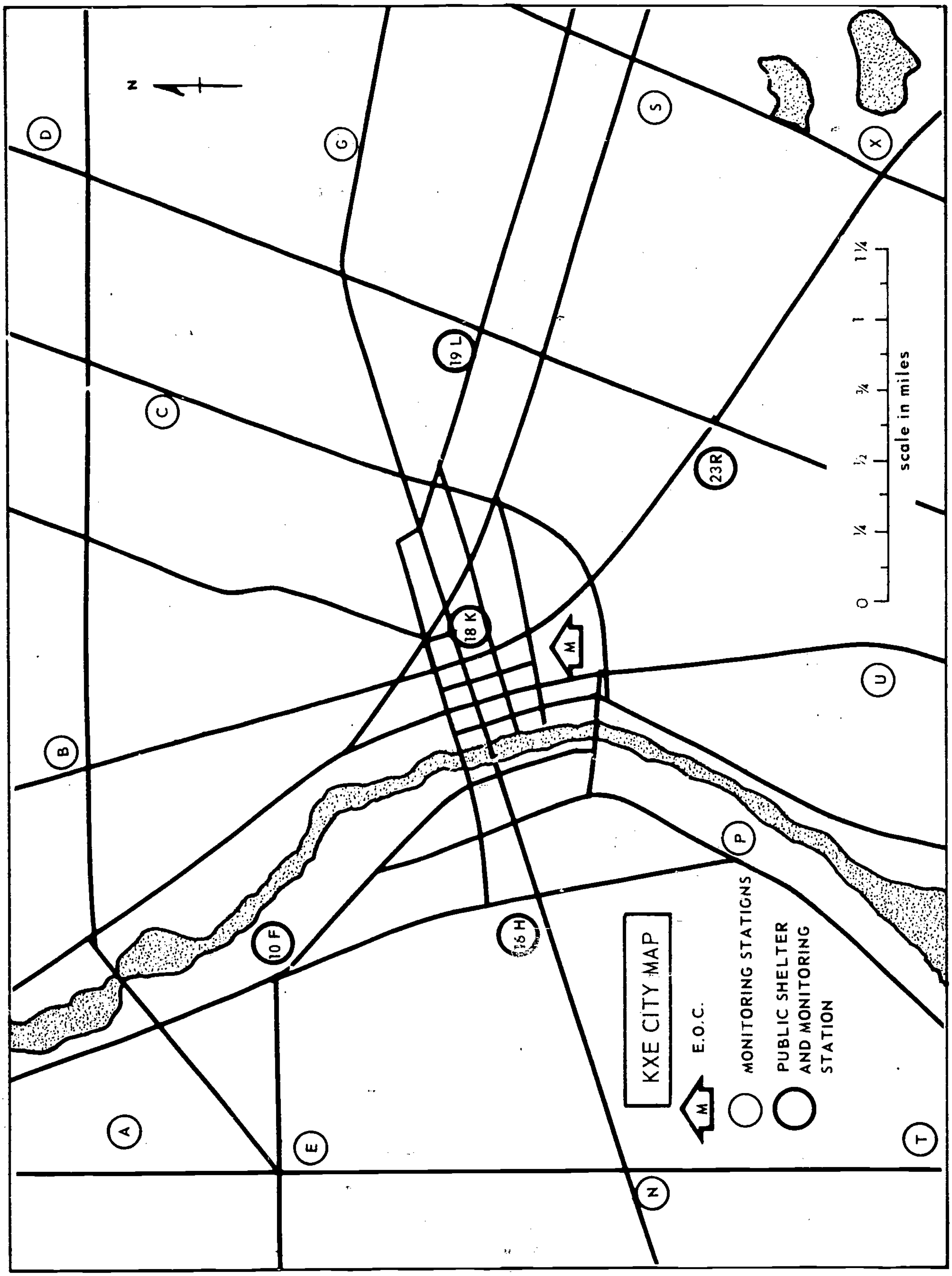
<u>The Local Plan</u> The City KXE plan calls for 18 monitoring stations geographically located throughout the city. Five of them are located in public shelters. All monitoring stations will report by telephone. Four monitoring stations have been selected to report hourly to the EOC during the first 12 hours after the arrival of fallout. They were selected on the basis of (a) absence of shielding obstacles such as trees, buildings, rough terrain, etc.; (b) strategic geographic locations; and (c) reliability of personnel and instrumentation. The average of the dose rates reported from the selected stations will be the "representative dose rate" for City KXE.



STATE OF KENT MAP
TARGET CITIES
RAWIN STATIONS
COUNTY SEATS
PRINCIPAL CITIES
SUBSTATE LINES
COUNTY LINES
N
ABC
DEF
GHI
KPE
KWG
KWH
KYH
KTY
KUH
KYN
KPD
KPN
KTX
KXZ
KPM
KUG
KNV
KTW
KXN
KYT
KUF
KXY
KNS
KPL
KTV
KUE
KXT
KXH
KNX
KPK
KTJ
KTP
KNR
KPJ
KXE
KWV
KSR
KTD
KYR
KMT
KPI
KSX
KWD
KWP
KPH
KSL
KVX
KWJ
0
20
40
60
80
100
scale in miles

E-3


KXE COUNTY
AND
SURROUNDING
AREA
COUNTY SEATS
MAJOR ROADS
CITIES
KUE
KTP
KTD
KXE
KWP
KWD
KWV
KXT
KXE
N
0
15
30
45
60
75
scale in miles


KXE CITY MAP
E.O.C.
MONITORING STATIONS
PUBLIC SHELTER
AND MONITORING
STATION
scale in miles
0
¼
½
¾
1
1¼
N
M
A
B
C
D
E
G
N
P
S
T
U
X
10 F
18 H
18 K
19 L
23R

Reporting Schedule (Local) Monitoring stations will report operational readiness to the EOC. Flash reports will be made to the EOC as soon as the outside radiation dose rate reaches .5 r/hr. After flash reports, monitoring stations will report unsheltered dose rates on a scheduled basis as identified in the exercise. Reports will be made at least once each three hours for the first 24 hours after the flash report. From 24 hours through 48 hours, reports will be at 6 hour intervals. After 48 hours, dose rate reports will be submitted to the EOC once daily. Each city EOC in County KXE will furnish to the county EOC a flash report and representative dose rate reports on the same reporting schedule as local monitoring stations.

(County) The KXE County EOC will furnish to the substate EOC a flash report and "representative dose rate" reports each 12 hours during the first 48 hours subsequent to the flash.

Radiological Reporting Logs The Radef staff at the KXE EOC will keep three logs for recording operational readiness of the stations, flash reports, dose reports, and dose rate reports. These are:

a. A log for the 18 monitoring stations in City KXE.
b. A log for the cities within KXE County.
c. A log for the neighboring counties.

Requirements Problems in this exercise are listed as requirements and should be completed in numerical order since, in most instances, time, dose, and dose rates are primary considerations to the situation. Solutions to the requirements should be written in brief form, labeled with the requirement number, and kept in consecutive order by the Radef staff group. This will provide for easy reference when each requirement is discussed during the critique at the end of the exercise. Some requirements will provide for the logging of data only, and will not require written solutions.

Briefings, which would normally be made to an EOC staff, should be made to the faculty umpire. These should be concise and should outline the important items of information. The briefings will be evaluated individually by the umpire, and will not be discussed during the critique of the exercise.

Staff Relationships Operational decisions will be made by the executive head of government, such as the Chairman of the County Board of Supervisors, or Mayor. The Radef Officer will act in a staff capacity on a parallel with other emergency service chiefs. He will provide technical guidance and recommendations to the head of government and to the service chiefs. For purposes of this exercise, the terms "civil defense director" and "executive head of government" are used synonymously.

Protection Factor Categories The protection of shelters will be identified in categories as follows:

PF Category	PF Range
8	over 1,000
7	500 - 1,000
6	250 - 499
5	150 - 249
4	100 - 149
3	70 - 99
2	40 - 69
1	20 - 39

Guidance for Permissible Activities When the dose rates inside and outside of the shelter or fallout monitoring station are known, the following general guide for permissible activities can be used. This guidance is based on observations made on large groups of people and, therefore, should be used with caution with small groups of individuals. The data must be modified as early as possible, taking into account the age of the fallout. If the fallout is relatively young (2 or 3 hours old), greater relaxation of shelter control can be tolerated than that indicated below. Conversely, if the fallout is relatively old (several days or weeks), more rigid control would be required. If in-shelter doses exceed 75 r, activities should, if possible, be restricted even more than indicated below.

If the outside dose rate has fallen to: (in r/hr)	Permissible Activities
Less than 0.5	No special precautions are necessary for operational activities. Keep fallout from contaminating people. Sleep in the shelter.
0.5 to 2	Outdoor activity (up to a few hours per day) is acceptable for essential purposes, such as fire fighting, police action, rescue, repair, securing necessary food, water, medicine and blankets, important communication, disposal of waste, exercise and obtaining fresh air. Eat, sleep, and carry on all other activities in the best available shelter.
2 to 10	Periods of less than an hour per day of outdoor activity are acceptable for the most essential purposes. Shelter occupants should rotate outdoor tasks to distribute exposures. Outdoor activities of children should be limited to 10 to 15 minutes per day. Activities such as repair or exercise may take place in less than optimum shelter.

If the outside dose rate has fallen to: (in r/hr)	Permissible Activities
10 to 100	Time outside of the shelter should be held to a few minutes and limited to those few activities that cannot be postponed. All people should remain in the best available shelter no matter how uncomfortable.
Greater than 100	Outdoor activity of more than a few minutes may result in sickness or death. Occasions which might call for outside activity are: (1) risk of death or serious injury in present shelter from fire, collapse, thirst, etc., and (2) present shelter is greatly inadequate--might result in fatality--and better shelter is known to be only a few minutes away.

Exercise Materials Maps, reporting logs, graph paper, and other materials will be needed in the play of this exercise. These have been placed at the end of the exercise and should be used as needed.

EXERCISE

A series of incidents have increased the international tension. Several out-and-out belligerent actions have been inflicted upon the United States. Patrol aircraft have been shot down and naval vessels fired upon. Increased troop maneuvers have been detected in unfriendly nations. There is a marked increase of unidentified submarine activity off both the East and West Coasts. KXE authorities have decided not to delay any longer, but to activate the EOC to preattack readiness. All key staff personnel have been notified to report immediately for duty.

Situation 1100 The city/county EOC at KXE is now manned. For the conduct of this exercise, each group will act as the RADEF staff for the EOC. The first action taken by the RADEF staff was to alert all available radiological monitors to man their monitoring stations.

The Civil Defense Director now requests a fallout forecast analysis for potential targets that could produce fallout on County KXE. The latest coded DF Data for the State and adjoining area is:

DF 010000

ABC	0914	0913	0811
DEF	0814	0813	0810
GHI	0914	0913	0811

Potential target areas are KPE, KPI, KPM, KSX, KUH, KWG, KWH, and KYH. These appear as stars on the State map.

Requirement No. 1

Examine the fallout forecasts plotted on the Kent State map (see map at end of this exercise). Why were forecasts not plotted for KPE, KPI, KPM, and KUH?

Requirement No. 2

Based on the fallout forecast outline, the items of information which you would include in a preattack public advisory for County KXE are: identification of targets that are expected to cause fallout and those that are not; expected fallout arrival times; recommended actions for the population; and other appropriate items. (Brief the umpire).

Situation 1115 All city monitoring stations, except Station X, have reported their operational readiness to the EOC. The available number of monitors that have reported to each station has been recorded on the radiological reporting log for City KXE.

Requirement No. 3

Should you reassign any of the monitors at this time? Why?

Situation 1200 (H-hour) At 1200 a bright sustained flash enveloped the western skyline, indicating a high yield nuclear detonation in the vicinity of KWG or KWH. At 1230 the EOC received a NUDET (nuclear detonation) report from the State Police stating that KWG sustained a 5-10 MT nuclear weapon surface detonation at 1200.

The Radef staff has been requested to brief the EOC staff in regard to expected fallout arrival in County KXE. The Public Information Officer will use information from this briefing to issue a public advisory for County KXE.

Requirement No. 4

Briefly outline the radiological information to be covered in the briefing. This should include such items as expected fallout arrival time, recommended actions for the population, and other appropriate items. (Brief the faculty umpire).

Situation 1445 (H + 2.75) The EOC received flash reports from the substate EOC located at KTP. The substate message read as follows:

1310 KWHFallout
1335 KWJFallout
1425 KWPFallout

The EOC also received a flash report from the neighboring County KWP. The KWP message read as follows:

1425 KWPFallout

Requirement No. 5

a. Enter the KWP flash report on the radiological reporting log for neighboring counties.

b. Plot all flash reports on the State map used for forecasting fallout.

c. Are actual fallout arrival times consistent with the KWG fallout forecast?

d. What actions are required?

Situation 1450 (H + 2.8) City KXE monitoring stations have continued to report increased readiness as additional monitors report for duty. The following readiness reports have been received since the situation given at 1115:

Station	Monitors Reported Since 1115
B	2
C	1
19L	1
M	3
S	3
U	1

Requirement No. 6

a. Correct the radiological reporting log by adding the additional monitors.

b. Will the reassignment of monitors increase the operational capability?

c. Should monitors be reassigned now?

d. Which monitors would you reassign, if any?

e. Correct the radiological reporting log for reassignment of monitors.

Situation 1500 (H + 3) A village a few miles south of City KXE has requested shelter for 200 people in the KXE area. The average PF currently available to the 200 people is about 5. If they transfer to City KXE, they will be assigned to Category 2 shelter (PF 40 - 69). The estimated time required to complete the transfer is forty-five minutes. Transportation is available.

Requirement No. 7

a. The Civil Defense Director wants to know if the transfer is advisable at this time?

b. Rationalize your answer to Requirement No. 7a.

Situation 1515 (H + 3.25) City KXE monitoring stations report fallout arrival at 1515. This information has been forwarded to neighboring counties and the substate EOC.

Requirement No. 8

Enter flash reports on radiological reporting logs.

Situation 1515 to 1600 (H + 3.25 to H + 4)

Additional flash reports received from County KXE and from neighboring counties through 1600 are as follows:

Flash reports from neighboring counties:	1510 KTDFallout 1510 KWDFallout 1553 KTPFallout 1555 KWVFallout
Flash reports from County KXE:	1520 3KXEFallout 1535 1KXEFallout 1540 4KXEFallout 1600 2KXEFallout 1600 5KXEFallout

Requirement No. 9

Enter flash reports on county and neighboring county radiological reporting logs.

Situation 1600 (H + 4)

The EOC received City KXE monitoring station dose rate reports as of 1600. This is the first regularly scheduled dose rate reports to be received since fallout arrival.

NOTE: OCD recommends that all local monitoring stations report dose rates once every 3 hours for the first 24 hours after fallout arrival; once every 6 hours from 24 to 48 hours; and once daily after 48 hours. Dose rate reports will be made at a common time throughout the nation. Monitors will measure dose rates at local times that correspond to the GMT reporting schedule. A chart to convert GMT time to local KXE time (exercise time) is found below. The underlined times identify the 3 hour reporting cycle that will be followed.

Time Conversion Chart

Greenwich Meridian Time	KXE (Exercise) Time
0100	2000*
0200	2100*
0300	2200*
0400	2300*
0500	2400*
0600	0100
0700	0200
0800	0300
0900	0400
1000	0500
1100	0600
1200	0700
1300	0800
1400	0900
1500	1000
1600	1100
1700	1200
1800	1300
1900	1400
2000	1500
2100	1600
2200	1700
2300	1800
2400	1900

* Add one day to the local calendar date for equivalent GMT date.

City KXE monitoring station dose rate reports received by telephone for 1600 are as follows:

Station	Dose Rate
A	2 r/hr
B	2 r/hr
C	2 r/hr
D	3 r/hr
E	3 r/hr
10F	2 r/hr
G	2 r/hr
16H	2 r/hr
18K	2 r/hr
19L	2 r/hr
M	2 r/hr
N	2 r/hr
P	2 r/hr

Station	Dose Rate
23R	2 r/hr
S	2 r/hr
T	2 r/hr
U	2 r/hr
X	3 r/hr

Requirement No. 10

a. Enter in the log the 1600 dose rate for each monitoring station.

b. What is the representative dose rate for City KXE?

To determine the representative dose rate, average the dose rates from the four local monitoring stations identified with asterisks on the radiological reporting log (Stations B, E, G, and P). Assume that this representative dose rate has been transmitted to neighboring counties in accordance with local plans.

c. Begin construction of dose rate history curves for the four monitoring stations that have been selected for determining the representative dose rate for City KXE. To better evaluate the increase in early dose rates and fallout radiation decay characteristics, these four stations will report on an hourly basis for the first 12 hours after fallout arrival. Thereafter, their reports will conform with the regular reporting schedule. The dose rate history curves should be constructed by plotting dose rate against time after burst on log-log graph paper. These curves should be kept up-to-date as additional dose rate reports are received from the selected monitoring stations. Remember that the number assigned to the beginning of the first cycle establishes the basic plotting unit. Normally, the plot should begin with H + 1, which is 1300 in this exercise.

Situation 1600 (H + 4) In its capacity as county EOC, KXE receives representative dose rates from all of the other EOC's within the county. These dose rate reports are received on the same schedule that local monitoring station reports are received. The dose rate reports from EOC's within County KXE are as follows:

1KXE001
2KXE001
3KXE002
4KXE001
5KXE001

Requirement No. 11

a. Enter in the log the 1600 dose rates for each city in County KXE.

Requirement No. 11 (Continued)

b. Enter in the log the representative dose rate for City KXE from Requirement No. 10b.

Situation 1600 (H + 4) In accordance with mutual agreements, County KXE will exchange representative dose rate reports with the county seats of neighboring counties. The schedule for exchange of these reports will be the same as the local monitoring station reporting schedule.

The representative dose rate reports at 1600 from the county seats of neighboring counties are as follows:

KTD004
KTP003
KWV001
KWP040
KWD003

Requirement No. 12

Enter in the log the 1600 dose rates for each neighboring county seat.

Situation 1630 (H + 4.5) The Police Chief has received a report of looting in a wholesale food warehouse, near shelter 18K. He does not want to sacrifice the lives of policemen, but he must stop the looting unless the radiological hazard prevents it. The PF of the warehouse is estimated to be about PF 5. In response to a request, shelter 18K advised the Radef staff that the dose rate at H + 4.5 was 6 r/hr. Each of the policemen assigned to the mission will be issued a dosimeter. The policemen are currently in a Category 7 shelter (PF 500 - 999).

Requirement No. 13

What advice should the Radef staff furnish to the Police Chief?

Situation 1700 (H + 5) The EOC receives dose rate reports from the selected monitoring stations in City KXE, which are reporting on an hourly basis. Their 1700 dose rate reports are as follows:

Station	Dose Rate
B	23 r/hr
E	26 r/hr
G	25 r/hr
P	21 r/hr

Requirement No. 14

Enter in the log the 1700 dose rate reports for the selected stations in City KXE and continue plotting the dose rate history curves.

Situation 1800 (H + 6) The EOC receives dose rate reports from the selected monitoring stations in City KXE. They are as follows:

Station	Dose Rate
B	180 r/hr
E	210 r/hr
G	200 r/hr
P	170 r/hr

Requirement No. 15

Enter in the log the dose rate reports at 1800 for the City KXE selected stations and continue plotting the dose rate history curves.

Situation 1900 (H + 7) The EOC receives dose rate reports from all the City KXE monitoring stations in accordance with the regular three hour reporting cycle. These dose rates are as follows:

Station	Dose Rate
A	320 r/hr
B	290 r/hr
C	320 r/hr
D	350 r/hr
E	340 r/hr
F	260 r/hr
G	320 r/hr
H	300 r/hr
K	220 r/hr
L	310 r/hr
M	260 r/hr
N	300 r/hr
P	270 r/hr
R	290 r/hr
S	310 r/hr
T	320 r/hr
U	300 r/hr
X	350 r/hr

Requirement No. 16

a. Enter in the log dose rate reports at 1900 for all City KXE stations and continue plotting dose rate history curves.

Requirement No. 16 (Continued)

b. Determine the 1900 representative dose rate for City KXE and assume it has been transmitted to the neighboring county EOC's.

Situation 1900 (H + 7) The representative dose rates reported from EOC's in County KXE are as follows:

1KXE250
2KXE090
3KXE240
4KXE150
5KXE020

Requirement No. 17

a. Enter in the log the 1900 dose rates for each city in County KXE.

b. Enter in the log the 1900 representative dose rate for City KXE from Requirement No. 16b.

Situation 1900 (H + 7) The representative dose rate reports at 1900 from the neighboring county seats are as follows:

KTD130
KTP110
KUE004
KWP400
KWV022
KWD090
KXT001

Requirement No. 18

Enter in the log the 1900 dose rates for each neighboring county seat.

Situation 1900 (H + 7) The Civil Defense Director requests that the Radef staff be prepared to give a briefing to the EOC staff indicating the current city and countywide radiological situation. The Public Information Officer will be prepared to take notes from the briefing so that he can issue an up-to-date public advisory.

Requirement No. 19

a. In preparation for the briefing, plot the representative dose rates for the six EOC's in County KXE, and for the neighboring county seats

Requirement No. 19 (Continued)

on the county map. This map will be used for data display purposes.

b. Outline items of information that should be included in this briefing. This should include such items as interpretation of radiation levels, recommended actions for the populace, operational status, and other appropriate items. (Brief the faculty umpire).

Situation 1900 (H + 7) A westbound train is due in City KXE at 1930. It is hoped that this train stopped at 2KXE or 1KXE and that the passengers took shelter. However, in the event that it arrives in town, preparations are being made to shelter an expected 200 passengers. The best protection available is two Category 2 shelters (PF 40 - 69) within six blocks of the railroad station. All 200 passengers can be sheltered here, if the shelters are overcrowded to 7 sq. ft. per person. The shelter managers have advised the EOC that the current shelter occupants are reluctant to accept the passengers for fear that they have been heavily exposed and contaminated, and will, thus, endanger the lives of the entire shelter community. The Radef staff has been asked for guidance on this problem.

Requirement No. 20

Identify the important elements of the guidance to be provided?

Situation 2000 (H + 8) The EOC receives dose rate reports from the selected monitoring stations at 2000. They are as follows:

Station	Dose Rate
B	230 r/hr
E	270 r/hr
G	260 r/hr
P	220 r/hr

Requirement No. 21

Enter in the log the 2000 dose rate reports for the City KXE selected stations, and continue plotting the dose rate history curves.

Situation 2100 (H + 9) The EOC receives dose rate reports from the selected monitoring stations at 2100. They are as follows:

Station	Dose Rate
B	200 r/hr
E	230 r/hr
G	220 r/hr
P	190 r/hr

Requirement No. 22

Enter the 2100 dose rate reports for the City KXE selected stations and continue plotting dose rate history curves.

Situation 2200 (H + 10) The EOC receives dose rate reports from all City KXE monitoring stations in accordance with the regular three hour reporting cycle. They also receive daily unsheltered dose reports as of 0300 GMT (2200) for the first six days. These doses and dose rates are as follows:

Station	Dose Rate	Doses
A	190 r/hr	1120 r
B	170 r/hr	1010 r
C	190 r/hr	1110 r
D	210 r/hr	1230 r
E	200 r/hr	1180 r
F	150 r/hr	900 r
G	190 r/hr	1130 r
H	180 r/hr	1070 r
K	130 r/hr	790 r
L	180 r/hr	1080 r
M	150 r/hr	880 r
N	180 r/hr	1080 r
P	160 r/hr	960 r
R	170 r/hr	1020 r
S	180 r/hr	1090 r
T	190 r/hr	1110 r
U	180 r/hr	1060 r
X	210 r/hr	1220 r

Requirement No. 23

a. Enter in the log 2200 dose rate reports for all City KXE stations, and continue plotting dose rate history curves.

b. Enter in the log 2200 dose reports for all City KXE stations.

c. Determine the 2200 representative dose rate for City KXE and assume it has been transmitted to neighboring county EOC's. Assume that it has also been transmitted to the substate EOC in accordance with State plans which require such information at 0300 GMT and 1500 GMT through H + 48.

Situation 2200 (H + 10) The representative dose rates reported from EOC's in County KXE are as follows:

1KXE170
2KXE140
3KXE160
4KXE140
5KXE120

Requirement No. 24

a. Enter in the log the 2200 dose rates for each city.

b. Enter in the log the 2200 representative dose rate for City KXE from Requirement No. 23c.

Situation 2200 (H + 10) The representative dose rates at 2200 from the neighboring county seats are as follows:

KTD080
KTP060
KUE030
KWP240
KWV080
KWD050
KXT020

Requirement No. 25

Enter in the log the dose rates at 2200 for each neighboring county seat.

Situation 2200 (H + 10) The Civil Defense Director requests that the Radef staff brief the EOC on the current radiological situation in KXE City and County. The Public Information Officer will prepare a public advisory based on this briefing.

Requirement No. 26

a. In preparation for the briefing, plot the representative dose rates for the six EOC's in County KXE, and for the neighboring county seats on the county map. This map will be used for data display purposes.

b. Outline the items of information that should be included in this briefing. This should include such items as interpretation of radiation levels, probability of survival under various shelter conditions, recommended actions for the populace, and other appropriate items.

NOTE: The logging of radiological data is a necessary mechanical operation that is time consuming. Since you have had experience in handling this data, all future data will be furnished. Remove the completed radiological reporting logs from the Student Workbook. Use them for the remainder

NOTE: (Continued)

of the exercise, which will emphasize problem solving. In using the furnished data, do NOT use any data beyond the time identified in the problem.

Situation 0100 (H + 13) The power plant is located across the street from monitoring station P. In order to keep the power plant in operation, a coal supply must be maintained in the power plant bunkers. These bunkers are normally filled once every 24 hours. However, in an emergency the coal in the bunkers will furnish power for at least 48 hours. The manager of the power plant has indicated that, in order to keep the plant in operation, the bunkers must be refilled starting no later than 0900 on the third day (H + 45). It will require a total of six hours to refill the bunkers with the one dozer available.

The three bulldozer operators experienced in filling these bunkers are sheltered in the basement of the power plant, which has a PF of 100. The operators have been in the basement since just before fallout arrival and will be sheltered there for the remainder of the emergency phase. Their accumulated exposure dose through H + 13, as read from a dosimeter, is 15 r. The operators are to be rotated on the mission so that each operator will receive approximately the same dose.

Requirement No. 27

What will be the total exposure dose for each operator at the completion of the mission? Should the coal bunkers be filled at H + 45? (Remember, do not use any data from the log beyond the time identified in the problem. The time is H + 13).

Situation 1300 (H + 25) Three new nuclear detonations have been observed. One to the southwest of City KXE at 1200 (H + 24); one to the west at 1215 (H + 24 hrs. and 15 min.); and one to the northwest at 1230 (H + 24 hrs. and 30 min.). The EOC just received an unconfirmed report indicating that the target cities were as follows:

To the southwest the target was City KYH.
To the west the target was City KWG.
To the northwest the target was City KSX.

1330 (H + 25 hrs. and 30 min.) The EOC has just received a NUDET report stating that the KSX detonation was a 5-10 MT surface burst, and the KWG and KYH detonations were 5-10 MT airbursts. The latest available DF data is as follows:

DF 020000			
ABC	0811	0809	0910
DEF	0811	0810	0910
GHI	0811	0809	0910

The Civil Defense Director has requested that the Radef staff evaluate the fallout threat to KXE as a result of the reported detonations.

Requirement No. 28

a. Examine the new fallout forecasts plotted on the Kent State map. Why were forecasts not plotted for KWG and KWH? Which RAWIN data was used for the forecasts?

b. Outline items of information that should be included in a briefing for the civil defense staff on the potential hazards to the city and county of KXE. This should include such items as probability of additional fallout in County KXE; any recommended action for the populace; and other appropriate items. (Brief the faculty umpire).

Situation 1400 (H + 26) The Air Force has requested that the Air National Guard airstrip, which is capable of handling jet aircraft, be activated for emergency use. This airstrip is near monitoring station E. Civilian help has been requested for the decontamination, which will require about four hours. The allowable mission dose has been established at 50 r.

Requirement No. 29

When can a decontamination crew perform the emergency assignment in this area without exceeding the established mission dose?

Situation 1500 (H + 27) Shelter 10 (Category 3) is overcrowded and its supplies will last only six more days. The shelter manager wants to know if people can leave shelter at about H + 7 days to obtain food.

Requirement No. 30

What guidance should be given to the shelter manager?

Situation 1600 (H + 28) The Radef staff has just received word that approximately 12 people have taken refuge in a motel located a few miles to the east of City KXE. From his knowledge of the motel, the Radef Officer estimates the protection factor to be about 10. Category 5 (PF 150 - 249) shelter is available in the downtown area. It will take about 30 minutes to move the people from the motel to the higher grade shelter.

Requirement No. 31

Would you recommend that these people be transferred? If so, when?

Situation Third Day 1300 (H + 49) The Civil Defense Director has requested that the Radef staff estimate the approximate time that people in City KXE can emerge from shelter for a few hours a day for essential purposes. Use a 2 r/hr outside dose rate as a guide for determining this emergence time.

Requirement No. 32

What is the estimated emergence time? How reliable is it?

Situation Third Day 1400 (H + 50) Operations at an essential industry in KXE must be resumed as soon as practicable. A skeleton staff of employees in several Category 4 shelters (PF 100 - 149) near monitoring station E will operate the plant for one eight-hour shift each day. The remaining time will be spent in their initial shelters. The plant has an estimated average protection factor of 10.

Because of the type of work to be performed, the Radef Officer concluded that the most practical approach for determining the exposure criteria of the staff was to establish a constant daily dose limit for the first month so that the ERD would not exceed 100 r. This would allow the skeleton staff to work increasingly longer shifts as the radiation levels decrease. He will reexamine these limits at H + 30 days.

Requirement No. 33

a. Based on (1) the current exposure of the plant personnel, (2) their current protection (assume PF 100), and (3) their expected protection in the shelter, what daily exposure limit will keep the ERD below 100 r?

b. Using this daily exposure limit, what is the earliest time the plant can be reactivated?

c. In reevaluating the exposure limit at H + 30 days, what new daily exposure schedule would keep the ERD below 100 r?

Situation Third Day 1600 (H + 52) At H + 9 the Civil Defense Director urgently requested guidance which required an estimate of future dose rates. Lacking sufficient monitored data to evaluate the radiation decay characteristics of the fallout, the Radef staff based their guidance on $t^{-1.2}$ decay. The Radef staff now has an opportunity to reevaluate this guidance.

Requirement No. 34

Determine the fallout decay exponent for City KXE. Is the actual decay rate greater or less than $t^{-1.2}$? What does this mean operationally?

Situation Third Day 2200 (H + 58) An industrial complex near monitoring station E must be reactivated as soon as practicable. The Radef Officer is evaluating the possibility of decontaminating the complex. Sufficient equipment and manpower are available to complete the decon in three days, working nine hours each day. Equipment operators in Category 2 (PF 40 - 69) shelters near the complex will perform the decon. Industry personnel in Category 2 shelters near the complex will operate the complex 12 hrs./day, 7 days/week when it is reactivated. The average protection factor of the industrial area will be only about 2 because part of the time must be spent outside. After decon, it is estimated to be 30. The acceptable (maximum) ERD has been set at 150 r for emergency operational personnel, including the decon workers, and 100 r for the public including the industry personnel.

Requirement No. 35 (Use the Estimating Forms for a through d)

a. What is the maximum acceptable mission dose the decon workers can be allowed for decon of the complex?

b. What is the maximum acceptable dose the industrial personnel can be allowed while operating the industrial complex?

c. When can the workers begin decon of the complex?

d. When can the industrial complex be reactivated without decon? With decon?

e. Should the complex be decontaminated?

Situation Third Day 2200 (H + 58) The EOC at KXE has received an urgent request from KUE for medical supplies. The supplies are stored at 1KTD and will be moved by truck. One truck (PF 2) from KXE will be used. At the request of KXE, the State conducted an aerial survey of three routes from 1KTD to KUE. These were: 1KTD - KTP - KUE; 1KTD - KXE - KTP - KUE; and 1KTD - KXE - 1KXT - KUE. The State was also requested to furnish dose rates for 1KTD, 2KTP and 1KXT, and the general variation in dose rates between these locations and the EOC's on the highway routes.

The State reported dose rates at 2200 as follows: 1KTD - 12 r/hr; 2KTP - 16 r/hr; 1KXT - 3 r/hr. Dose rates varied approximately uniformly between locations along the route with the exception of a hot spot around 3KTP where the dose rate was about 16 r/hr.

It will require about 1 hour to load the supplies with personnel at the warehouse, which has a PF of about 10. The truck will be able to average about 45 m.p.h. on the road, and the driver will remain in shelter at KUE.

Requirement No. 36

What route should the driver follow? What is his estimated exposure for the mission?

Situation Fourth Day 1300 (H + 73) The Radef Officer at KTP has had little training and experience. His Civil Defense Director has asked him to estimate when the dose rate will reach 1 r/hr. Since he does not know the procedures to use in solving this problem, he has asked for your help.

Requirement No. 37

When should the dose rate reach 1 r/hr at KTP? Can you arrive at a reliable estimate at this time?

Situation Fourth Day 1300 (H + 73) A decontamination operation is to begin at H + 90 close to monitoring station E. A crew of 8 men is required to operate the equipment. The operation will require 12 hours, and will continue until it is completed. The crews will be rotated so that no man will exceed a dose of 30 r.

Requirement No. 38

How many men are needed to complete the decontamination?

Situation Fourth Day 2200 (H + 82) In evaluating recovery actions, the Radef staff must determine the maximum ERD and the time when the maximum ERD will be reached for persons in shelter. All persons are in Category 2 shelter (PF 40 - 69), or better. Since the PF 40 situation places an upper limit on the seriousness of the radiological condition, this calculation is more important than similar calculations for better protected areas.

Requirement No. 39

Using the data from monitoring station E, calculate the maximum ERD and the time it will be reached for those persons in PF 40 shelters. Operationally, what is the significance of the maximum ERD?

Situation Fifth Day 2200 (H + 106) The KXE Telephone Company is in a two-story building near monitoring station E. Three of the persons on duty at the time the fallout warning was issued were asked to remain on duty to provide for continued service. Since the building had only the minimum Category 1 protection (PF 20), the three persons erected an emergency shelter, which was completed and occupied at 2100 on the first day (H + 9). From this sheltered area, which had an estimated protection factor of about 100, they could perform most of their essential duties. Sufficient food and water supplies were available for the three people to remain at the telephone company until the outside dose rate was 4 r/hr. Thereafter, their activity --which included some outside work--was controlled so that their exposures did not exceed more than 3 r/day.

In evaluating all KXE recovery actions, including the possible decon of the telephone company building, the Radef Officer needs (1) an estimate of the maximum ERD of these three persons, assuming they continue to work under the existing exposure criteria through H + 30 days, and (2) an estimate of their ERD at the end of H + 30 days.

Requirement No. 40

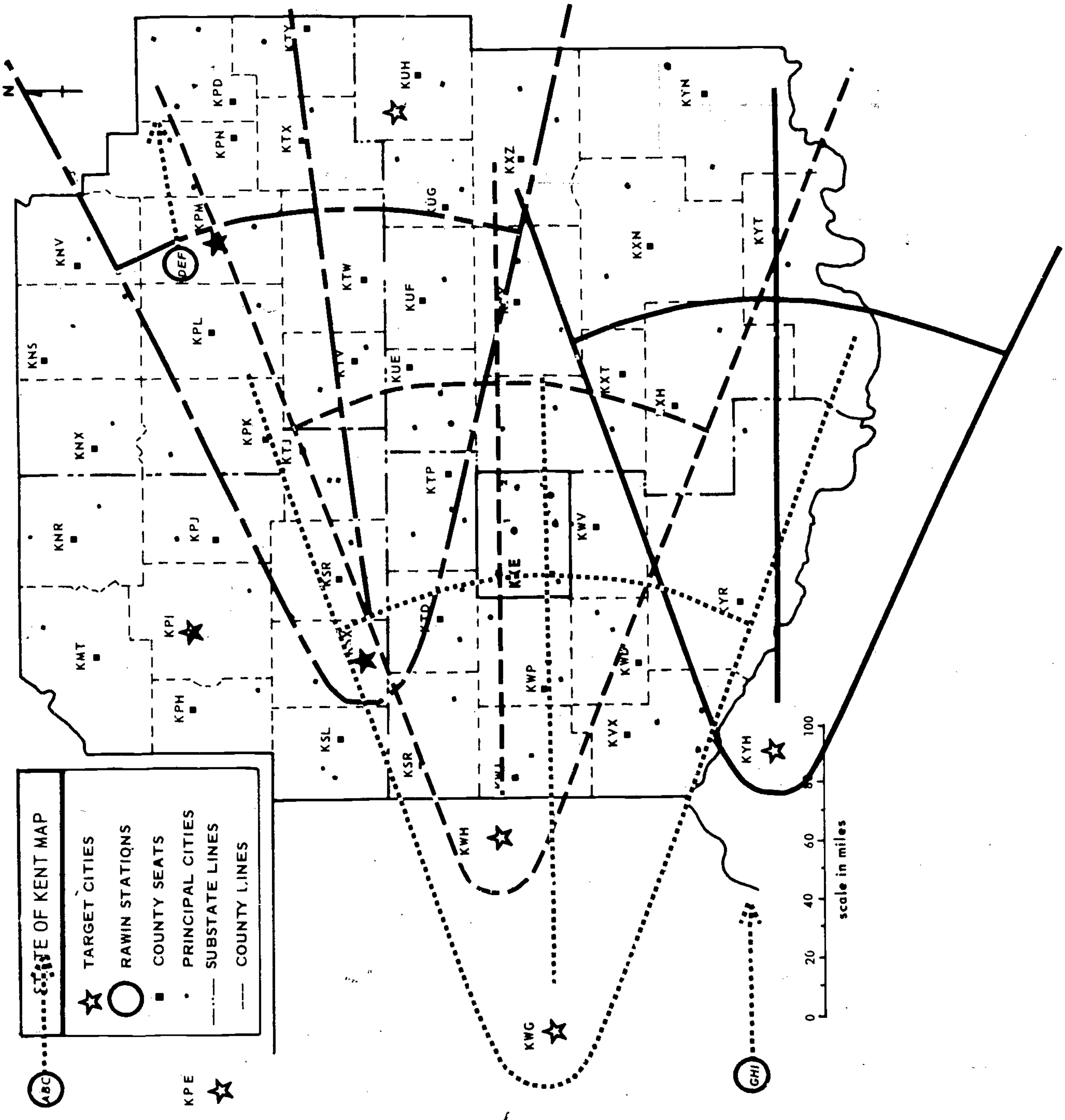
What will be the ERD of these people at H + 30 days, and what was their maximum ERD?

Situation (Shelter Emergence Time) On the advice of the Radef Officer, the Civil Defense Director has determined that the people in City KXE can leave shelter. He has asked the Radef Officer to furnish specific recommendations and guidance to the people on radiological safety procedures to follow upon emergence from shelters. These will be included in a public advisory.

Requirement No. 41

What recommendations should be included?

Requirement No. 1



E-27 /E-28

City KXE

RADIOLOGICAL REPORTING LOG

* Selected monitoring stations

LOCATION DESIGNATOR	NO. OF MONITORS ON DUTY	FLASH REPORT TIME	DATE	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2
			TIME	1600	1700	1800	1900	2000	2100	2200	2200	2300	2400	0100	0200	0300	0400	0700	1000	1300	1600	2200
			r/hr. or r	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.
A	4																					
*B	2																					
C	2																					
D	3																					
*E	4																					
10F	4																					
*G	1																					
16H	4																					
18K	4																					
19L	3																					
M	2																					
N	4																					
*P	4																					
23R	4																					
S	3																					
T	4																					
U	2																					
X																						

Requirement No. 3

City KXE

RADIOLOGICAL REPORTING LOG

* Selected monitoring stations

LOCATION DESIGNATOR	NO. OF MONITORS ON DUTY	FLASH REPORT TIME	DATE	2	3	3	3	3	3	4	4	5	5	6	6	7	8	9	10	11	12	13
			TIME	2200	0400	1000	1600	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200
			r/hr or r	r.	r/hr.	r/hr.	r/hr.	r/hr.	r.	r/hr.	r.	r/hr.	r.	r/hr.	r.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.
A																						
*B																						
C																						
D																						
*E																						
10F																						
*G																						
16H																						
18K																						
19L																						
M																						
N																						
*P																						
23R																						
S																						
T																						
U																						
X																						

Requirement No. 3
Page 2

Neighboring Counties

RADIOLOGICAL REPORTING LOG

LOCATION DESIGNATOR	NO. OF MONITORS ON DUTY	FLASH REPORT TIME	DATE	1	1	1	2	2	2	2	FLASH REPORTS	2	FLASH REPORTS	2	2	2	3	3	3	3	3	3
			TIME	1600	1900	2200	0100	0400	0700	1000		1300		1600	1900	2200	0100	0400	0720	1000	1300	1600
			r/hr or r	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.		r/hr.		r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.
KTD																						
KTP																						
KUE																						
KWP																						
KWV																						
KWD																						
KXT																						

Neighboring Counties

RADIOLOGICAL REPORTING LOG

LOCATION DESIGNATOR	NO. OF MONITORS ON DUTY	FLASH REPORT TIME	DATE	3	4	4	4	4	5	6	7	8	9	10	11	12	13					
			TIME	2200	0410	1000	1600	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200					
			r/hr or r	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.					
KTD																						
KTP																						
KUE																						
KWP																						
KWV																						
KWD																						
KXT																						

County KXE

RADIOLOGICAL REPORTING LOG

LOCATION DESIGNATOR	NO. OF MONITORS ON DUTY	FLASH REPORT TIME	DATE	1	1	1	2	2	2	2	2	2	2	3	3	3	3	4	5	6	7	8
			TIME	1600	1900	2200	0100	0400	0700	1000	1300	1600	2200	0400	1000	1600	2200	2200	2200	2200	2200	2200
			r/hr or r	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.
KXE																						
1KXE																						
2KXE																						
3KXE																						
4KXE																						
5KXE																						

Requirement No.

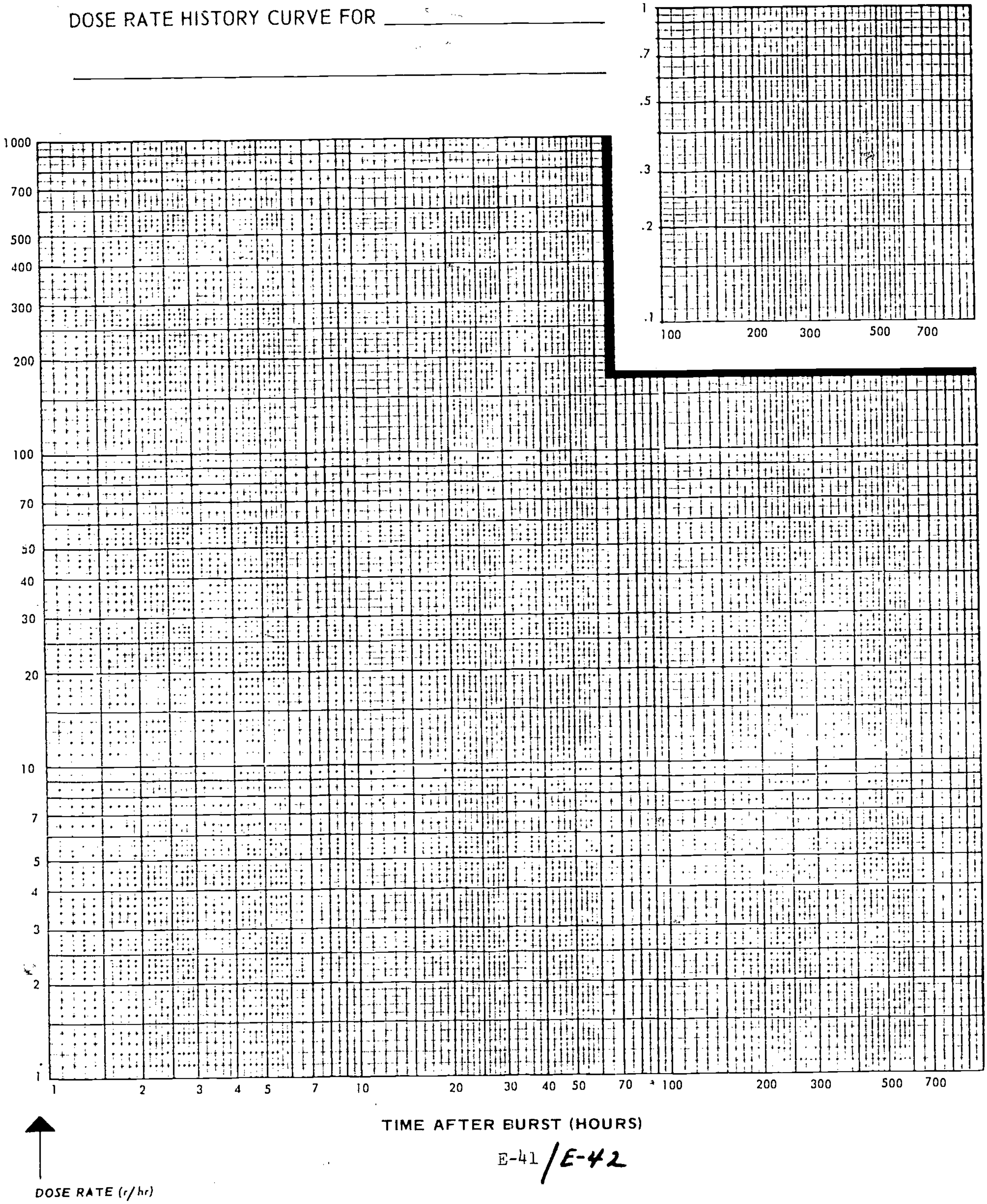
County KXE RADIOLOGICAL REPORTING LOG

LOCATION DESIGNATOR	NO. OF MONITORS ON DUTY	FLASH REPORT TIME	DATE	9	10	11	12	13														
			TIME	2200	2200	2200	2200	2200														
			r/hr or r	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.														
KXE																						
1KXE																						
2KXE																						
3KXE																						
4KXE																						
5KXE																						

Requirement No. 10

DOSE RATE HISTORY CURVE FOR ______________________

____

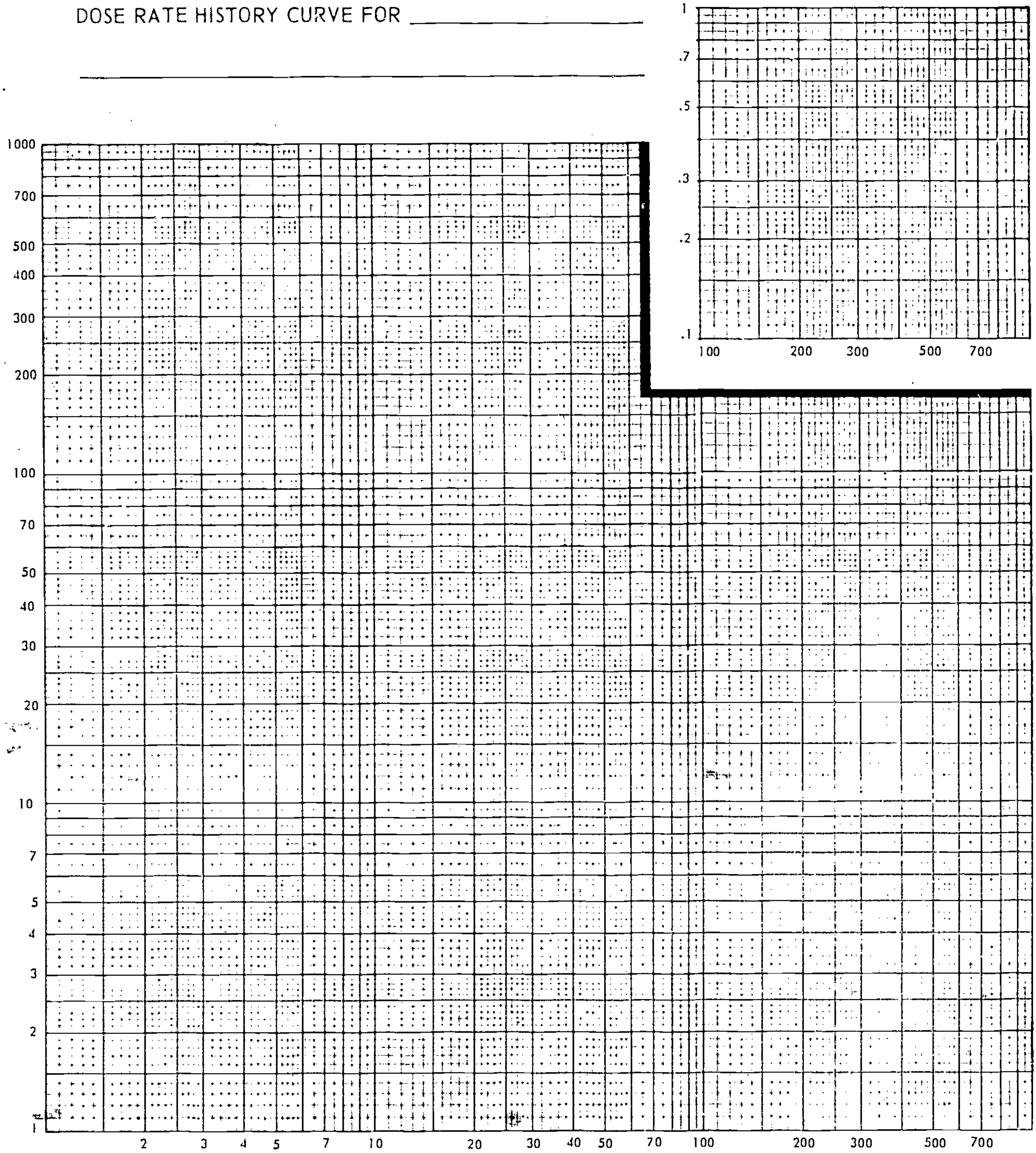


E-41/*E-42*

Requirement No. 10

DOSE RATE HISTORY CURVE FOR ____________________

____



TIME AFTER BURST (HOURS)

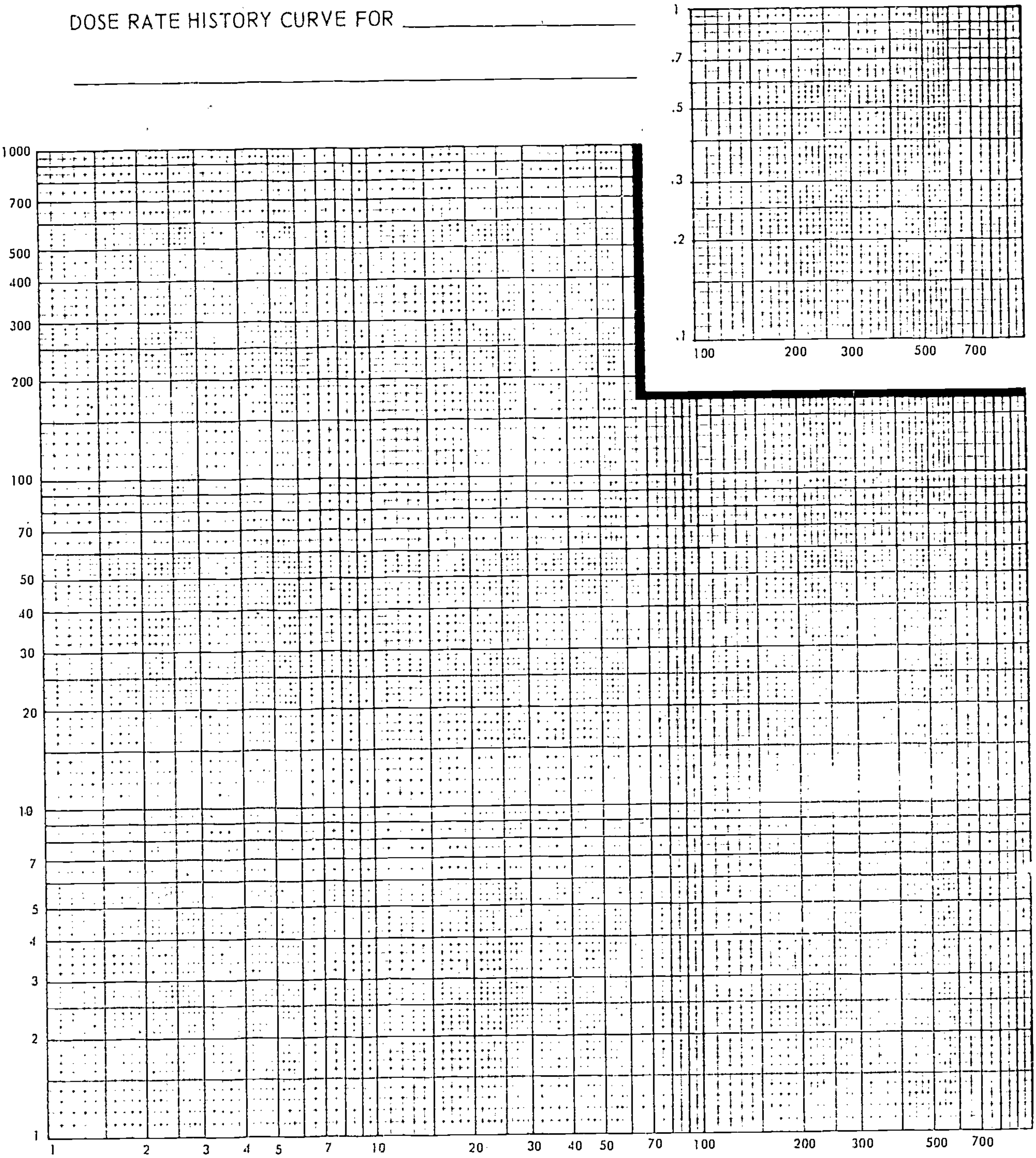
DOSE RATE (r/hr)

E-43 /E-44

Requirement No. 10

DOSE RATE HISTORY CURVE FOR ______________________

____



TIME AFTER BURST (HOURS)

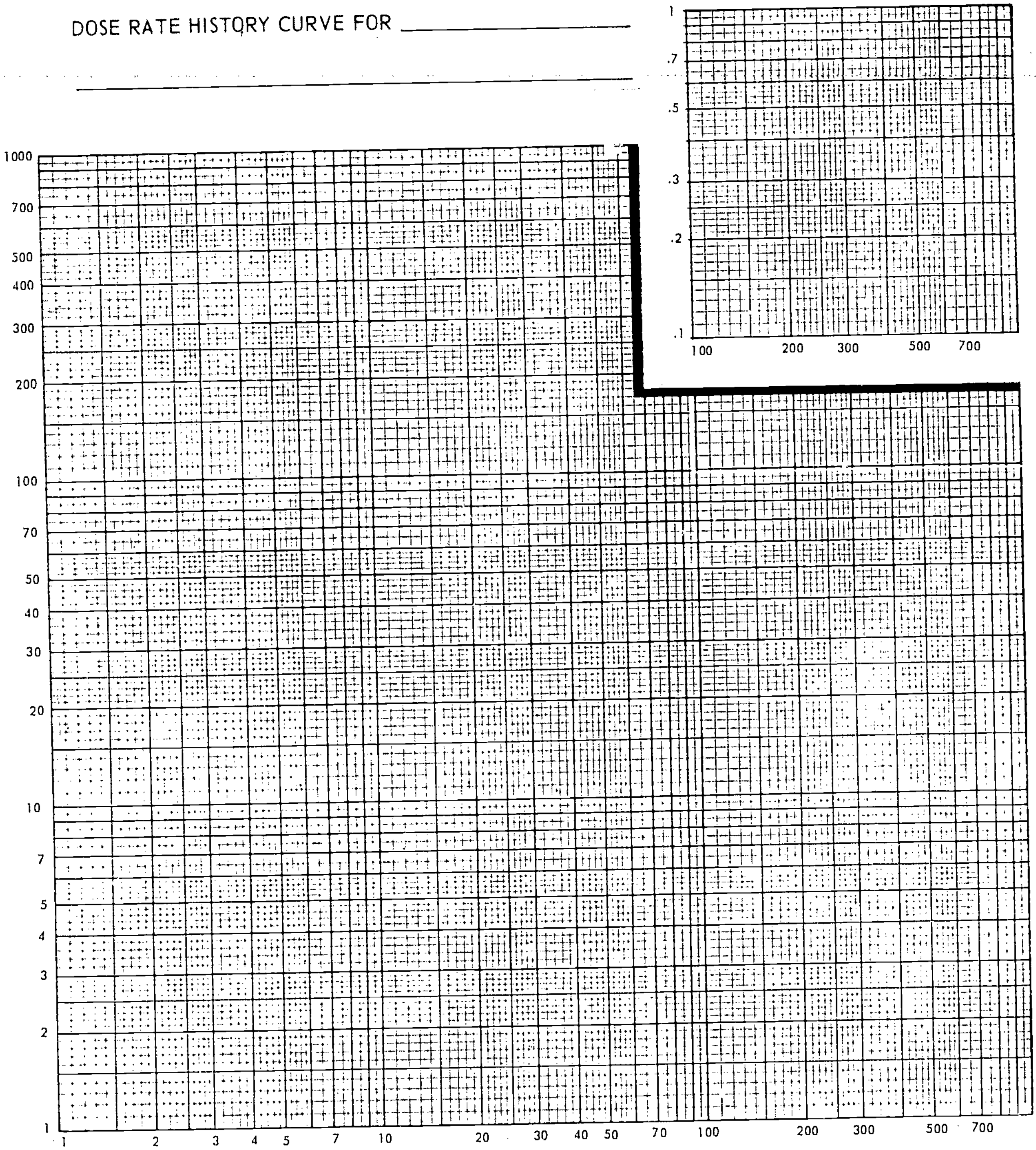
DOSE RATE (r/hr)

E-45/E-46

Requirement No. 10

DOSE RATE HISTORY CURVE FOR ______________________

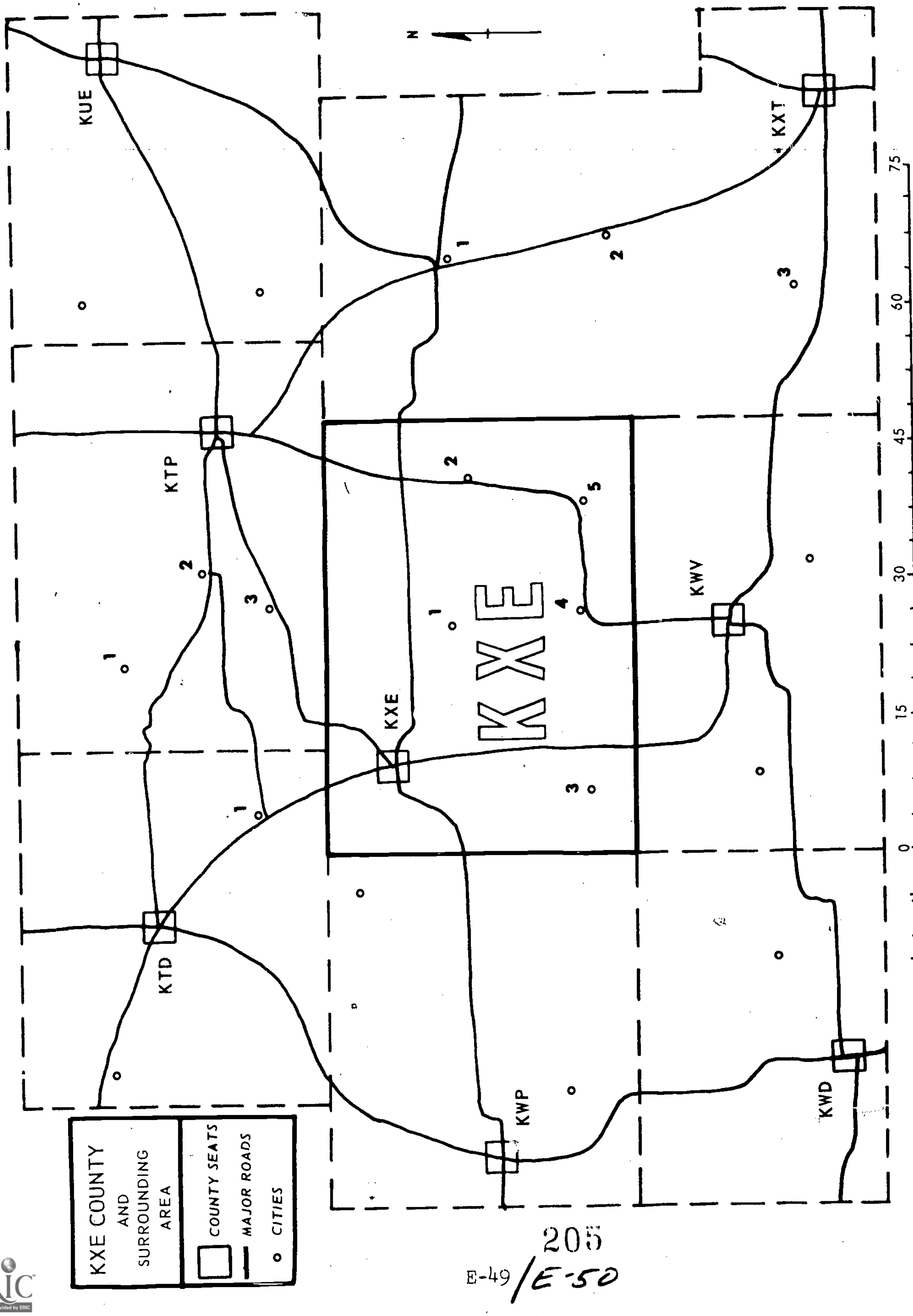
____



TIME AFTER BURST (HOURS)

DOSE RATE (r/hr)

E-47/E-48


N
KUE
KXT
KTP
KXE
KWV
KTD
KWP
KWD
KXE
1
2
3
4
5
0
15
30
45
60
75
scale in miles
KXE COUNTY
AND
SURROUNDING
AREA
COUNTY SEATS
MAJOR ROADS
CITIES

City KXE

RADIOLOGICAL REPORTING LOG

LOCATION DESIGNATOR	NO. OF MONITORS ON DUTY	FLASH REPORT TIME	DATE	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2
			TIME	1600	1700	1800	1900	2000	2100	2200	2200	2300	2400	0100	0200	0300	0400	0700	1000	1300	1600	2200
			r/hr or r	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.
A	4			2			320			190	1120			120			96	62	48	38	31	21
*B	2			2	23	180	290	230	200	170	1010	140	130	110	100	90	86	56	43	34	28	19
C	2			2			320			190	1110			120			96	62	48	38	31	21
D	3			3			350			210	1230			130			100	68	53	42	34	25
*E	4			3	26	210	340	270	230	200	1180	170	150	130	120	110	100	65	50	40	33	22
10F	4			2			260			150	900			100			77	50	38	30	25	17
*G	1			2	25	200	320	260	220	190	1130	160	140	120	110	100	96	62	48	38	31	21
16H	4			2			300			180	1070			110			91	59	46	36	29	20
18K	4			2			220			130	790			84			67	43	34	27	22	15
19L	3			2			310			180	1080			120			92	60	46	37	30	20
M	2			2			260			150	870			100			77	50	38	30	25	17
N	4			2			300			180	1080			110			71	59	46	36	21	20
*P	4			2	21	170	270	220	190	160	900	140	130	110	95	85	82	53	41	32	26	18
23R	4			2			290			170	1020			110			86	56	43	34	28	19
S	3			2			310			180	1090			120			93	60	47	37	30	20
T	4			2			320			190	1110			120			96	62	48	38	31	21
U	2			2			300			180	1060			110			89	58	45	35	29	20
X				3			350			210	1220			130			100	68	53	42	34	23

Requirements No. 27 to 41

E-51/E-52

City KXE

RADIOLOGICAL REPORTING LOG

LOCATION DESIGNATOR	NO. OF MONITORS ON DUTY	FLASH REPORT TIME	DATE	2	3	3	3	3	3	4	4	5	5	6	6	7	8	9	10	11	12	13
			TIME	2200	0400	1000	1600	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200
			r/hr or r	r.	r/hr.	r/hr.	r/hr.	r/hr.	r.	r/hr.	r.	r/hr.	r.	r/hr.	r.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.
A				2690	15	12	9.6	9	3020	4.8	3140	3.5	3280	2.8	3360	2.3	1.9	1.6	1.5	1.3	1.2	1.1
*B				2420	14	11	8.6	8.1	2720	4.3	2870	3.2	2960	2.5	3020	2.1	1.7	1.4	1.3	1.1	1.0	.95
C				2680	15	12	9.6	9	3050	4.8	3190	3.5	3280	2.8	3330	2.3	1.9	1.6	1.5	1.3	1.2	1.1
D				2970	17	13	11	9.9	3320	5.3	3510	3.9	3410	3.1	3700	2.5	2.1	1.8	1.7	1.4	1.3	1.2
*E				2920	16	13	10	9.4	3170	5	3350	3.7	3450	2.9	3530	2.4	2.0	1.7	1.6	1.4	1.3	1.2
10F				2170	12	9.6	7.7	7.2	2420	3.8	2550	2.8	2630	2.3	2680	1.8	1.5	1.3	1.2	1.1	.96	.88
*G				2670	15	12	9.6	9	3040	4.8	3170	3.5	3270	2.8	3370	2.3	1.9	1.6	1.5	1.3	1.2	1.1
16H				2560	14	11	9.1	8.6	2870	4.6	3030	3.3	3120	2.7	3190	2.2	1.8	1.5	1.4	1.2	1.1	1
18K				1990	11	8.4	6.7	6.3	2110	3.4	2230	2.5	2300	2.0	2350	1.6	1.3	1.2	1.1	.91	.84	.77
17L				2580	14	11	9.2	8.6	2900	4.6	3060	3.4	3150	2.7	3230	2.2	1.8	1.5	1.4	1.3	1.2	1.1
M				2130	12	9.6	7.7	7.2	2430	3.8	2530	2.8	2620	2.3	2650	1.8	1.5	1.3	1.2	1.1	.96	.88
N				2560	14	11	9.1	8.6	2850	4.6	3000	3.3	3130	2.7	3170	2.2	1.8	1.5	1.4	1.2	1.1	1
*P				2210	13	10	8.2	7.7	2570	4.1	2720	3.0	2790	2.4	2940	2.0	1.6	1.4	1.3	1.1	1	.94
23K				2440	14	11	8.6	8.1	2710	4.3	2850	3.2	2940	2.5	3020	2.1	1.7	1.4	1.3	1.1	1	.95
S				2600	15	12	9.3	8.7	2930	4.7	3070	3.4	3190	2.7	3250	2.2	1.8	1.5	1.4	1.3	1.2	1.1
T				2680	15	12	9.6	9	3030	4.8	3180	3.5	3280	2.8	3340	2.3	1.9	1.6	1.5	1.3	1.2	1.1
U				2520	14	11	8.9	8.4	2810	4.5	2960	3.3	3050	2.6	3120	2.1	1.8	1.5	1.4	1.2	1.1	1
X				2960	17	13	11	9.9	3340	5.3	3510	3.9	3600	3.1	3700	2.5	2.1	1.8	1.7	1.4	1.3	1.2

Neighboring Counties

RADIOLOGICAL REPORTING LOG

LOCATION DESIGNATOR	NO. OF MONITORS ON DUTY	FLASH REPORT TIME	DATE	1	1	1	2	2	2	2	FLASH REPORTS	2	FLASH REPORTS	2	2	2	3	3	3	3	3	3
			TIME	1600	1900	2200	0100	0400	0700	1000		1300		1600	1900	2200	0100	0400	0700	1000	1300	1600
			r/hr or r	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.		r/hr.		r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.
KTD	-	1510		4	130	80	52	36	26	20	1240	246		352	185	114	76	53	34	31	24	21
KTP	-	1553		2.5	110	64	40	28	20	16	1310	12.5	1310	260	140	87	57	41	31	23	18	15
KUE	-	-			4	27	17	12	4	7	1350	5.6	1350	425	224	133	71	63	47	56	29	23
KWP	-	1425		40	400	240	155	110	80	62		50		41		27		22		17		13
KWV	-	1555		.7	22	80	50	35	25	20		16		12.5		9		7		5.1		4
KWD	-	1510		3	90	54	35	28	18	14		10.5		7		6.4		4.5		3.6		2.7
KXT	-	-			1	23	23	16	12	7.1		7.2		5.7		4.2		3.1		2.4		1.8

Requirements No. 27 to 41

Neighboring Counties

RADIOLOGICAL REPORTING LOG

LOCATION DESIGNATOR	NO. OF MONITORS ON DUTY	FLASH REPORT TIME	DATE	3	4	4	4	4	5	6	7	8	9	10	11	12	13
			TIME	2200	0400	1000	1600	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200
			r/hr or r	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hv.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.
KTD				18	13	10	7.6	7	4.3	3.2	2.5	2	1.8	1.5	1.4	1.3	1.1
KTP				12	9	7	6	5	4	3	2	1.5	1.2	1	.8	.8	.7
KUE				16	12	10	8	7	4	3	2.3	1.8	1.5	1.3	1.2	1.1	1.0
KWP				12				7	5	3.7	3.1	2.6	2.2	2	1.8	1.6	1.4
KWV				3.5				2	1.5	1.2	1	.82	.72	.64	.56	.52	.48
KWD				2.5				1.5	1	.8	.64	.56	.47	.41	.37	.34	.32
KXT				1.5				.94	.68	.52	.42	.36	.31	.28	.25	.23	.21

E-57/E-58

County KXE

RADIOLOGICAL REPORTING LOG

LOCATION DESIGNATOR	NO. OF MONITORS ON DUTY	FLASH REPORT TIME	DATE	1	1	1	2	2	2	2	2	2	2	3	3	3	3	4	5	6	7	8
			TIME	1600	1900	2200	0100	0400	0700	1000	1300	1600	2200	0400	1000	1600	2200	2200	2200	2200	2200	2200
			r/hr or r	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.
KXE	—	1515		2.4	310	180	120	96	62	48	38	31	21	16	12	9.6	9	4.8	3.5	2.8	2.3	1.9
1KXE	—	1535		1	250	170	110	78	54	43	33	27	19	15	11	9	7.6	4.5	3.2	2.5	2	1.7
2KXE	—	1600		.5	90	140	96	62	48	38	28	22	15	12	7	[illegible]	6	3.8	[illegible]	2	1.6	1.4
3KXE	—	1520		2	240	160	100	72	51	41	31	24	17	13	10	8.2	6.8	4.1	2.9	2.3	1.8	1.5
4KXE	—	1540		.8	150	140	88	61	46	37	26	21	14	10	[illegible]	[illegible]	5.7	3.3	2.2	1.1	1.5	1.3
5KXE	—	1600		.5	20	120	80	56	41	31	24	20	14	10	8	6.6	5.4	3.2	2.2	1.8	1.4	1.2

Requirements No. 27 to 41

Requirements No. 27 to 41
Page 2

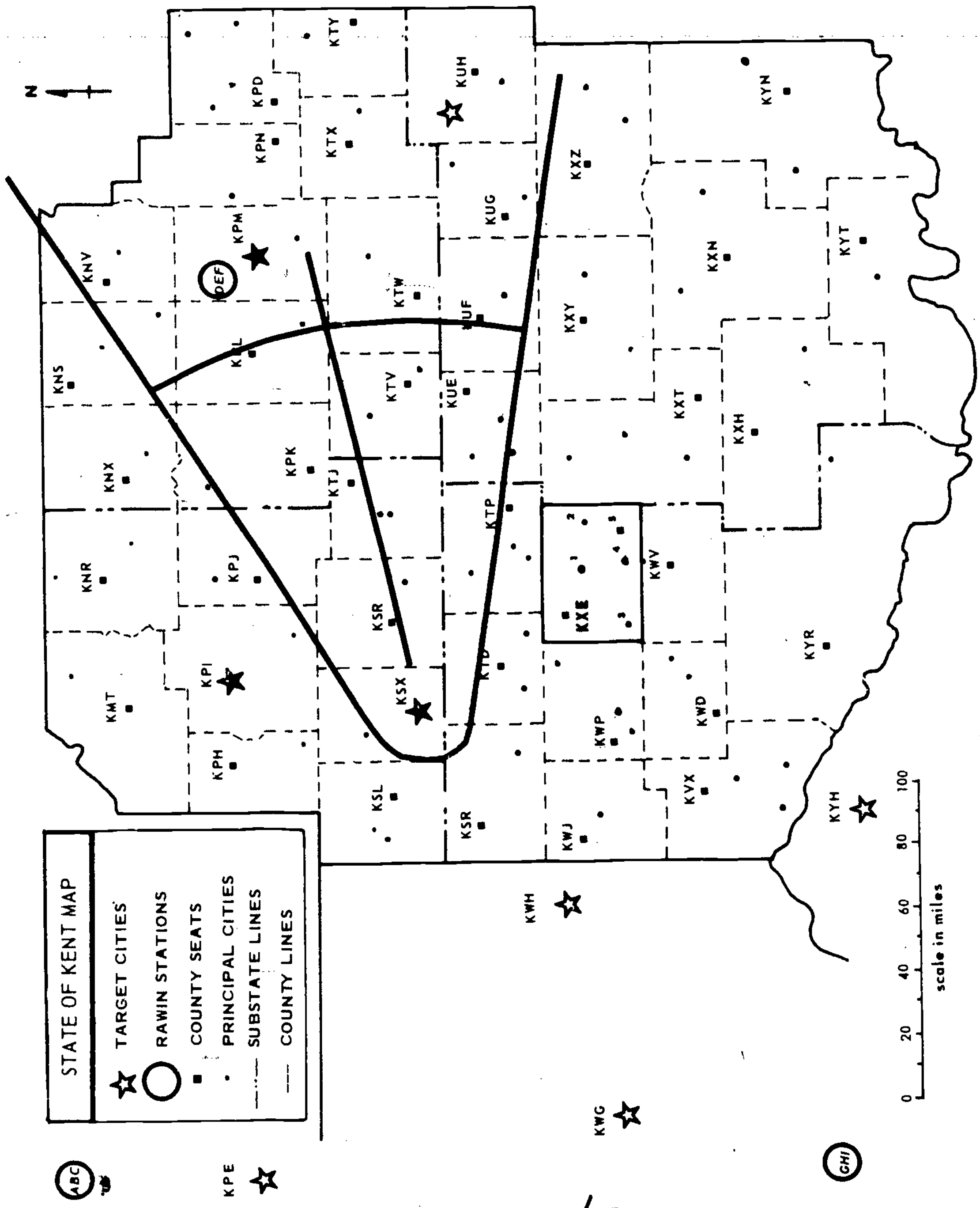
County KXE

RADIOLOGICAL REPORTING LOG

LOCATION DESIGNATOR	NO. OF MONITORS ON DUTY	FLASH REPORT TIME	DATE	9	10	11	12	13
			TIME	2200	2200	2200	2200	2200
			r/hr or r	r/hr.	r/hr.	r/hr.	r/hr.	r/hr.
KXE				1.6	1.5	1.3	1.2	1.1
1KXE				1.5	1.3	1.2	1.1	1.0
2KXE				1.2	1.1	1	.9	.8
3KXE				1.3	1.2	1.1	.96	.9
4KXE				1.1	1	1	.8	.7
[illegible]KXE				1.1	.94	.85	.76	.68

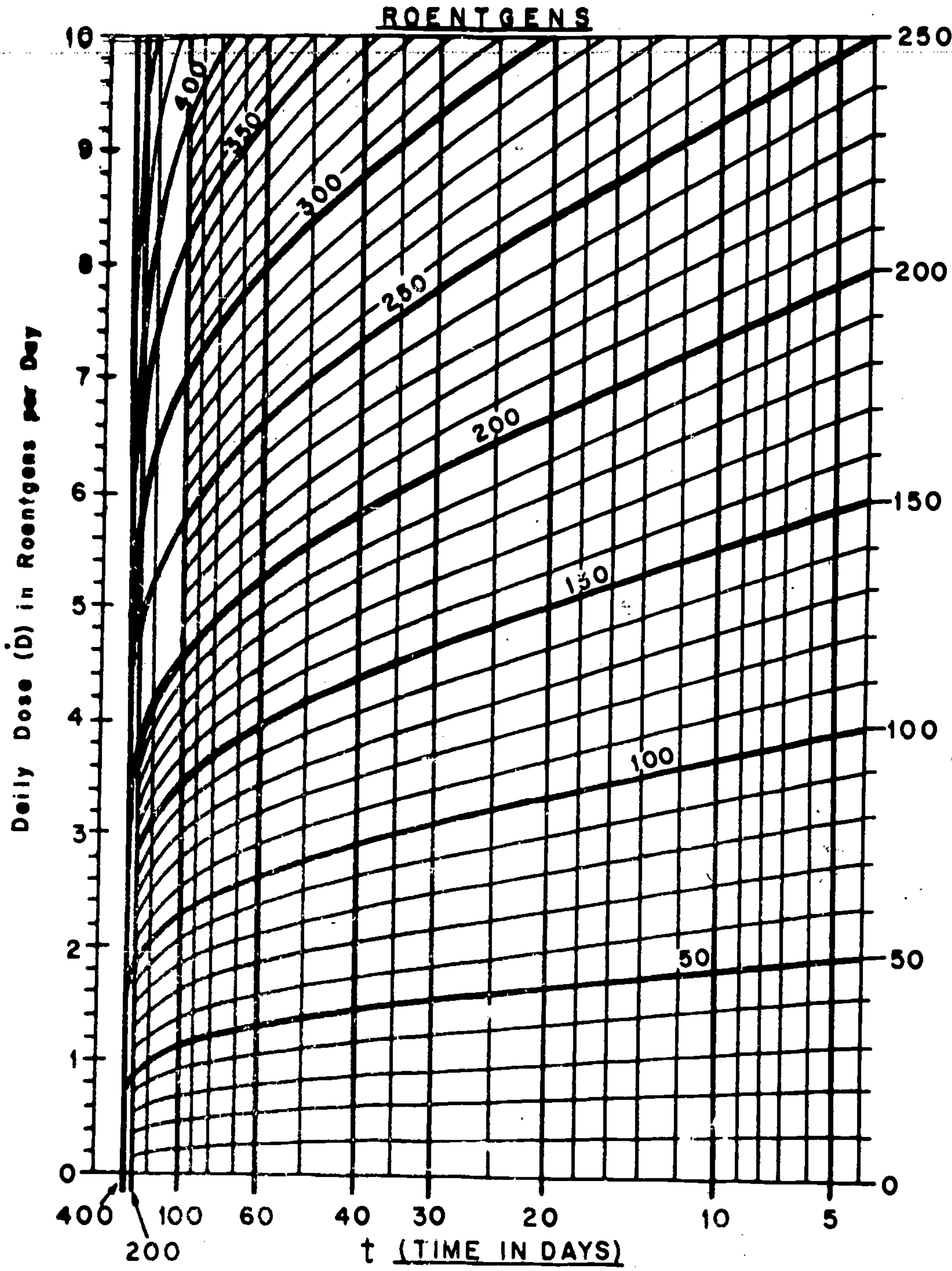
E-61 / E-62

Requirement No. 28



E-63 / E-64

EQUIVALENT RESIDUAL DOSE



E-65/E-66

2.5%

Requirement No. 35

CALCULATION OF ACCEPTABLE MISSION DOSE
(Estimating Form)

FOR ____

1. Protection factor of shelter ________

2. Unsheltered dose during first month (estimated from dose rate history curve). ________

3. Shelter dose during first month (Item 2 ÷ Item 1). ________

4. Acceptable ERD dose during first month (command decision) ________

5. Total exposure dose during first month (1.25 X Item 4). ________

6. Total mission dose for first month (Item 5 - Item 3). ________

7. Separate mission doses

a. ________ d. ________

b. ________ e. ________

c. ________ f. ________

g. Total (not to exceed Item 6) ________

8. Calculation of ERD based on the expected exposure schedule (to be completed after an estimate of the entry time is made).

CALCULATION OF ACCEPTABLE MISSION DOSE
(Estimating Form)

FOR ______________________________

1. Protection factor of shelter ________
2. Unsheltered dose during first month (estimated from dose rate history curve). ________
3. Shelter dose during first month (Item 2 ÷ Item 1). ________
4. Acceptable ERD dose during first month (command decision) ________
5. Total exposure dose during first month (1.25 X Item 4). ________
6. Total mission dose for first month (Item 5 - Item 3). ________
7. Separate mission doses

   a. ________ d. ________

   b. ________ e. ________

   c. ________ f. ________

   g. Total (not to exceed Item 6) ________
8. Calculation of ERD based on the expected exposure schedule (to be completed after an estimate of the entry time is made).

CALCULATION OF ENTRY TIME
(Estimating Form)

FOR ______________________________

1. Estimate of entry time:
   a. /_/ without countermeasure
   b. /_/ with countermeasure

2. Acceptable mission dose ______

3. Protection of working area
   a. Without countermeasure ______
   b. With countermeasure ______

4. Personnel exposure time ______

5. Total elapsed time during exposure period ______

6. Ratio of total elapsed time to personnel exposure time(5÷4) ______

7. Acceptable unsheltered dose during total elapsed time

   a. Without countermeasure (2 X 3a X 6) ______

   b. With countermeasure (2 X 3b X 6) ______

8. Average (midpoint) dose rate during exposure period (7a or 7b ÷ 5) ______

9. H-time at midpoint of exposure period (enter dose rate history curve at 8) ______

10. First estimate of entry time (9 - 1/2 of 5) ______

11. Estimated unsheltered dose for exposure period (from dose rate history curve) ______

12. Dose during exposure period

    a. Without countermeasure (11 ÷ 3a ÷ 6) ______

    b. With countermeasure (11 ÷ 3b ÷ 6) ______

13. Revised entry time ______

14. Revised unsheltered dose for exposure period (repeat 11) ______

15. Revised dose to personnel during exposure period (repeat 12) ______

16. Final estimate of entry time ______

Requirement No. 35

CALCULATION OF ENTRY TIME
(Estimating Form)

FOR ______________________________

1. Estimate of entry time:
   a. /_/ without countermeasure
   b. /_/ with countermeasure

2. Acceptable mission dose ______

3. Protection of working area
   a. Without countermeasure ______
   b. With countermeasure ______

4. Personnel exposure time ______

5. Total elapsed time during exposure period ______

6. Ratio of total elapsed time to personnel exposure time (5÷4) ______

7. Acceptable unsheltered dose during total elapsed time

   a. Without countermeasure (2 X 3a X 6) ______

   b. With countermeasure (2 X 3b X 6) ______

8. Average (midpoint) dose rate during exposure period (7a or 7b ÷ 5) ______

9. H-time at midpoint of exposure period (enter dose rate history curve at 8) ______

10. First estimate of entry time (9 - 1/2 of 5) ______

11. Estimated unsheltered dose for exposure period (from dose rate history curve) ______

12. Dose during exposure period

    a. Without countermeasure (11 ÷ 3a ÷ 6) ______

    b. With countermeasure (11 ÷ 3b ÷ 6) ______

13. Revised entry time ______

14. Revised unsheltered dose for exposure period (repeat 11) ______

15. Revised dose to personnel during exposure period (repeat 12) ______

16. Final estimate of entry time ______

CALCULATION OF ENTRY TIME
(Estimating Form)

FOR ______________________________

1. Estimate of entry time:
   a. /__/ without countermeasure
   b. /__/ with countermeasure

2. Acceptable mission dose ________

3. Protection of working area
   a. Without countermeasure ________
   b. With countermeasure ________

4. Personnel exposure time ________

5. Total elapsed time during exposure period ________

6. Ratio of total elapsed time to personnel exposure time (5÷4) ________

7. Acceptable unsheltered dose during total elapsed time

   a. Without countermeasure (2 X 3a X 6) ________

   b. With countermeasure (2 X 3b X 6) ________

8. Average (midpoint) dose rate during exposure period (7a or 7b ÷ 5) ________

9. H-time at midpoint of exposure period (enter dose rate history curve at 8) ________

10. First estimate of entry time (9 - 1/2 of 5) ________

11. Estimated unsheltered dose for exposure period (from dose rate history curve) ________

12. Dose during exposure period

    a. Without countermeasure (11 ÷ 3a ÷ 6) ________

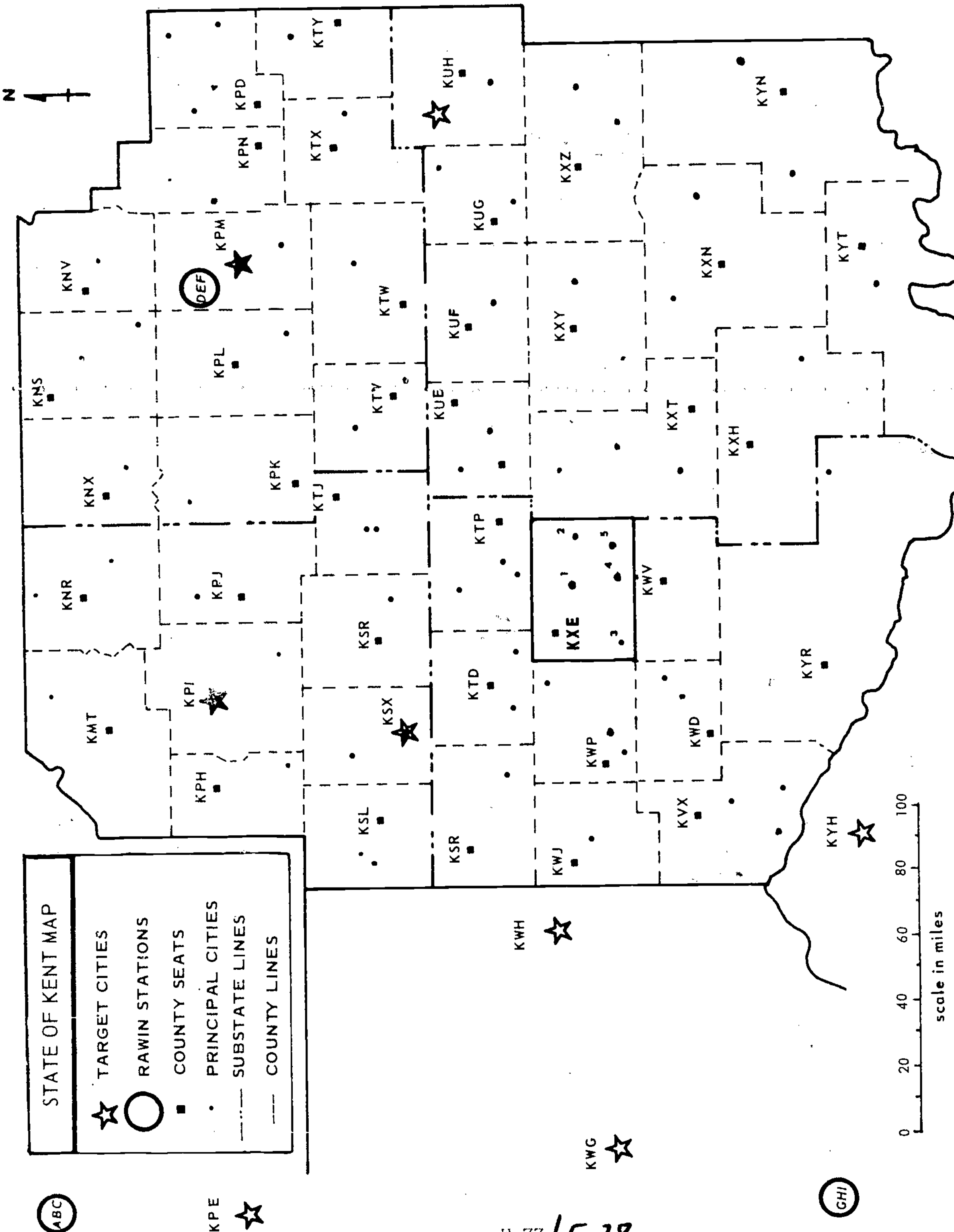
    b. With countermeasure (11 ÷ 3b ÷ 6) ________

13. Revised entry time ________

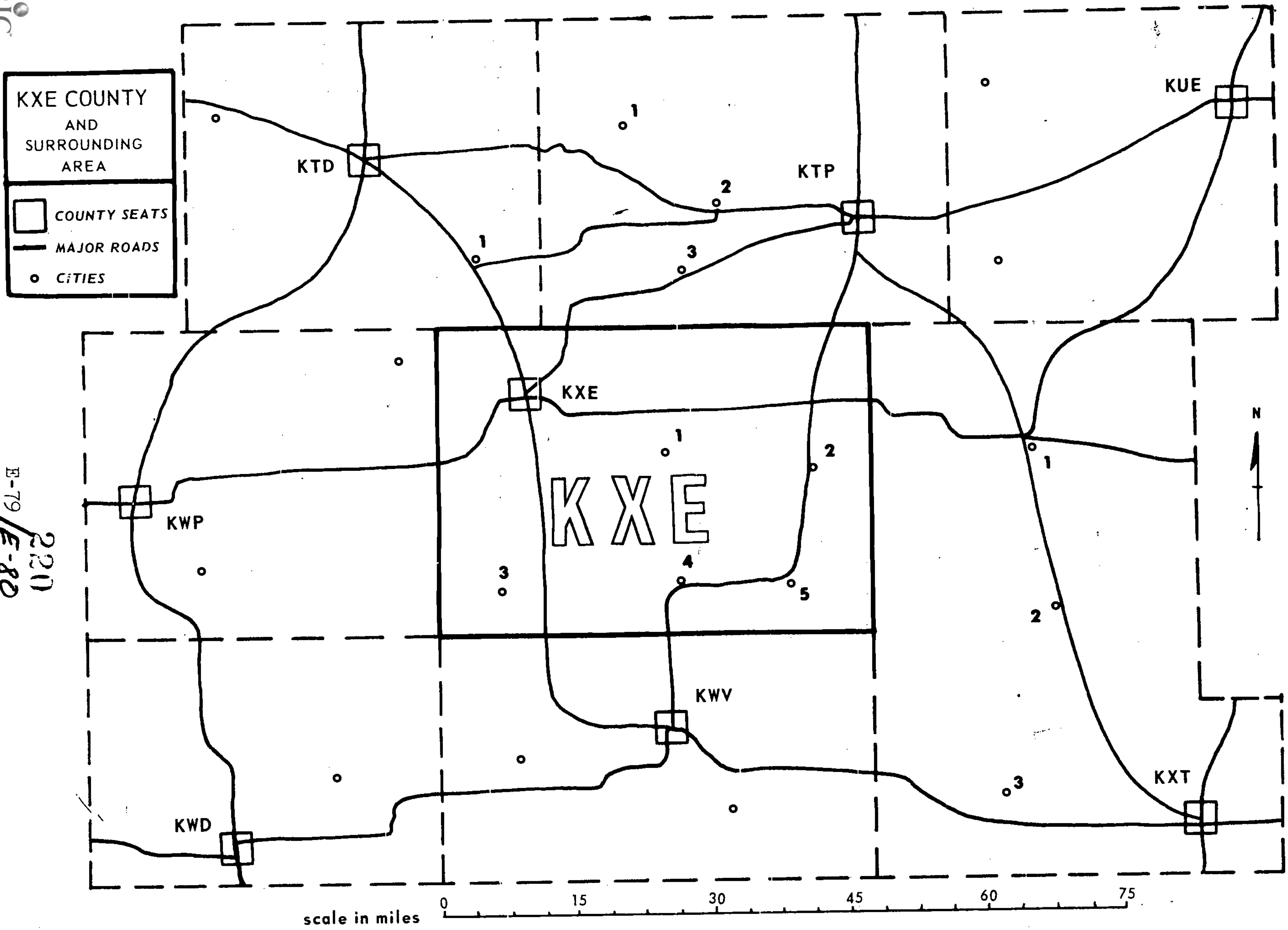
14. Revised unsheltered dose for exposure period (repeat 11) ________

15. Revised dose to personnel during exposure period (repeat 12) ________

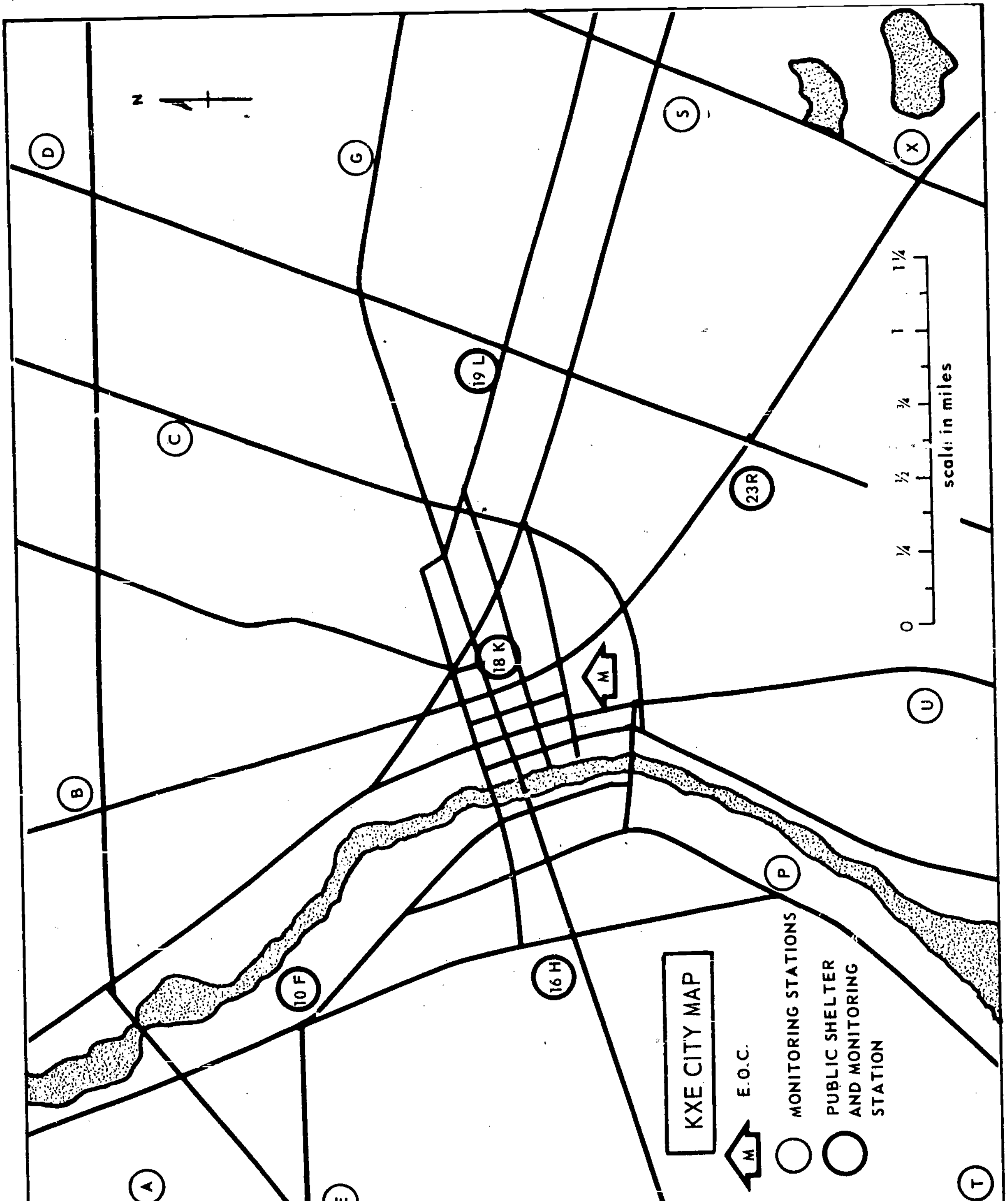
16. Final estimate of entry time ________


STATE OF KENT MAP
TARGET CITIES
RAWIN STATIONS
COUNTY SEATS
PRINCIPAL CITIES
SUBSTATE LINES
COUNTY LINES
N
DEF
ABC
GHI
KPD KTY KUH KYN
KPN KTX KXZ
KPM KUG KYT
KNV KTW KXN
KUF KXY
KNS KPL KTV KUE KXT KXH
KNX KPK KTJ
KTP KWV
KNR KPJ KSR KXE
KYR
KMT KPI KTD KSX KWD
KWP
KPH KSL KSR KWJ KVX KYH
KWH
KWG
KPE
0 20 40 60 80 100
scale in miles

E-77/E-78

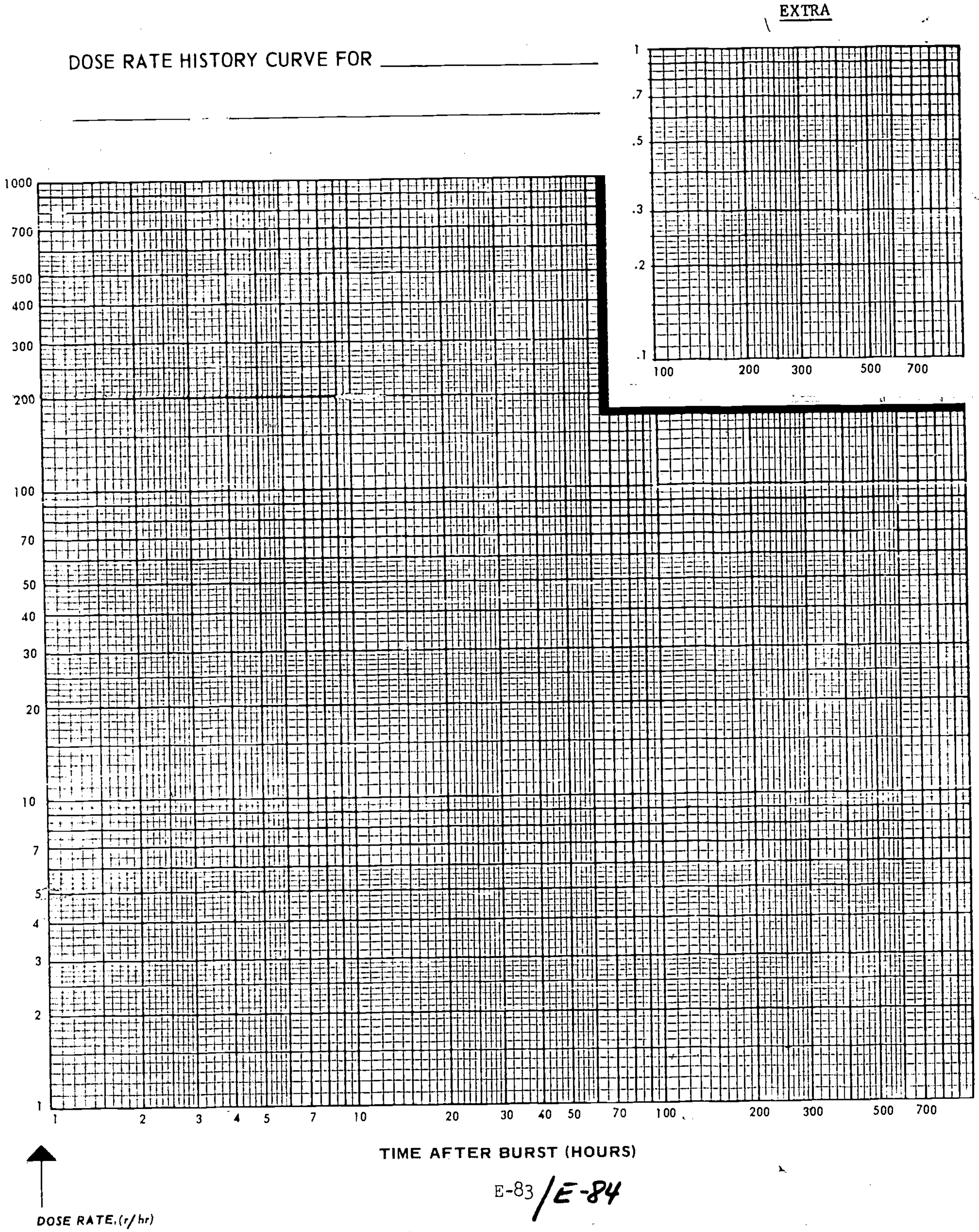

KXE COUNTY
AND
SURROUNDING
AREA
COUNTY SEATS
MAJOR ROADS
CITIES
KTD
KTP
KUE
KXE
KWP
KWV
KWD
KXT
N
1
2
3
4
5
0
15
30
45
60
75
scale in miles

EXTRA


KXE CITY MAP
E.O.C.
MONITORING STATIONS
PUBLIC SHELTER AND MONITORING STATION
scale in miles
0
¼
½
¾
1
1¼
N
A
B
C
D
E
10 F
G
16 H
18 K
19 L
M
N
P
23R
S
T
U
X

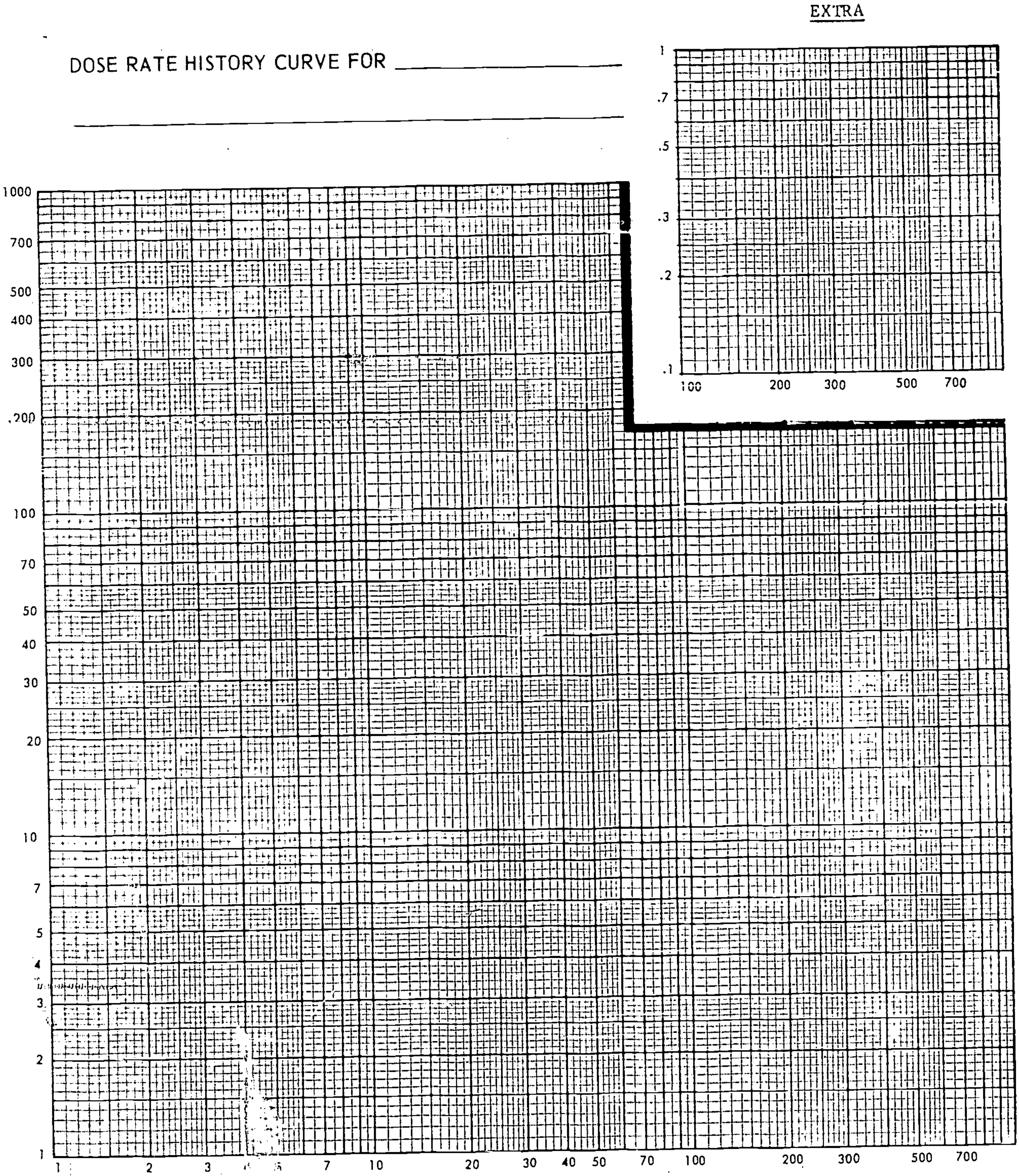
DOSE RATE HISTORY CURVE FOR ______________________

_______ - ______________________



DOSE RATE HISTORY CURVE FOR ______________________

____



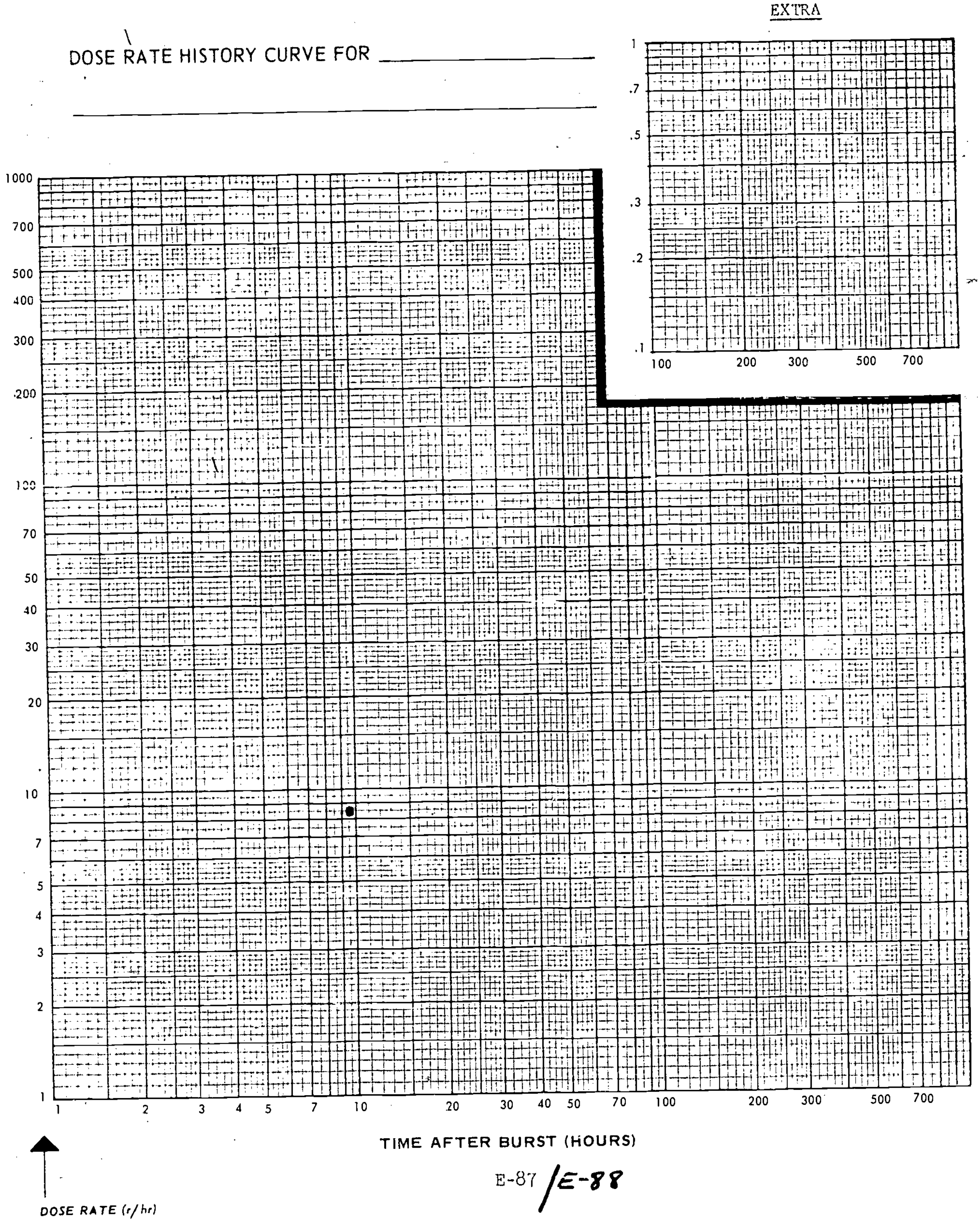
TIME AFTER BURST (HOURS)

DOSE RATE (r/hr)

E-85 / E-86

DOSE RATE HISTORY CURVE FOR ____________________

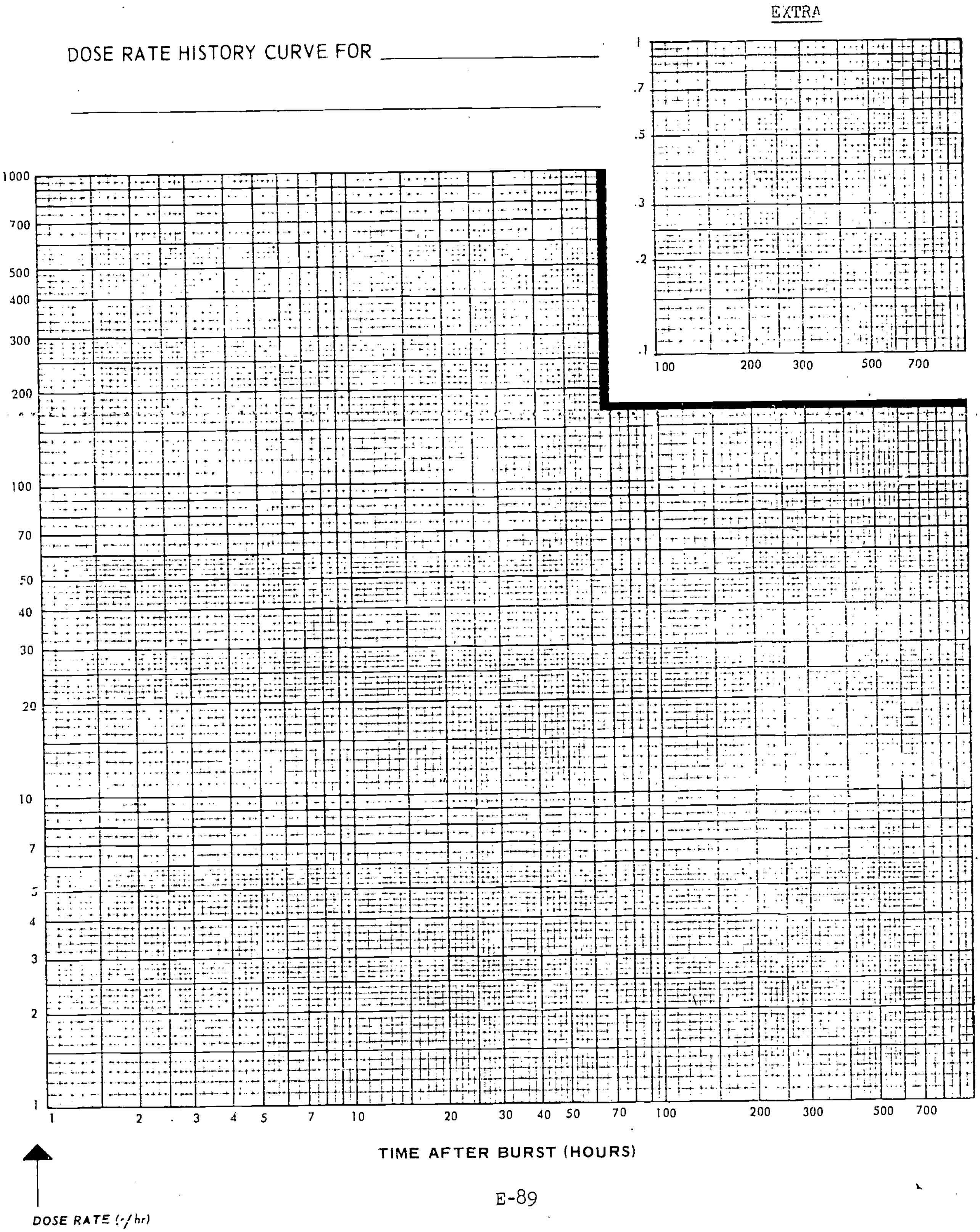
____



E-87 / E-88

DOSE RATE HISTORY CURVE FOR ______________________

____



Name ____________________

RADIOLOGICAL DEFENSE OFFICER

QUIZ I - ANSWER SHEET

PART I
MATCHING (3 points)

1. ( )
2. ( )
3. ( )
4. ( )
5. ( )
6. ( )

PART II
MULTIPLE CHOICE (3 points)

	a	b	c	d
7.	( )	( )	( )	( )
8.	( )	( )	( )	( )
9.	( )	( )	( )	( )
10.	( )	( )	( )	( )
11.	( )	( )	( )	( )
12.	( )	( )	( )	( )

PART III
PROBLEMS (4 points)

Problem No. 13 (1 point)

ANSWER __________

Problem No. 14 (1 point)

ANSWER __________

Problem No. 15 (2 points)

ANSWER __________

Score ____________________ Student Number ____________________

Name ____________________

RADIOLOGICAL DEFENSE OFFICER

QUIZ II - ANSWER SHEET

PART I
MULTIPLE CHOICE (6 points)

	a	b	c	d		a	b	c	d		a	b	c	d
1.	( )	( )	( )	( )	5.	( )	( )	( )	( )	9.	( )	( )	( )	( )
2.	( )	( )	( )	( )	6.	( )	( )	( )	( )	10.	( )	( )	( )	( )
3.	( )	( )	( )	( )	7.	( )	( )	( )	( )	11.	( )	( )	( )	( )
4.	( )	( )	( )	( )	8.	( )	( )	( )	( )	12.	( )	( )	( )	( )

PART II
PROBLEM (4 points)

ANSWER ____________________

SCORE ______________ STUDENT NUMBER ____________________

Name ______________________

RADIOLOGICAL DEFENSE OFFICER

QUIZ III - ANSWER SHEET

Problem No. 1 (2 points)

ANSWER ______________

Problem No. 2 (2 points)

ANSWER ______________

Score ______________ Student Number ______________

Problem No. 3 (3 points)

ANSWER ____________________

Problem No. 4 (3 points)

ANSWER ____________________

Q-III-2

NAME ______________________

PART I
RADIOLOGICAL DEFENSE OFFICER

COURSE EXAMINATION ANSWER SHEET

	a	b	c	d		a	b	c	d		a	b	c	d
1.	( )	( )	( )	( )	13.	( )	( )	( )	( )	25.	( )	( )	( )	( )
2.	( )	( )	( )	( )	14.	( )	( )	( )	( )	26.	( )	( )	( )	( )
3.	( )	( )	( )	( )	15.	( )	( )	( )	( )	27.	( )	( )	( )	( )
4.	( )	( )	( )	( )	16.	( )	( )	( )	( )	28.	( )	( )	( )	( )
5.	( )	( )	( )	( )	17.	( )	( )	( )	( )	29.	( )	( )	( )	( )
6.	( )	( )	( )	( )	18.	( )	( )	( )	( )	30.	( )	( )	( )	( )
7.	( )	( )	( )	( )	19.	( )	( )	( )	( )	31.	( )	( )	( )	( )
8.	( )	( )	( )	( )	20.	( )	( )	( )	( )	32.	( )	( )	( )	( )
9.	( )	( )	( )	( )	21.	( )	( )	( )	( )	33.	( )	( )	( )	( )
10.	( )	( )	( )	( )	22.	( )	( )	( )	( )	34.	( )	( )	( )	( )
11.	( )	( )	( )	( )	23.	( )	( )	( )	( )	35.	( )	( )	( )	( )
12.	( )	( )	( )	( )	24.	( )	( )	( )	( )					

QUIZ SCORES __________ PART I SCORE __________ PART II SCORE __________

FINAL SCORE ______________ STUDENT NUMBER ______________

CE-1 /CE-2

NAME ____________________

RADIOLOGICAL DEFENSE OFFICER
COURSE EXAMINATION ANSWER SHEET

PART II - PROBLEMS

36. (7 points)

ANSWER ____________

37. (7 points)

ANSWER ____________

38. (7 points)

ANSWER ____________

PROBLEM	36	37	38	39	40	Total
SCORE						

STUDENT NUMBER ____________

39. (7 points)

ANSWER ____________________

40. (7 points)

ANSWER ____________________

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