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Emergency Response Concept Plan for the Chemical Stockpile Emergency Preparedness Program, Rev. 1, Vol. 5:

Emergency Planning Guide for the Newport Chemical Depot CSEPP Site

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Emergency Response Concept Plan for the Chemical Stockpile Emergency Preparedness Program, Rev. 1, Vol. 5:

Emergency Planning Guide for the Newport Chemical Depot CSEPP Site

Vol. 1: Anniston Chemical Activity
Vol. 2: Blue Grass Chemical Activity
Vol. 3: Deseret Chemical Depot
Vol. 4: Edgewood Chemical Activity
Vol. 5: Newport Chemical Depot
Vol. 6: Pine Bluff Chemical Activity
Vol. 7: Pueblo Chemical Depot
Vol. 8: Umatilla Chemical Depot

by CSEPP Accident Planning Base Review Group, Argonne National Laboratory, Innovative Emergency Management, Inc., Oak Ridge National Laboratory

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1 INTRODUCTION

WHERE DID THIS DOCUMENT COME FROM?

In December 1992, the Planning Subcommittee of the Chemical Stockpile Emergency Preparedness Program (CSEPP) convened a new working group, the Accident Planning Base Review Group (APBRG). This group's mission was to update the accident planning base for CSEPP. Such action was needed because of a number of changes in CSEPP and in the Chemical Stockpile Disposal Program (CSDP) since the publication of the original, site-specific Emergency Response Concept Plans in 1988. These changes include the reassessment of dispersion distances; changes in CSDP process design and operations; and a change to planning on the basis of accident categories, not accident scenarios.

The APBRG's goals were:

1o To inform the site planning community (state, local, and installation CSEPP planners) of changes to the planning base as information unfolded throughout the process;

2. To involve the site planning community in documenting the planning base to create shared ownership of the final products; and

3. To address and promote site-specific development of protective action strategy plans.

The APBRG decided to publish the revised planning base in a practical form for use by state, local, and installation CSEPP planners. For this reason, the group concluded that it would publish eight site-specific Emergency Planning Guides (EPGs). Each guide would contain information and explanations needed to develop protective action strategy plans.

To meet these goals, the APBRG closely interacted with the site planning community throughout the development of the EPGs. To facilitate this interaction, the APBRG membership included representatives of state, local, and installation planners. The APBRG held a workshop in March 1993, and breakout sessions at the CSEPP national conferences in May 1993 and July 1994, to solicit comments from CSEPP planners on the concepts and draft outlines of the EPGs. Further interaction occurred at the CSEPP Planning Workshop in December 1993 and during visits to each CSEPP site by the APBRG.

WHO IS THIS DOCUMENT FOR?

This document is intended for the use of' the Newport Chemical Depot (NECD) planning community, including state, local, and installation planners. If you are a CSEPP planner, this guide gives procedures you can follow to develop protective action strategy plans. The guide is meant to help you develop, revise, and update plans to protect the public in case of a chemical stockpile emergency at NECD.

NEED FOR AN EMERGENCY PLANNING GUIDE

We have CSEPP planning guidance and existing plans. Why do we need an EPG now? The revised EPGs supersede the previous site-specific Emergency Response Concept Plans (ERCPs). They expand on, update, and replace the ERCPs. *Note that plans based on the ERCPs are still valid.* However, with the publication of this EPG, revising or updating those plans should use the information in this EPG, rather than that included in the previous ERCP; likewise, in developing any new plans for NECD and vicinity, use this EPG.

The EPGs do not replace the CSEPP Planning Guidance, nor, for the most part, do they repeat material found in the other guidance. The EPG presents site-specific data needed for planning and gives practical instructions for developing protective action strategy plans. The EPGs should be consistent with the CSEPP Planning Guidance; but, in an actual or apparent conflict, the CSEPP Planning Guidance should be considered as authoritative.

Some of the material in the EPGs covers familiar ground for experienced planners for chemical stockpile emergencies at the eight sites. For example, existing plans encompass the geographic, demographic, and socioeconomic characteristics of the jurisdictions surrounding the Army installations. They also are based on hazard identifications done by installation planners. Some of this material was covered in the original ERCPs. However, these data are included in the EPGs for several reasons:

- The EPGs replace the ERCPs. Therefore, the EPGs should include basic data of interest to planners, rather than require planners to refer back to the ERCPs for such information.

- Some information has changed since publication of the ERCPs; for example, demographic data have probably changed at all eight sites. At some sites, better data are now available, such as local meteorology data.

- Personnel in planning organizations may have changed since publication of the ERCPs and of existing plans. Current or future planners need ready access to the information that may be "old hat" to more experienced planners.

PARTS OF THIS DOCUMENT

The EPG has four major parts:

- Part I contains data that characterize the NECD site and the surrounding jurisdictions. These data include geographic, demographic, and socioeconomic/infrastructure characteristics of the Immediate Response Zone (IRZ) and the Protective Action Zone (PAZ).

- Part II characterizes the chemical stockpile hazard at NECD. This part describes the hazard, discusses risk analysis and the use of the D2PC model to estimate the consequences of accidental releases, and describes *accident categories* as a basis for protective action planning.

- Part III discusses protective action strategies for CSEPP, protective action decision making, the use of computer models in protective action planning, and the process of developing protective action strategy plans.

- Part IV consists of Appendixes A through F. These appendixes include a glossary of terms and acronyms, technical data, and additional discussions that support the development of the accident categories. The appendixes provide the rationale for reexamining the CSEPP planning base, describe how hazard distances were calculated, and contain tables of distance calculations and Material Safety Data Sheets. The appendixes also discuss how to apply the results of the Army's study of agent deposition to NECD accident scenarios.

1.1 USING ACCIDENT CATEGORIES AS A PLANNING BASE

This guide focuses on the use of *accident categories* rather than scenarios as the basis for developing protective action strategy plans. The scenarios cited in the previous ERCP have been sorted into a small number of categories on the basis of the distance to which the hazardous effects of each scenario might extend. You should develop plans for this small number of categories rather than for the large number of scenarios for two practical reasons:

- At the time of an accident, the information immediately available from the installation is likely to be rather limited. Indeed, at first report, the cause of the release of chemical agent may not be known, and for reaching a protective action decision, initially it may not matter what caused the release of agent (that is, what accident category is in effect). What matters is the direction, the distance, and the times at which hazardous effects are likely to be reached. The accident categories provide that level of immediately available, required information for planners and decision makers.

- Protective action decisions must be made quickly if a chemical agent is released. Decision makers will not have time to sort through the many possible protective action strategies. Therefore, the number of options must be kept small. The accident categories are designed to group a potentially large number of options into a few options.

1.2 USING D2PC IN PLANNING

This guide contains extensive discussions of how to use the D2PC modeling system and gives cautions that the user should be aware of in using D2PC:

> *Your first reaction upon receiving a notification of a chemical agent accident should not be to run D2PC or to wait for someone else to run it.*

Doing so will lose valuable time that you need for implementing a protective action. The accident categories in the EPG are designed to help you make appropriate protective action decisions without waiting to run D2PC first at the time of an accident.

However, it is also important to note what *are* appropriate uses of D2PC:

- At the time of an accident, run D2PC, as time and available data allow, to perform ongoing assessment of the accident. But do not delay putting a protective action in place while waiting for a D2PC run.

- In the planning stage, run D2PC as much as you wish to test out various options. Appendix C gives instructions to enable you to reproduce the distances calculated in Appendix D of the EPG. You may wish to calculate some of those scenarios. In addition, you will find it instructive to calculate other scenarios--vary the quantity of agent release, for instance, to find out "what happens if...." Even if you never touch D2PC during an actual incident, the insight you gain from running D2PC during the planning stage will give you a much better understanding of what is happening during an actual incident.

- You should be aware that the Army has benchmarked and field tested D2PC. Where conditions exist that approximate the assumptions of the model (such as flat terrain and steady weather conditions), D2PC estimates were relatively accurate in comparison to the results of actual tests.

- However, in many cases D2PC *overestimates* the hazard distance that you need to be concerned about for a given quantity of release. This overestimate occurs because many things impede the downwind movement of materials released to the atmosphere. For example, wind meandering and rough terrain (natural features or buildings) interrupt the steady movement of a plume of agent. So, the D2PC estimate of downwind effects is usually greater than that which would occur if an actual release took place.

- Therefore, the use of D2PC should enable you to assure decision makers that the EPG accident categories, which are based on D2PC results, provide a conservative basis for protecting the public.

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PART I: SITE CHARACTERIZATION

2 IMPORTANCE OF SITE CHARACTERISTICS FOR EMERGENCY PREPAREDNESS

This section discusses the significance of particular site characteristics to the preparation of an emergency response plan. Several types of data should be collected on the characteristics of a site before starting emergency planning: *geographic*, *demographic*, and *socioeconomic/ infrastructure* data.

2.1 GEOGRAPHIC DATA

The importance of geographic data cannot be overestimated; the planner needs geographic data to begin designing an emergency response plan. Within geographic data are subcategories, including *location, topographic characteristics,* and *climate and weather patterns.*

Information about geographic location should include the location of the depot, the area surrounding the depot that might be affected by activities and/or accidents at the depot, and the location of the hazardous material stored and handled at the depot. Distances between the chemical storage and handling areas (including planned or existing demilitarization plants) to the depot boundaries must be determined. The transportation routes on the depot and beyond the depot in the larger emergency planning area should be described to assist with planning for evacuation of the site. In planning for potential incidents involving the chemical stockpile, exactly what is stored on the site (and the quantities involved) should be known. The results of computer modeling programs (i.e., D2PC) for predicting the plume cannot be interpreted without geographic information. Protective actions (such as evacuation) cannot be determined or communicated without geographic information. In addition, the special characteristics of the area surrounding the depot need to be known, such as the recreation areas (i.e., parks, hunting and fishing areas, etc.) where people may need special warnings in addition to the alert and notification of the general public through the usual methods.

Also of great importance are the topographic characteristics of the area to be used to determine the location of the emergency planning zones (the IRZ and the PAZ). Determination of the emergency planning zones assists the planner in defining the level of planning and preparedness needed in a particular area. Finally, maps of the area should depict all of the above.

2.2 DEMOGRAPHIC AND SOCIOECONOMIC DATA

Demographic data--information about population of an area--are also critical knowledge for an emergency response planner. Knowing the population base (i.e., how many people live and work in an area, and where they are concentrated) assists the planner in determining the threat of an accident at the installation to the public and to personnel on site. Socioeconomic factors also must be considered as part of the overall demographic picture. For example, daytime distribution of population often differs from nighttime distribution of the population. People usually do not work at home and may move around an area to perform other activities (i.e., shopping, attending sporting or recreational events, etc.). Therefore, planners should take into account where the population is concentrated at a particular time of day (i.e., offices, factories, shopping areas, recreation centers, etc.) and where they are at night (i.e., home, night shift, etc.).

Information about special populations, such as institutionalized persons (i.e., hospitals, nursing homes, prisons, etc.) and mobility impaired persons, is needed for special planning for these facilities, including how they will be notified and how their populations will be moved, if necessary. Where special populations will be taken also needs to be determined.

Schools are also considered facilities with special populations. The location of schools and day care centers must be known so that children can be protected. Emergency response plans for schools may, /'or example, include special alerting procedures and, if there is time, precautionary protective actions that can be implemented before an agent is released or becomes airborne. How parents will be notified and where school children will be sheltered and cared for in the event of an evacuation must be determined.

2.3 SUMMARY

In summary, considerable background data need to be gathered and developed before you create an effective emergency response plan. In addition to the information mentioned above, particular circumstances unique to an area also should be part of the database for an emergency response plan. Remember that the database changes over time and, therefore, so should the emergency response plan. Effective emergency response plans are "living" documents that are updated as circumstances change.

3 GEOGRAPHIC CHARACTERISTICS

This section provides background information on the geographic characteristics of the NECD and surrounding area. The description includes the general location of the depot and distances from chemical and handling areas to depot boundaries. Specifically, the minimum and maximum distances from the storage facility, demilitarization plant, and the on-site transportation route between the two to the depot boundaries are identified. Topographic characteristics and climate and weather patterns of the surrounding area are discussed as well.

The section further identifies the local jurisdictions constituting the IRZ and the PAZ. These political boundaries may affect planners' protective action strategies.

3.1 LOCATION AND PHYSICAL LAYOUT OF NECD

The depot is in Vermillion County in west-central Indiana. Bordering counties are Fountain and Parke Counties in Indiana, as well as Vermilion and Edgar Counties in Illinois. The installation is 42 km (26 mi) north of Terre Haute, Indiana, and 38 km (24 mi) south-southwest of Danville, Illinois. For a more local perspective, it lies 18 km (11 mi) west-northwest of Rockville, Indiana, and 8 km (5 mi) northwest of Montezuma, Indiana.

The depot's primary mission was manufacturing explosive and chemical materials and filling chemical munitions. The only remaining mission is to store chemical agent VX in ton containers. The chemical is stored in a single warehouse. The building is approximately 24 m (79 ft) wide and 85 m (279 ft) long and is in a restricted area adjacent to the former VX production facility. The grounds within the restricted area are all concrete or macadam-covered surfaces. Large storage tanks, now empty, which once stored agent, are located along the southeast side of the warehouse. The approximate minimum distance from the warehouse to the depot boundary is 1.05 km (0.65 mi), which corresponds to the distance from the east face of the warehouse to the eastern boundary of the depot. The maximum distance is from the west face of the warehouse to the westernmost point on the depot boundary, which is about 6.04 km (3.75 mi).

The demilitarization plant is expected to be located about 150-300 m (492-984 ft) southwest of the warehouse. For this guide, a point 225 m (738 ft) southwest of the center of the warehouse has been selected as the approximate center of the demilitarization site. The minimum distance from this center point to a depot boundary is 1.2 km (0.8 mi), the distance to the eastern boundary of the depot. The maximum distance from the approximate center of the demilitarization site to a depot boundary is 5.9 km (3.7 mi), which represents the distance to the westernmost point on the depot boundary.

The transportation route is assumed to be located entirely between the warehouse and demilitarization facility. The minimum distance from the transportation route to a depot boundary is 1.1 km (0.7 mi), which corresponds to the distance from the warehouse to the eastern boundary of the depot. The maximum distance is 6.0 km (3.7 mi), which corresponds to the distance from the warehouse to the westernmost point of the depot boundary. Table 3.1.1 summarizes distances from points on the depot to the depot boundaries.

TABLE 3.1.1 Summary of Minimum and Maximum Distances to Depot Boundary

	Distance to Depot Boundary			
	Minimum		Maximum	
Location on Depot	km	mi	km	mi
Storage area	1.05	0.65	6.04	3.75
Demilitarization facility	1.2	0.8	5.9	3.7
Transportation route	1.1	0.7	6	3.7

3.2 TOPOGRAPHY

The NECD is located in a relatively flat, upland area. The most pronounced terrain feature in the vicinity is the fairly broad, fiat, Wabash Valley, about 3-5 km (2-3 mi) east, northeast, and southeast of the installation. This valley could affect the dispersion of an accidental release of chemical agent under some meteorological conditions. The valley, or river bluffs, though not deep enough to act as a barrier, could pool a release if it occurred during light winds and stable atmospheric conditions. In higher winds and unstable atmospheric conditions, the valley is not a sufficient barrier to the further eastward movement of agent released.

Because of the moderate effect of topographic features on the dispersion of agent from the full range of possible releases and weather conditions, the significant topographic features listed in Table 3.2.1 should be used in defining emergency planning zones that are easily identifiable to the public and emergency response teams.

TABLE 3.2.1 Topographic Features in the Area Surrounding NECD

Direction	Description	Distance (km)	Absolute Elevation (m)	Elevation Relative to NECD (m)
- - -	NECD	0	220	0
N	Little Vermillion River[a]	4	150	–70
	Wabash River[a]	7	150	–70
NNE	Little Vermillion River	4	150	–70
	Wabash River	6	150	–70
NE	Little Vermillion River	4	150	–70
	Wabash River	6	150	–70
ENE	Wabash River	6	150	–70
E	Wabash River	6	150	–70
	Turkey Run State Park	24	170	–50
ESE	Wabash River	5	150	–70
	Town of Rockville	19	210	–10
SE	Wabash River	6	150	–70
SSE	Town of Montezuma	9	165	–55
	Wabash River	11	150	–70
S	Norton Creek	11	165	–55
	City of Clinton	19	165	–55
SSW	Norton Creek	3	165	–55
SW	Town of Dana	8	165	–55
	City of Paris (IL)	34	180	–40
WNW	Little Vermillion River	5	150	–70
NW	Little Vermillion River	4	150	–70
NNW	Little Vermillion River	3	150	–70

[a] The “bluffs” of the Little Vermillion and Wabash Rivers vary in height from approximately 15 to 45 m (49 to 148 ft).

3.3 CLIMATOLOGY

The climate in the NECD area is classified as humid and variable because it is in a transition area between the warm southern and the cool northern climates. The NECD climate, characterized as continental, has a wide range of temperatures. Frequent cold waves from Canada, which are usually modified by the time they reach the area, allow temperatures to fall as low as -18°C (0°F). In the summer, temperatures higher than 38°C (100°F) occur occasionally. It is usually warm and humid when moist air from the Gulf of Mexico moves into the area. The spring and fall typically experience dramatic changes in weather, often caused by a rapid succession of fronts.

Large-scale systems cause much of the precipitation during the fall through the spring, while thunderstorms produce most of the precipitation in the summer. On the average, the region receives about 102 cm (40 in.) of precipitation per year. Amounts are greater in the late spring and early summer and less during the winter than in other periods of the year.

In the NECD area, the prevailing winds are from the south. The direction of the winds is a consequence of the local topography, which modifies wind direction from the prevailing southwest direction generally found in the central United States.

Innovative Emergency Management, Inc. (IEM), has analyzed available weather records near NECD. Its analysis identified 12 profiles of weather conditions that would be likely to occur at NECD: three weather profiles for each of the four seasons. The weather profiles are given in Tables 3.3.1 and 3.3.2. *Note that these weather profiles are not meant to be a complete picture of the weather at the site.* This statement is true because:

- The analysis always made three profiles for each season, whether the site had three, or more, or fewer, prevailing weather patterns.

- The profiles are only average. Individual weather records sometimes vary significantly from the averages.

The weather profiles were generated using the IEM K-means weather data clustering algorithm. Raw weather data were taken from 15-min surface observations for the depot from April 23, 1991, to December 25, 1993. In generating the daytime weather patterns (Table 3.3.1), data records from nighttime were removed, whereas the generation of nighttime weather patterns (Table 3.3.2) excluded data records from daytime. The data for both daytime and nighttime weather patterns were further filtered by removing any records that had missing data in any of the relevant variables (variables needed to calculate stability or variables needed directly).

TABLE 3.3.1 Daytime Weather Profiles for NECD

Profile	Wind Speed m/s	Wind Speed mph	Stability[a]	Temperature °C	Temperature °F	Wind Direction (deg from)
Winter 1	4.80	10.5	D	0	32	281
Winter 2	4.20	9.20	D	3	38	182
Winter 3	4.30	9.40	D	0	32	34
Spring 1	5.10	11.2	D	22	71	219
Spring 2	3.40	7.50	C	21	70	129
Spring 3	3.80	8.40	C	17	63	18
Summer 1	2.60	5.70	C	22	72	21
Summer 2	3.40	7.50	C	26	79	246
Summer 3	3.00	6.60	C	25	77	166
Fall 1	4.90	10.8	D	14	57	191
Fall 2	4.60	10.1	D	7	45	281
Fall 3	3.30	7.30	D	11	52	51

[a] Stability codes are discussed in Pasquill (1994).

TABLE 3.3.2 Nighttime Weather Profiles for NECD

Profile	Wind Speed m/s	Wind Speed mph	Stability[a]	Temperature °C	Temperature °F	Wind Direction (deg from)
Winter 1	4.20	9.20	E	1	34	293
Winter 2	3.80	8.40	E/F	–8	18	305
Winter 3	4.80	10.5	E	11	52	196
Spring 1	3.40	7.50	E/F	16	61	114
Spring 2	3.20	7.00	F	23	73	169
Spring 3	3.70	8.10	E/F	7	45	358
Summer 1	2.40	5.30	F	20	68	144
Summer 2	2.60	5.70	F	25	77	179
Summer 3	1.90	4.20	F	14	57	18
Fall 1	3.60	7.90	E/F	7	45	171
Fall 2	4.70	10.3	E	17	63	180
Fall 3	4.00	8.80	E	–3	27	262

[a] Stability codes are discussed in Pasquill (1994).

The Pasquill stability class (Pasquill 1974) for each 15-rain record was calculated by means of the net solar radiation index algorithm provided by U.S. Army Edgewood Research, Development and Engineering Center (ERDEC) (1980). The data were subsequently divided into seasonal sets, as follows:

Winter	December 21-March 20
Spring	March 21-June 20
Summer	June 21-September 20
Fall	September 21-December 20

The decision variables used to derive the clusters were wind speed, wind direction, and stability. In the nighttime weather profile (Table 3.3.2), the stability designator "E/F" is used for profiles where stability is near the boundary between the two classes. In these cases, both stabilities should be considered as realistic choices. Temperature and barometric pressure were averaged for each cluster after each cluster had been chosen.

Weather profiles are presented for performing "what-if' calculations. Actual weather conditions frequently are similar to a profile, making these data useful for this purpose. However, actual weather conditions are very different from any of the 12 profiles often enough that you should not assume the profiles are the whole story about the weather at NECD.

3.4 COUNTY-SPECIFIC GEOGRAPHIC DATA

The following sections discuss townships and incorporated towns that are in the IRZ or PAZ.

3.4.1 Vermillion County, Indiana

Vermillion County is located in west-central Indiana, adjoining the Illinois line, the county's western boundary. The Wabash River is the county's eastern border. On the north and the south are Warren and Vigo Counties, respectively. The county is one of the narrowest and longest in Indiana. It is 60 km (37 mi) long and averages 8-10 km (5-6 mi) wide. Its widest point is about 15 km (9 mi) across. Newport is the county seat. Townships and incorporated towns in either the IRZ or PAZ are listed in Table 3.4.1. Information on incorporated towns is from the *City and Town Clerk's Directory* (1996).

3.4.2 Parke County, Indiana

Parke County is located in west-central Indiana, 97 km (60 mi) west of Indianapolis and 40 km (25 mi) northeast of Terre Haute. The county is bounded on the north by Fountain County, on the west by Vermillion County, on the south by Vigo and Clay Counties, and on the east by Putnam and Montgomery Counties. The county is divided into 13 townships, and there are 6 incorporated towns, the largest being Rockville, the county seat. Of the remaining 5 incorporated towns, Marshall is in the north; Bloomingdale, Montezuma, and Mecca are in the central; and Rosedale is in the southern area of the county. Table 3.4.2 lists townships and incorporated towns in the IRZ or PAZ.

3.4.3 Fountain County, Indiana

Fountain County is located in west-central Indiana, 97 km (60 mi) west and slightly north of Indianapolis. The county is bounded on the north by Warren County, on the west by Warren and Vermillion Counties, on the south by Parke County, and on the east by Montgomery and Tippecanoe Counties. Its elevation varies between 168 and 229 m (550 and 750 ft) above sea level. The physiography of the county ranges from broad, level bottom lands and terraces along the Wabash River to broad glacial till and outwash plains in most other parts. The county is divided into 11 townships and 8 incorporated towns; Covington is the county seat. The remaining incorporated towns include Attica, Veedersburg, Kingman, Wallace, Mellott, Hillsboro, and Newtown. Table 3.4.3 lists townships and incorporated towns in the IRZ or PAZ.

TABLE 3.4.1 Vermillion County Townships and Incorporated Towns in the IRZ and PAZ

Zone	Township	Incorporated Town[a]
IRZ	Eugene	Cayuga
	Helt	Dana
	Vermillion	Newport
PAZ	Clinton	Fairview, Clinton City, and Universal
	Highland	Perrysville

[a] Source: *City and Town Clerk's Directory* (1996).

TABLE 3.4.2 Parke County Townships and Incorporated Towns in the IRZ and PAZ

Zone	Township	Incorporated Town
IRZ	Liberty	--
	Reserve	Montezuma[a]
PAZ	Adams	Rockville
	Florida	Rosedale
	Howard	--
	Penn	Bloomingdale
	Raccoon	--
	Sugar Creek	--
	Wabash	Mecca
	Washington	Marshall
None	Greene	
	Jackson	
	Union	

[a] Largest incorporated town in entire (two-county) IRZ.

TABLE 3.4.3 Fountain County Townships and Incorporated Towns in or not in the IRZ and PAZ

Zone	Township	Incorporated Town
IRZ	None	None
PAZ	Fulton	Kingman
	Millcreek (partial)	--
	Wabash (partial)	--
None	Cain	
	Davis	
	Jackson	
	Logan	
	Richland	
	Shawnee	
	Troy	
	Van Buren	

3.4.4 Edgar County, Illinois

Data will be added to future updates as available.

3.4.5 Vermilion County, Illinois

Data will be added to future updates as available.

4 DEMOGRAPHIC AND ECONOMIC CHARACTERISTICS

This section presents the following demographic and economic data:

- Demographic data and maps drawn from U.S. Bureau of the Census files,
- Economic data (total and per capita personal income) from the U.S. Department of Commerce, and
- County-specific data provided by IRZ and PAZ counties.

Efforts are underway to develop databases of interest to CSEPP planners, including special populations and infrastructure characteristics. These databases are being designed because Census Bureau data do not have this information.

Population characteristics provided by the Census Bureau accurately describe a population at a particular point and time (i.e., a population at home, usually nighttime, and at the beginning of each decade). Data analysis now centers on determining daytime populations and identifying economic characteristics that affect emergency planning decisions.

As in establishing a database for nighttime population characteristics, the first step in establishing a database for daytime population characteristics is to determine what information an emergency planner needs to make effective decisions. First, the different infrastructure characteristics of the area must be established. These characteristics include the industrial base (major industrial plants, warehouses), retail base (major shopping facilities, especially enclosed malls), agricultural base, and major public facilities (city hall, convention centers, schools).

The planner must then decide what information is needed about the facilities to include in a database. This information generally includes a census of day and night populations, including employees and clients. In certain facilities, peak and normal usage is included. A database could be constructed in either a spreadsheet or a database program to generate tables and to import data into a geographic information system (GIS).

4.1 U.S. CENSUS BUREAU DEMOGRAPHIC DATA

To establish the database of populations and infrastructure in the NECD area, U.S. Census Bureau data were accessed. Figures 4.1-4.6 were prepared to demonstrate the capability to create regional maps from these data useful to CSEPP planners. The data used to generate the geographic features (i.e., county boundaries, block group and block polygons, block group and block centroids, major highways, streets, water and railway lines) came from the Census Bureau's geographic database, the Topologically Integrated Geographic Encoding and Referencing (TIGER) system, a digital map database that automates the mapping and related geographic activities required to support the census and survey programs of the Census Bureau. The TIGER/Line files, available on CD-ROM, are an extract of selected geographic and cartographic information from the TIGER database. In its present form, the TIGER data are not graphically visible. Utility software developed at Oak Ridge National Laboratory (ORNL) reads files directly from the TIGER/Line CD-ROM and creates Maplnfo Exchange Format Files that can be directly imported into Maplnfo for graphical display of the geographic objects.

The database information on population and housing associated with the maps was taken from the *1990 Census of Population and Housing* (U.S. Department of Commerce, Bureau of the Census 1996). Information was obtained at either the block group level or the block level. Block groups, a level below census tracts, are special statistical areas for which the Census Bureau publishes information that can be used for demographic analysis. Block groups are further subdivided into blocks. A block is the smallest geographic unit for which census information is reported. Data used for block group display in the NECD maps come from the *1990 Census of Population and Housing,* Summary Tape File 1A (STF-1A) and Summary Tape File 3A (STF-3A) on CD-ROM (U.S. Department of Commerce, Bureau of the Census 1996). Data for the block level are from the *1990 Census of Population and Housing,* Public Law 94-171 (P.L. 94-171) data on CD-ROM (U.S. Department of Commerce, Bureau of the Census 1996). Because of privacy laws, the block level contains much less information than the block group level, but it has many more centroids, or data points, because of the level of detail. In addition to population and housing, the census provides a wide variety of information on social and economic characteristics, such as household composition, ethnicity, and income.

FoxPro, a commercial database package, allowed us to take a subset of the STF databases and a subset of the P.L. 94-171 database for analysis by CSEPP. For a complete list of data elements available on the STF-1A, STF-13A, and P.L. 94-171 CD-ROMs, see the data dictionary in the *1990 Census of Population and Housing* (U.S. Department of Commerce, Bureau of the Census 1996).

Maplnfo, a commercially available GIS, was used to link the population and housing data to the geographic data generated from the TIGER/Line files. This linking allows for simultaneous display for geographical and statistical analyses. MapInfo runs on PC or Macintosh platforms as well as on high-performance workstations.

Figure 4.1 shows the boundaries of the counties around the NECD site that are in either the IRZ or the PAZ. Also shown are the block level centroids (data points) for each county. For clarity the block level polygons are not shown. (Figure 4.2 displays block level polygons with block level centroids in Vermillion County, Indiana.) The county boundaries and centroid locations were generated from the Census Bureau TIGER/Line files. Total population counts are indicated for 10- and 20-km (6- and 12-mi) radii. The total population counts for the different radii were calculated by using MapInfo's statistical capabilities based on information contained in the 1990 Census, P.L. 94-171 CD-ROM.

Figure 4.2 shows the block polygons and block centroids for Vermillion County, Indiana. The polygons and centroids were generated from the TIGER/Line files. The centroid is defined by the latitude and longitude of the centroid for each block polygon. The latitude and longitude of each centroid are the unique identifiers that allow mapping and display of the census data for each polygon. Block level is the smallest geographic unit for which census information is reported. Privacy laws limit the information at this level to race, total population, and total housing units within each polygon area.

Figure 4.3 shows the location of the railroad lines, water bodies, and major highways in Edgar County, Illinois. These geographic objects were generated from the 1990 U.S. Census, TIGER/Line files. The TIGER/Line files also contain a database of information on some features, including street and highway names and the names of some of the water bodies.

Figure 4.4 is a close-up view (3-km [2-mi] radius around the disposal site), showing streets, some of which are labeled with the feature name. Also shown are the block level centroids (data points) labeled with the total population count within a particular polygon area. The population information comes from the 1990 Census, P.L. 94-171 data. The streets, street names, polygons and centroids were generated from the TIGER/Line files.

Figure 4.5 shows the approximate location of the IRZ and PAZ boundaries around the NECD site and the total population for each zone. The county boundaries were generated from the Census Bureau TIGER/Line files. Total population counts for the two zones were calculated by using MapInfo's statistical capabilities based on information contained in the 1990 Census, P.L. 94-171 CD-ROM. Note: The IRZ/PAZ boundaries have been changed since the production of Figure 4.5. Geopolitical descriptions and maps of the IRZ and PAZ are maintained by the NECD community. Such descriptions and maps may be incorporated into future updates of this guide as desired by the NECD community.

Figure 4.6 is a thematic map that shows the median value of the housing units in Vermillion and Parke Counties, Indiana. The counties are divided into block group polygons generated from the TIGER/Line files. The information on house values was obtained from the 1990 U.S. Census of Population and Housing, Summary Tape File 1-A on CD-ROM.

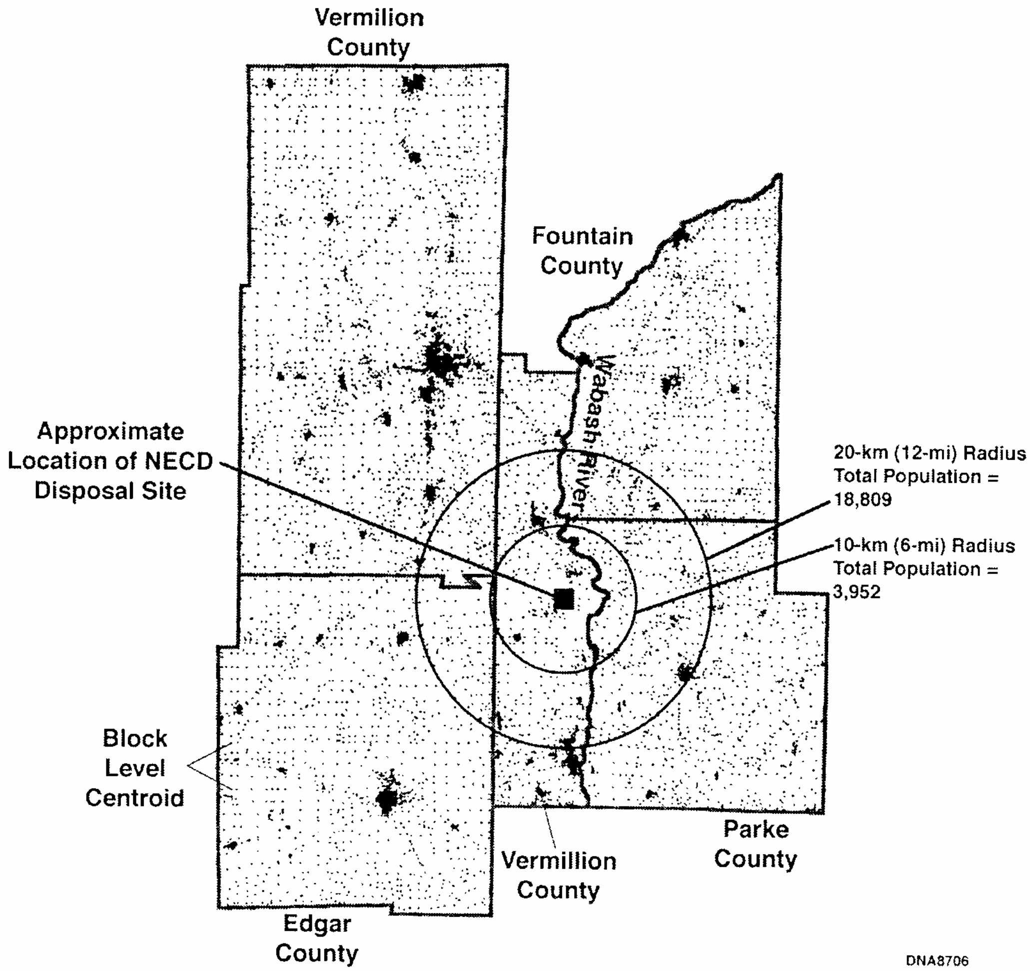

FIGURE 4.1 Boundaries of Counties around the NECD Site in Either the IRZ or the PAZ and Block Level Centroids (data points) for Each County

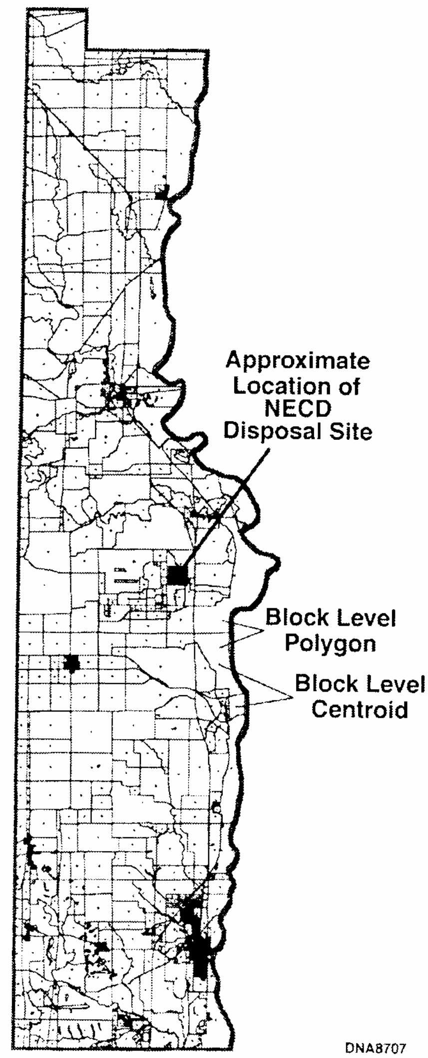

FIGURE 4.2 Block Polygons and Block Centroids for Vermillion County, Indiana

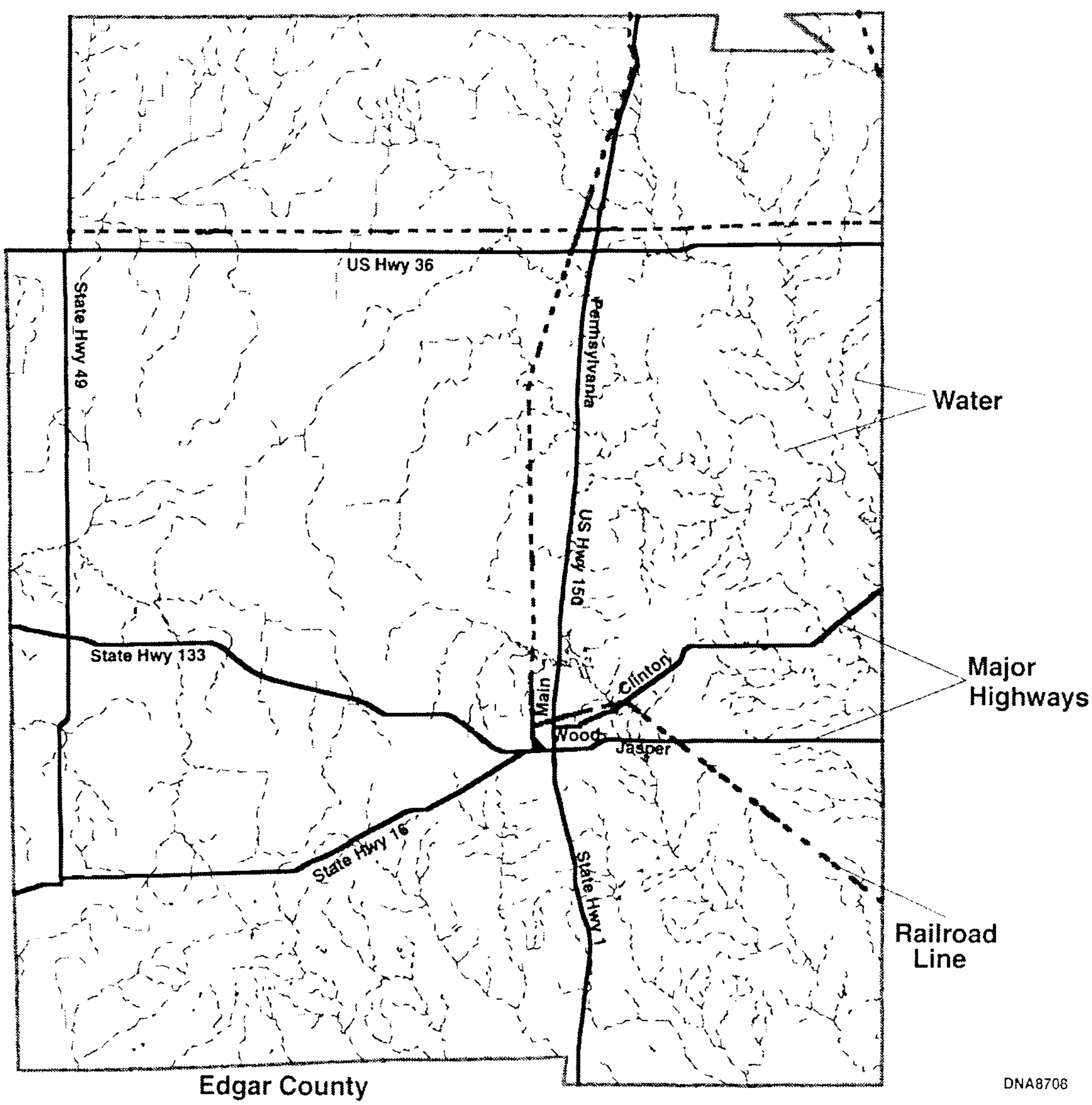

FIGURE 4.3 Location of Railroad Lines, Water Bodies, and Major Highways in Edgar County, Illinois

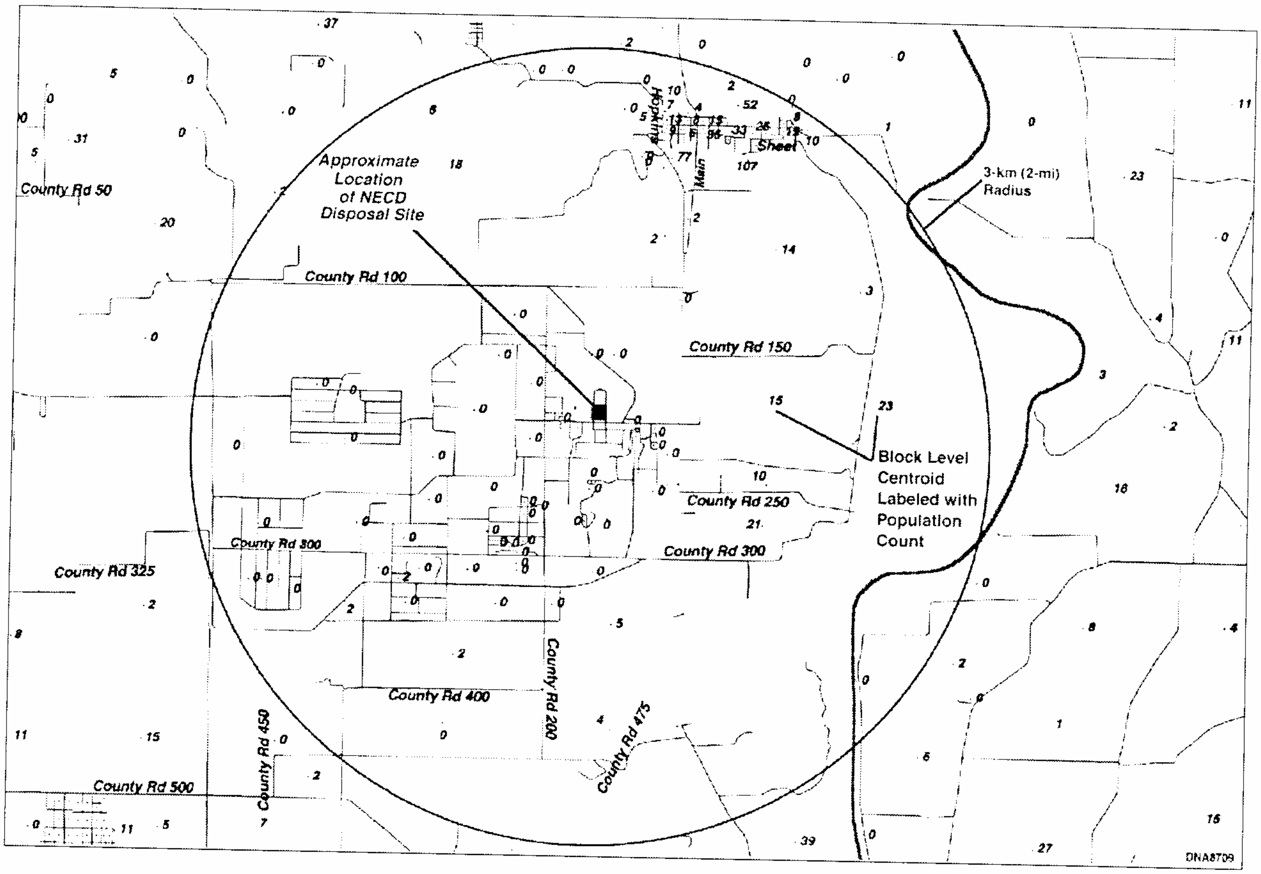

FIGURE 4.4 Close-up of Streets and Block Level Centroids (data points) around the Disposal Site

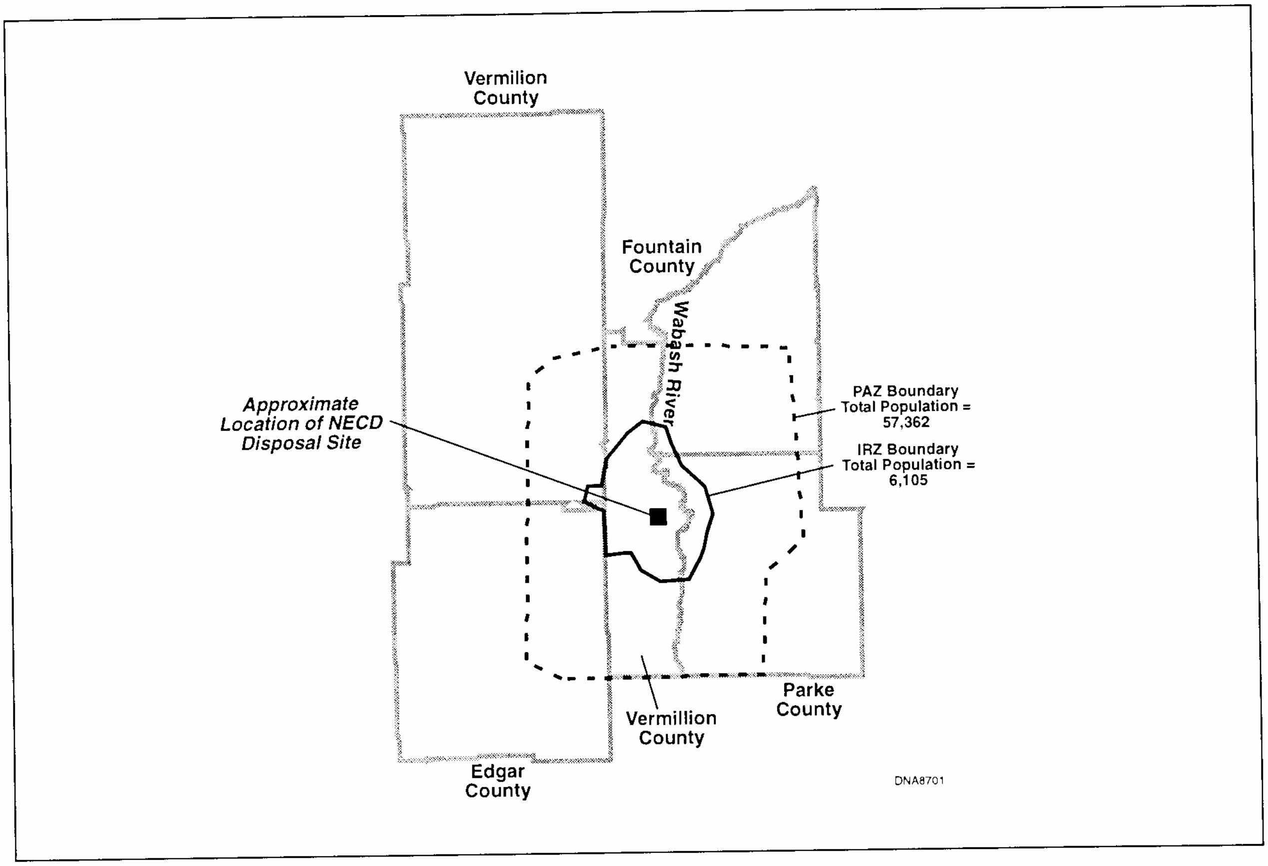

FIGURE 4.5 Approximate Location of IRZ and PAZ Boundaries around the NECD Site and Total Population for Each Zone

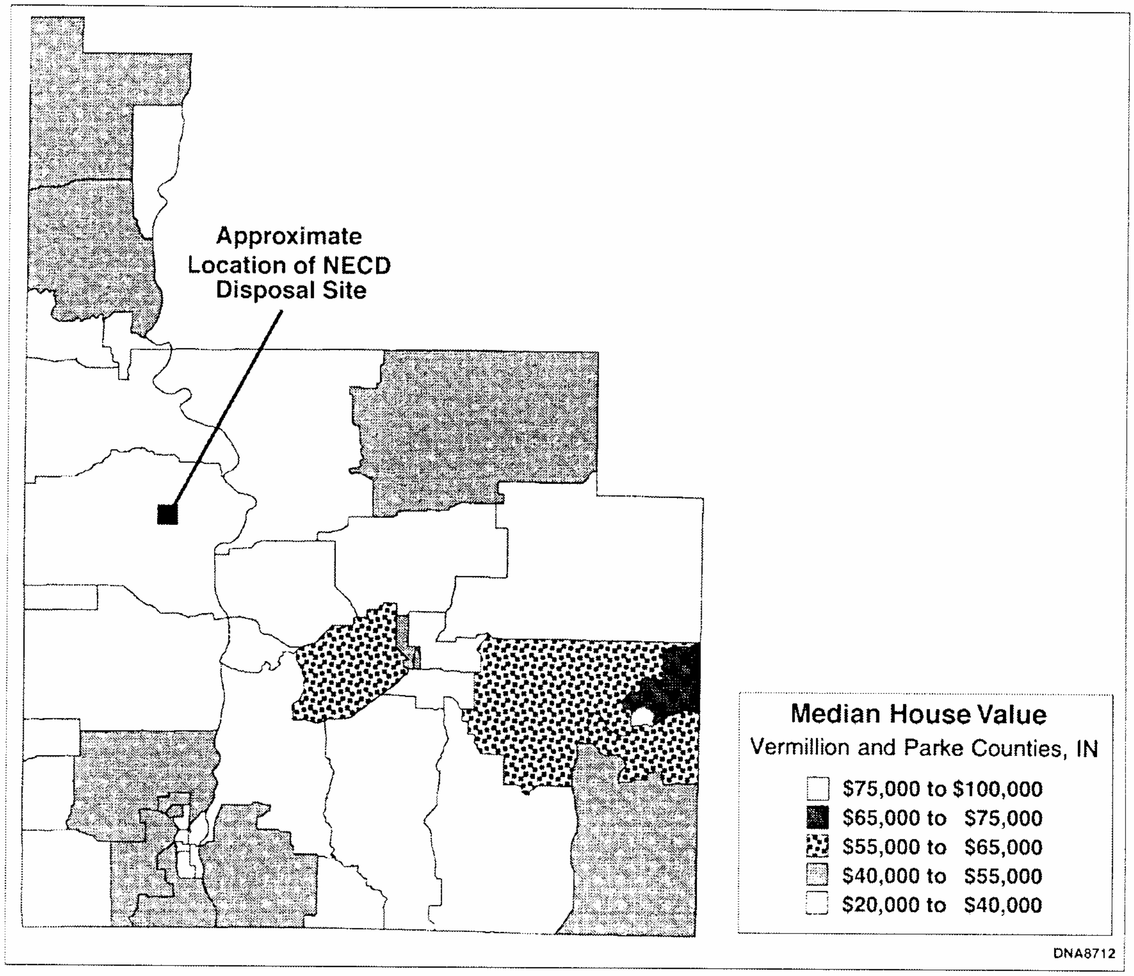

FIGURE 4.6 Median Value of Housing Units in Vermillion and Parke Counties, Indiana

4.2 U.S. DEPARTMENT OF COMMERCE ECONOMIC DATA

Tables 4.2.1 and 4.2.2 present the total personal income and per capita personal income from 1989 to 1994 for each of the counties in the NECD IRZ/PAZ.

TABLE 4.2.1 Total Personal Income for IRZ and PAZ Counties, 1989–1994 (thousands of dollars)

	Year					
State/County	1989	1990	1991	1992	1993	1994
Indiana						
Fountain	241,658	251,261	239,828	275,403	291,827	305,127
Parke	201,241	212,489	222,511	243,824	256,248	269,826
Vermillion	227,350	240,710	254,201	270,265	280,429	288,443
Illinois						
Edgar	290,043	292,281	292,699	312,867	315,948	350,017
Vermilion	1,292,018	1,336,097	1,353,928	1,433,714	1,482,956	1,580,442

Source: U.S. Department of Commerce (1996).

TABLE 4.2.2 Per Capita Personal Income for IRZ and PAZ Counties, 1989–1994 (dollars)

	Year					
State/County	1989	1990	1991	1992	1993	1994
Indiana						
Fountain	13,516	14,110	13,440	15,368	16,256	16,955
Parke	13,010	13,793	14,344	15,568	16,184	17,004
Vermillion	13,501	14,364	15,277	16,252	16,689	17,217
Illinois						
Edgar	14,711	14,955	15,036	16,081	16,123	17,843
Vermilion	14,578	15,159	15,410	16,355	16,974	18,098

Source: U.S. Department of Commerce (1996).

4.3 DEMOGRAPHIC/ECONOMIC DATA FOR VERMILLION COUNTY, INDIANA

This section provides background information on the demographic and economic characteristics for Vermillion County, Indiana. The description includes population distribution, land usage, transportation, education, emergency medical services, law enforcement, medical services, fire services, and communications. Most of the information is from the 1990 census. Information on incorporated towns is from the *City and Town Clerk's Directory* (1996). Some employment information was provided by the Clinton City Chamber of Commerce.

4.3.1 Population Distribution

On the basis of 1990 federal census information, the population of Vermillion County is 16,755 (Table 4.3.1). Some 9,971 live in incorporated communities (Table 4.3.1), and 7,430 live in rural areas. Of the individuals who live within the county, 6,826 are employed. The balance consists of retirees, spouses, dependents, and unemployed individuals. Table 4.3.2 lists the major areas of employment for Vermillion County residents. The number of Vermillion County workers by class is listed in Table 4.3.3. Farming is the chief occupation in Vermillion County. Major nonfarming occupations revolve around the service industries. Eli Lilly and the Newport Chemical Depot are the two largest employers, followed by PSI Generating Plant and Inland Container. Vermillion County residents who work in the county total 3,453 (50.06%).

The remainder of employed residents travel outside county boundaries to work. On the basis of the latest estimates, 3,373 (49.04%) individuals are in this category. Some 2,290 out-of-county residents are employed in Vermillion County.

4.3.2 Land Usage

Vermillion County covers 681 km^2 (263 mi^2) or 68,117 ha (168,320 acres). In recent years, the area of urban land has increased by 4%. Cropland has decreased by 1% and grass by 26%, while forest land has increased by 59%. The average of urban land is expected to slowly increase at the expense of farmland, although farming is still the chief occupation, with cash grain crops and livestock being the major income producer.

TABLE 4.3.1 Total Population of Vermillion County by Township and Incorporated Communities

Township[a]	Population	Community[b]	Population
Clinton	9,240	Cayuga	1,250
Eugene	2,140	Clinton	5,040
Helt	2,679	Dana	700
Highland	1,670	Fairview	1,446
Vermillion	1,026	Newport	700
		Perrysville	443
		Universal	392
Total	16,755	Total	9,971

[a] Source: U.S. Bureau of the Census (1990).

[b] Source: *City and Town Clerk's Directory* (1996).

TABLE 4.3.2 Major Areas of Employment in Vermillion County

Area of Employment	Number of Employees
Agriculture	180
Construction	433
Manufacturing, nondurable goods	1,115
Manufacturing, durable goods	741
Transportation	326
Communications and other public utilities	203
Wholesale trade	185
Retail trade	1,284
Personal services	257
Entertainment and recreation	57
Health services	638
Educational services	445
Other professional and related services	273
Public administration	213
Finance, insurance, and real estate	251
Business and repair service	225
Total	6,826

TABLE 4.3.3 Number of Workers by Class in Vermillion County

Class	Number of Workers
Private wage and salary workers	5,622
Government workers	839
Self-employed workers	153
Unpaid family workers	26
Total	6,640

4.3.3 Transportation

Vermillion County is served by five east-west highways: 1-74 across the northern tip; U.S. 36, about two-thirds of the way down; and state highways 32, 234, and 163. Two major north-south state roads are highways 63 and 71. In all, about 773 km (480 mi) of roads crisscross the county.

CSX Railroad is the only rail line in Vermillion County. It enters the county from Illinois at Rileysburg (Highland Township) and travels near the east boundary, exiting into Parke County at Clinton (Clinton Township). The single-track line is part of the CSX Railroad service to Chicago, Terre Haute, and Evansville. All other track has been abandoned and removed.

The closest major airfield is Hulman Airport in Terre Haute.

4.3.4 Education

Vermillion County consists of two school districts. Basically the three northern townships of Highland, Eugene, and Vermillion are in North Vermillion Community School Corporation, and the two southern townships of Helt and Clinton are in South Vermillion Community School Corporation. Each district maintains a I<-12 system, offering a broad curriculum and extracurricular activities. North Vermillion elementary also houses the Community Action Head Start Program for three- and four-year-old preschoolers. Clinton has two private schools -- Pentecostal Church School for grades K-12 and Sacred Heart Elementary School for grades K-6.

4.3.5 Emergency Medical Services

Vermillion County is served by the Vermillion County Ambulance Service, a privately owned service under contract to the county. The service is centered in Cayuga and also has a station in Clinton. This service provides both basic and advanced emergency medical technician care. West Central Community Hospital in Clinton provides 24-hour emergency care. This hospital is a modem, well-equipped facility with 57 beds, capable of handling routine medical cases and patients from most disasters. It is associated with and managed by Union Hospital in Terre Haute. LifeLine helicopter service from Indianapolis and LifeFlight from Evansville provide emergency transport to larger hospitals if the need arises.

4.3.6 Law **Enforcement**

Law enforcement services consist primarily of the Sheriff's Department, which employs 28 persons and operates 11 vehicles. Clinton City has 15 police officers and 4 vehicles. Cayuga has 3 officers and 2 vehicles; Fairview has 2 officers and 1 vehicle; and Dana has 1 officer and 1 vehicle.

4.3.7 Medical Services

Vermillion County has three clinics: the West Central Community Wellness Center in Clinton, the West Central Community Cayuga Clinic, and the Cayuga Community Health Center. Seven full-time physicians practice in the county: four are affiliated with the clinics, and three are in private practice. Several physicians in the surrounding area serve in the clinics or work at the hospital on a part-time basis. Visiting nurses have an office in Clinton. Three chiropractors serve the county, two in Clinton and one in Cayuga. Vermillion County has three dentists, all in the Clinton area.

4.3.8 Fire Services

Vermillion County is served by 10 volunteer fire departments. Only Clinton City has three paid dispatchers with 24-hour dispatch capabilities. Cayuga, Newport, Dana, and Perrysville are toned out by 911 in the Vermillion County Sheriff's Department. Clinton City, Fairview, Clinton Township, Hillsdale, St. Bernice, and Universal are toned out by 91 l in the Clinton City Police Department.

4.3.9 Communications

Vermillion County has two local newspapers, the *Daily Clintonian* and the *Cayuga Herald News,* which is a weekly paper. Daily papers are also provided by the *Terre Haute Tribune,* the *Indianapolis Star,* and, in the northern part of the county, the *Danville Commercial News,* a daily paper from Danville, Illinois.

Vermillion County does not have any television or radio stations. However, three companies provide cable service. Perrysville and Cayuga receive service from Danville Warner Cable; Newport and Dana receive it from New Path Communications in Champaign, Illinois; and Clinton Township area receives it from Clinton Cable.

Local television stations are WTHI/CBS and WTWO/NBC from Terre Haute and WCIA/CBS and WICD/NBC from Champaign. Local radio stations are listed in Table 4.3.4.

Emergency FM radio capability (both very high frequency [VHF] and ultra high frequency [UHF]) serves all of Vermillion County's emergency response agencies, including both local and state organizations. The primary system is a trunked 800-MHz five-base station system, housed at the Vermillion County Jail site. This communication network links Vermillion, Parke, and Fountain Counties, along with NECD; District 32, Indiana State Police; District 5, Indiana Department of Natural Resources (DNR); and the Indiana State Emergency Management Agency. The backup to this system is the ordinary Federal Communications Commission (FCC)-assigned, high-band frequencies, used by most emergency response agencies. Indiana State Police also rely on low-band frequencies for some internal transmissions.

TABLE 4.3.4 Local Radio Stations Serving Vermillion County

Location	Call Letters	Frequency
Terre Haute	WZZQ	107.5 FM
	WBOW	640 AM
	WTHI	99.9 FM
	WTHI	1480 AM
	WSDM	97.7 FM
Rockville	WAXI	104.9 FM
Danville, Ill.	WDAN	102.1 FM
	WDNL	1490 AM
	WIAI	99.1 FM
	WITY	980 AM
	WWDZ	94.9 FM
Covington	WCDV	103 FM
	WFOF	90.3 FM

4.4 DEMOGRPHIC/ECONOMIC *DATA* FOR PARKE COUNTY, INDIANA

This section provides background information on the demographic and economic characteristics of Parke County. The description includes population distribution, land usage, transportation, education, emergency medical services, law enforcement, medical services, fire services, and communications.

4.4.1 Population Distribution

On the basis of the 1990 U.S. census, the population of Parke County is 15,410. About 5,674 people live in incorporated communities, and 9,736 live in rural areas (Table 4.4.1).

Of the individuals who live within the county, 5,922 are employed. The remainder of the population consists of retirees, spouses, dependents, and unemployed individuals. Table 4.4.2 lists the major sources of employment in Parke County.

The balance of employed residents travel outside county boundaries to work. Recent estimates show that 2,033 individuals are in this category. Some 371 out-of-county residents are employed in Parke County.

4.4.2 Land Usage

Parke County covers 1,168 km^2 (451 mi^2) or 116,809 ha (288,640 acres), of which 93,483 ha (231,000 acres) is dedicated to rural usage; the balance 23,326 ha (57,640 acres) is classified as urban lands. The county contains 29,745 ha (73,500 acres) of woodlands, primarily deciduous trees on terrain too hilly for agriculture. Tillable land accounts for 62,727 ha (155,000acres), with 11,736ha (29,000acres) devoted to pasture land. Urban development accounts for 4,047 ha (10,000 acres), while water covers approximately 1,174 ha (2,900 acres). The remaining 7,382 ha (18,240 acres) are devoted to all other categories of use, including roads, cemeteries, and public lands.

4.4.3 Transportation

Parke County contains two U.S. highways. U.S. 36 traverses the county east to west, slightly south of the section line that divides the county in half, north and south. U.S. 41, the main north-south artery enters Parke County from the north and intersects U.S. 36 at Rockville, then angles to the southwest, exiting the county one mile east of the Wabash River into Vigo County.

TABLE 4.4.1 Total Population of Parke County by Township and by Incorporated Town

Township (total)	Population	Township (rural areas)	Population	Incorporated Town	Population
Adams	4,628	Adams	1,922	Bloomingdale	341
Florida	2,480	Florida	1,697	Marshall	379
Greene	416	Greene	416	Mecca	331
Howard	244	Howard	244	Montezuma	1,134
Jackson	667	Jackson	667	Rockville	2,706
Liberty	719	Liberty	719	Rosedale	783
Penn	843	Penn	502		
Raccoon	818	Raccoon	818		
Reserve	1,444	Reserve	310		
Sugar Creek	300	Sugar Creek	300		
Union	1,169	Union	1,169		
Wabash	778	Wabash	447		
Washington	904	Washington	525		
Total	15,410	Total	9,736	Total	5,674

TABLE 4.4.2 Major Sources of Employment in Parke County

Source	Number of Employees
Farming	1,320
Services and goods	1,130
Government (all)	332
Industry (six largest)	520
Other employers	308
Total	3,610

Indiana state roads also serve Parke County. Starting in the north, Indiana 234 crosses the extreme northwest corner of Parke County at Lodi. Indiana 47 enters Parke County fi'om Montgomery County, providing direct highway access to Turkey Run State Park and terminating at its intersection with U.S. 41, some 13 km (8 mi) north of Rockville. Indiana 236 originates 8 km (5 mi) north of Rockville on U.S. 41 and travels in an easterly direction through the town of Marshall, leaving Parke County at the Putnam County line. Indiana 59 serves eastern county areas in a north-south direction, entering from Montgomery County in the extreme northeast corner, intersecting U.S. 36 at Bellmore, and exiting Parke County into Clay County just north of Brazil.

In addition, Parke County is served by a county road system of some 1,207 km (750 mi), 483 km (300 mi) of which are all-weather surfaced; the balance is graded gravel and/or crushed stone. Few county roads are laid out in section grid format because of the highly irregular topography. All county roads are numbered according to the Congressional Numbering System.

While no interstate roads traverse Parke County, the county enjoys easy access with 1-70 some 40 km (25 mi) to the south through Terre Haute, via U.S. 41. To the north via U.S. 41, there is an interchange with 1-74 approximately 16 km (10 mi) north of the Parke-Fountain County line.

Parke County is served by only three operating rail lines. Conrail operates approximately one mile of double track in the extreme southeast corner of the county. This section of track is part of what once was the main line of the New York Central Railroad system between St. Louis, Missouri, and New York City. The second line serves the southwest corner of the county, entering at Clinton (Vermillion County) across the Wabash River, a distance of about 6 km (4 mi), and exiting into Vigo County. This single-track line is part of the CSX Railroad line serving Chicago, Terre Haute, and Evansville. The third line is a single-track CSX Railroad spur entering Parke County at Montezuma, across the Wabash River and extending eastward approximately one mile to the east edge of Montezuma. All other rail lines have been abandoned, and track has been removed.

Parke County has no scheduled airline service. The closest commercial airports are in Indianapolis (105 km [65 mi]) and Terre Haute (40 km [25 mi]). Both offer frequent, scheduled airline passenger and freight service. Several private, noncontrolled airports exist in Parke County. The largest is Butler Airfield on county road 200S, which is 1.6 km (1 mi) south of Rockville. The grass runway is 701 m (2,300 ft) long and can accommodate visual flight rules (VFR) only.

4.4.4 Education

Three separate school systems serve Parke County. The northernmost district, composed of Liberty, Penn, Sugar Creek, Howard, Greene, and Washington Townships, is Turkey Run School Corporation. Serving Adams and Union Townships is Rockville Community School District. Southwest Parke School District serves Reserve, Wabash, Florida, and Raccoon Townships. Only Jackson Township transports its students out of the county for their public school education. Each district maintains a K-12 system, offering a broad curriculum and extensive extracurricular activities.

4.4.5 Emergency Medical Services

Two agencies within Parke County provide emergency medical services. One is a private enterprise organization, and the other is a function of county government. Parke County Emergency Medical Service provides advanced emergency medical technician level of service, while West Central Indiana Emergency Medical Service offers both basic and advanced emergency medical technician level of care. In addition to this highway transport capability, two emergency medical helicopter services are available to Parke County: LifeLine from Indianapolis and LifeFlight from Evansville. West Central Community Hospital at Clinton provides emergency room service and is less than 30 minutes from any point in the county. Two Terre Haute hospitals operate full-service, 24-hour emergency room service, less than 45 minutes from any road point in Parke County.

4.4.6 Law **Enforcement**

The senior law enforcement official in Parke County is the sheriff. Although he has direct authority over only his department (6 deputies, 1 matron, 12 reserve deputies, and jail staff), he coordinates the law enforcement activities of town marshals and their staffs. His communications office is the county's 24-hour, continuously staffed, emergency radio contact. All emergency medical, fire, highway, and law enforcement radio traffic can be transmitted from and received by the sheriff's dispatch. In addition, the sheriff maintains a liaison among Indiana state law enforcement agencies, the Indiana State Police, and Indiana DNR Conservation Officers. The Indiana DNR maintains a correctional facility in Parke County. More than 400 inmates are housed in a self-sufficient facility approximately one mile northwest of Rockville. Expansion of this capacity to 1,000 is planned by 1998.

4.4.7 Medical Services

Parke County medical services are provided by eight physicians and three chiropractors, all in private practice. In addition to these private practices, governmental-sponsored clinics operate, including the Well-Child Clinic; the Women, Infant, Children Clinic; and the Parke County health nurse. Also, four dentists provide dental care in Parke County. The hospital of record for Parke County is West Central Community Hospital in Clinton. Three health care facilities serve Parke County, all in the Rockville area.

4.4.8 Fire Services

No local governmental fire services exist in Parke County. The county is served by nine volunteer fire departments. One maintains two full-time employees who serve as emergency fire dispatchers for all of Parke County, except for one department in the southwest part of the county (Lyford), which is dispatched by the Clinton Fire Department. In Rockville, two dispatchers, one of whom works at a time, also double as fire truck drivers. When they do, the Parke County sheriff becomes the official fire dispatcher for the county. No overall, umbrella organization coordinates the activities of the nine fire departments.

4.4.9 Communications

Parke County is a lightly populated, rural county, and public communication is quite limited. A weekly newspaper is published in excess of 4,000 copies per issue. A 1,200-Watt FM radio station transmits from within Parke County and serves patrons within a 64-kin (40-mi) radius. Although no television transmissions originate from permanent studios, all three major television networks transmit from Terre Haute. Further, most populated areas in the county receive cable television service, which broadens the offering to more than 20 different channels. Numerous AM and FM radio stations broadcast from the Terre Haute metropolitan area, as well as a limited number of FM stations from Brazil, Greencastle, and Crawfordsville. Several of these stations participate in the Emergency Broadcast System (EBS)/Emergency Alert System (EAS). Daily papers published in Clinton, Terre Haute, and Greencastle serve the Parke County market. The *Indianapolis Star* maintains a local distributorship for morning and afternoon papers, with both daily and Sunday editions.

Emergency FM radio capability (both VHF and UHF) serves all of Parke County's emergency response agencies, including both local and state organizations. The primary system is a trunked 800-MHz, five-base station system, housed at the Vermillion County Jail site. This communication network links Parke, Vermillion, and Fountain Counties, along with NECD; District 32, Indiana State Police; District 5, Indiana DNR; and the Indiana State Emergency

Operating Center in Indianapolis. The backup for this new system is the ordinary FCC-assigned, high-band frequencies used by most emergency response agencies. Indiana State Police also rely on low-band frequencies for some internal transmissions. Only one of three local school districts has an operating emergency FM (400-MHz) radio station. The remaining two must rely on telecommunications and a Minitor II pager system to transmit emergency information. The Army National Guard battery has emergency radio capability; however, its available transmitting frequencies preclude it from communicating with any civil emergency response agencies.

Several private industries operate FM radio systems from low band to UHF. Businesses known to have self-contained emergency radio systems include:

- Parke County Rural Electric Membership Corporation,
- Indiana Gas Company,
- Panhandle Eastern Pipeline Company, and
- Ameritech.

4.5 DEMOGRAPHIC/ECONOMIC DATA FOR FOUNTAIN COUNTY, INDIANA

This section provides background information on the demographic and economic characteristics for Fountain County. The description includes population distribution, land usage, transportation, education, emergency medical services, law enforcement, medical services, fire services, and communications.

4.5.1 Population Distribution

On the basis of 1990 U.S. census information, the population of Fountain County is 17,808. About 10,010 persons live in incorporated communities, and 7,798 live in rural areas (Table 4.5.1).

Of the 17,808 individuals who live within the county, 7,881 are employed. The remainder of the population consists of retirees, spouses, dependents, and unemployed individuals. Table 4.5.2 lists the major sources of employment in Fountain County.

4.5.2 Land Usage

Fountain County covers 1,028 km^2 (397 mi^2) or 102,823 ha (254,080 acres), of which 92% (94,597 ha [233,754 acres]) is dedicated to rural, agricultural usage. The balance (8,226 ha [20,326 acres]) is classified as urban lands.

4.5.3 Transportation

Fountain County is served by one interstate highway, I-74, which divides the county in half. The county is also served by two U.S. highways. U.S. 41 extends north and south and U.S. 136 extends east and west. The county also has five Indiana state highways. Those highways are 28, 32, 55, 234, and 341. In addition, Fountain County is also served by a county road system that has several paved roads, with the remainder being gravel.

One main railroad line (Norfolk and Southern) crosses Fountain County across the northern boundary. There are no airfields in Fountain County. The closest major airfields are Lafayette Airport and the Indianapolis International Airport.

TABLE 4.5.1 Total Population of Fountain County by Township and by Incorporated Town

Township (total)	Population	Township (rural areas)	Population	Incorporated Town	Population
Cain	1,136	Cain	637	Attica	3,457
Davis	501	Davis	501	Covington	2,747
Fulton	791	Fulton	791	Hillsboro	499
Jackson	619	Jackson	530	Kingman	561
Logan	4,161	Logan	704	Mellott	222
Millcreek	1,431	Millcreek	870	Newtown	243
Richland	1,044	Richland	579	Veedersburg	2,192
Shawnee	586	Shawnee	586	Wallace	89
Troy	3,822	Troy	1,075		
Van Buren	3,022	Van Buren	830		
Wabash	695	Wabash	695		
Total	17,808	Total	7,798	Total	10,010

TABLE 4.5.2 Major Sources of Employment in Fountain County

Source	Number of Employees
Manufacturing	2,682
Retail trade	1,288
Government (all)	992
Health services	625
Educational services	620
Agriculture	504
Total	6,711

4.5.4 Education

Three separate school systems and one parochial school serve Fountain County. These schools include Attica Community School System (Logan, Davis, Shawnee, Richland Townships), Covington Community School System (Troy, Wabash, Fulton, Shawnee), Southeast Fountain School System (Van Buren, Richland, Cain, Jackson, and Millcreek), and the First Baptist Church of Covington. Each district maintains a K-12 system (except the First Baptist Church of Covington, which offers K-5), offering a broad curriculum and extensive extracurricular activities.

4.5.5 Emergency Medical Services

All of Fountain County's emergency medical services are provided by the Fountain County Ambulance Service, which has sites in Attica and Veedersburg.

4.5.6 Law Enforcement

Law enforcement services consist of the Fountain County Sheriff's Department with the sheriff, five deputies, and seven reserve and jail staff. Covington has one police chief, five police officers, and four reserve officers. Attica has one police chief, one assistant chief, four patrolmen, and six reservists. The towns of Veedersburg and Kingman each have one Town Marshal and several Assistant Marshals. Fountain County is covered by the Indiana State Police District Post 14 and has one full4ime DNR Conservation Officer.

4.5.7 Medical Services

Fountain County receives medical services from the Warren County Community Hospital, 16 km (10 mi) to the north, and hospitals in Crawfordsville, Indiana, 32 km (20 mi) to the east, and Danville, Illinois, 32 km (20 mi) to the west. The towns of Attica, Covington, and Veedersburg have medical clinics and the town of Kingman has the Kingman Family Health Care Center.

The Fountain County Ambulance Service provides emergency medical services. It has sites in Attica and Veedersburg and serves the entire county.

4.5.8 Fire Services

Fire protection in Fountain County is provided by eight volunteer fire departments and operates under mutual aid agreements with the Tri-County Fire Association.

4.5.9 Communications

Fountain County is served by one local newspaper, *The Fountain County Neighbor* (published in Attica). Three other newspapers serve the area but are published outside the county: *The Review-Republican* (published in Williamsport), *The Commercial-News* (published in Danville, Illinois), and the *Journal-Review* (published in Crawfordsville). Two radio stations broadcast from Fountain County: WCDV-103 and WFOF-90.3.

Fountain County has enhanced 911 emergency service that serves the entire county for emergency situations. The 911 dispatch center in Attica responds to all fire, police, sheriff, and ambulance emergency medical service calls throughout the county.

Although no television transmissions originate from permanent studios, all three major television networks transmit to this area. Most populated areas in the county receive cable television service.

The primary emergency FM radio capability (VHF, high band, 155 MHz) serves all of Fountain County's emergency response agencies, including both local and state organizations. The Fountain County sheriff, chief deputy, Kingman town marshal, Kingman fire department, and Fountain County Emergency Management have a trunked 800-MHz station as well as two base stations that are operating in Fountain County. The 800-MHz communication system links Parke, Vermillion, and Fountain Counties along with NECD, Indiana State Police District 32, and the Indiana State Emergency Operations Center in Indianapolis. The Army National Guard service battery has emergency radio capability. However, its available frequencies preclude it from communicating with any of the other emergency response agencies.

Several private industries operate FM radio systems from low band to extremely high frequency (EHF). Businesses known to have self-contained emergency radio systems include:

- Tipmont Rural Electric,
- Indiana Gas Company,
- Ameritech,
- Public Service of Indiana, and
- Overpeck Gas Company.

4.6 DEMOGRAPHIC/ECONOMIC DATA FOR VERMILION COUNTY, ILLINOIS

Data will be added to future updates as available.

4.7 DEMOGRAPHIC/ECONOMIC DATA FOR EDGAR COUNTY, ILLINOIS

Data will be added to future updates as available.

PART II: HAZARD CHARACTERIZATION

5 HAZARD IDENTIFICATION

The first step in characterizing a hazard is to identify the hazard. In general, this step involves identifying the source of the hazard for any specific site. Potential hazards at each site have been identified as a part of the final programmatic environmental impact statement (FPEIS) and the site-specific environmental impact statements (EISs). Installation planners have determined where and how the agents (hazards) are stored, handled, and processed. They have also determined how and by what routes the agents are transported to and from facilities. Planners have characterized potential accidents in detail, which has allowed them to formulate possible release scenarios and analyze potential impacts. Several possible release scenarios are presented in Appendix D of this EPG.

The stockpile at NECD is unique in that only VX is stored, and it is stored only in ton containers. As of December 15, 1995, the U.S. chemical stockpile stored at NECD consisted of 1,690 ton containers of agent VX, totaling 1,151.51 metric tons (MT) (1,269.33 tons) of agent (Figure 5.1). The size of the inventory is important, as it affects the probability of an agent release (Section 6.1). The stockpile mix (the assortment of agent and munition types at a stockpile) also has important implications for emergency planning. The limited mix found at NECD means that only a limited variety of potential releases could occur.

The concept of accident categories further simplifies the problem of off-post protective action strategy planning. For example, a forklift collision with fire involving a ton container of VX produces about the same off-post consequences as a metal parts furnace (MPF) explosion. Therefore, off-post protective action planners need not plan individually for these two accidents. Rather, off-post protective action strategies should be planned for a category of accidents that includes these two examples and others having similar consequences.

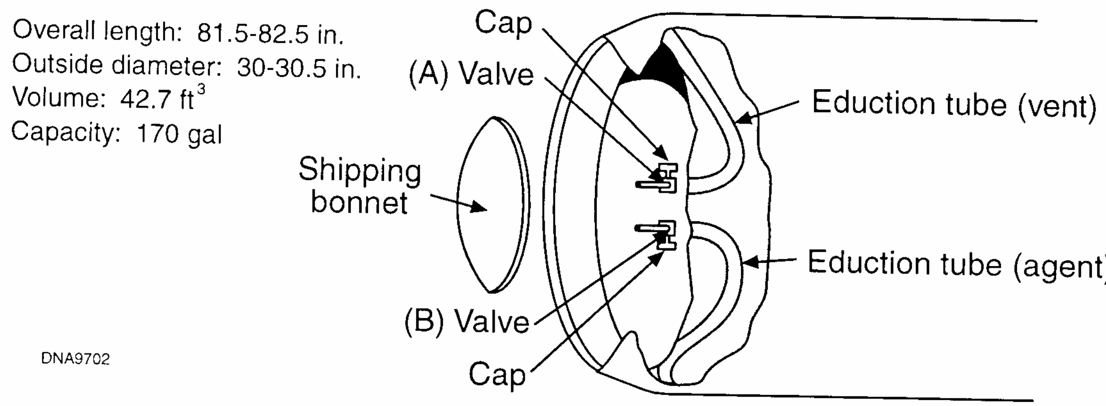

FIGURE 5.1 Typical Ton Container

5.1 POTENTIAL HUMAN HEALTH EFFECTS

VX is a lethal cholinesterase inhibitor. Potentially life-threatening doses may be only slightly greater than those that produce the least effects. Death usually occurs within 15 minutes after absorption of a fatal dosage.

Symptoms of exposure can occur within minutes or hours, depending on the dose. They include miosis (constriction of pupils) and visual effects, headaches and pressure sensation, runny nose and nasal congestion, salivation, tightness in the chest, nausea, vomiting, giddiness, anxiety, difficulty in thinking, difficulty sleeping, nightmares, muscle twitches, tremors, weakness, abdominal cramps, diarrhea, and involuntary urination and defecation. After severe exposure, symptoms progress to convulsions and respiratory failure.

Additional details about the human health effects of exposure to VX can be found in the Material Safety Data Sheet (MSDS) for VX, included in Appendix E. This data sheet contains (1) information on emergency responses to accidents involving chemical agent and (2) scientific data about the agent.

Emergency response information is useful to personnel who might be called to respond to an incident involving release of a chemical agent. This information should be easy to use and readily accessible to emergency services personnel. Emergency response information lists precautions for response personnel, fire-fighting procedures, and procedures used to respond to chemical spills.

Scientific data are useful to personnel who model (conduct simulations of) the release, or dispersion, of chemical agents. Examples of scientific data used in planning and analysis of such releases are chemical compositions, physical properties, and exposure limits.

5.2 POTENTIAL EFFECTS ON WATER SUPPLIES AND AQUATIC LIFE

Personnel at several CSEPP sites have raised the issue of the potential for chemical agent contamination of surface water and groundwater. This complex issue is unique to each site because of differences in topography, proximity to water bodies, climatic conditions, types of stored munitions, and the chemical and physical characteristics of the agents that could be released.

The principal watersheds near NECD are the Wabash River and the Little Vermillion River. The Wabash River lies about 5 km (3 mi) east of the NECD boundary. The Little Vermillion River lies about 3-5 km (2-3 mi) north of NECD.

To determine whether agent contamination could be a problem at NECD, the planner should consider how chemical agents would be dispersed.

The first step in assessing the impacts on aquatic resources from a release of chemical agent is to determine how the agent came in contact with surface water or groundwater. With regard to the NECD scenarios described in Appendix D, possible contamination modes include airborne deposition onto surface water and runoff from heavy rain flowing over contaminated ground into surface water.

Agent contamination of groundwater is not generally considered a problem unless a direct spill or leak enters into a well or spring. VX is viscous (like oil) and would remain on and near the soil surface, where it could be readily dug up and contained, so VX would not be a threat to groundwater.

Determining the effects of an accidental chemical agent release on surface water resources depends on a number of factors (Tolbert and Breck 1989):

- Amount and type of agent involved,
- Proximity of the agent release to a water body,
- Volume and flow characteristics of the receiving water body, and
- Biological organisms present.

Solubility, water temperature, and pH influence the rate of hydrolysis of chemical agents. The rate of hydrolysis determines how long a chemical remains reactive in water. Of the agents in the U.S. unitary chemical stockpile, VX is the slowest to hydrolyze (Breck 1989).

Potential contamination effects from agent spills on surface waters depend on the amount released and the volume and flow of the water body receiving it. Accidents involving large atmospheric releases could result in agent deposition on surface waters, but the concentrations produced in water would likely be much less than those from a spill directly into a stream (Breck 1989).

The FPEIS concluded that aquatic organisms that contacted agents would be killed. Thus, there is little potential for human ingestion of contaminated organisms. However, the issue may need to be addressed in planning documents when discussing public information needs following an accidental release. The economic effects from even a minor spill are most likely to occur from lost market sales of produce or fish because of perceived contamination by the public. Unless efforts are made to set up monitoring procedures immediately following a chemical agent release, economic recovery could be delayed.

Additional information can be obtained from Leffingwell (1990) and Watson and Munro (1992). The characteristics of chemical agents are also explained in the MSDSs (Appendix E) or in *General and Detailed Facts about Mustard Agents (H, HD, and HT); Nerve Agents GA and GB; Nerve Agent VX; and Lewisite (L)* developed by the U.S. Army Environmental Hygiene Agency and the CSEPP Subcommittee on Reentry Restoration (1994). Appendix M of the *Planning Guidelines for Recovery Phase Activities for the CSEPP,* Final Draft, Aug. 31, 1994, also contains information on planning for water resources.

5.3 POTENTIAL EFFECTS ON AGRICULTURAL RESOURCES

The potential for chemical agent contamination of agricultural resources is a concern at several CSEPP sites. Each site, however, differs in geography, agricultural practices and products, climatic conditions, types of stored munitions, and the chemical and physical characteristics of the agent(s) that could be released. In addition, the density of important plant and animal species in the potential zones of impact, the toxicity of chemical agent to those species, and uncertainties about the size of the agent spills or direction of atmospheric plumes at individual sites add to the complexity of the situation. This section discusses the issue in general; specific concerns should be addressed by the planning document developed at each site.

To determine whether agent contamination of agricultural resources could be a problem, the planner should consider how chemical agents would be dispersed and what precautions, if any, would be needed to protect agricultural resources or the public who consume agricultural products. In general, accidents that result from an explosion or a fire have the greatest impact and therefore the greatest potential effects on terrestrial resources. The nerve agent VX is of concern because of its persistence in the environment.

Although the issues related to reentry, monitoring, and restoration are important in planning for a chemical accident, this section does not address those issues specifically. Rather, this section discusses the impact pathways and what plans emergency responders might consider for protecting those resources. Further discussion of reentry-related issues can be found in *Reentry Planning.' Tile Technical Basis for Offsite Recovery Following Warfare Agent Contamination* (Watson and Munro 1992).

The military developed VX primarily as a terrain deterrent (e.g., to prevent an enemy from entering certain areas). Thus, the impacts on terrestrial species other than humans were not then considered. For example, much of the information on impacts to nondomestic animal species (such as native birds) has been extrapolated from laboratory animal data because of the lack of basic research on native species. Because of the persistent release of a chemical warfare agent, however, some potential exists for contamination of drinking water, forage crops, grains, produce, and livestock (Watson and Munro 1992). In addition, agricultural workers can be at risk from contact with dislodgeable residue or from the inhalation of de-gassing chemical agent residue on crops.

In the unlikely event that an agent would be transported through the atmosphere and outside the installation, planners would need to consider surface contamination of food forage crops and structures. In cold and/or dry weather, VX would likely remain on vegetation. Meat or milk could thus become suspect because livestock could ingest or come in contact with contaminated forage or other materials. This issue is especially problematic for VX, which does not rapidly degrade and could pose a potential health concern for those who need to return to the affected area (Watson and Munro 1992).

Sigal and Surer (1989) considered both the direct and indirect effects of chemical agents on terrestrial resources. Depending on the mode of release, direct effects on animals could result from inhalation; grooming of the pelt or skin; absorption through the skin, nose, or eyes; or ingestion of contaminated vegetation or other food. However, no evidence suggests that the contamination would proceed through the food chain and affect human consumption.

It is thought that the most significant effect of an organophosphate agent release (such as VX) is the mortality of honeybees and native bees, for which organophosphate compounds are known to be particularly toxic. Indirect effects could result from loss of bees and other insect pollinators, as well as loss of accessibility to food or forage for grazing species. Areas could also be closed to public use or remain unsuitable for crops or foraging, depending on the nature of the accident and the agent involved.

5.3.1 Livestock, Companion, Exotic, and Laboratory Animals

The available ingestion toxicity data for VX suggest that on a per weight basis, of all the species observed, steer and sheep are the most sensitive, rats and rabbits the least sensitive, and that VX is the most toxic of the unitary chemical agents. Grasses and grazing land in the impact area might continue to be lethal to animals because of surface contamination if large quantities of chemical agent were released.

5.3.2 Native Species and Birds

The release of chemical agent and its effect on native species have not been studied; however, it is known that the effects of nerve agents and organophosphate insecticides are similar. Since no data were available on the effects of VX-contaminated food on birds, Sigal and Suter (1989) developed a model to extrapolate toxicity data obtained from feeding studies of rats to estimate the effects of a nerve agent on native birds. Their model indicates that, if a nerve agent was released in an agricultural area, dietary exposure to nerve agent could be sufficient to kill all sensitive bird species in all exposure zones.

5.3.3 **Soil**

The persistence of an agent in soil depends on the soil characteristics (such as clay and organic matter content, pH, and moisture), the type and amount of agent released, and the ambient air and soil temperatures. Persistence is an indication of the time a chemical compound (agent or not) continues to exist in measurable quantities. VX is considered persistent in or on soil because of its low volatility. Temperature also affects agent persistence.

5.3.4 Preventive Emergency Techniques

A number of techniques can be used to reduce the potential contamination of agricultural resources. Such techniques include sheltering companion animals or stock, closing or covering vents temporarily, covering food with tarps, or evacuating livestock and other animals from the area. Actions taken for reentry are discussed in Watson and Munro (1992).

The planner should be aware that there will probably be a number of questions about the consumption of agricultural products and the care of companion animals and livestock following a chemical release. The planner needs to coordinate with other agencies that have expertise in monitoring and advising the public on agricultural issues. These agencies include the U.S. Department of Agriculture (USDA), which can inspect and quarantine agricultural products; local Agricultural Extension Service agencies; local veterinary and humane societies; and the Food and Drug Administration.

5.4 SCIENTIFIC DATA FOR CHEMICAL AGENTS

Information that can be input into the D2PC model generally falls into three categories:

- Source characteristics,
- Meteorology or weather conditions, and
- Threat levels.

Source characteristics describe the properties of the initial release of the chemical agent: the type and weight of agent, the particle size (whether vapor or aerosol), the length of release (instantaneous or "semicontinuous"), and the size (volume) of the release. Data sheets typically do not include information about source characteristics because they differ from site to site (i.e., they are "site-specific").

Weather conditions at the time of the accident affect the behavior and the consequences of the plume. The plume is the column of gases or aerosols released into the atmosphere. Data sheets also do not include information about weather conditions because they are site-specific.

Threat level refers to the toxicity of the chemical agent and how much danger it poses to humans exposed to the agent. Highly toxic materials (i.e., those with lower permissible exposure levels) pose a threat for greater distances downwind from the accident than do less toxic materials.

The D2PC model has a set of standard (default) toxicity data built into the system. The default exposure limits included in the D2PC model are set at levels that will protect the entire population. These standard toxicity data are used in both the Emergency Management Information System (EMIS) and the Integrated Baseline System (IBS). The D2PC model allows the user to override these data to input other dosage values. However, MSDSs for the chemical agents list only "airborne exposure limits" (AELs) that have limited applicability to general populations. Normally, the user of D2PC should use the standard toxicity data built into the model. The user must weigh carefully the reasons for any decision to override the standard toxicity data, given the limited data available. For a more detailed discussion of exposure limits for chemical agents, see Chapter 9 of the *Reference Manual: D2PC and Hazard Analysis* (U.S. Army Nuclear and Chemical Agency [USANCA] 1993).

Recently, the Army assessed threat levels for off-post deposition of agent in aerosol form. This study was conducted primarily to evaluate the need for dermal (skin) protection for emergency workers; the primary hazard from any conceivable accident for public protective action strategy planning is still vapor dispersion. To enable NECD planners to apply the results

6 RISK ANALYSIS CONCEPTS

An analysis of accident risk was performed for the FPEIS. This analysis entails combining the probability that an accident will occur with a measure of the predicted consequences:

risk = probability of accident X consequences of accident.

This definition provides an overall measure of risk that can be used to prioritize planning. As a combined measure of the probability and severity of potential threats, it is possible for a threat with low probability of occurrence and high potential severity to pose a high risk. Threats with a high probability of occurrence but lower severity can be equally high in risk. Risk analysis permits all threats to be viewed from a perspective that is not biased by consideration of either probabilities or consequences alone.

6.1 PROBABILITIES

The CSDP risk analysis included a definition of "credible" accidents that could occur. All accidents with a 10^{-8} and greater frequency of occurrence have been included in the CSDP accident base. It is worthwhile to compare this standard to that of other hazard programs. One useful comparison is to the standard applied for such facilities as nuclear power plants. The fixed nuclear facility program of the U.S. Nuclear Regulatory Commission uses a 10^{-6} accident frequency as the accident base. Let us now consider what these relative frequencies actually me an.

The 10^{-8} frequency used as a cutoff is a "per year" figure derived as follows. Suppose that a specific accident associated with a handling operation had a probability *per operation* of 10^{-11}. Such an accident would then be expected to occur once in every 100 billion operations. If 1,000 such handling operations occurred per year, that accident would have a frequency of occurrence of 10^{-8} *per* year (10^{-11} times 1.000). Thus, the accident would be expected to occur only once every, 100 million years. A frequency of 10^{-6} per year means that an accident would be likely to occur only once every 1 million years. These are both very high numbers or, conversely, very low frequencies. However. the 10^{-8} value differs from the 10^{-6} value by two *orders of magnitude.* This value is represented by the difference in the power to which 10 is raised in each case (8 - 6 = 2). Two orders of magnitude means a difference in frequency of 10^{-2}, or that the CSEPP planning base is 100 times more conservative. In other words, it includes accidents that are 100 times less likely to occur than the most unlikely accidents from the nuclear industry planning base. Analysis in the FPEIS also included how the agent would disperse into the atmosphere and the expected toxic effects on humans, plant or animal life, and property.

After hazard identification, the second step in the hazard analysis process is probability analysis. This step involves assigning priorities to chemical threats in terms of probability, which permits attention to threats in an orderly fashion. The process also reduces the possibility that time and resources will be expended on low-risk scenarios. Historical accident data are combined with local factors to predict the frequency of future accidents. Prediction of the future is, of course, an inexact science. Probability accident assessment methods can, however, provide approximate indications of the number and nature of accidents, that is, the number of accidents *on average* within a specified period. These estimates provide valuable guideposts for decision making.

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6.2 CONSEQUENCES

The third step in the hazard analysis process is consequence analysis. This step involves estimating the impacts or consequences of a potential accident. Using a computer program, such as a dispersion model, is an effective means of performing such an analysis. Dispersion models consist of sets of variables and coefficients related by mathematical equations. These models can predict the dispersion in air of atmospheric contaminants and are virtually indispensable for prediction and policy options involving airborne chemical hazards.

The D2PC chemical agent dispersion model has been used to assess the effects of postulated agent releases. This model has been approved for use by the U.S. Department of Defense Explosives Safety Board (DDESB) and has been subjected to an expert panel review by the U.S. Department of Health and Human Services (DHHS). The model allows a comparison of impacts associated with possible alternatives. It estimates maximum downwind distances and areas receiving dosages that would result in human fatalities. The dosages used in the FPEIS are those resulting in no effects and fatality rates of 0% and 1%. The dosage corresponding to the 0% rate, also known as the "no-deaths" dosage, is the largest dosage that would result in no fatalities to the population.

Three modes of accidental release were examined in the CSDP risk analysis to define the range of potential accidents: semicontinuous, instantaneous, and evaporative. A semicontinuous release, applicable to all chemical agents, involves a steady plume of vapor (e.g., during a fire or from spilled agent venting from storage) over a specified time (such as 60 rain). An instantaneous release is a single burst of agent, for example an explosion. An evaporative release would follow a spill of liquid agent onto a surface.

Because atmospheric dispersion varies considerably according to meteorological conditions during an accidental release, the impact of a release can also vary tremendously. The FPEIS evaluated releases under two conditions, which it called "conservative most likely" and "worst case." The conservative-most-likely scenario was a frequently occurring meteorological condition that resulted in relatively large doses compared with other frequently occurring conditions. Specifically, this scenario was defined as occurring during neutral atmospheric stability (between stable and unstable; Pasquill-Gifford Class D) with a wind speed of 3 m/s (6.7 mph). The worst-case scenario was a credible condition that resulted in near-maximum dosages. This scenario was defined as occurring during a stable atmosphere (Pasquill-Gifford Class E) with a wind speed of 1 m/s (2.2 mph). With all other conditions identical, the downwind distance to the no-effects dose was greater in the FPEIS by a factor of approximately 3 to 4 for the worst-case scenario as compared with the conservative-most-likely scenario. (Hazard distances associated with extreme meteorological conditions could be greater than the worst-case results.)

The CSDP risk analysis used a methodology that minimized site-specific differences. *"A specific location was not specified in the D2PC model runs; a generic location was used because of the number of potential release points at each facility as well as the potential for off-site release in the transportation alternatives. Therefore, identical downwind distances were obtained for identical accidents for all alternatives"* (Miller and Kornegay 1989).

Although the two meteorological conditions in the CSDP risk analysis were selected to represent all facility sites, different sites may have somewhat different typical conditions. Therefore, these values were a compromise among data from the various sites. They were selected as the basis for useful comparisons among disposal alternatives.

Other atmospheric conditions were kept constant for the two meteorological scenarios in the CSDP risk analysis. Wind direction was not specified but was assumed to remain constant throughout individual runs of the D2PC model. This assumption was likely to produce conservative results. Downwind distances and areas predicted by the model were subsequently rotated about the source to evaluate all directions of interest. The height of the mixing layer (the upper limit of the atmosphere in which material readily disperses) was assumed in the CSDP risk analysis to be 750 m (2,460 ft) above ground level.

The downwind distances produced by the CSDP risk analysis were for locations along the center of the plume or cloud of agent as it traveled downwind. Dosages would be greater along this "centerline" than on either side.

6.3 RISK AND THE USE OF ACCIDENT CATEGORIES AS A PLANNING BASE

The CSDP risk analysis identified potential accidents that contributed significantly to risk. A key part of this process was identifying *credible* events. Analysts were able to narrow the very large group of "all possible" events to a more realistic and manageable list. The credible events were then analyzed for the severity of effects (or consequences) to the public. The combination of the credibility and severity analysis resulted in an overall picture of the relative risk involved with the scenarios considered. Ample technical detail exists on the risk analyses conducted with the CSDP.

Nonetheless, the results of the CSDP risk analysis provided installation and off-post planners with guidance for planning for possible accidents. The accident scenarios that the CSDP risk analysis selected for a planning base are included in Appendix D. These scenarios are not all equally likely or severe, but all are above the 10^{-8} frequency threshold.

In this guide, *accident categories* are recommended as an alternative to using individual accident scenarios for several key reasons. First, depending on the level of detail presented, hundreds or even thousands of accident scenarios could occur at a site. For example, the scenarios presented in the ERCPs represent groupings of accidents with common release points. It would be feasible to divide them into many more scenarios that would capture additional details about the accident. The resulting problem would be unwieldy and unnecessary. The use of more general accident categories makes the problem of accident classification and protective action recommendations more tractable.

Second, the accident scenarios are moving targets. They change with new plant designs, discovery of new engineering information, the addition of new munitions handling activities, and the adoption of new accident mitigation measures. The use of categories makes plans more insular to such changes and prevents plans from becoming outdated soon after they are finished.

Finally, accident categories should be, if developed with a sound rationale, more understandable to the public. Emergency plans should be documents that can be easily read and understood. Building unneeded complexity into a plan obscures this goal.

In January 1993, the National Research Council recommended that the Army update its risk assessments supporting the site-specific EISs. Following the Council's recommendation, the Army has scheduled quantitative risk assessments (QRAs) for all stockpile sites. Like the previous planning base for CSEPP, the QRAs focus on individual accident scenarios as a basis for estimating total risk. The analysis of each identified scenario includes assessing its likelihood, assessing the quantity and timing of agent release, and assessing the consequences of that release. The QRA process, therefore, is obviously similar to the APBRG's approach toward developing accident categories. Planners should be aware that the individual scenarios used in the QRAs may differ from scenarios previously used in the CSDP risk analysis and in the ERCPs. However, pending completion of the QRAs, the results of those scenarios should fit within the categories defined in this guide. We emphasize that the categories are intended to be robust enough to encompass more hypothetical scenarios or actual accidents than the initial list from the ERCP. If the finished QRA scenarios do not fit into the accident categories, the category definitions should be reviewed.

6.4 DEALING WITH CATASTROPHIC EVENTS

In recommending accident categories based on hazard and accident distributions, externally initiated accidents (such as earthquakes and airplane crashes) have been set apart from the primary planning base, as a matter of national policy, for three reasons. First, these events are often low-probability events that contradict a common-sense approach to planning. Second, the event that causes the accident can also reduce or eliminate response capabilities, as in an earthquake. Third, these events typically stretch atmospheric dispersion models beyond their limits, resulting in fairly unreliable downwind hazard estimates. Most externally initiated events fit well into existing planning categories based on internally initiated events. For more catastrophic events, detailed planning is not warranted when time allows a response to be implemented as an expansion of activities beyond the PAZ.

If emergency planners are concerned with catastrophic events, a formal designation of the precautionary zone can be made. In no case is the precautionary zone expected to extend more than 100 km (62 mi). It is almost impossible to develop an accident scenario and transport conditions that would lead to a lethal dose of agent exceeding that distance. This policy was adopted in the 1989 ERCP. Current scientific guidelines indicate that most gaussian models are only applicable to a nominal distance of 50km (31 mi) (EPA 1986). When improved atmospheric dispersion models become available, these external events will be assessed to determine if a different planning policy is needed.

7 USING D2PC FOR CONSEQUENCE ANALYSIS

One of the most important functions of the CSEPP is to assess the effects of an accidental release of a chemical agent to a civilian population. Planning the possible dosage that unprotected personnel would receive downwind of the accidental release is an especially important component of the program.[1] Emergency management personnel use this information to select protective actions that reduce or eliminate the hazard to the affected populations.

Computer models can help determine how the chemical agent is transported and dispersed downwind from the accident. The CSEPP uses a personal computer program developed by the U.S. Army's Chemical, Research, Development, and Engineering Center (Whitacre et al. 1987). Known as the D2PC, this program can predict the dosage and, consequently, the effects of a chemical agent on humans at various distances from a release.

The D2PC program models air dispersion and assumes a "gaussian" (or "normal") distribution of chemical agent in the vertical and cross-wind directions as the agent moves downwind. That is, at any given distance downwind, the concentration of agent is highest at the center of the plume and falls off toward the edges. The D2PC model predicts the centerline concentration of chemical agent and the resulting dosage at different locations downwind of an accidental release.

The development of this type of dispersion model is documented extensively in the literature (Gifford 1968; Pasquill 1974; Hanna 1982), and many models currently use this type of methodology. The gaussian model remains the basic workhorse for dispersion calculations (Hanna 1982) and is the most commonly used model for the following reasons:

- It produces results that agree with experimental data as well as any model.
- It is fairly easy to perform mathematical operations on this equation.
- It is appealing conceptually.
- It is consistent with the random nature of turbulence.

l For planning purposes, the dosage to a person at a given location is determined by assuming that an unprotected person is exposed to the projected concentration of chemical agent at that location for the entire duration of the plume.

- It is a solution to diffusion equations for constant eddy diffusivity and wind speed.

- Other so-called theoretical formulas contain large amounts of empiricism in their final stages.

For these reasons, the gaussian model is included in most government guidebooks (EPA 1986).[2] Consequently, the D2PC gaussian model remains the model of choice for calculating potential consequences within CSEPP.

2 The EPA categorizes atmospheric dispersion models into four generic classes: gaussian, numerical, statistical or empirical, and physical.

Gaussian models are the most widely used technique for estimating the impact of nonreactive pollutants. Numerical models may be more appropriate than gaussian models for such applications as area source urban that involve reactive pollutants, but they require much more extensive input databases and resources and therefore are not as widely accepted. Statistical or empirical techniques are frequently used when incomplete scientific understanding of the physical and chemical processes or lack of the required databases makes the use of a gaussian or numerical model impractical.

Physical modeling, the fourth generic type, involves the use of a wind tunnel or other fluid modeling facilities. This class of modeling is a complex process requiring a high level of technical expertise, as well as access to the necessary facilities. Nevertheless, physical modeling may be useful for complex flow situations, such as building, terrain or stack downwash conditions, plume impact on elevated terrain, diffusion in an urban environment, or diffusion in complex terrain. If physical modeling is available and its applicability demonstrated, it may be the best technique.

In addition to the various classes of models, there are two levels of sophistication. The first level consists of general, relatively simple estimation techniques that provide conservative estimates of the air quality impact of a specific source, or source category. These are screening techniques or screening models. (D2PC can be considered such a tool.)

The second level consists of those analytical techniques that provide more detailed treatment of physical and chemical atmospheric processes, require more detailed and precise input data, and provide more specialized concentration estimates. As a result, they provide a more refined and, at least theoretically, a more accurate estimate of source impact and the effectiveness of control strategies (i.e., mitigation). These techniques are referred to as refined models.

The use of screening techniques followed by a more refined analysis is always desirable; however, at times the screening techniques are practically and technically the only viable option for estimating source impact. In such cases, an attempt should be made to acquire or improve the necessary databases and to develop appropriate analytical techniques.

7.1 ATMOSPHERIC DISPERSION

Atmospheric dispersion is a commo n phenomenon. Anyone who has watched smoke coming out of a chimney, water vapor coming from a stack at a power plant, or smoke trailing from a cigarette, pipe, or cigar has seen atmospheric dispersion. Atmospheric dispersion is the movement of particles in air. For example, emissions (water vapor) from a power plant seem to be dense just above the stack. On windy days, the visible vapor cloud quickly disappears from sight. On calm days, however, the vapor trail can continue for some distance. On windy days, the water vapor evaporates, disperses, and is quickly diluted in the atmosphere. On cahn days, the water vapor remains concentrated and moves slowly across the landscape.

Dosages of chemical agent released to the atmosphere are greater along the centerline of the plume. As the plume "fans out," the dosages decrease according to a "normal" distribution. Thus, a given dose occurs at a maximum distance along the centerline but is also found at shorter distances on either side of the centerline.

The plume, which forms an oval cross section, can be graphically depicted by using contour lines. The shape of the oval depends on the weather conditions (e.g., winds) at the time of the accidental release. For example, high winds and unstable atmospheric conditions produce relatively wide ovals, while light winds and stable atmospheric conditions produce narrow ovals. The latter result when only minimal mixing takes place in the cross-wind direction as the chemical agent travels downwind, producing high concentrations.

A release to the atmosphere can occur either continuously or in a "puff." A useful way to look at puff dispersion is to examine the ground area covered by a particular concentration (which could be a toxicity limit of some kind). Figure 7.1 shows how this ground area changes from the source to the downwind locations above the selected concentration. The view is looking down at the puff from above, and each oval represents a different time frame. The outer line around the set of ovals encloses the ground area that will be subjected at some time to airborne contaminant concentrations *at or above* the preselected concentration. In technical terms, the individual ovals are referred to as "isopleths." The outer oval defines the cloud's "footprint" on the ground for a particular hazardous concentration. (Note that the D2PC plume depicted in Figure 7.1 is idealistic. The actual shape and concentration levels of plume isopleths can vary considerably from ideal ovals.)

Figure 7.2 illustrates the footprint following an accidental release of a chemical agent for two different conditions. The first condition is a wind speed of 3 m/s (6.7 mph) and a stability class of D. (The stability class represents the amount of turbulence in the atmosphere. Stability class D represents "neutral" conditions, that is, neither highly stable nor highly unstable.) The second condition, called the "relatively stable" condition, is a wind speed of 1 m/s (2.2 mph) and

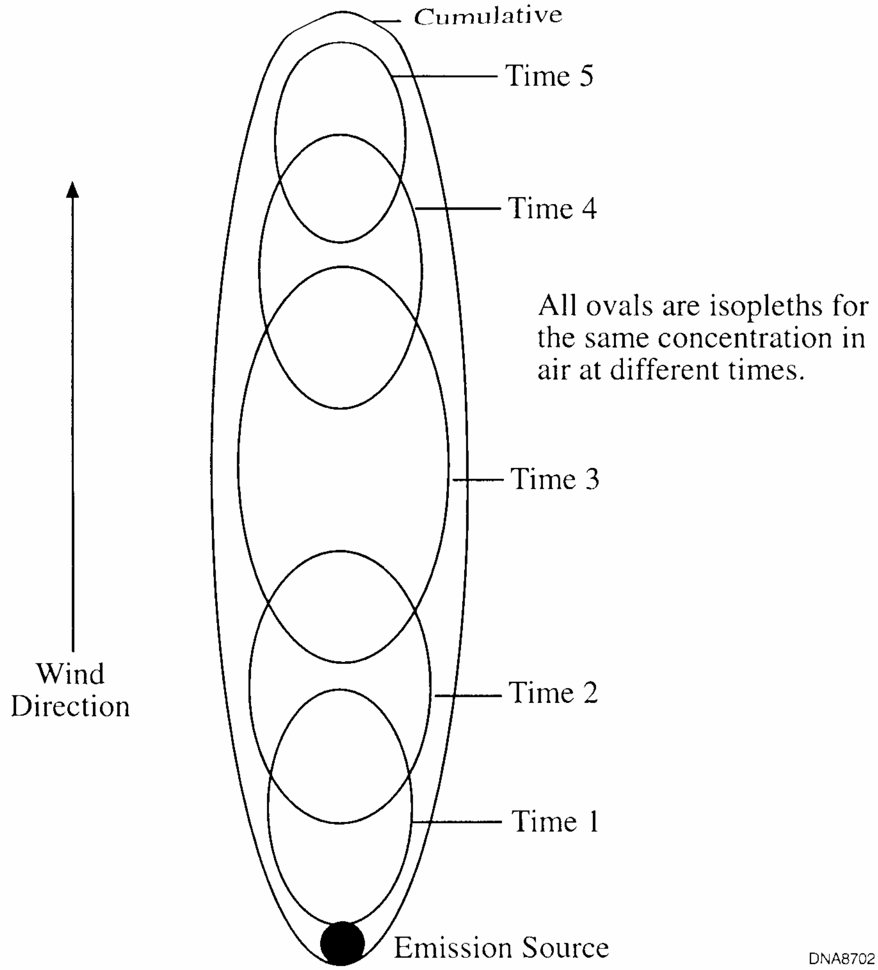

FIGURE 7.1 Plume Footprint for a Given Concentration

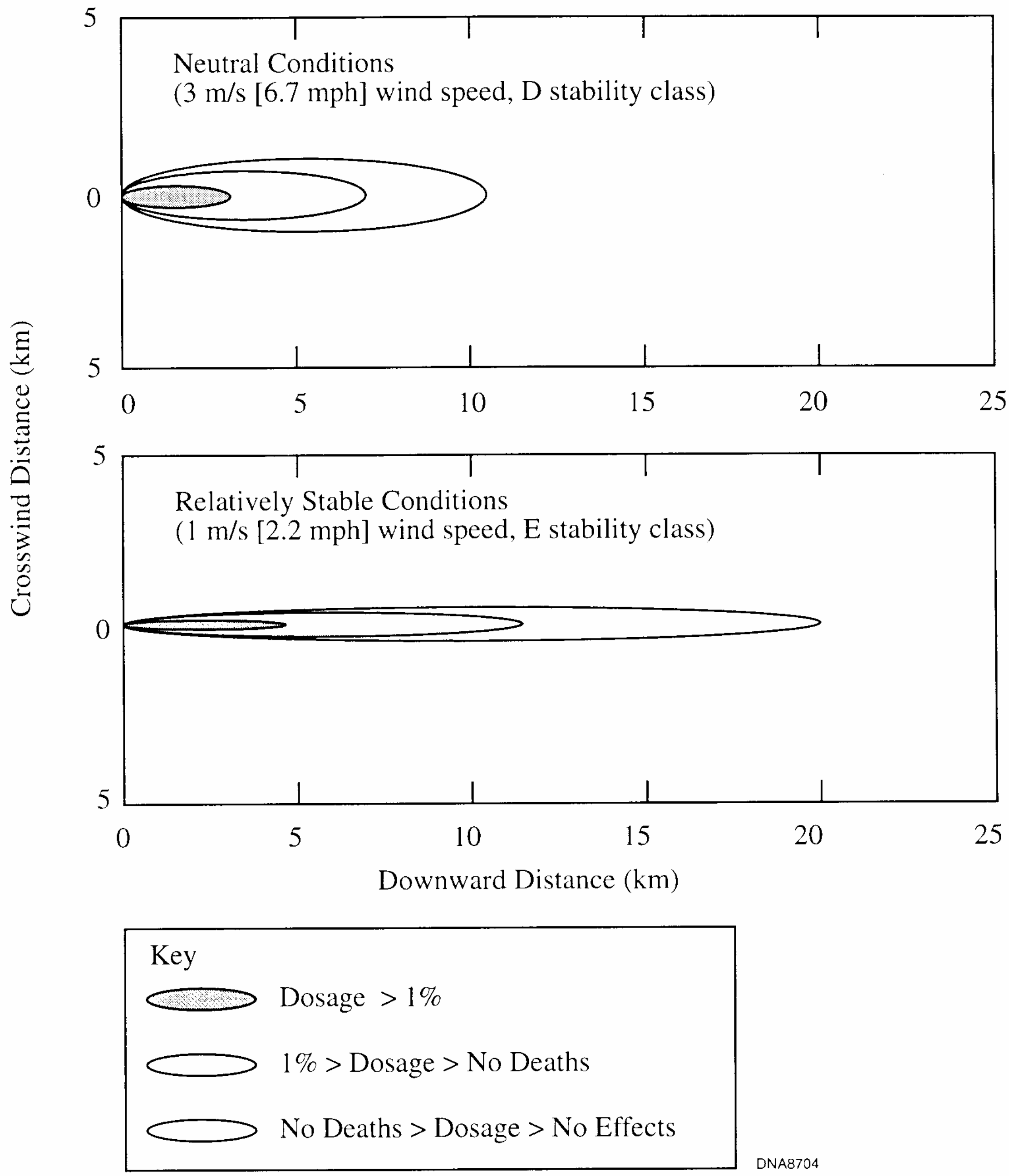

FIGURE 7.2 Hypothetical Scenario Resulting from Identical Accidental Releases under Two Meteorological Conditions

a stability class of E (stable). Both ovals are relatively narrow (as measured by width-to-length ratio). However, the second oval is narrower than the first because of the limited crosswind mixing associated with the weather conditions. Relatively stable conditions result in greater dosages downwind than do neutral conditions.

Atmospheric dispersion is an important consideration when simulating accidental releases of chemical agents. In particular, it is important to remember the following:

- High winds deliver chemical agents to a given distance more quickly than do low winds (Figure 7.3).

- Generally, high winds dilute the chemical agent considerably.[3]

The potential hazard associated with a release of chemical agent decreases as downwind distance increases, but the amount of decrease depends on wind and stability conditions.

3 In some cases, such as winds directed into a box canyon, high winds could cause plume concentration.

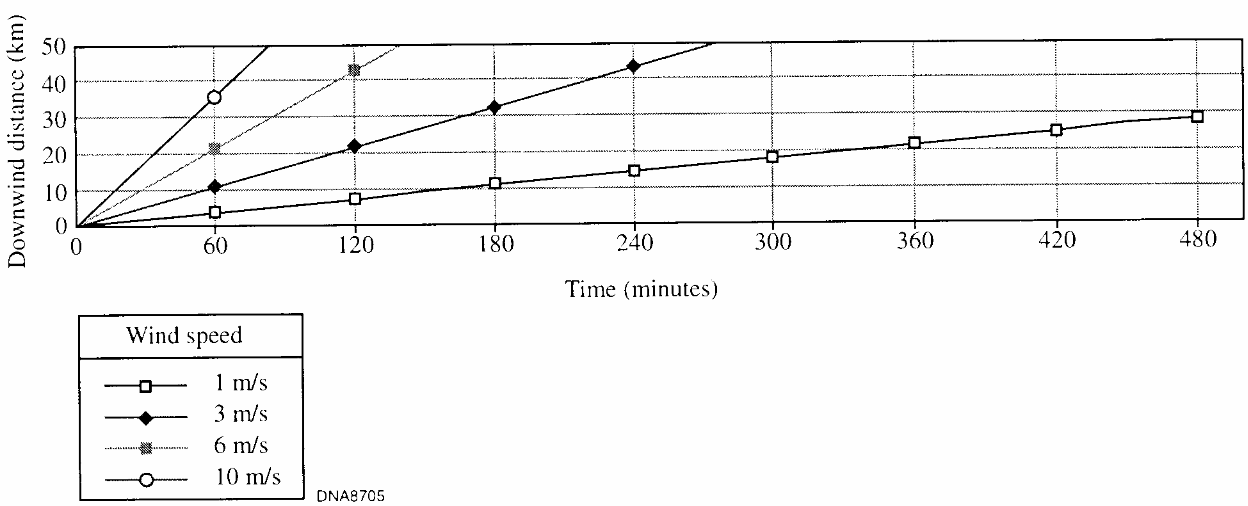

FIGURE 7.3 Time/Distance Relationships for the Leading Edge of a Plume at Four Different Wind Speeds

7.2 DISPERSION MODELS AS APPROXIMATIONS OF REALITY

Although the principal hazard from an accidental release of a chemical agent is that the chemical is dispersed in either aerosol or vapor form, the major *off-post* hazard is from vapor. Thus, it is important to be able to determine the off-post areas that would be affected by the vapor and the time at which the vapor would reach those areas. This information is critical for finding effective ways to mitigate releases of chemical agents, that is, reduce the severity of the effects of the release.

Using a computer model is one way of simulating the movement of chemical agents. Dispersion models predict the movement of atmospheric contaminants in the air. These models are indispensable for predicting the effects of accidental releases of hazardous chemicals and for investigating policy options involving airborne chemical hazards.

The *D2PC* model assesses the effects of hypothetical releases of chemicals. It looks at possible alternatives and allows the user to compare the effects of those alternatives. The model estimates the distances to which exposure would affect human health.

Users of a dispersion model for emergency planning and operations should be aware of intrinsic approximations in the model. Such approximations are inherent in any dispersion model, including D2PC.

Many (but not all) of the differences between dispersion models and field tests result from estimates in the input data. Usually, only the maximum values are input into the model; however, the *actual* plume length and downwind distance are often less than the calculated estimate. Even well-known variables (e.g., wind speed and precipitation) are generally nonspecific numbers because they vary in time and space. Hence, entering a specific number for such a variable leads to errors in the output. Other differences arise because of the difficulty of accurately representing turbulent airflow over rough terrain.

The largest uncertainty in predicting hazards arises from estimating wind direction, especially at distances beyond 2 km (1.2 mi) (Freeman et al. 1986). Freeman et al. compared the relative contribution of uncertainties in input variables with the final uncertainty of results given by a typical dispersion model. They found that uncertainty in the final results was largely due to uncertainties in emission rate, wind speed, wind direction, width of the "normal" distribution, emission height, and height of the mixing layer.[4] Users of the D2PC model must understand these uncertainties when they interpret results, especially when the user is conveying the projected hazard to decision makers.

[4] The mixing layer depth is the depth of turbulent region near the ground. More important, the mixing layer is the height to which turbulent mixing of pollutants (such as chemical agents) extends in the atmosphere (Panofsky and Dutton 1984).

During convective (unstable) conditions, the boundary layer is often used as a synonymous term for mixing layer depth. Alternatively, the boundary layer is defined as either the height of the lowest temperature inversion or that part of the atmosphere where the influence of surface friction and heating and cooling is felt (Fleagle 1980).

Typically, temperature decreases with increasing height in the atmosphere near the earth's surface. The top of the mixing layer is often marked by the beginning of a temperature inversion, i.e., an increase of temperature with height. In meteorological terms, a temperature inversion represents a stable layer of air and acts as a barrier to plume travel and diffusion.

For applications in hazard analysis, the top of the mixing layer is treated as a cap to the vertical diffusion of chemical agents. The presence of this lid can produce higher concentrations than would otherwise be expected at ground level if the plume travel distance is sufficient. The D2PC model accounts for the presence of the mixing layer through "reflections" of the plume from this boundary.

7.3 LIMITATIONS OF D2PC

The D2PC model has inherent limitations. Users must be aware of these limitations so they can avoid misusing the model. The limitations of the D2PC model are that it:

- Usually gives a conservative estimate,
- Does not forecast weather,
- Requires secondary information,
- Gives a single location release,
- Gives results that do not depend on time, and
- Cannot absolutely simulate atmospheric dispersion.

Each of these limitations is discussed in detail in the following sections.

7.3.1 Usually Gives a Conservative Estimate

If all of the D2PC model input has been correctly defined, the model output is expected to be conservative; that is, in most cases, it will probably overestimate the hazard. This conservatism is the result of the following features of the model:

- The model assumes steady-state diffusion over open, flat terrain. It does not account for topography, vegetation, or buildings. Accounting for terrain and vegetation creates more turbulence, or mixing, which reduces the expected downwind safety distances.

- The model assumes that wind direction is uniform over the entire area modeled. If wind direction changes, the model only applies the change to that part of the release that occurs after the wind shift. In reality, wind shifts would probably cause the plume to meander (drift) as it moved downwind. Meandering would spread the plume over a wider area and reduce the expected hazard distance of the plume. (Imagine that the plume is following a line of fixed length. If the line is wavy, going left and right, it will cover a wider area, but it will not go as far downwind as if the line were straight.) To compensate for this meandering, we use a "wedge" for planning purposes, covering an angle left and right of the centerline, to help ensure that the estimated area contains the entire hazard width. A 40° to 60° wedge (20° to 30° each side of the plume center) is recommended: 40° for stability classes D, E, or F, and 60° for stability classes A, B, or C. (The effective wedge angle may end up much larger than 40° or 60° because a wedge line through any portion of a zone would cause a protective action to be taken for the entire zone.)

- The model outputs the peak, centerline concentration/dosage. Exposure to a plume away from the center is expected to produce fewer effects.
  The model assumes total exposure and dosage; that is, it assumes that a person exposed to the chemical agent at a given distance stays in the center of the plume until the entire plume passes.
  The model assumes a (default) constant breathing rate equivalent to moderate work activity. Lower breathing rates would reduce a person's intake of the chemical agent, thereby reducing the effects of exposure.
  For most releases, the model assumes a "point source" (zero volume), which maximizes the downwind concentration, especially close to the source. The two exceptions are instantaneous/explosive (from the database) and evaporation (computed) release types.

- The model assumes the exposure occurs outdoors, without mitigation from sheltering structures.

While terrain conditions usually mitigate the effects of a release, three specific terrain conditions exist that could cause D2PC to underestimate the effects:

- A plume trapped in a depression (low-lying area) with insufficient wind to ventilate the area.

- A plume released into a narrow valley that restricts the natural spreading (and dilution) of the plume.

  A condition in which an elevated plume released in a stable atmosphere encounters a turbulent (unstable) area, such as an early morning plume flowing over a body of water and then reaching land. Such a scenario could cause rapid downward mixing of the plume toward the ground, producing a chemical plume at ground level where it would not be expected.

For complex terrain scenarios, it is not advisable to adhere to the absolute predictive value of a gaussian plume model (such as D2PC). Too much uncertainty exists in atmospheric dispersion models even for the "ideal" steady-state meteorological conditions over open, fiat terrain. Applying the model in complex terrains, where plume bifurcation could exist, is even less certain.

When applying a model in situations involving public health, the analyst needs to be conservative, i.e., predict concentration levels higher than would actually be experienced. With this philosophy, use of a safety wedge is recommended to account for the uncertainty in actual location of the plume in complex terrain. In this case, a wedge (such as 60° in arc) with origin at the agent release site is centered about the prevailing wind direction. The resulting plot indicates which areas are potentially at risk from agent exposure, with the "tail" of the plume identified as the no-effects distance. Because any portion of a planning zone intersected by the wedge necessitates identifying the entire zone as potentially at risk, the safety wedge, in practice, could be much wider than the original wedge. When applying the model, where bifurcation or other terrain obstacles could re-direct or otherwise modify the flow, it is appropriate to account for the uncertainty by using a larger safety wedge. The hazard analyst should also rely on physical evidence, such as location of the population experiencing agent symptoms or detector readings, to more precisely identify the location of the plume and adjust the response accordingly.

A basic CSEPP premise is that detailed planning is not required beyond the PAZ. Similarly, during an emergency response, planning would not be required beyond the projected no-effects distance, partly because of the expected conservative nature of the hazard prediction model (D2PC), especially for long plume travel distances. The chemical plume is not expected to travel beyond these distances and, therefore, planning would not be necessary. Should a projected no-effects distance extend to a particular CSEPP planning zone, whatever emergency response concept is selected (evacuation or sheltering) would be completed for the entire zone. As a result, planning would extend somewhat beyond the projected no-effects distance from the model, which is expected to be conservative.

No definitive model for long-range travel exists. However, the EPA recognizes the applicability of gaussian models to 50 km (31 mi) (EPA 1986). CSEPP recommends that the D2PC model results not be applied definitely beyond 20 km (12 mi).

Unfortunately, no rule of thumb exists for modifying projected plume concentrations in complex terrain to overcome the deficiency of conservative model estimates. Such precision would require field trials at the site for a variety of meteorological conditions and would then apply only to that site. (The field trials would involve the release to the atmosphere of a chemical tracer to simulate the chemical agent and the measurement of its concentration at specified locations under a variety of meteorological conditions.) But since, in virtually all instances for long-range plume travel, sufficient time exists for evacuation, detailed planning for populations at great distances is not necessary.

In recognition of the known limitations of gaussian dispersion models, CSEPP is funding development of the HOTMAC/RAPTAD (Higher Order Turbulence Model for Atmospheric Circulation/Random Particle Transport and Diffusion) modeling systems. These three-dimensional, complex terrain models could provide more confidence in the predicted location of a chemical plume than that given by a gaussian plume model. (A detailed description of these models is outside the scope of this planning guide.) It must be recognized, however, that much uncertainty is common in model prediction even with such sophisticated model usage. As a result, proper planning will continue to make use of safety wedges to account for the uncertainty in the actual location of the agent plume.

7.3.2 Does Not Forecast Weather

The D2PC is an atmospheric dispersion model, not a meteorological model, which means it does not forecast weather conditions for specific locations. The user must define the appropriate weather conditions and "tell" the model. The model then simulates the release of the agent under those conditions to determine the potential hazard.

7.3.3 Requires Secondary Information

The model is useful for both planning guidance and emergency response activities. However, the results of the analysis should not be the sole source of data used to plan such activities. To determine the extent of the hazard, these results should always be used with other information or data, such as terrain analysis, confidence in source terms, and observed weather conditions at downwind locations.

The model provides a quantitative analysis of the expected exposure. It does not provide a solution for reducing the expected hazard. It does not, for instance, recommend a particular protective action, such as evacuation or shelter-in-place. To address these questions, the results of the D2PC model must be linked with other simulation models and data (such as the Oak Ridge Evacuation Modeling System [OREMS] and the Protective Action Dosage Reduction Estimator [PADRE]) to determine appropriate actions (Section 9).

7.3.4 Gives a Single Location Release

The model requires that all the chemical agent be released from one location; however, it can simulate multiple release types at a single location. For most realistic potential accidents, this limitation presents no particular problem, as the source of agent release would be expected to be a single location.

7.3.5 Gives Results that Do Not Depend on Time

The results given by the D2PC model are not time dependent. The program computes only the total dosage and peak concentration (including the expected exposure downwind). To compute when the exposure occurs, the user needs the Partial Dosage (PARDOS) model.

7.3.6 Cannot Absolutely Simulate Atmospheric Dispersion

Simulating atmospheric conditions is complex and not entirely understood. The simulations are performed by using a model that estimates what could happen as a result of an accident. Users should always view the results as relative and never as absolute. D2PC should be considered to be a tool for hazard analysis, yielding an initial estimate as to the consequences of a chemical agent release. In an actual event, analysts must also incorporate physical evidence, such as the location and amount of exposure measured by detectors, in their analysis and adjust the model projections accordingly.

7.4 USING D2PC IN ANALYSIS, PLANNING, AND DECISION MAKING

The D2PC model has been incorporated into two interim automation systems used by the CSEPP: the IBS and the EMIS. The IBS was designed for use by the civilian community, whereas the EMIS was designed for use by on-post Army personnel responsible for installing a stockpile.

The D2PC reference manual (USANCA 1993) provides information on the use and limitations of the D2PC model. The D2PC model has been approved by the DDESB for site planning and other studies for the chemical depots. USANCA has approved D2PC for emergency response planning and response within CSEPP. However, users must be aware of the model's limitations so that they can avoid drawing inaccurate conclusions when they are using it.

Although the D2PC model gives conservative estimates, its predictions are relatively accurate when real-world conditions match the model's inputs and assumptions. Test runs at the Dugway Proving Ground in Utah and Edgewood Arsenal in Maryland agreed closely with the D2PC results. However, both test sites are flat and have little vegetation. Also, source term and meteorological data were well known and could be input into the model. These tests were generally conducted over very short distances, usually less than 1 km (0.6 mi) with favorable (persistent) meteorological conditions. The model extrapolates the results from these tests over longer distances and plume travel times than measured in the field tests and is generally applied over the rougher terrain found at the depots rather than the terrain at the test sites. Interpretations of model results must incorporate these assumptions and limitations.

Ideal conditions at the test sites are relatively rare, so, as discussed earlier, the D2PC model often will overestimate the hazard distance needed by emergency planners and decision makers. *This feature of the model means that the EPG categories, which are based on D2PC results, provide a conservative basis for protective action planning and decision making.*

Dennis (1982, p. 16) discussed the accuracy of computers in predicting hypothetical scenarios:

> Because the models have a degree of uncertainty in their predictions, and because the predictions of the model may be different from what we intuitively would have guessed, because no model covers all aspects of the problem, and because no model has been so thoroughly validated as to be without questions, decision makers are not going to (or at least should not) accept blindly what comes out of the computer. Therefore the most successful uses of models in decision making have involved a high degree of effort in communication between modeler and decision maker.

One of the principal concerns in the use of dispersion models is how to determine what dosage levels are "hazardous" or what *is* hazardous to the general public. A technical assessment predicts the hazardous area under certain conditions -- what is *possibly* hazardous. If the technical assessment and the social value are not definitely linked, one of two conditions prevails: either the technical modelers must make policy judgments or the policy makers must define important information from the model and decide what is relevant. The following information must be included:

- Direction,
- Hazard distance,
- Time of arrival at the hazard distance,
- Duration of the event,
- Threat level at the hazard distance, and
- Preferred protective action alternative, recognizing that different areas can require different protective actions.

7.4.1 Direction

Decision makers must know the direction in which the hazard is moving for the same reasons as given in Section 7.3.1. In addition, the user must let the decision maker know the limitations of the model with respect to wind direction. Because of these limitations, the wedge projection is used in estimating downwind hazards (USANCA 1993). The user must provide appropriate information in terms that the decision maker can use effectively. For example, the user could give the additional zones affected rather than the degrees to either side of the plume, or additional members of the general public exposed.

7.4.2 Hazard Distance

Decision makers must know the distances from the source of the accident to the hazard limit for different levels of effects. This information is crucial for identifying and prioritizing areas for warning, response, and potential evacuation. Also, accurate information is critical for using limited resources effectively and protecting the public exposed to the chemical agent.

7.4.3 Time of Arrival, Duration, and Threat Level at the Hazard Distance

Among the most critical information for emergency planning is knowing the time the hazard is expected to arrive and depart at different points. (D2PC does not calculate arrival and departure times, but the PARDOS model can be used for this purpose.) This information can help decision makers calculate the time they have to react to (or prepare for) the hazard. First, knowing the expected time of arrival enables emergency personnel to allocate resources and to prioritize their responses. Information must be provided quickly and accurately on the basis of the decision maker's needs. Time of arrival relates closely to hazard distance in this regard. Second, the decision maker must know the expected concentration level of the chemical plume when it arrives. The hazard value must be expressed in terms that the decision maker can understand and put to use quickly.

On the other hand, the decision maker must also translate critical information needs to the user. Following this procedure prevents the user from wasting valuable time and effort in modeling or extracting factors of less relevance to emergency planning or response. Once the technical and social aspects of emergency management achieve this working relationship, the effectiveness of both aspects in emergency planning and operations will increase.

7.5 CONCLUSIONS

The discussion about the D2PC model is meant to help inform you so that you can use the model in planning and decision making. However, this material should not mislead you. We repeat the following caution from the Introduction:

> **CAUTION: Your first reaction upon receiving a notification of a chemical agent accident should not be to run D2PC or wait for someone else to run it.**

Doing so will cause you to lose valuable time needed for implementing a protective action. The accident categories in the EPG are designed to help you make appropriate protective action decisions without first running the D2PC model at the time of an accident.

However, it is also important to note what *are* appropriate uses of D2PC:

> At the time of an accident, run D2PC, as time and available data allow, to perform ongoing assessment of the accident. Do not, however, put off implementing a protective action while waiting for a D2PC run.
>
> In the planning stage, run D2PC as much as you wish to test various options. Instructions in Appendix C enable you to reproduce the distances calculated in Appendix D of the EPG. You may wish to calculate some of those scenarios. In addition, you will find it instructive to calculate other scenarios -- vary the quantity of agent release, for instance, to find out "what happens if...." Even if you never touch D2PC during an actual incident, the insight you gain from running D2PC during the planning stage will give you a much better understanding of what is happening during an actual incident.

You should be aware that the Army has benchmarked and field tested the D2PC model,[5] Where conditions exist that approximate the assumptions of the model (such as flat terrain and steady weather conditions), D2PC estimates were relatively accurate in comparison to the results of actual tests.

However, in many cases D2PC *overestimates* the hazard distance that you need to be concerned about for a given quantity of release. In the real world, many things impede the downwind movement of materials released to the atmosphere. For example, wind meandering and rough terrain (natural features or buildings) interrupt the steady movement of a plume of agent. So, D2PC's estimate of downwind effects are usually greater than that which would occur if an actual release took place.

5 The D2PC model has not been specifically "validated" for any particular CSEPP site. Validation requires comparison of predicted model output with actual data measured on site, to include meteorological and dispersion data, i.e., plume concentration data. Because no model can faithfully reproduce the complex behavior of plumes released to the atmosphere, models are often "tuned" for site-specific purposes. Generally, models are tuned either in the model physics or model input so that model results better replicate the data collected. The collection of data appropriate for model validation is quite expensive, however. Data should necessarily include the four seasons, the diurnal cycle, and a range of stability categories and wind speed and direction to properly account for the variety of expected meteorological conditions at that site and their effect on plume travel. Such a combination of parameters necessitates a large matrix of field trials and large financial investment.

The D2PC model was developed specifically for chemical hazard prediction to support the chemical depots. In fact, field data employing actual chemical agents and munitions (prior to the 1969 ban on open-air testing) has been collected, in part, for model validation and proper model input. Several internal model parameters to D2PC, including the dispersion coefficients, are based on the data collected from these field trials. (The dispersion coefficients determine the rate of plume growth, thereby specifying the plume size and concentration).

These chemical agent field trials were conducted over generally ()pen, flat terrain, and it is recognized that D2PC model results are most suited for such terrain. It is also recognized that the terrain surrounding most of the CSEPP sites is not fiat and contains vegetation. Although the terrain around many of the CSEPP areas is not particularly complex, airflow (and potential agent plumes) over such terrain is expected to exhibit more turbulence than that over a completely open, fiat terrain site. As such, D2PC model applications at these sites are expected to provide a conservative estimate of plume concentrations. So, although the D2PC model has not been validated specifically for the CSEPP sites, you should have confidence that the model output will in most cases be both conservative and appropriate.

In reviewing how the D2PC models applies specifically to any of the CSEPP areas, it is important to recognize how the model would be applied in the response phase. The important consideration in hazard analysis is the projected location and duration of the plume, and whether evacuation or sheltering-in-place would be the appropriate response. The actual plume concentrations predicted by the model are not critical. The concept to remember is that the precise concentrations/dosages calculated by the model are not all that important; instead, the emergency response to the projected plume location and duration should be the focus of the hazard analysis. The D2PC model is appropriate then as both a planning and response tool.

The use of D2PC should enable you to assure decision makers that the EPG accident categories, which are based on D2PC results, provide a conservative basis for protecting the public.

8 ACCIDENT CATEGORIZATION

Protective action strategies should be selected on the basis of the hazards posed by the NECD stockpile and its disposal. These hazards, in turn, should be based largely on characteristics of the stockpile, the potential accident scenarios associated with interim storage and disposal activities, and the distribution of natural features that can affect an agent release (e.g., topography and meteorology). Vulnerability for the NECD area is based on the distribution of people and resources potentially affected by an accident scenario and the time it would take for the hazard to reach the people and resources from the site of the accident.

This section presents current thinking on accident categories for NECD and supersedes accident categories identified in the *Emergency Response Concept Plan for Newport Army Ammunition Plant and Vicinity (ERCP)* (Carnes et al. 1989). The discussion summarizes relevant information from the previous ERCP (particularly from Section 2 [Planning Basis Accident Categories] and Appendix A), documents the current status of efforts to update estimates on potential accident scenarios at NECD, and identifies new accident categories that should facilitate the development of protective action strategy plans for NECD and neighboring populations.

8.1 CURRENT NECD ACCIDENT DISTRIBUTION

A list of NECD accidents from the FPEIS is shown in Appendix D. The list contains accidents that could occur either in storage or during disposal activities. Of the 14 NECD accidents in the FPEIS, 4 are internally initiated (that is, initiated by causes at NECD), and 10 are initiated by external causes, such as earthquake or aircraft crash.

The accidents in Appendix D have been sorted by the downwind no-effect distances that pertain to each scenario. The order is the same under both sets of meteorological conditions used in the study -- neutral conditions (D stability, 3 m/s [6.7 mph] wind speed) and relatively stable conditions (E stability, 1 m/s [2.2 mph] wind speed).

The no-effect distances listed in Appendix D were developed from running the Army's atmospheric dispersion model D2PC (Whitacre et al. 1987) for the accident scenarios and from associated source terms identified in the FPEIS and in the risk assessment underlying that document (APG 1987). The no-effect distances can differ from those published in the FPEIS and the previous ERCP because those values were developed as interpolations of a more limited number of D2PC runs. Details regarding how D2PC was used in developing Appendix D are provided in Appendix C of this guide.

To maintain historical continuity, the accidents listed in Appendix D are the same as those identified in previous planning documents. However, as described in the next section of this guide, the NECD planning community has identified a simpler and more practical scheme for characterizing and categorizing potential accidents at NECD.

8.2 ACCIDENT CATEGORIES

The protective action planning strategy advocated in this guide is based on accident categories -- groupings of accidents with similar off-post consequences -- rather than on causative accident scenarios. Two different causes -- such as an MPF explosion or a forklift collision involving fire -- can result in similar off-post consequences. These accidents should be treated similarly as far as public protective action planning is concerned.

At NECD, the definition of categories is made easier by the simple composition of the stockpile mix -- only ton containers of VX. The only accidents with the potential to require off-post public protective actions are those involving fire, from whatever physical cause. Under these simple circumstances, categories can be defined simply on the basis of the number of ton containers involved in an incident and the presence or absence of fire.

The NECD planning community has identified public protective action strategies for a semicontinuous release with fire, involving 1, 2, or 3 ton containers, for various wind directions and wind speeds. These protective action strategies are summarized in Section 12 of this guide.

8.3 INITIAL PROTECTIVE DISTANCE CONCEPT

Catastrophic accidents beyond those categorized as in Section 8.2 are covered under the "initial protective distance" concept discussed in the following paragraphs, whether they are caused by internal or external events.

For emergency planning, decision makers should take large D2PC-calculated distances to be indicators of a need to implement protective actions for an initial protective distance, rather than for the literal calculated distance. This initial protective distance -- a site-specific distance determined by the off-post and installation planning communities -- should be in keeping with the following principles:

- In the first few minutes following an accident, detailed information about the accident may be lacking. Almost certainly there will not be enough time to fully analyze the accident before needing to decide on protective actions for the public.

- Therefore, initial protective actions should be planned on the basis of default accident categories and default protective actions to be taken.

- For the worst accidents, initial protective actions should be taken for a distance large enough to protect the area that might be initially affected, while more detailed analysis of the accident is proceeding. This distance should protect people who might be affected within the first hour or two.

- A large release of agent might extend beyond even the initial protective distance. Therefore, the distance should be large enough to allow implementing protective actions for people beyond that initial distance, should the first hour or two of analysis indicate such a need.

The use of such a strategy (versus, for instance, planning to a distance of "zero risk") is necessitated by realities of risk management, and it is consistent with the planning basis for other technological hazards. A guaranteed zero risk distance does not exist, but if it did exist, it would be so great as to make detailed emergency response planning prohibitively costly and impractical. For these reasons, planning for man-made hazards typically focuses on an initial protective action area. For example, for possible nuclear power plant accidents, immediate protective actions are planned for approximately a 16-km (10-mi) radius around each plant. This distance does not mean that people outside that range would never have to evacuate in case of a large-scale accident. However, the 16-km (10-mi) distance for the initial response gives time to analyze and implement protective actions for people beyond that distance, if necessary. Also, the detailed planning performed for people within the defined distance provides a basis for carrying out similar actions for people beyond that distance.

While the category framework works well overall, special considerations are needed for the final, largest distance category. In the lesser categories, emergency planners should default to the worst case within each category. This valid and useful way simplifies planning and ensures that, in an uncertain emergency response environment, actions are protective of human health and safety. However, the final category contains the largest, and least probable, accidents and the greatest hazard distances. It is not meaningful for emergency planners to default to the most massive accident every time in this category. It causes the planning process to lose its focus, and in virtually every case, will grossly exaggerate the actual hazard. Consequently, in the final category, the concept of an initial protective distance should be used.

The initial protective distance concept initiates emergency actions out to a site-specific, predetermined distance when there is a catastrophic (largest distance category) accident. This distance is chosen to be protective of the population in most large accidents. It must allow sufficient time to direct additional emergency management measures beyond the initial protective distance, if necessary. This concept allows the response process to start very quickly and facilitates the rapid notification of the population closest to the hazard. It also gives the emergency response system time to assess the actual event and to determine the need for additional emergency response measures beyond the initial protective distance.

8.4 CONSTRAINTS AND LIMITATIONS OF THIS STUDY

The accident scenarios listed in Appendix D are the same as those used for the risk assessment in the FPEIS. Since the publication of that document in 1988, several changes in design and operating procedures have evolved for the proposed NECD disposal activities. Any variations in the NECD accident scenarios resulting from those changes have not been included to date. In addition, the list of accident scenarios is limited to those events considered to be "credible." Credibility of a scenario is defined as having a frequency of occurrence greater than 1 x 10^{-8} events per year.

The calculation of distances in Appendix D does not take into account the specific location of each accident relative to the site boundary. Accidents may occur at the storage location, the disposal facility, or along the transportation routes between them. The distance from the proposed disposal facility at NECD to the nearest boundary is only slightly greater than the distance from the storage area to the nearest boundary (1.20 vs. 1.05 km [0.74 vs. 0.65 mi]). Therefore, for off-post protective action planning, a similar set of accident categories should work for all accidents.

8.5 CONCLUSION

The ultimate objective of accident categories is to make and disseminate appropriate protective action recommendations as quickly as possible for people who are potentially at risk in the event of an actual accident. The process of developing accident categories is *logically* simple -- if "x" pounds of "y" agent have been released in "z" manner under "set w" meteorological conditions, what is (are) the recommended protective action(s) for persons in subzones "a," "b," and "c" downwind of the accident? However, since dozens of values are possible, given the number of variables involved, it is important to simplify the problem by establishing logically sound and empirically valid categories for each of these variables to reduce the decision-making problem to one of manageable proportions.

The set of accident categories presented here constitute a first step in developing protective action strategy plans for the NECD area that will meet the goal of providing maximum protection to the public. Additional steps, however, need to be taken and are described in Part III, Protective Action Planning.

PART III: PROTECTIVE ACTION PLANNING

9 PROTECTIVE ACTION STRATEGIES AND OPTIONS

Although the set of accident categories discussed in Section 8 and presented in Appendix D is a first step, additional steps need to be taken. In particular, various time elements are critical to the overall process of determining and implementing appropriate protective actions for persons potentially at risk. Time is needed to assess the accidental release and determine appropriate protective action recommendations. Also, time is required to notify relevant authorities of the release and its character, to alert the public and inform them of appropriate protective actions, and to allow the public to implement those protective actions. All are critical to a successful response.

Equally important is the amount of time that will elapse before a toxic plume reaches a population at risk. For example, at 1 m/s (2.2 mph) wind speed, it would take more than 2 hours for an accidental release to reach 8 km (5 mi), but, at 3 m/s (6.7 mph) wind speed, it would take only 9 minutes for a release to reach 1.6 km (1 mi). Time is therefore both an asset and a liability **-- plume** travel time to populations at risk is an asset, but the time required to assess, decide, communicate, alert and notify, and respond effectively is a liability. CSEPP's goal is to ensure that the "net" time is always positive, that is, that the public can be warned and can implement appropriate protective actions before the arrival of a toxic plume.

The material in this section is derived from technical and policy reports prepared for CSEPP. Principal sources include:

- Appendixes D and E of the *Planning Guidance for CSEPP* (FEMA/DA 1996);
- *Technical Planning and Evaluation Workbook* (draft) (Clevenger et al. 1993);
- *Emergency Response Concept Plan for Newport Army Ammunition Plant and Vicinity* (Carnes et al. 1989);
- *Evaluating Protective Actions for Chemical Agent Emergencies* (Rogers et al. 1990a); and
- *Protective Action Evaluator for Chemical Emergencies: A User's Manual* (Rogers and Sharp 1990).

9.1 PROTECTIVE ACTIONS FOR CSEPP

Under CSEPP, protective actions consist of measures that members of the public can take to protect themselves from exposure to airborne releases of chemical agent. The purpose of CSEPP planning is to determine appropriate protective action strategies. Once strategies have been selected, the various governments will use CSEPP education initiatives to educate the public and configure the CSEPP alert and notification system to provide prompt and effective communication to the public.

Programmatic requirements for identifying appropriate protective actions for particular situations and for preparing for implementing the identified actions are spelled out in Appendixes D and E of the Planning Guidance for CSEPP. These requirements provide programmatic support for five protective action options: (1)evacuation, (2)normal shelter-in-place, (3) enhanced shelter-in-place, (4) expedient shelter-in-place, and (5) pressurized shelter-in-place.

Research performed for CSEPP has established that evacuation is the preferred protective action. That is, evacuation should be the selected protective action whenever it can be accomplished before exposure to hazardous concentrations of chemical agent occurs. The other protective action options should be recommended only when evacuation cannot be completed quickly enough to avoid dangerous exposure. Moreover, it should be recognized that selection of the shelter-in-place options also requires an ability to extricate sheltered individuals without unduly exposing them to any contaminated surface or airborne concentrations of chemical agent.

The following sections summarize the characteristics of each protective action option. The intent of these sections is to provide information that will help decision makers identify appropriate protective actions for the citizens in their jurisdictions. Each section describes an option, discusses the conditions under which it would be an appropriate choice, summarizes the planning needed if that option is selected, and lists the major advantages and disadvantages of the option.

9.1.1 Evacuation

Evacuation consists of temporarily removing people from an area of actual or potential hazard to a safe area. It is the most effective of all protective actions, provided it is completed before the arrival of the toxic plume. Evacuation may be either precautionary or responsive in nature. A precautionary evacuation involves moving out of the risk area before chemical agent is released, while a responsive evacuation involves moving after a release has been detected.

Conceptually, evacuations involve a series of organizational and individual or family decisions. Considerable communication and social interaction is sometimes necessary in making these decisions. At the organizational level, the following decisions are common in evacuation situations:

- Whether to notify,
- Whether to recommend evacuation,
- Which areas to evacuate,
- When to issue warning,
- Via what channels to communicate,
- Nature of recommendations and instructions,
- Content of evacuation notifications, and
- When to return.

At the individual or family level, comparable types of decisions include:

- Whether to evacuate,
- When to evacuate,
- What to take,
- How to travel,
- Route of travel,
- Where to go, and
- When to return.

Without an extensive training and education program, evacuation is not a simple stimulus-response type of behavior--upon hearing an evacuation recommendation, people do not automatically and immediately begin to leave the area. Instead, they begin a process in which they form an image of the threat and evaluate information available to them to decide on an action or inaction.

9.1.1.1 Appropriate Conditions for Use

When sufficient time is available, evacuation is the best protective action because it eliminates exposure to chemical agent. In the unlikely event that sufficient advance warning could be given of an impending release, a precautionary evacuation of the entire area at risk would be advisable. Similarly, a responsive evacuation of the entire risk area would be appropriate under conditions that would allow all people to leave the area before being affected by the toxic plume. Such conditions would include slow wind speeds and a relatively long distance from the point of release to the nearest members of the downwind public.

It is more likely that evacuation would be appropriate for some, but not all, of the people in the area at risk. The decision of who can evacuate and who must take another protective action should be based on the time required to evacuate compared to the time available before the arrival of the chemical agent plume. Evacuation is always the principal protective action for the general public in the PAZ, although other actions may be appropriate for special populations and institutions in the PAZ. Within the IRZ, evacuation is recommended for the general population in specific areas when it can be completed in time.

9.1.1.2 Planning Requirements

Effective evacuation requires extensive planning for densely populated areas or locations with unusual road conditions. Quantitative estimates of evacuation times, based on the number and characteristics of potential evacuees and the availability of evacuation resources (vehicles, roadways, etc.), must be performed to guide the development of evacuation strategies. These strategies should designate evacuation routes for specific areas, identify appropriate measures to assist any special populations that would be evacuated, designate measures to be used to expedite the flow of evacuation traffic, and specify procedures that would be followed to issue and implement an evacuation recommendation.

9.1.1.3 Advantages

- Evacuation eliminates the possibility of agent exposure if it is completed before the arrival of the chemical agent plume.

- Evacuation requires no changes in the daily living environment of affected areas during nonemergency periods.

9.1.1.4 Disadvantages

- Evacuation planning may require extensive work in highly urbanized areas.

  Evacuation can require a significant amount of time to complete in large and densely populated areas, as well as in areas with large transient populations.

- Evacuation may not be effective for people living near the release point or for special populations who cannot evacuate quickly.

- Evacuation is disruptive to all population groups.

9.1.2 Shelter-in-Place

Shelter-in-place involves taking cover in a building. Generally, any building suitable for winter habitation provides some protection if windows and doors are closed and heating, ventilation, and air conditioning systems are turned off. The degree of protection a shelter can provide depends on the ability of the structure to slow or stop the infiltration of contaminated air from outside. In addition, the effectiveness of shelter-in-place varies substantially with the nature of the chemical agent release--it provides appropriate protection for short-term releases (e.g., up to 30 minutes for nonenhanced shelters, or up to 3 hours for enhanced shelters) but may be of limited effectiveness for long-term releases (pressurized shelter-in-place can be effective for long-term releases). Finally, people who are sheltered may have to be evacuated through a toxic environment (an area with surface contamination) once the toxic plume has passed. Extricating those individuals requires significant resources, including rescue teams, vehicles, and decontamination checkpoints and stations.

Four types of shelter-in-place are available for CSEPP: normal, enhanced, expedient, and pressurized. Each type is discussed in the following sections.

The level of protection provided by shelter-in-place options is largely a function of air exchange or air infiltration rates. Studies of air exchange have shown that housing in the United States varies from 0.2 to about 5 air changes per hour (acph). An air change is having the inside air replaced by air from outside the structure. A 0.2 acph means that it takes about 5 hours for the air to change over in a house. The average for U.S. houses is about 0.7 acph, which represents a replacement time of about 1 hour and 25 minutes. Older houses have significantly higher rates than modern houses.

In enhanced shelters, the air exchange rate is lowered to some goal or standard by using weatherization techniques. A tight house is considered to have an air exchange of less than 0.5 acph, and the goal would be to achieve a rate of 0.25 acph.

Expedient shelter through taping and sealing a room, when applied to a normal or average house, gives a similar level of protection. One study showed in a limited number of trials that the air exchange for expedient rooms ranged from about 0.1 to 0.6 acph, with a mean of 0.3 (Rogers et al. 1990a). When used in a very leaky structure, expedient shelter is much less effective, and some weatherization would be needed to make it feasible.

Estimating the air exchange reduction from using both enhanced and expedient measures on the same structure is somewhat complicated. The room that is expediently sealed will exchange air with both the interior and exterior of the house. If most of that exchange is with the exterior (e.g., an exterior bathroom), little additional protection will occur. If the exchange is with the interior air (e.g., an interior room with no outside walls), which already has a lower concentration of agent than the exterior, then the reduction will be much more substantial. Further research is needed to quantify the size of the reduction.

To minimize their exposure to chemical agent, people who have implemented nonpressurized shelter-in-place must leave or open up their shelters after the toxic plume has passed. Failure to do so results in increased exposure inside the shelter. As the toxic plume passes by a structure, contaminated air begins to leak into the structure, and the concentration of chemical agent inside slowly begins to rise. The plume then passes, and the concentration of agent in the air outside the structure begins to drop. Unless the shelter is ventilated or abandoned at that point, however, the people inside continue to be exposed to the agent that has leaked in and is trapped inside the structure. If the people remain inside the closed shelter indefinitely, they receive the same dosage of agent as if they had stayed outside while the plume passed. Shelter-in-place can significantly reduce the dosage of chemical agent that people receive if they go into their shelter before the toxic plume arrives, and they open up or leave the shelter soon after the plume has passed. This way they are exposed to the lower concentrations inside the shelter while the plume is heavy and to a zero concentration outside after the plume passes by.

Emergency management officials must cooperate with the Army installation to jointly develop capabilities for determining when the toxic plume has passed a given area and for notifying people in shelters in that area to open up or leave their shelters. It is almost certainly impossible to perform real-time chemical agent monitoring throughout the affected area within the time required to support the decision to end shelter-in-place. Instead, officials will probably rely on the results of dispersion modeling to determine when it is appropriate to advise people to

Planning Requirements

Any jurisdiction that proposes to recommend normal shelter-in-place must develop capabilities to (1) advise people to implement shelter-in-place, (2) determine when shelters in a particular area should be abandoned or ventilated, (3) advise people in selected areas to abandon or ventilate their shelters, and (4) evacuate people who have abandoned their shelters.

As with all nonpressurized shelter-in-place options, the decision to recommend normal shelter-in-place entails a particularly ambitious public education and training effort: (1)the affected public must be convinced that it is in their interest to seek shelter rather than give in to an impulse to flee the hazard; (2)they must know how to implement normal shelter-in-place; (3) they must understand the necessity of abandoning or ventilating the shelter when advised to do so; (4) they must know how to minimize the risk of exposure after leaving the shelter; and (5) they must know what action is appropriate for evacuating the contaminated area.

Advantages

- Normal shelter-in-place requires only existing resources.

- Normal shelter-in-place is not intrusive on the normal living environment of affected areas.

  Because structures cannot increase exposure, normal shelter-in-place can only increase protection. For a home with an average infiltration rate (0.7 acph), normal shelter-in-place can be expected to reduce exposure by a factor of between 1.3 and 10, depending on how long it takes the plume to pass by (Chester 1988). Thus, normal shelter-in place provides a minimum level of protection in situations where emergency actions are precautionary or where concentrations are low and the toxic plume would pass quickly.

  Normal sheltering can be implemented quickly. Sorensen (1988) estimates that it can be accomplished in less than 10 minutes.

  Normal sheltering can also serve as a convenient anticipatory step for evacuations by assembling the family unit in one place.

Disadvantages

- Normal sheltering provides only limited protection under restricted conditions.

  If an accident anticipated to result in low concentrations and to be of limited duration develops into a more extensive release (higher concentrations or longer duration), people who have implemented normal shelter-in-place may have to be evacuated through a toxic environment.

  Officials must be able to determine (by monitoring or modeling) when the toxic plume has passed through a specific area and to notify people who have implemented normal shelter-in-place within that area to abandon or ventilate their shelters.

  People who have implemented normal shelter-in-place may have to be extricated through a contaminated environment even if the release had low concentrations and was of a limited duration.

- Normal sheltering can cause discomfort under extreme temperature conditions.

9.1.2.2 Enhanced Shelter-in-Place

Enhanced shelter-in-place differs from normal shelter-in-place only in that weatherization techniques are applied before the occurrence of a chemical agent release to reduce the infiltration rate of the structures to be used as enhanced shelters. Reducing the infiltration rate enables enhanced shelters to provide protection from higher concentrations of chemical agent and for longer periods.

During an emergency, implementation of enhanced shelter-in-place would proceed the same as for normal shelter-in-place. Upon receiving an enhanced shelter-in-place recommendation, people in the affected area would go into the enhanced structure; close all doors and windows; turn off **all** heating, ventilation, and air conditioning systems; take necessary supplies (e.g., radio, flashlight, water); go into a room with few or no openings to the outside; and close the door(s) to the room. People should remain in the shelter until they receive notification (via EBS/EAS radio broadcast or tone-alert radio, if available) that it is time to leave their shelter. At that time, it is important that people leave their shelters or open the doors and windows and turn on ventilation systems. Staying in closed enhanced shelters after the plume has passed increases the exposure of people within the shelters.

Enhanced sheltering is quite intrusive on the normal day-to-day environment, while actions are being taken to reduce the infiltration rate of the structure. These actions consist of standard weatherization techniques, such as packing cracks, weather-stripping or caulking windows and doors, installing door sweeps, weather-stripping attic hatches, repairing fireplace dampers, closing off fireplaces, and replacing broken window panes.

Appropriate Conditions for Use

Enhanced shelter-in-place is appropriate for the general public and for special populations and institutions under the following conditions:

- Conditions would not allow evacuation before the arrival of a potentially life-threatening level of chemical agent.

- Normal shelter-in-place would not provide adequate protection from all accident categories identified in the EPG.

  The institution or member of the general public or special population to be protected is located within the no-deaths distance for the largest accident identified in the EPG or within the IRZ boundary if the no-deaths distance exceeds the IRZ boundary.

Planning Requirements

Any jurisdiction that proposes to use enhanced shelter-in-place must develop and implement a plan to reduce infiltration rates of **all** structures proposed for use as enhanced shelters. In addition, the jurisdiction must develop capabilities to (1) advise people to implement shelter-in-place, (2)determine when shelters in a particular area should be abandoned or ventilated, (3)advise people in selected areas to abandon or ventilate their shelters, and (4) evacuate people who have abandoned their shelters.

As with **all** nonpressurized shelter-in-place options, the decision to recommend enhanced shelter-in-place entails a particularly ambitious public education and training effort: (1) the affected public must be convinced that it is in their interest to seek shelter rather than give in to an impulse to flee the hazard; (2)they must know how to implement shelter-in-place; (3) they must understand the necessity of abandoning or ventilating the shelter when advised to do so; (4) they must know how to minimize the risk of exposure after leaving the shelter; and (5) they must know what action is appropriate for evacuating the contaminated area.

Advantages

- Enhanced sheltering requires that existing structures be improved in much the same way that they would be for energy conservation.

Because structures cannot increase exposure, enhanced shelter-in-place can only increase protection. If weatherization techniques can reduce the infiltration rate of a structure to one air change in four hours, the structure would reduce exposure by a factor of between 2 and 60. Thus, enhanced shelter-in-place provides a limited level of protection in situations where chemical agent concentrations are low to moderate and the toxic plume will pass *within 1 to 3 hours.*

Enhanced shelter-in-place can be implemented very quickly. Sorensen (1988) estimates that the required actions could be completed in less than 10 minutes.

Disadvantages

Enhanced shelter-in-place provides a moderate level of protection under conditions where plumes are of limited size. Thus, enhanced sheltering would not prevent fatalities where long or continuous releases of agent are anticipated.

If an accident that is anticipated to be of limited duration develops into a more extended release, people who have implemented enhanced shelter-in-place could have to be evacuated through a toxic environment.

Officials must be able to determine (by monitoring or modeling) when the toxic plume has passed through a specific area and to notify people who have implemented enhanced shelter-in-place within that area to abandon or ventilate their shelters.

- Enhanced shelter-in-place is somewhat intrusive because it requires modifying the structure to reduce the rate of air infiltration.

Enhanced shelter-in-place requires that the public be taught how to implement and abandon shelters when directed to do so and how to protect themselves after leaving the shelter.

People who have implemented enhanced shelter-in-place may have to be extricated through a contaminated environment even if the release had relatively low concentrations and was of a limited duration.

Enhanced shelter-in-place can cause discomfort under extreme temperature conditions.

9.1.2.3 Expedient Shelter-in-Place

Expedient shelter-in-place differs from normal shelter-in-place only in that actions are taken at the time of the emergency to reduce the infiltration rate of the room being used as an expedient shelter. Reducing the infiltration rate enables expedient shelters to provide protection from higher concentrations of chemical agent and for longer periods. Expedient sheltering can be used in conjunction with enhanced sheltering to further reduce the air infiltration rates of shelters.

During an emergency, implementation of expedient shelter-in-place would proceed in the following manner. Upon receiving a shelter-in-place recommendation, people in the affected area would go into an available structure; close all doors and windows; turn off all heating, ventilation, and air conditioning systems; take necessary supplies (e.g., radio, flashlight, water, and expedient sheltering materials); go into a room with few or no openings to the outside; close the door(s) to the room; and reduce the air infiltration rate of the room through such actions as taping around doors and windows, covering vents and other outlets with plastic sheeting, and placing a wet towel under the door(s). People would remain in the shelter until they receive notification (via local radio stations or tone-alert radio, if available) that it is time for them to leave. At that time, it is important that people leave their shelters or open the doors and windows and turn on ventilation systems. Staying in closed expedient shelters after the plume has passed increases the exposure of people within the shelters.

Expedient shelter-in-place is somewhat intrusive on the normal day-to-day environment because of the need to maintain and store a kit containing materials that would be used to seal the shelter at the time of an accident and the need to undergo rudimentary training in the use of these materials. An expedient shelter kit might include duct tape, plastic sheeting, towels, scissors, and other items.

Appropriate Conditions for Use

Expedient shelter-in-place in one room of a structure is appropriate for the general public and for special populations and institutions under the following conditions:

- Conditions would not allow evacuation before the arrival of a potentially life-threatening level of chemical agent.

- Normal shelter-in-place would not provide adequate protection from all accident categories identified in the EPG.

- The institution or member of the general public or special population to be protected is located either

  - outside the no-deaths distance for the largest accident identified in the EPG but within the IRZ, or

  - within the no-deaths distance for the largest accident identified in the EPG and within the PAZ.

Planning Requirements

Any .jurisdiction that proposes to use expedient shelter-in-place must develop and implement a program to help the inhabitants of each affected structure choose an appropriate room for shelter-in-place and provide them with materials and training for reducing infiltration into the selected room. In addition, the jurisdiction must develop capabilities to (1) advise people to implement shelter-in-place, (2)determine when shelters in a particular area should be abandoned or ventilated, (3) advise people in selected areas to abandon or ventilate their shelters, and (4) evacuate people who have abandoned their shelters.

As with all nonpressurized shelter-in-place options, the decision to recommend expedient shelter-in-place entails a particularly ambitious public education and training effort: (1) the affected public must be convinced that it is in their interest to seek shelter rather than give in to an impulse to flee the hazard: (2)they must know how to implement shelter-in-place; (3) they must understand the necessity of abandoning or ventilating the shelter when advised to do so: (4) they must know how to minimize the risk of exposure after leaving the shelter: and (5) they must know what action is appropriate for evacuating the contaminated area.

Advantages

Expedient shelter-in-place requires only commonly available resources but can be more effective if a kit containing these resources is provided for each structure that may have to implement this protective action.

Because structures cannot increase exposure, expedient shelter-in-place can only increase protection. If the infiltration rate of the shelter can be reduced to one air change in four hours, the structure would reduce exposure by a factor of between 2 and 60. Thus, expedient shelter-in-place provides a limited level of protection in situations where chemical agent concentrations are low to moderate, and the toxic plume will pass *within 1 to 3 hours*.

When necessary, expedient shelter-in-place can be used in combination with enhanced shelter-in-place to further increase the effectiveness of shelters.

Expedient shelter-in-place can be implemented fairly quickly. Sorensen (1988) estimates that taping and sealing an average room can be accomplished in 10-15 minutes.

Disadvantages

Expedient shelter-in-place provides moderate protection under conditions where plumes are of limited size but will not prevent fatalities if long or continuous release of agent is anticipated.

If an accident anticipated to be of limited duration develops into a more extended release, people who have implemented expedient shelter-in-place might need to be evacuated through a toxic environment.

Officials must be able to determine (by monitoring or modeling) when the toxic plume has passed through a specific area and when to notify people who have implemented expedient shelter-in-place within that area to abandon or ventilate their shelters.

· Expedient shelter-in-place is somewhat intrusive because it requires that people in the affected area maintain and store a kit containing materials to be used to seal the shelter at the time of an accident and undergo rudimentary training in the use of these materials.

Expedient shelter-in-place requires that the public be taught how to implement and abandon shelters when directed to do so and how to protect themselves after leaving the shelter.

People who have implemented expedient shelter-in-place may have to be extricated through a contaminated environment even if the release had relatively low concentrations and was of a limited duration.

Expedient shelter-in-place can cause discomfort under extreme temperature conditions.

9.1.2.4 Pressurized Shelter-in-Place

Pressurized shelter-in-place involves taking refuge in existing structures that are pressurized to eliminate the infiltration of toxic vapors. By eliminating the infiltration of chemical agent into the shelter, pressurized shelter-in-place provides effective protection against chemical agent releases that produce large concentrations over a long period of time.

During an emergency, pressurized shelter-in-place would be implemented in much the same way as normal shelter-in-place. Upon receiving a shelter-in-place recommendation, people in the affected area would go into the designated structure; close all doors and windows; turn off all heating, ventilation, and air conditioning systems; turn on the pressurization/filtration system; take necessary supplies (e.g., radio, flashlight, water); go into the room designated to provide shelter; and close the door(s) to the room. Unlike the other forms of shelter-in-place, pressurized shelter-in-place does not require that shelters be opened up and abandoned as soon as the plume has passed by. People can remain in their shelters for a longer time until emergency workers can rescue them and escort them to a safe area.

Pressurized shelter-in-place is very intrusive on the normal day-to-day environment because of the need to install pressurization/filtration equipment and to perform periodic maintenance and inspection of this equipment.

Appropriate Conditions for Use

Pressurized shelter-in-place should be recommended for special populations and institutions under the following conditions:

- Conditions would not allow evacuation before the arrival of a potentially life-threatening level of chemical agent.
- Normal, enhanced, and/or expedient shelter-in-place would not provide adequate protection for all accident categories identified in the EPG.
- The institution or member of the special population to be protected is located within the no-deaths limit.

(Only institutions and special populations within the no-deaths limit are eligible for pressurized sheltering under CSEPP.)

Planning Requirements

Any jurisdiction that proposes to use pressurized shelter-in-place must develop and implement a program to install adequate pressurization/filtration equipment in rooms and structures to be used as pressurized shelters and to inspect and maintain the equipment regularly. In addition, the jurisdiction must develop capabilities to (1) advise people to implement shelter-in-place, (2)determine when it is safe for people in specific areas to leave their shelters, and (3) evacuate people when it is safe to do so.

Advantages

Pressurized shelter-in-place provides excellent protection from the full range of potential chemical agent accidents and is particularly suitable for institutionalized populations and other special populations who would have difficulty evacuating in a timely manner.

Pressurized sheltering can be implemented fairly quickly. Sorensen (1988) estimates that activating a pressurization/filtration system would take about 5 minutes.

Because pressurized shelter-in-place protects beyond the duration of the longest expected accidents, it avoids the problems associated with misjudging accident duration and chemical agent concentration.

Pressurized shelter-in-place does not require prompt abandonment or airing of the shelter when the toxic plume has passed.

Disadvantages

- Pressurized shelter-in-place requires the installation of expensive equipment and implementation of a costly inspection/maintenance program.

  Pressurized shelter-in-place is very intrusive because of the installation of new equipment in the shelter environment and the need to inspect and maintain this equipment regularly.

  People who have implemented pressurized shelter-in-place might have to be extricated through a toxic environment, in the unlikely event that the release produced residual contamination in the area.

Facility Guidelines

The Army has developed technical criteria for overpressurization systems, which are outside the scope of this guide. However, beyond the overpressurization system itself, the criteria also include some guidelines pertaining to the facility to be pressurized:

- The shelter is to contain sufficient carbon monoxide detectors.
- The shelter manager's station is to include a means for communication with the County Emergency Management Agency office.
- A schematic depicting each shelter within the facility is to be available.
- The shelter manager is to have a condensed version of system startup procedures and a comprehensive operation and maintenance manual. The shelter manager and an alternate are to be trained in operation and maintenance of the system, including troubleshooting.

There is to be visual indication at the shelter manager's station that each shelter door leading to an unprotected area is completely closed. Limit switches, or the equivalent, are to be attached to each shelter door to indicate complete closure. Entry into and exit from the shelter is to be controlled to prevent loss of overpressure. All doors leading into the shelter are to have latches that prevent their inadvertent opening from the outside and are to allow entry to be controlled from the inside of the shelter. These latches are to allow unrestricted emergency exit from the shelter. Doors leading into the shelter should have a window in or adjacent to the door. Occupants of the shelter are to be cautioned against opening doors once overpressure is established.

- Each shelter is to provide access to standard or expedient toilet facilities within the pressurized envelope.

- Each shelter is to provide potable drinking water within the pressurized envelope.

9.1.2.5 Summary of Shelter-in-Place Options

The comparative characteristics of the four types of shelter-in-place are listed in Table 9.1.1. The table allows planners to evaluate each type of shelter-in-place according to eight variables: how much it costs initially to provide the sheltering capability; how much it costs to maintain that capability; the level of protection provided; the degree to which the type of shelter intrudes on the normal daily living environment; how easy it is to store necessary equipment and supplies; the level of training required to successfully implement the type of shelter-in-place; the speed with which sheltering can be implemented after a warning is received; and the degree to which the necessary equipment or supplies could deteriorate before an emergency occurs.

9.1.3 Relationship between Protective Actions and Other Aspects of the Emergency Response System

To determine what protective action should be recommended for a given area or population group in a particular situation, planners must consider numerous other aspects of the emergency response system. The protective action decision is obviously influenced by accident detection and monitoring capabilities, communications equipment, public warning systems, command and control procedures, public education efforts, and transportation network characteristics. Planners may need to reevaluate the protective action decision, as these other aspects of the emergency response system evolve.

TABLE 9.1.1 Comparative Characteristics of Shelter-in-Place Options

		Type of Shelter Improvement		
Parameter	Normal Shelter	Enhanced	Expedient	Pressurized
Initial cost	None	High	Low	High
Cost of maintenance	None	Low	Low	High
Level of protection	Low	Moderate	Moderate to high	High
Intrusiveness	Low	High	Moderate	Very high
Ease of storage	NA[a]	NA	Moderate	NA
Training needs	Low	Low	Low	Moderate
Speed of implementation	High	High	Low	Moderate
Degradation concern	NA	NA	Low	High

[a] NA = not applicable.

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Evacuation has been determined to be the preferred protective action whenever it can be accomplished before the toxic plume arrives. Thus, the time required to evacuate people from all or part of the risk area is an important consideration in protective action decision making. Several actions must take place during this critical time period: (1) officials at the Army installation must detect and assess the chemical agent release and notify off-post officials; (2)off-post officials must first decide whether to warn the public and then activate the public alert and notification system; and (3) members of the public must hear the warning, decide to evacuate, and implement the evacuation by traveling to a safe area.

When planning for protective action decision making, officials must estimate the time required to accomplish all of the actions involved in an evacuation. It is important that these estimates be as accurate as possible. Underestimating the time required to evacuate an area could mean that some people would be evacuating through toxic concentrations of chemical agent. Overestimating the time required could mean that some people would be encouraged to shelter-in-place when they would have had time to successfully evacuate. As a community's emergency response capability evolves, the time required to accomplish one or more of these actions can change. When such a change occurs, officials should consider whether the change is significant enough to warrant reconsidering the protective action decision. In other words, would the change in the time required to evacuate be large enough to produce different protective action recommendations for some population groups?

Under some conditions, the public can implement protective actions only if detection and assessment of the chemical agent release, notification of off-post officials, and decision to warn the public are accomplished very quickly. The CSEPP planning guidance stipulates time limits within which these actions must be accomplished. These time limits are ambitious and require a high level of sophistication in the chemical agent detection equipment and reporting procedures at the Army installation, the communications links between the installation and nearby communities, and the emergency protective action decision-making processes used in the off-post communities~

According to the Planning Guidance for CSEPP, personnel at the Army installation should notify appropriate off-post contact points of an actual or potential release of chemical agent within 5 minutes of initially detecting the actual or potential release. This initial notification should include the estimated chemical event emergency notification level and protective action recommendations.

Activation of the public alert and notification system also must be accomplished quickly. Appendix F of the Planning Guidance calls for the initial alert and notification process for the IRZ to be initiated within 2 minutes and completed within 8 minutes of the time a decision is made to warn the public. To ensure that as many people as possible hear and understand the warning messages quickly, CSEPP provides sophisticated systems of outdoor and indoor alert and notification devices in the IRZ and at appropriate locations in the PAZ.

Experience has shown that the public does not immediately obey a recommendation to evacuate in the face of a technological hazard. Rather, people seek information to confirm the threat and to find out how friends and family members intend to respond to the situation (Sorensen 1988; Rogers et al. 1990a, 1990b). Such delays must be considered in protective action decision making. CSEPP proposes that risk-area communities undertake an energetic public education program to persuade people of the importance of evacuating promptly when advised to do so. If such public education programs prove to be effective, protective action planners can reduce their estimate of the time required to evacuate, thus allowing evacuation to be recommended for a larger number of people.

Once the public begins to evacuate, the time required to reach safety is determined by the characteristics of the transportation system and the number of vehicles using the system. Changes in the characteristics of the transportation system (e.g., closing lanes during highway construction, opening additional lanes upon completion of the construction) affect the time required to evacuate and could lead planners to reevaluate their protective action decision.

9.2 PLANNING FOR PROTECTIVE ACTION DECISION MAKING: WHETHER TO RECOMMEND EVACUATION OR SHELTER-IN-PLACE

Protective action decisions take into account projected or actual exposure, availability of adequate shelter, evacuation time estimates, and other relevant factors. If shelter-in-place is chosen, there should be a reasonable assurance that the (1) movement of people beyond their residence/office/school would endanger the health and safety of the public *more so* than allowing them to remain in place and (2) the movement of people outside an affected area is in the best interests of their health and safety and involves minimal risk.

In reality, an evacuation decision is largely resource dependent. The availability of transportation, medical, and other resources, including shelters, can factor heavily in the protective action decision-making process. All strategies to protect the health and safety of the public from a release of hazardous chemicals are explicitly considered during emergency decision making. Each institutional facility (such as hospitals, schools, day cares, correctional facilities, or nursing homes) in the community should be considered separately to determine what special protective actions may be necessary and should be integrated into the overall plan.

Conceptually, the evacuation/shelter-in-place decision is simple and involves answering two questions (Glickman and Ujihara 1989):

- Is there enough time to evacuate?
- Will shelter-in-place provide adequate protection?

The answers to these questions indicate the appropriate response. Obviously, if the answer to one, but not both, is "yes," the appropriate response has been determined. If the answers to both are "yes," either option is satisfactory, although evacuation would be the preferred protective action under CSEPP. If, however, both questions are answered "no," emergency planners and officials face a serious problem and must consider exceptional alternatives (e.g., expedited evacuation, enhanced sheltering, or evacuation of only those persons with access to private automobiles).

While the two questions pertinent to the evacuation/shelter-in-place decision are simple, the process of answering the questions is complicated. The answer to each depends on the interaction of various pieces of information regarding the chemical and the nature of its release, the affected community, and the weather. Some of the necessary information can be gathered by the emergency planning agency before an emergency occurs; other data must be collected during the decision process following notification that a chemical agent has been (or is likely to be) released. In many cases, there is uncertainty regarding the interaction of the various types of information, and answers to the two pertinent questions are not clear-cut. Emergency planners and officials are more able to deal with this uncertainty when they have a thorough understanding of the mechanical, technical, and sociological aspects of the evacuation and shelter-in-place options.

9.2.1 Determining If There Is Enough Time to Evacuate

Determining whether enough time is available to evacuate an area or special population depends on the answers to two questions:

- How long will it be before the toxic plume reaches the area or special population?
- How long will it take to evacuate the area or special population?

Step 1: Estimate the time available before the area is contaminated.

First, the characteristics of the release and the weather conditions largely determine the time available before an area becomes contaminated. The timing of the release --when it occurred or is expected to occur -- and the distance of the release from the area being considered for evacuation are the principal release characteristics that affect the time available before contamination reaches the area. These factors, along with wind direction and wind speed, indicate which areas are likely to be contaminated by a release and how long the contamination would take to reach each area. Second, the emergency planner should consider the amount of chemical released and the rate of release to estimate the expected variation in concentration over time. Computer models are available to forecast the dispersion of contamination from a chemical release; however, current versions of the models are too complex to be of real assistance in actual emergency situations.

Step 2: Estimate the time required for evacuation.

Evacuation is a complex undertaking that requires the coordination of a wide variety of factors (see Appendix H of EPA et al. 1987). To estimate the time required to evacuate an area affected by a release of a toxic chemical, planners use various types of information, many of which can be collected beforehand. Adequate time must be allowed for all phases of the evacuation: (1)reaching a decision to evacuate, (2) mobilizing evacuation resources, (3) communicating appropriate instructions to the public, and (4)accomplishing the physical evacuation of people occupying the affected area.

The time required to reach a decision and to mobilize resources depends greatly on the quality of emergency response preplanning, although planners and decision makers must deal with some aspects specific to the situation. Research indicates that once a decision is made to protect the public, considerable time (up to one to two hours using conventional warning practices) can elapse before most people in the affected area hear, absorb, and respond to the instructions (Sorensen et al. 1987; Sorensen 1988; Glickman and Ujihara 1989). Innovative design of the alert/warning system, along with an effective public education program, reduces, but does not eliminate, the delay.

The time required to accomplish the evacuation once people are physically moving depends on the characteristics of the area and the available evacuation resources. Pertinent characteristics of the area include the size and density of the population to be evacuated, the presence of people requiring special attention (e.g., hospitals, nursing homes, prisons, handicapped, elderly, children, and transients), and the geometry and capacity of the transportation network (considering current weather conditions). Research indicates that contrary to popular belief, warning and evacuation times do not necessarily increase with population size and density, because, as these factors increase, so does the capability of the infrastructure (e.g., street system, public transportation resources) necessary for moving people out of the area (Vogt and Sorensen 1992). Crucial evacuation resources include appropriate modes of transport, personnel to guide the evacuees and facilitate the flow of traffic, and safe shelters for the evacuees. Private automobiles are the primary mode of transportation in most situations, but buses, taxis, and ambulances are often required.

9.2.2 Determining If Shelter-in-Place Will Provide Adequate Protection

Determining whether shelter-in-place will adequately protect people in an affected area for the duration of the emergency depends on the nature of the chemical agent release, meteorological conditions, the characteristics of the population affected, and the ability of available structures in the area to provide protection from outdoor chemical concentrations. The emergency planner must predict the outdoor concentration of the toxic chemical(s) that can occur in the area, estimate the concentration that results inside the buildings in which people seek shelter, and compare the indoor estimate to the level of concentration that endangers human health.

Step 1: Determine the characteristics of the release.

The type and amount of chemical agent released (or expected to be released), the rate of release, the expected changes in the rate of release, and the expected duration of the release are important considerations in evaluating the effectiveness of shelter-in-place. The amount of chemical released and the rate of release are among the determinants of the outdoor concentration that, in turn, is a determinant of the indoor concentration. The expected duration of the release is significant because shelter-in-place is most effective at reducing indoor concentrations associated with a short-term release. For a longer-term release, more of the chemical seeps into the sheltering structures, resulting in higher indoor concentrations.

Step 2: Determine potential meteorological conditions at the site.

Wind speed and direction are important in determining which areas are affected and how long it takes the contamination to reach them. Predicted weather conditions are also important to consider, as the at-risk area can increase as the weather changes. In addition, wind speed influences the ability of a structure to provide protection from contamination. The higher the wind speed, the more quickly a chemical vapor infiltrates a structure and raises concentrations to dangerous levels (Wilson 1988). Temperature is also a consideration --the greater the difference in inside and outside temperatures, the more quickly the chemical infiltrates the structures providing protection.

Step 3: Collect data on structures surrounding the facility.

Data should be gathered during the planning process on the effectiveness of protective structures in the area surrounding the chemical facility. Are there mostly older wooden frame buildings or newer more energy efficient (air-tight) houses? If the structures surrounding the chemical facility are old and in poor condition, they would probably provide little protection from a chemical vapor release because of high air exchange rates. It may be feasible, however, to implement enhanced or expedient shelter-in-place actions or charcoal filtration technology for some of the structures (see Planning Guidelines for Protective Actions and Responses for the CSEPP, Appendix E). It may also be feasible to recommend evacuation for residents in the highest risk zones and shelter-in-place for less vulnerable zones.

9.2.3 Determining If a Decision-Making Procedure Is Needed

Determining whether people should be sheltered or evacuated depends on the answers to two questions:

- Will contamination occur before people evacuate the area?
- Will shelters prevent people from receiving the same dose as if they were outdoors in the plume?

A successful evacuation removes people from the affected area and avoids exposing them to even low concentrations of the toxic chemical. An inappropriate decision to evacuate, on the other hand, can have negative consequences if it results in the population of the affected area being caught outdoors when contamination enters the area. Sheltering can be worse than evacuation if shelters are leaky, people are not told when to come out of the shelter, or the release lasts for a long time.

The planning process can help predetermine situations for which evacuation and sheltering are clearly preferred. If such an exercise results in ambiguous cases, an emergency procedure is needed to make a final choice of actions on the basis of the conditions at the time of the emergency.

9.3 USE OF PROTECTIVE ACTION MODELS IN PLANNING

The CSEPP has supported the development and/or use of a variety of models and automated management information systems for planning (and operational and response) purposes. Models are useful in planning because they allow the user to ask and answer "what if..." questions; the user can collect answers to a series of such questions and combine those answers to form new knowledge and understanding. The models force the user to explicitly identify assumptions about the chemical agent accident and the physical and social environment in which it occurs. The user can document categories of information and understanding (i.e., categories of answers) about those "what if ..." questions to guide future action.

Models are also problematic. As simplifications of reality, models can never substitute for the real thing -- some pieces of information, knowledge, and reality are inevitably missing in models. For instance, the D2PC atmospheric dispersion model is a flat terrain model and, as such, has limited ability to estimate the effect of topographic features on atmospheric dispersion of chemical agents. The models and management information systems developed for CSEPP and described below also are "imperfect" representations of the real world, but they allow the user to connect bodies of knowledge that can help in developing protective action strategy plans.

This section describes five models and management information systems --PADRE (Protective Action Dose Reduction Estimator), IDYNEV (Integrated Dynamic Network Evacuation), OREMS (Oak Ridge Evacuation Modeling System), IBS (Integrated Baseline System), and EMIS/FEMIS (Emergency Management Information System/Federal Emergency Management Information System). The section also provides information on a systems analysis performed by IEM and discusses how that information should help off-post planners develop protective action strategy plans.

Although these models and information systems allow the user to run large numbers of emergency scenarios (i.e., varying accident scenarios, meteorological conditions, warning systems, protective actions, and responses), this EPG identifies a limited number of accident categories that can be used with the models and information systems and with the guidance in Appendixes D and E of the CSEPP Planning Guidance to develop protective action strategies and plans.

9.3.1 PADRE

A software program that evolved from an earlier model called PAECE (Protective Action Evaluator for Chemical Emergencies), PADRE is an emergency planning tool developed for CSEPP. It allows planners to assess the expected reduction in dose by implementing alternative protective actions under different scenarios. PADRE evaluates the effectiveness of evacuation, sheltering, and respiratory protection. Scenarios can be specified with respect to the accident characteristics, meteorological conditions, and emergency response system.

In running PADRE, the user enters a description of the characteristics of the accident to be evaluated by inputting the type of agent involved, the amount released, and the duration of release. The user also describes the meteorological conditions at the time of the release by selecting the wind speed, atmospheric stability, and mixing height. Finally, the user describes pertinent characteristics of the emergency response system by inputting the time needed for decision makers to warn the public, the type and effectiveness of the warning system available, the time needed for the public to respond to the warning, and the type of protective action the public can implement. The user can vary these inputs to evaluate the effectiveness of different protective action options under a wide range of conditions.

Once the user has described the accident, meteorology, and emergency response system, the model is run to provide information on the effectiveness of the selected protective action. PADRE output for a simulation tells the planner:

- When the plume would arrive at a location downwind,
- When the plume would depart that location,
- The expected outdoor unprotected dose of chemical agent, and
- The reduction of dose after implementing alternative protective actions.

This information allows planners to address such questions as:

- Given a specific detailed scenario, what is the dose reduction from shelter-in-place and from evacuation? Which action provides more protection? Is the level of protection sufficient?
- How much time do officials have to make a protective action decision?
- At what wind speeds is shelter-in-place a better choice than evacuation?

- At what accident duration is shelter-in-place less preferable than evacuation?
- What traffic speed is needed in an evacuation to avoid exposure?

The major use of PADRE is in protective action planning -- deciding when to evacuate versus sheltering and what type of shelter option to use. PADRE can be used in a systematic fashion to develop a protective action decision matrix, as called for in Appendix D of the CSEPP Planning Guidance. An example format for a protective action decision matrix is shown in Figure 9.1. The Technical Planning and Evaluation training course provides more detailed instructions on PADRE.

9.3.2 IDYNEV and OREMS

Evacuation is perhaps the most viable means of protection in most regional emergencies. One of the key factors used in evaluating the effectiveness of evacuation is the estimate of time required for evacuation. The time required for evacuation is the time associated with clearing an area at risk to areas far enough away to be considered safe.

Decision Process for Planning Subzones in an Accident Involving Agent ____

If **Amount** of Release is:	AND **Duration** is:	AND **Windspeed** is:	AND **Stab. Class** is:	AND **WD** is:	THEN **Implement**	
					for Subzone	Strategy

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FIGURE 9.1 Summary Decision Matrix for All Zones

The IDYNEV and OREMS models consist of a set of computer programs that can be used to estimate evacuation time and to develop evacuation plans for different events or scenarios (e.g., good or bad weather conditions, day- or nighttime evacuations) for user-defined spatial boundaries. These models allow the user to experiment with alternative routes, destinations, traffic control and management, and evacuee response rates. IDYNEV and OREMS can help the planner identify the evacuation or clearance times, traffic operational characteristics (e.g., average speed), bottlenecks, and other information necessary to develop effective evacuation plans. All of this information can be obtained for a given section of highway, an area within the network, a sector/ring, or at any other level of spatial aggregation. Detailed information on traffic operational characteristics can also be obtained at user-specified intervals between the beginning and end of an evacuation.

IDYNEV and OREMS allow the user to input data on highways, including the highway network, traffic, geometrics, turn percentages, and traffic control. In addition, the user inputs pertinent demographic data, such as daytime and nighttime populations, special populations, number of vehicles, and vehicle occupancy rates. After these data have been entered, the models simulate traffic conditions over the transportation network as the evacuation progresses. Through simulations, the models determine the destinations selected by evacuees and the routes taken to reach the selected destinations. Through a detailed simulation of traffic operations on the evacuation network, the models allow the analyst to estimate service rates in the network by location and time, identify performance characteristics of traffic, identify bottlenecks, and estimate evacuation times across various categories (links or roads, sectors, or regions).

For each simulation, IDYNEV and OREMS display the input data and the results of the simulation. These data allow the user to analyze traffic conditions during a regional evacuation. The models produce data on a variety of measures of effectiveness at user-specified time intervals. The statistics are provided for individual roads as well as for the entire transportation network in a summary format.

9.3.3 Systems Analysis

IEM has developed and assisted in implementing systems analysis at CSEPP sites. This systems analysis is intended to provide a thorough understanding of the emergency response system at a site, emphasizing the connections between and among the various emergency response organizations (including installation, county, and state) that would respond to an accidental release of chemical agent and the affected population's response. The goals are to determine what parts of an existing response system consume more time than is available to provide maximum protection and to revise the response system to counteract that time deficiency (e.g., for some accidents, it may be necessary for the installation to alert and warn the public, bypassing off-post authorities in the interest of providing as much time as possible for the public to take appropriate protective actions). The systems analysis process has consisted of hazard analysis, response modeling, and time compression.

9.3.3.1 Hazard Analysis

The hazard analysis portion of the overall process includes identifying an accident scenario of interest, selecting meteorological inputs for running the accident scenario on D2PC, selecting a threatened area downwind from the hazard, and determining the arrival time of the plume/hazard. The accident scenario is selected by consensus of on-post and off-post personnel; typically, accident scenarios have been selected from the site's ERCP or tactical maximum credible events (MCEs) used by the installation during daily operations.

Weather profiles developed for the installations' areas are based on approximately 20 years of weather observations, the calculation of atmospheric stability associated with the data record (with assistance from ERDEC), the development of seasonal weather clusters (three for each season, including wind directions), and the development and use of average values for each season as D2PC inputs.

The time of plume/hazard arrival is determined by running D2PC and PARDOS with the selected accident and meteorological inputs. A populated area is selected as a benchmark, and the time of plume/hazard arrival at that populated area is determined. This value provides the planner with an estimate of how much time is available to protect the population.

9.3.3.2 Response Modeling

By using emergency response plans, standard operating procedures, implementing procedures, and checklists, a model of the response systems is developed. The response is modeled like a project, with a series of interconnected tasks leading toward the goal of protecting people. The software used to model the response tracks the duration of each task and its dependency on other tasks. The software calculates the time at which each task occurs, based on the duration and dependencies.

The response model includes the actions of the installation, the county agencies, and state agencies (e.g., accident detection, off-post notification, and warning dissemination). The links between the agencies are also incorporated in the model (e.g., actions by the county cannot begin until the installation has completed its off-post notification process)~

The last section of the response model incorporates the protective actions taken by the threatened population. Using information developed by ORNL, the model shows the warning spreading through the community (warning diffusion), followed by implementation of alternative protective actions (i.e., evacuate or shelter-in-place). The duration of protective action response by the population is estimated from the literature, including the evacuation time estimate studies prepared by ORNL and other emergency management literature.

9.3.3.3 Time Compression

Once the response model is completed, the time taken to protect the population is compared to the time available (i.e., the time of plume/hazard arrival as determined by the hazard analysis). If it is determined that the plume/hazard reaches the population before protective actions have been completed, it is necessary to compress the response time.

By using information from emergency management, general management, and CSEPP literature related to time issues and reducing response time, site personnel and IEM work together to develop an alternative response model. The Time Compressed Model includes possible changes in technology (e.g., fax, automated ring down, sirens, tone-alert radios, e-mail, databases, spatial analysis) or work processes (e.g., protocol for off-post notification, protective action decision making, default actions) to speed response.

9.3.3.4 Conclusion

The systems analysis helps by encouraging planners and managers to (1)organize around the main sequences of what it takes to get a job done well and on time (identifying and, where possible, eliminating bottlenecks); (2) integrate technology and processes to help people interact across distances, make decisions in advance through simulation and decision rules, and increase organizations' flexibility; and (3) create and share more information. Systems analysis and time compression help achieve the main objective in CSEPP, providing maximum protection, by starting with the fundamental limiting condition, time, and promoting the development and use of technologies and processes that keep the time needed to provide that protection to a minimu m°

9.3.4 IBS

The IBS was developed by Pacific Northwest National Laboratory and disseminated to off-site emergency management personnel by IEM. In contrast to PADRE and OREMS, which are specifically designed to assist during the planning phase of protective action strategy plan development, IBS is a computer system designed principally to help emergency managers respond to chemical events by providing tools for data management, monitoring, and analysis.

IBS provides states and counties with the ability to create and test implementing procedures related to hazards presented by the chemical stockpile and the results of implementing procedures. On a day-to-day basis, IBS links on-post emergency management systems (using EMIS) with the off-post emergency management system (IBS) (when FEMIS is completed, it will be available to both on-post and off-post emergency managers). The on-post and off-post systems need to exchange information on a daily basis so that the users of each system are aware of current conditions and planned activities. For instance, the daily work plans (i.e., daily activities involving chemical agents) at the installations result in pre-identified MCEs with associated downwind hazard distances, providing both the on-post and off-post emergency management teams with early warning of the kinds of accidental releases that are plausible on a given day. It also is important for both on-post and off-post managers to be prepared for externally initiated accidental releases (e.g., tornadoes, airplane crashes, and earthquakes), but accidents are more likely to result from handling operations, with higher probabilities and lower consequences.

In its planning dimension (as contrasted with its day-to-day operational and actual emergency event uses), emergency planners and managers can use IBS to build and maintain protective action strategy plans for particular categories of events and site conditions. Many features of the IBS are particularly useful for developing protective action strategy plans:

- *Map analysis.* Uses GISs, including the storage and retrieval of such data as roads, county boundaries, D2PC plume contours, facilities and resources, and population;

- *Hazard analysis.* Identifies hazards; sources of hazards, with emphasis on MCEs; dispersion of hazards, with D2PC dispersion model and emphasis on the use of prevailing meteorological conditions at the time of accidental release; and consequences of hazards;

- *Evacuation modeling.* Examines the role of evacuation modeling in the planning process, evacuation behavior, traffic planning concepts, and actual modeling in IBS;

- *Resource management.* Looks at resource and facility identification for allocation for emergency response;

- *Personnel management.* Describes human resources in terms of people, agencies, and positions; and

- *Scenario development.* Links D2PC hazard analysis, demographic assumptions, evacuation modeling, and implementing procedures.

Although some of these functions are also addressed by other CSEPP planning tools, IBS provides a comprehensive package or system that should help CSEPP planners by addressing the full complement of emergency planning, preparedness, and response systems composing CSEPP.

9.3.5 EMIS and FEMIS

EMIS is a software system designed for on-post use in CSEPP, although it is also used at some off-post jurisdictions. Developed by ORNL and Applied Computing Systems, Inc. (ACS), the system includes hazard prediction (D2PC), mapping, database, status board, and communications functions.

FEMIS, currently being developed by Pacific Northwest National Laboratory, is an automation system for use by both the on-post and off-post CSEPP community. FEMIS also supports continued use of EMIS through a FEMIS-to-EMIS interface. FEMIS will support planning, operations, exercises, and training with respect to emergency preparedness, emergency response, recovery/reentry, and mitigation.

Several FEMIS system requirements will be of use in planning. These include:

- Databases (e.g., population, special populations, evacuees, facilities),
- Operational spatial database (GIS),
- Resource management,
- Decision matrix (to link classes of event scenarios to protective action recommendations),
- Dispersion modeling, and
- Evacuation modeling.

10 EVACUATION TIME ESTIMATES FOR NECD AND VICINITY

An evacuation time estimate (ETE) is used to analyze the feasibility of evacuating people as a means of protection. In doing so, it estimates the time it takes for a population to evacuate an area (i.e., zone) under threat. A number of assumptions are made in the methodology that, if changed, can affect the outcome of the analysis. There are also two caveats. First, the reader is cautioned that the estimates were generated for planning purposes. Second, the ETE is for an emergency requiring evacuation of the entire zonal population and not an estimate of how long it takes an individual vehicle to move across the zone prior to the plume's arrival. If the estimates of the population at risk or the representation of the network used for analysis are altered, the ETEs will change accordingly. The ETE is discussed in greater detail in Rathi et al. (1991).

In CSEPP, zonal boundaries were determined on the basis of political and geographic features, with the spatial and temporal distributions of the hazard being the most important considerations. It is assumed that everyone in the area moves within a specific time frame (within 1 hour of notification for the IRZ and 5 hours in the PAZ), that evacuees are relatively familiar with zonal boundaries, and that evacuees use the nearest route to cross those boundaries. The reader should keep in mind that the terrain around NECD is generally rural and used for agricultural purposes and that no major population concentrations exist within the evacuation zone boundaries. More than 20 county and state roads can be used by evacuees to leave the IRZ and PAZ.

Both the chemical storage area and the proposed Chemical Stockpile Disposal Plant (CSDP) are located in the eastern part of the NECD, approximately equidistant from the installation's northern and southern boundaries. The IRZ and PAZ incorporate sections of two states, Illinois and Indiana. The NECD, located in Vermillion County, Indiana, is located approximately 38 km (24 mi) southwest of Danville, Illinois, and 42 km (26 mi) north of Terre Haute, Indiana. The nearest residential community is located approximately 4 km (2.4 mi) from the site. The outer boundary used for the NECD PAZ in the estimates is documented in Table 10.1.

The ETE study for NECD generated evacuation time estimates under certain weather conditions for daytime and nighttime hours, as well as for special events. The 1990 estimate for the total nighttime IRZ/PAZ population is approximately 59,500, of which 7,300 are located in the IRZ. The daytime IRZ/PAZ at risk population is approximately 34,800, of which 4,500 are located in the IRZ. The lower daytime totals reflect a loss of workers to surrounding counties. At the time of the analysis, approximately 320 people were employed at NECD.

The ETE consisted of the following activities:

- Creation of a database for demand estimation,

  Network representation of the existing roadway system and the creation of associated input data files, and

  Iterative application of the model itself to compute reasonable evacuation times under different scenarios and the documentation of the findings.

TABLE 10.1 NECD PAZ Outer Boundary

The NECD emergency planning zone, for this analysis, consists of two distinct areas, the PAZ and the IRZ, located in the center of the study area. The northern boundary of the PAZ parallels 1-74. Moving counterclockwise toward the south, the PAZ is bounded by U.S. 150/Illinois State Highway I until it reaches the Edgar County Airport. The boundary then continues as follows:

- Southeast along an unnamed road for approximately 4 km (2.5 mi) to another unnamed road that runs in a south-southwesterly direction;
- South-southwest along this road approximately 5.6 km (3.5 mi) to its intersection with the boundary between Hunter and Stratton townships;
- East along the township boundary to the Illinois/Indiana state line;
- South along the state line to a point where it intersects U.S. 150, which is also the county boundary between Vermillion and Vigo Counties, Indiana;
- East along the county boundary to the boundary between Raccoon and Jackson townships in Parke County, Indiana;
- North along the township boundary to a point where it meets the boundary for Montgomery Township;
- West 2.4 km (1.5 mi) to a point where the boundary between Howard and Sugar Creek Townships occurs;
- North along the boundary to the point where Indiana State Highway 341 begins;
- North following Route 341 to its intersection with Highway 136;
- East 1 km (0.6 mi) along Route 136;
- North again along Route 341 until it intersects 1-74.

10.1 DEVELOPMENT OF A DATABASE

The following information is needed to create a database to estimate times associated with major population evacuation:

- Accurate and reasonably detailed description of the highway system,
- Accurate distribution of population of the study area by location and by time of day,
- Accurate representation of vehicle utilization during an emergency under study, and
- Accurate representation of the timing of people's response to the emergency and how this timing varies by a person's location and current activity at the time that person learns of the threat.

Maps are the starting point for the database. An initial highway network was plotted on U.S. Geological Survey 1:100,000 maps. General county highway maps were acquired, and a revised highway network was plotted, which provided sufficient detail for the analysis. A field survey conducted in July 1990 recorded network link distances and determined such network link characteristics as number of lanes, pavement width, shoulder width and type, intersection lane channelization, posted speed limits, grades, attainable speed, and adjacent land use. With this information, the evacuation network representation of the roadway system for NECD was developed. The full IRZ/PAZ network for computer runs contains 80 nodes (major highway intersections or changes in road capacity or geometry), 45 traffic origination nodes, 24 destination nodes outside the PAZ outer boundary, and 90 links (i.e., unidirectional highway sections).

The locations referred to above are defined as specific trip origination nodes on the highway network database, that is, where persons are geographically located in the community when starting to evacuate. While populations are more or less continuously distributed across an area, for practical, modeling, and planning purposes, they must be loaded onto evacuation routes at a finite number of individual network access points. The access points represent the loading of local traffic onto primary and secondary highways associated with evacuation.

Demographic data were obtained from the U.S. Census, County Emergency Management Offices, school boards, and other local public and private agencies in the study area. Telephone inquiries identified special events and facilities, such as hospitals, nursing homes, prisons, and schools. Local planners may want to supplement the data used for the ETE with additional information related to transient populations.

Few data exist on vehicle utilization rates during emergency evacuations. The procedure adopted in this ETE derives reasonable vehicle utilization rates so that sensible "worst case" analysis can be carried out. Thus, 1.0 vehicle per household was used for the analysis. Free flow speeds and capacities of networks were reduced 25% throughout the network to account for bad weather conditions.

TABLE 10.2 Summary Statistics for NECD Evacuation Scenarios

Location/Scenario	Demand Data		Evacuation Time	
	Population[a]	Vehicles[b] (vphh[c] = 1.0)	100% Clearance	Average Speed (mph)
IRZ				
Night, good weather	7,300	2,800	1.5 h	48.70
Night, bad weather	7,300	2,800	1.75 h	50.04
Day, good weather	4,500	2,400	1.3 h	54.67
Day, bad weather	4,500	2,400	1.5 h	52.13
Special events, night, good weather	10,950	4,561[d]	1.5 h	45.90
IRZ/PAZ				
Night, good weather	59,700	23,500	2.5 h	21.88
Night, bad weather	59,700	23,500	2.5 h	17.47
Day, good weather	34,800	18,200	2.5 h	30.20
Day, bad weather	34,800	18,200	2.5 h	25.01
Special events, night, good weather	89,550	35,909[d]	3 h	12.20
Special events, day, good weather	89,550	27,748[d]	2.5 h	18.62

a Population for city/community is 1990 population. Additional demographic data were obtained from County Emergency Management offices, school boards, and other public and private agencies in the study area.
b Includes all the vehicles on all links within specified locations. Note that population and vehicle

loading are based on census-track centroids and not on aggregate population of a particular location. c Vehicles per

household assumed in this analysis. d Vehicle demand for special events is assumed to be 50% more than normal demand.

The major finding is that once traffic is loaded onto the network, traffic would move as fast as the speed limit allows. Of major importance to planners are

- How fast traffic is moving, and
- Where potential bottlenecks to impede movement are located on the network.

Another factor that influences evacuation times is the vehicle occupancy rate. When occupancy levels reach 2.0 or more persons per vehicle, evacuation time estimates for NECD IRZ-only evacuations are reduced noticeably.

The total time to evacuate the IRZ and IRZ/PAZ is thus not a measure of whether people are safe, because the ETE only tells how many people can be expected to leave at what level. The planner should be very careful in interpreting the results of the ETE, because it means that if some people can start to move out of the danger area ahead of the plume' s arrival, they can continue to move away from the plume at the same time or considerably faster than the plume moves as it dissipates.

The time required to evacuate is chiefly determined by assumptions regarding the loading curve, i.e., how long it takes people to get in their cars and leave. If one assumes a slow loading curve, the potential for exposure from chemical agent increases. If one assumes a rapid loading curve, the potential for exposure decreases. The major risk to people in an evacuation is departing after the plume has arrived at a location. Areas where bottlenecks can cause traffic slowdowns can lead to exposure of persons moving slower than the plume.

The nature of impediments to traffic movement is critical in planning for an evacuation. The planner should note from the ETE where the bottlenecks are likely to occur and how movement can be enhanced through directional control or where control in general is needed. Mechanisms to control or facilitate traffic include:

- Signal control,
- Traffic guides,
- Staffed roadblocks,
- Unstaffed roadblocks,
- Lane reversal, and
- Use of shoulders.

If serious congestion is predicted, other strategies may be warranted, which could include reducing the size of the sector to be evacuated or planning for a staged evacuation. The latter consists of immediately moving the people closest to the release point and sequentially moving others as distances increase from the source.

The development of traffic management strategies and the presence of traffic control guides could be useful where traffic flow is constrained and/or slowed due to an accident or other situation not readily simulated. Thus, the findings from the ETE can be utilized for enhanced traffic flow.

10.3 RELATIONSHIP TO THE EPG PLANNING PROCESS

At this time, given the planning process outlined in the EPG, the chief use of ETEs is to establish an average traffic speed for input into the PADRE evacuation dialogue box. In this case, it might be the average of the speed limits on the roads in a given planning subzone. As more integration takes place in CSEPP automation efforts, the models will exchange such information, reducing the need for planners to manually use the results of one model as input into another.

11 DEVELOPING SITE-SPECIFIC PROTECTIVE ACTION STRATEGY PLANS

A very strong if not dominant concept emerges from the emergency planning literature with respect to what planning is and is not. Stated simply, planning is an ongoing process and not a collection of paper stored in a binder sitting on a shelf. The modern version of this concept is that a plan is not merely a collection of binary information encoded on a floppy disc or hard drive.

In a sense, emergency planning is like a culture. It represents a set of shared knowledge, beliefs, and tools, with each member of the culture guided by norms as to what is proper behavior and what is not. The norms should be understood by all involved and codified as part of normal activity. Emergency responders should not need to read a plan to determine if an action is appropriate.

At an abstract level, there is general agreement on the content of an emergency plan. However, no one single way of organizing and customizing information in a plan is correct. In fact most would argue that filling out a template or a fill-in-the-blank form, goes against good planning practices. Planning should bring people together to communicate and gain an understanding of role, function, and process.

Lindell and Perry (1992) have set forth a number of principles of good emergency planning:

- Base planning on accurate knowledge of the hazard.
- Encourage appropriate actions by officials.
- Maintain flexibility.
- Focus on concepts, not details. Details should be addressed in operating procedures.
- Stress interorganizational coordination.
- Involve training.
- Involve testing.
- Be process-oriented not product-oriented.

- Withstand conflict and resistance.

- View planning as only one part of emergency response effort.

For CSEPP we can add these other principles:

- Do not let the tools overwhelm or dictate the planning process.

- When in doubt use a "common-sense" approach.

One of the chief dangers of CSEPP is to let the complexities of both the problem and the tools create a dense mass of trees that obscure the forest -- the goals of planning. While the tools and automation systems can facilitate planning, they are not the sole driving force behind a plan. Above all, a plan should make sense to those who must carry out the concepts within the plan.

11.1 PLANNING PROCESS

The general planning process should be viewed as a circular or iterative process and not a linear one. While there appear to be significant end points to reach, in fact, they are only intermediate steps in repetitive process.

The planning process for CSEPP begins with the Planning Guidance for CSEPP, along with its appendixes, which define detailed guidelines. The guidelines are designed to be somewhat flexible to accommodate differing ways of developing plans. Some people find them too prescriptive, others, not prescriptive enough.

It is extremely important to distinguish between plans and implementing procedures. A plan is a concept of operation, while procedures define the step-by-step process to implement a plan.

To develop procedures, tasks must be defined to carry out a plan. Tasks and associated Standard Operating Procedures (SOPs) contain a much greater level of detail than a plan.

For Each Functional Area, a Plan Should Address

- Who?
- Does what?
- How?
- Where?
- When?
- Why?

Standard Operating Procedures

- Define the proper steps to take in alternative situations.
- Provide a quick reference.
- Contain details appropriate to the task.
- Are written at a level appropriate for the assigned staff.
- Are supported by training.
- Provide methods to determine if workers and decision makers know and understand SOPs.
- Provide a yardstick by which performance of emergency workers and decision makers can be evaluated.

Finally, a plan needs to be tested through exercises and other means of evaluation and revised on the basis of the lessons learned from those activities. One of the more difficult aspects of planning is to revise a plan once it is on paper. It is always easier to stay with the *status quo,* even when it is in the best interest to seek change.

11.2 PLANNING AND AUTOMATION

The use of automation in all phases of emergency management has increased steadily. Computer tools have proven their worth in a number of recent disasters. This section discusses the use of automation tools in emergency management, with an emphasis on the role of such tools in planning.

11.2.1 Automation Tools in CSEPP

CSEPP has provided a number of automation tools that can be used to support both planning and emergency response activity. These tools, like any automation tools, are beneficial if they are used appropriately, and if their powers and limitations are appreciated.

Tools are useful in planning if they are used systematically, the results are analyzed in an accurate and meaningful way, and the analysis is documented in a way useful to the planning process. The use of tools often requires specialized training beyond that for general emergency planning.

CSEPP Tools Include Models and Information Systems

- D2PC - Assessment of Downwind Hazard Distances
- PADRE - Expected Dose Reduction of Alternative Scenarios and Protective Actions
- IDYNEV - Evacuation Time and Traffic Speeds
- OREMS - Evacuation Time and Traffic Speeds

- IBS - Integrated Baseline System (off~post emergency planning and response tool; includes D2PC and IDYNEV)
- EMIS - Emergency Management Information System (on-post emergency response tool; includes D2PC)
- FEMIS - Federal Emergency Management Information System (on-post and off-post tool for planning and response support; includes D2PC and will integrate the model in OREMS)

11.2.1.1 Models

Models are representations of reality. They are used to explore the behavior of systems without having to observe the system itself. In CSEPP, dispersion models and protective action models have been provided.

The D2PC model is described in detail in Chapter 7. The reader is encouraged to revisit that chapter for a discussion of the role of D2PC in emergency planning, as well as a discussion of its limitations as a model. Section 9.3 addresses the other models listed, PADRE, IDYNEV, and OREMS.

The most critical thing to remember about models is that they are always approximations of reality and always simplifications based on assumptions. The user must constantly ask whether the assumptions underlying the model in use are appropriate for the situation being modeled and apply that understanding to the results the model provides.

11.2.1.2 Information Systems

Information systems are simply systems designed to organize large amounts of information and make that information accessible in a useful format and in a timely manner. One computer technology, the GIS, has become particularly prominent in emergency management, including CSEPP. GISs represent real objects by storing their

- Locations, referenced to a coordinate system;
- Relevant attributes, such as elevation, soil type, or population; and
- Spatial relationships, describing how the objects relate to one another in terms of distance, direction, and contiguity°

One British governmental study hailed the GIS as "the biggest step forward in the history of geographic information since the invention of the map" (HMSO 1987). The GIS is especially promising in the arena of emergency management because most emergency management information is spatial in nature. A GIS helps the performance of emergency management personnel in the planning, response, and recovery phases of disaster by simplifying the management of this spatial information.

CSEPP has provided three information systems, IBS, EMIS, and FEMIS, each of which incorporates a GIS. In all three systems, the GIS is integrated with models and databases. Hence, one or more of these systems can be used for plotting D2PC plumes, displaying zones at risk, indicating areas where protective actions are in place, estimating populations in an area, locating facilities and resources, and animating dispersion or evacuation models.

11.2.2 Relationship of Planning to Automation

The relationship of planning to automation can be seen as two-fold. On one hand, automation tools can be used to support the planning process. On the other hand, the planning process should include decisions regarding how automation will be used during emergency situations. These two roles of automation, which could also be called automation's use in plan development and plan implementation, respectively, are discussed below.

11.2.2.1 Use of Automation in the Planning Process (Plan Development)

Automation has been one of the single greatest advances in emergency management planning. The capacities of automation tools are well-suited to the demands of the planning process, which seeks to assemble a vast array of information and organize and assess it to provide a better understanding of risks and potential consequences in complex systems.

Strategic planning consists of three steps: hazard analysis, capability assessment, and plan development. Automation can play a useful part in all three steps of the process.

Step 1: Hazard Analysis

Hazard analysis is supported by the use of models. The D2PC model allows the planner to gain an understanding of the range of possible hazards for which he or she must plan. Of equal importance, because a computer model can be run many times in a short period of time, the user can systematically vary dispersion cases to learn what factors are most important in shaping a hazard's potential consequences.

Step 2: Capability Assessment

Case studies have frequently pointed to problems associated with the management of information, resources, and personnel during disasters. Frequently, the equipment or expertise exists, but the person or agency in need is not aware of its availability. Past efforts to track such information (before computer technology was employed) have encountered the dilemma that such a large amount of information is burdensome to keep current and cannot be accessed or summarized quickly when needed.

Automated databases can address these concerns. Databases allow an agency to truly form a good picture of the people, information, and things available to aid in the response to a disaster. Computers can store the large amounts of data needed, while information search capabilities still allow the user to find any particular piece of needed information in a timely manner. In addition, the ability of automated systems to create summaries of the stored data provides a great benefit to planners. For instance, a planner can use a resource database to track the total number of buses in an area to support planning the evacuation of special populations.

One critical aspect of capability assessment is addressed by computer models, rather than databases. Evacuation models can be used to assess the effectiveness of the road infrastructure in allowing people at risk to exit an area quickly.

The ability to handle vast amounts of data should not automatically lead to a demand for more data. Planners should only accumulate necessary and useful information, which will lead to more accurate and/or faster decisions.

Step 3: Plan Development

In plan development, the planner must first decide which protective actions will be taken for different kinds of hazards. Section 9.2 describes this decision-making process for CSEPP. The process can be supported by evaluating the output of dispersion model and evacuation model runs to assess whether the time available to evacuate is likely to be sufficient. The planner can also apply the PADRE model to a number of scenarios to estimate the efficacy of different protective options under different situations.

The planner must then determine how a protective action will be implemented, i.e., actually produce a plan. The plan should reflect the understanding that has been gained through the use of automation. The planner can also confirm that the response goals are feasible by taking advantage of automated tools. In particular, the availability of planned resources and personnel can be checked against the appropriate databases. In addition, IBS and FEMIS allow the user to estimate task completion time for the steps in a response plan; the systems then provide an assessment of when key milestones are expected to be reached and, thus, whether those key milestones are likely to be reached quickly enough to achieve the agency's response goals.

11.2.2.2 Planning for the Use of Automation in Emergencies (Plan Implementation)

While the value of automation as an emergency planning tool is widely accepted, the proper role of automation tools during an emergency itself is more controversial. Different agencies have applied automation during emergency response with varying degrees of success. The CSEPP information systems, IBS, EMIS, and FEMIS, include a number of functions designed to be helpful during emergency response, such as electronic mail and status boards.

This planning guide does not recommend a particular strategy of automation use during emergency response activity, but the use of automation is a central question to consider in emergency response planning. An agency must have a coherent strategy for deploying automation, acquire the hardware, software, and training needed to support that strategy, and exercise its planned use of automation if it hopes to integrate these tools effectively into its emergency response processes.

11.2.3 Limitations on the Use of Automation in Planning

The use of automation tools in planning is not without its pitfalls. The tools often require specialized training beyond that for general emergency planning. Without a full understanding of the system, there is a danger of misinterpreting the information the tool provides, which can lead to poorer, rather than better, decisions. Perhaps most important, there is a tendency among people newly introduced to automation tools to lend added credibility to information merely because it is in a computerized form. A user must always remember that a tool given inappropriate input is likely to give inappropriate output, and thus the user must not trust automation uncritically.

This last pitfall is especially critical to the use of computers in emergency planning, because of the wide use of models as the basis for planning decisions. It must be remembered that models are always abstractions, or simplifications, of reality. They are more useful for comparison of alternatives than for learning exactly how something will behave. For example, an evacuation model generally is more reliable for finding which of a number of traffic control alternatives will be most effective, than for learning exactly how many minutes it will take to clear a particular area.

The ability of automation to store massive amounts of data and make that data available in a wide range of forms makes such tools invaluable to emergency planning. While the limitations of computers must be kept in mind, automation tools are a great asset if they are used systematically, the results are analyzed in an accurate and meaningful way, and the analysis is documented in a way useful to the planning process.

12 *PROTECTIVE* ACTION STRATEGIES FOR **NECD AND** VICINITY

The NECD planning community has developed the information in Table 12.1 to show the zones affected by an accidental release. The planning community's analysis assumes a semi-continuous release, with a 30 minute burn. Except where marked "None," affected zones in Illinois (IL) are yet to be determined (TBD). The zones are depicted in Figure 12.1.

TABLE 12.1 Zones Affected by an Accidental Release at NECD

Wind Direction (degrees from)	Wind Speed (mph)	No. of Ton Containers	No Effects Distance kilometers	No Effects Distance miles	Zones Affected[a]
349-11	<10	1	12.7	7.9	IN G-2; H-1,2,3; J-1,2,3; K-1,2,3 IL None
		2	19.4	12.1	IN G-2; H-1,2,3,4; J-1,2,3,4; K-1,2,3,4 IL None
		3	>20	>12.4	IN G-2; H-1,2,3,4,5; J-1,2,3,4,5; K-1,2,3,4,5 IL None
349-11	>10	1	6.3	3.9	IN G-2; H-1,2; J-1,2; K-1,2 IL None
		2	9.3	5.8	IN G-2; H-1,2; J-1,2; K-1,2 IL None
		3	11.9	7.4	IN G-2; H-1,2,3; J-1,2,3; K-1,2,3 IL None
12-33	<10	1	12.7	7.9	IN J-1,2,3; K-1,2,3; L-1,2,3 IL TBD
		2	19.4	12.1	IN J-1,2,3,4; K-1,2,3,4; L-1,2,3,4 IL TBD
		3	>20	>12.4	IN J-1,2,3,4,5; K-1,2,3,4,5; L-1,2,3,4,5 IL TBD
12-33	>10	1	6.3	3.9	IN J-1,2; K-1,2; L-1,2 IL TBD
		2	9.3	5.8	IN J-1,2; K-1,2; L-1,2 IL TBD
		3	11.9	7.4	IN J-1,2,3; K-1,2,3; L-1,2,3 IL TBD

TABLE 12.1 (Cont.)

Wind Direction (degrees from)	Wind Speed (mph)	No. of Ton Containers	No Effects Distance kilometers	No Effects Distance miles		Zones Affected[a]
34-56	<10	1	12.7	7.9	IN	K-1,2,3; L-1,2,3; M-1,2
					IL	TBD
		2	19.4	12.1	IN	K-1,2,3,4; L-1,2,3; M-1,2
					IL	TBD
		3	>20	>12.4	IN	K-1,2,3,4,5; L-1,2,3; M-1,2
					IL	TBD
34-56	>10	1	6.3	3.9	IN	K-1,2; L-1,2; M-1,2
					IL	TBD
		2	9.3	5.8	IN	K-1,2; L-1,2; M-1,2
					IL	TBD
		3	11.9	7.4	IN	K-1,2,3; L-1,2,3; M-1,2
					IL	TBD
57-79	<10	1	12.7	7.9	IN	L-1,2,3; M-1,2; N-1,2
					IL	TBD
		2	19.4	12.1	IN	L-1,2,3; M-1,2; N-1,2
					IL	TBD
		3	>20	>12.4	IN	L-1,2,3; M-1,2; N-1,2
					IL	TBD
57-79	>10	1	6.3	3.9	IN	L-1,2; M-1,2; N-1,2
					IL	TBD
		2	9.3	5.8	IN	L-1,2; M-1,2; N-1,2
					IL	TBD
		3	11.9	7.4	IN	L-1,2,3; M-1,2; N-1,2
					IL	TBD
80-101	<10	1	12.7	7.9	IN	M-1,2; N-1,2; P-1,2
					IL	TBD
		2	19.4	12.1	IN	M-1,2; N-1,2; P-1,2
					IL	TBD
		3	>20	>12.4	IN	M-1,2; N-1,2; P-1,2
					IL	TBD
80-101	>10	1	6.3	3.9	IN	M-1,2; N-1,2; P-1,2
					IL	TBD
		2	9.3	5.8	IN	M-1,2; N-1,2; P-1,2
					IL	TBD
		3	11.9	7.4	IN	M-1,2; N-1,2; P-1,2
					IL	TBD

TABLE 12.1 (Cont.)

Wind Direction (degrees from)	Wind Speed (mph)	No. of Ton Containers	No Effects Distance kilometers	miles		Zones Affected[a]
170-191	<10	1	12.7	7.9	IN	R-1,2,3; A-1,2,3; B-1,2,3
					IL	TBD
		2	19.4	12.1	IN	R-1,2,3,4; A-1,2,3,4; B-1,2,3,4
					IL	TBD
		3	>20	>12.4	IN	R-1,2,3,4,5; A-1,2,3,4,5; B-1,2,3,4,5
					IL	TBD
170-191	>10	1	6.3	3.9	IN	R-1,2; A-1,2; B-1,2
					IL	TBD
		2	9.3	5.8	IN	R-1,2; A-1,2; B-1,2
					IL	TBD
		3	11.9	7.4	IN	R-1,2,3; A-1,2,3; B-1,2,3
					IL	TBD
192-214	<10	1	12.7	7.9	IN	A-1,2,3; B-1,2,3; C-1,2,3
					IL	None
		2	19.4	12.1	IN	A-1,2,3,4; B-1,2,3,4; C-1,2,3,4
					IL	None
		3	>20	>12.4	IN	A-1,2,3,4,5; B-1,2,3,4,5; C-1,2,3,4,5
					IL	None
192-214	>10	1	6.3	3.9	IN	A-1,2; B-1,2; C-1,2
					IL	None
		2	9.3	5.8	IN	A-1,2; B-1,2; C-1,2
					IL	None
		3	11.9	7.4	IN	A-1,2,3; B-1,2,3; C-1,2,3
					IL	None
215-236	<10	1	12.7	7.9	IN	B-1,2,3; C-1,2,3; D-1,2,3
					IL	None
		2	19.4	12.1	IN	B-1,2,3,4; C-1,2,3,4; D-1,2,3,4
					IL	None
		3	>20	>12.4	IN	B-1,2,3,4,5; C-1,2,3,4,5; D-1,2,3,4,5
					IL	None
215-236	>10	1	6.3	3.9	IN	B-1,2; C-1,2; D-1,2
					IL	None
		2	9.3	5.8	IN	B-1,2; C-1,2; D-1,2
					IL	None
		3	11.9	7.4	IN	B-1,2,3; C-1,2,3; D-1,2,3
					IL	None

TABLE 12.1 (Cont.)

Wind Direction (degrees from)	Wind Speed (mph)	No. of Ton Containers	No Effects Distance kilometers	No Effects Distance miles		Zones Affected[a]
237-259	<10	1	12.7	7.9	IN	C-1,2,3; D-1,2,3; E-1,2,3
					IL	None
		2	19.4	12.1	IN	C-1,2,3,4; D-1,2,3,4; E-1,2,3,4
					IL	None
		3	>20	>12.4	IN	C-1,2,3,4,5; D-1,2,3,4,5; E-1,2,3,4,5
					IL	None
237-259	>10	1	6.3	3.9	IN	C-1,2; D-1,2; E-1,2
					IL	None
		2	9.3	5.8	IN	C-1,2; D-1,2; E-1,2
					IL	None
		3	11.9	7.4	IN	C-1,2,3; D-1,2,3; E-1,2,3
					IL	None
260-281	<10	1	12.7	7.9	IN	D-1,2,3; E-1,2,3; F-1,2,3
					IL	None
		2	19.4	12.1	IN	D-1,2,3,4; E-1,2,3,4; F-1,2,3,4
					IL	None
		3	>20	>12.4	IN	D-1,2,3,4,5; E-1,2,3,4,5; F-1,2,3,4,5
					IL	None
260-281	>10	1	6.3	3.9	IN	D-1,2; E-1,2; F-1,2
					IL	None
		2	9.3	5.8	IN	D-1,2; E-1,2; F-1,2
					IL	None
		3	11.9	7.4	IN	D-1,2,3; E-1,2,3; F-1,2,3
					IL	None
282-304	<10	1	12.7	7.9	IN	E-1,2,3; F-1,2,3; G-1,2,3
					IL	None
		2	19.4	12.1	IN	E-1,2,3,4; F-1,2,3,4; G-1,2,3,4
					IL	None
		3	>20	>12.4	IN	E-1,2,3,4,5; F-1,2,3,4,5; G-1,2,3,4,5
					IL	None
282-304	>10	1	6.3	3.9	IN	E-1,2; F-1,2; G-1,2
					IL	None
		2	9.3	5.8	IN	E-1,2; F-1,2; G-1,2
					IL	None
		3	11.9	7.4	IN	E-1,2,3; F-1,2,3; G-1,2,3
					IL	None

TABLE 12.1 (Cont.)

Wind Direction (degrees from)	Wind Speed (mph)	No. of Ton Containers	No Effects Distance kilometers	No Effects Distance miles		Zones Affected[a]
305-326	<10	1	12.7	7.9	IN	F-1,2,3; G-1,2,3; H-1,2,3
					IL	None
		2	19.4	12.1	IN	F-1,2,3,4; G-1,2,3,4; H-1,2,3,4
					IL	None
		3	>20	>12.4	IN	F-1,2,3,4,5; G-1,2,3,4,5; H-1,2,3,4,5
					IL	None
305-326	>10	1	6.3	3.9	IN	F-1,2; G-1,2; H-1,2
					IL	None
		2	9.3	5.8	IN	F-1,2; G-1,2; H-1,2
					IL	None
		3	11.9	7.4	IN	F-1,2,3; G-1,2,3; H-1,2,3
					IL	None
327-348	<10	1	12.7	7.9	IN	G-1,2,3; H-1,2,3; J-1,2,3
					IL	None
		2	19.4	12.1	IN	G-1,2,3,4; H-1,2,3,4; J-1,2,3,4
					IL	None
		3	>20	>12.4	IN	G-1,2,3,4,5; H-1,2,3,4,5; J-1,2,3,4,5
					IL	None
327-348	>10	1	6.3	3.9	IN	G-1,2; H-1,2; J-1,2
					IL	None
		2	9.3	5.8	IN	G-1,2; H-1,2; J-1,2
					IL	None
		3	11.9	7.4	IN	G-1,2,3; H-1,2,3; J-1,2,3
					IL	None

[a] IN = Indiana; IL = Illinois.

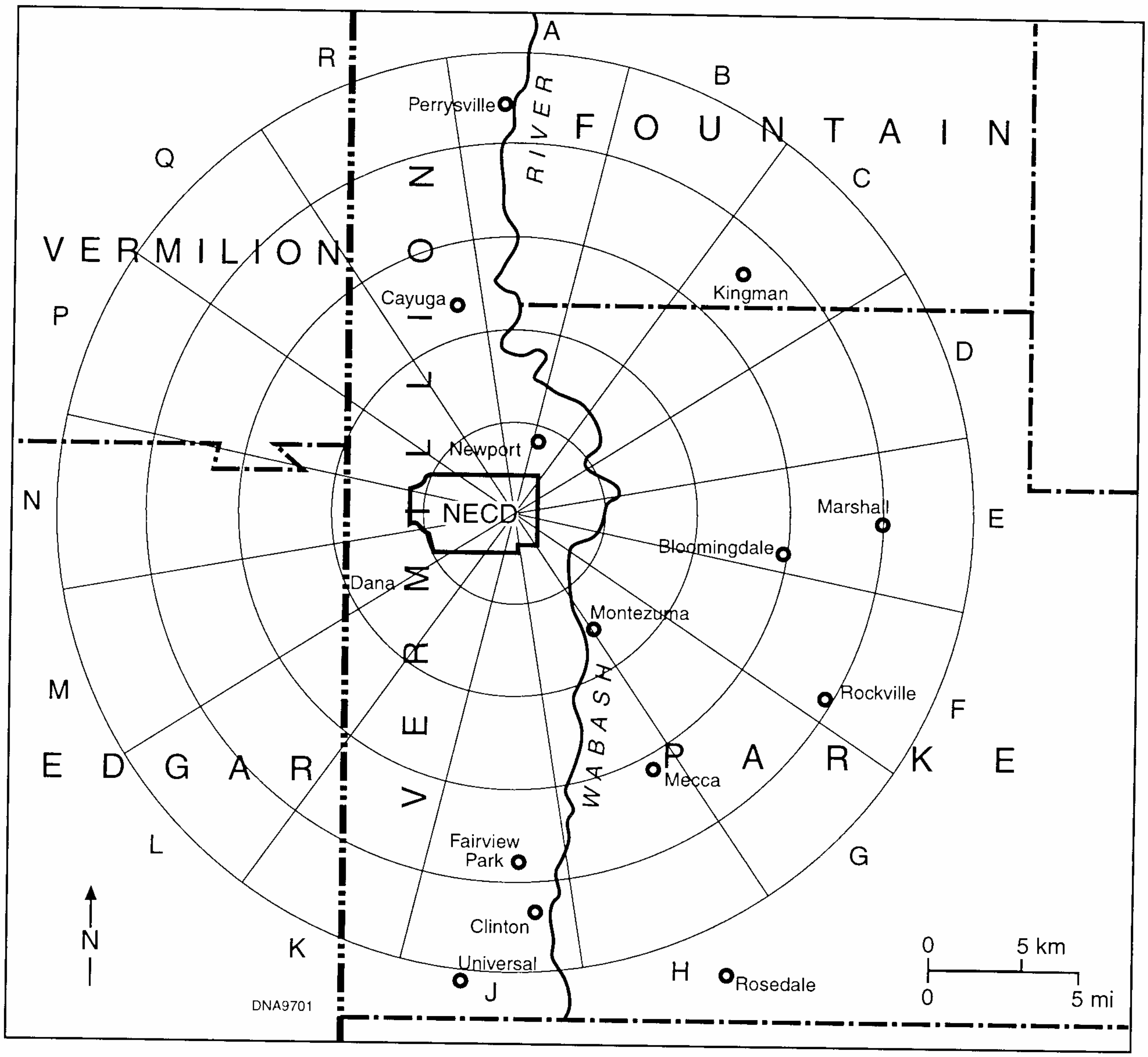

FIGURE 12.1 Diagram of Zones Affected by an Accidental Release at NECD

13 REFERENCES

Aberdeen Proving Ground, *1987, Risk Analysis of the Onsite Disposal of Chemical Munitions*, SAPEO-CDE-15-87010, Program Executive Officer -- Program Manager for Chemical Demilitarization, Aberdeen Proving Ground, Md.

Breck, J.E., 1989, "Behavior of Chemical Warfare Agents in Water: Aquatic Transport Modeling for Assessing the Potential Impacts of Accidental Releases," *The Environmental Professional* 11(4):367-375.

Carnes, S.A., J.H. Sorensen, G.O. Rogers, B.L. Shumpert, R.L. Miller, A.P. Watson, and C.V. Chester, 1989, *Emergency Response Concept Plan for Newport Army Ammunition Plant and Vicinity,* ORNL/TM-11095, Oak Ridge National Laboratory, Oak Ridge, Tenn.

City and Town Clerk's Directory, 1996, I.C.E. Miller, Donadio, and Ryan (317-236-2216), Indianapolis, Ind.

Chester, C.V., 1988, *Technical Options for Protecting Civilians from Toxic Vapors and Gases*, ORNL/TM-10423, Oak Ridge National Laboratory, prepared for the Office of Program Manager for Chemical Munitions, Aberdeen Proving Ground, Md.

Clevenger, W.F., C.J. Coomer, E.D. Copenhaver, and J.H. Sorensen, 1993, *Technical Planning and Evaluation Workbook* (Draft), ORNL/M-3096, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Dennis, R.L., 1982, "The Impact of Models on Decision Making: An Assessment of the Role of Models in Air-Quality Planning," *Mathematical Models for Planning and Controlling Air Quality, Proceedings of an lISA Workshop,* held at Oxford, England, pp. 11-22.

EPA: see U.S. Environmental Protection Agency.

ERDEC: see U.S. Army Edgewood Research, Development and Engineering Center.

Federal Emergency Management Agency, 1996, *Guide for All-Hazard Emergency Operations Planning*, State and Local Guide (SLG) 101, Sept.

Fleagle, R.G., 1980, An *Introduction to Atmospheric Physics,* 2nd ed., Academic Press, Inc., New York, N.Y.

Freeman, D.L., R.T. Egami, N.F. Robinson, and J.G. Watson, 1986, "A Method for Propagating Measurement Uncertainties through Dispersion Models, *Journal of the Air Pollution Association* 36(3):246-253.

Gifford, F.A., 1968, "An Outline of Theories of Diffusion in the Lower Layers of the Atmosphere," pp. 66-116 in *Meteorology and Atomic Energy -- 1968*, D.H. Slade (editor), U.S. Atomic Energy Commission, Washington, D.C.

Glickman, T.S., and A.M. Ujihara (editors), 1989, *Proceedings of the Conference on by-Place Protection during Chemical Emergencies*, held November 30-December 1, 1988, Resources for the Future, Center for Risk Management.

Hanna, et al., 1982, *Handbook on Atmospheric Dispersion*, DOE/TIC- 11223, U.S. Department of Energy, Washington, D.C.

Her Majesty's Stationery Office (HMSO), 1987, *Handling Geographic Information*, London, England.

Leffingwell, S.S., 1990, Results of a Workshop Meeting to Discuss Protection of Public Health and Safety during Reentry into Areas Potentially Contaminated with a Lethal Chemical Agent (GB, VX, or mustard agent). Availability announced in 55 FR 28940-28941, July 1990.

Lindell, M.K., and R.W. Perry, 1992, *Behavioral Foundations of Community Emergency Planning*, Hemisphere Publishing Corp., Washington, D.C.

Miller, R.L., and F.C. Kornegay, 1989, "Downwind Doses from Potential Releases Associated with the Chemical Stockpile Disposal Program," *The Environmental Professional* 11 (4):315-323.

Munro, N.B., K.R. Ambrose, and A.P. Watson, 1994, "Toxicity of Organophosphate Chemical Warfare Agents GA, GB, and VX: Implications for Public Protection," *Environmental Health Perspectives* 102:18-32.

Panofsky, H.A., and J.A. Dutton, 1984, *Atmospheric Turbulence, Models and Methods for Engineering Applications*, John Wiley & Sons, New York, N.Y.

Pasquill, F., 1974, *Atmospheric Diffusion*, 2nd ed., Halsted Press, John Wiley & Sons, New York, N.Y.

Rathi, A.J., Southworth, F., Venigalla, M.M., and J.M. Jacobi, 1991, *Evacuation Time Estimates for Newport Army Amnunition Depot and Vicinity*, ORNL/TM-Draft, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Rogers, G.O., and R.D. Sharp, 1990, *Protective Action Evaluator for Chemical Emergencies.' A User's Manual (MS-DOS Version 1.0)*, ORNL/TM-11594, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Rogers, G.O., A.P. Watson, J.H. Sorensen, R.D. Sharp, and S.A. Carnes, 1990a, *Evaluating Protective Actions for Chemical Agent Emergencies,* ORNL-6615, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Rogers, G.O., B.L. Shumpert, and J.H. Sorensen, 1990b, *Description of Interview Data Regarding Pittsburgh and Confluence Toxic Chemical Accidents,* ORNL/TM- 11599, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Sigal, L.L., and G.W. Suter, 1989, "Potential Effects of Chemical Agents on Terrestrial Resources," *The Environmental Professional* 11 (4):376-384.

Sorensen, J.H., 1988, *Evaluation of Warning and Protective Action Implementation Times for Chemical Weapons Accidents,* ORNL/TM-10437, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Sorensen, J.H., B.M. Vogt, and D.S. Mileti, 1987, *Evacuation: An Assessment of Planning and Research,* prepared for Federal Emergency Management Agency, RR-9.

Tolbert, V.R., and J.E. Breck, 1989, "Effects of Chemical Agent Destruction on Aquatic Resources," *The Environmental Professional* 11 (4):324-334.

USANCA: see U.S. Army Nuclear and Chemical Agency.

U.S. Army Edgewood Research, Development, and Engineering Center, 1980, Chemical Systems Laboratory Technical Report ARCSL-TR-80048, Edgewood, Md.

U.S. Army Environmental Hygiene Agency and the CSEPP Sub-Committee on Reentry Restoration, 1994, *General and Detailed Facts about Mustard Agents (H, HD, and HT); Nerve Agents GA and GB; Nerve Agent VX; and Lewisite (L),* U.S. Army Environmental Hygiene Agency, Aberdeen, Md.

U.S. Army Nuclear and Chemical Agency, 1993, *Reference Mcmual: D2PC and Hazard Analysis,* prepared by Innovative Emergency Management, Inc., and U.S. Army Edgewood Research, Development, and Engineering Center, for U.S. Army Nuclear and Chemical Agency, Springfield, Va.

U.S. Department of the Army, 1991, *Chemical Accident or Incident Response and Assistance (CAIRA) Operations,* Pamphlet 50-6.

U.S. Department of the Army, Federal Emergency Management Agency, and Oak Ridge National Laboratory, 1996, *Planning Guidance for the Chemical Stockpile Emergency Preparedness Program.*

U.S. Department of Commerce, 1996, "STAT-USA/Internet," URL http://stat-usa.gov, accessed Oct. 21, 1996.

U.S. Department of Commerce, Bureau of the Census, 1996, "U.S. Census Bureau, the Official Statistics, 1990 Census Lookup," URL http://venus.census.gov/cdrom/lookup.

U.S. Environmental Protection Agency, 1986, *Guideline on Air Quality Models* (Revised), EPA-450/2-78-027R, July.

U.S. Environmental Protection Agency, Federal Emergency Management Agency, and U.S. Department of Transportation, 1987, *Technical Guidance for Hazards Analysis: Emergency Planning for Extremely Hazardous Substances,* Dec.

Vogt, B., and J. Sorensen, 1992, *Evacuation Research.' A Reassessment,* ORNL/TM-11908, Oak Ridge National Laboratory, Oak Ridge, Tenn., Nov.

Watson, A.P., and NB. Munro, 1992, *Reentry Planning: The Technical Basis for Offsite Recovery Following Warfare Agent Contamination,* ORNL-6628, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Whitacre, C.G., J.H. Griner, M.W. Myirski, and D.W. Sloop, 1987, *Personal Computer Program for Chemical Hazard Prediction (D2PC)*, CRDEC-TR-87021, Chemical Research, Development, and Engineering Center, Aberdeen Proving Ground, Md.

Wilson, D.J., 1988, "Variation of Indoor Shelter Effectiveness Caused by Air Leakage Variability of Houses in Canada and the USA," presented at USEPA/FEMA Conference on Sheltering in Place during Chemical Emergencies, Nov. 30-Dec. 1.

PART IV: APPENDIXES

APPENDIX A:

ACRONYMS AND GLOSSARY

A.1 INTRODUCTION

During a series of meetings in Fall 1993, a group of Chemical Stockpile Emergency Preparedness Program (CSEPP) planners identified disagreements in terminology as a primary problem in CSEPP planning. They decided that a common source of definitions was needed for all program participants. As a result, Innovative Emergency Management, Inc., (IEM) was tasked to develop a glossary of common CSEPP terms. This glossary, adapted from the glossary developed by IEM, contains definitions for many terms and acronyms used in this Emergency Planning Guide (EPG).

The reader is encouraged to check the following sources for definitions that are not found in this glossary:

Department of the Army. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations.* Department of the Army Pamphlet 50-6, 1991.

Department of the Army, Federal Emergency Management Agency (FEMA), and Oak Ridge National Laboratory (ORNL). *Planning Guidance for the Chemical Stockpile Emergency Preparedness Program.* Department of the Army, FEMA, ORNL, 1996.

Federal Emergency Management Agency, *Guide for All-Hazard Emergency Operations Planning,* State and Local Guide (SLG) 101, September 1996.

A.2 CSEPP ACRONYMS

ACP	Access Control Point
acph	air change(s) per hour
ACS	Applied Computing Systems, Inc.
AEL	Airborne Exposure Limit
ANCA	Anniston Chemical Activity

ANL	Argonne National Laboratory
APBRG	Accident Planning Base Review Group
AR	Army Regulation
ARC	American Red Cross
ARES	Amateur Radio Emergency Service
ASA (IL & E)	Assistant Secretary of the Army (Installation, Logistics, and Environment)
BGCA	Blue Grass Chemical Activity
CAI	Chemical Accident or Incident
CAIRA	Chemical Accident or Incident Response and Assistance
CBDCOM	Chemical and Biological Defense Command
CDC	Centers for Disease Control
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CONUS	continental United States
CPG	Civil Preparedness Guide
CSDP	Chemical Stockpile Disposal Program
CSEPP	Chemical Stockpile Emergency Preparedness Program
D2PC	(Army computer dispersion model)
DA	Department of the Army
DCD	Deseret Chemical Depot
DCX	Direction and Control Exercise
DDESB	Department of Defense Explosive Safety Board
DHHS	Department of Health and Human Services
DNR	Department of National Resources
DOD	Department of Defense
DOE	Department of Energy
DOT	Department of Transportation
EAS	Emergency Alert System
EBS	Emergency Broadcast System
ECA	Edgewood Chemical Activity
EHF	Extremely High Frequency
EIS	Emergency Information System
EMI	Emergency Management Institute
EMIS	Emergency Management Information System
EOC	Emergency Operations Center
EOP	Emergency Operations Plan
EPA	Environmental Protection Agency
EPG	Emergency Planning Guide
EPZ	Emergency Planning Zone

ERCP	Emergency Response Concept Plan
ERDEC	Edgewood Research, Development and Engineering Center
ETE	Evacuation Time Estimate
FCC	Federal Communication Commission
FEMA	Federal Emergency Management Agency
FEMIS	Federal Emergency Management Information System
FPEIS	Final Programmatic Environmental Impact Statement
FSX	Full-Scale Exercise
GAPCAP	Generation of Assessment Patterns for Clouds of Airborne Particles
GIS	Geographic Information System
HAZMAT	Hazardous Materials
HOTMAC	Higher Order Turbulence Model for Atmospheric Circulation
HQDA	Headquarters, Department of the Army
HVA	Hazard Vulnerability Analysis
IBS	Integrated Baseline System
ICS	Incident Command System
IDLH	Immediately Dangerous to Life and Health
IDYNEV	Interactive Dynamic Evacuation model
IEM	Innovative Emergency Management, Inc.
IP	Implementing Procedure
IRZ	Immediate Response Zone
JACADS	Johnston Atoll Chemical Agent Disposal System
JIC	Joint Information Center
JIS	Joint Information System
JPIC	Joint Public Information Center
LEPC	Local Emergency Planning Committee
MCE	Maximum Credible Event
MDB	Munitions Disposal Building
MHI	Munitions Handling Igloo
MOA	Memorandum Of Agreement
MOU	Memorandum Of Understanding
MPB	Munitions Processing Bay
MPF	Metal Parts Furnace
MSDS	Material Safety Data Sheet
MSEL	Master Scenario Event List
MT	Metric Ton(s)
N/A	Not Applicable
NCP	National Contingency Plan
ND	No Deaths
NE	No Effects

NECD	Newport Chemical Depot
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
ONC	On-site Container
OREMS	Oak Ridge Evacuation Modeling System
ORNL	Oak Ridge National Laboratory
OSC	On-Scene Coordinator
OSHA	Occupational Safety and Health Administration
PAD	Protective Action Decision
PADRE	Protective Action Dose Reduction Estimator
PAECE	Protective Action Evaluator for Chemical Emergencies
PAR	Protective Action Recommendation
PARDOS	Partial Dosage model
PAZ	Protective Action Zone
PBCA	Pine Bluff Chemical Activity
PCD	Pueblo Chemical Depot
PIO	Public Information Officer
P.L.	Public Law
PNNL	Pacific Northwest National Laboratory
PPE	Personal Protective Equipment
PZ	Precautionary Zone
QRA	Quantitative Risk Assessment
RACES	Radio Amateur Civil Emergency Service
RAPTAD	Random Particle Transport and Diffusion
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendments and Reauthorization Act of 1986
SERC	State Emergency Response Commission
SOP	Standard Operating Procedure
STF	Summary Tape File
TAR	Tone Alert Radio
TBD	To Be Determined
TCP	Traffic Control Point
TIGER	Topologically Integrated Geographic Encoding and Referencing system
TTX	Tabletop Exercise
TWA	Time-Weighted Average
UHF	Ultra High Frequency
UMCD	Umatilla Chemical Depot
USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine

USDA	United States Department of Agriculture
USGS	United States Geological Survey
VFR	Visual Flight Rules
VHF	Very High Frequency

A.3 GLOSSARY

1% lethality dosage

Maximum dosage at which an individual exposed has a 1% chance of dying.

See also: no effects dosage, no deaths dosage

access

Close physical proximity to a chemical agent, container, or munition under circumstances that could provide an opportunity to acquire, release, tamper with, damage, or come in direct contact with the chemical agent.

Source: Department of the Army. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations.* Department of the Army Pamphlet 50-6, 1991.

access control point

A location staffed to restrict the entry of unauthorized personnel into a risk area. Access control is normally performed just outside of the risk area. It involves the deployment of vehicles, barricades, or other measures to deny access to a particular area.

See also: traffic control point

Source: Department of the Army, Federal Emergency Management Agency (FEMA), and Oak Ridge National Laboratory (ORNL). *Planning Guidance for the Chemical Stockpile Emergency Preparedness Program.* Department of the Army, FEMA, ORNL, 1996.

accountability

The obligation to keep accurate records of property, documents, or funds. Accountability is concerned primarily with records and does not necessarily imply actual possession.

activity

A related set of chemical agent operations performed on post. Information on the activity is expected to be transferred periodically to off-post agencies in a work plan. For example, the operation of maintenance could include activities such as load, transport, and inspect.

aerosol

Airborne solid or liquid substances classified as dusts, fumes, smokes, mists, and fogs according to their physical nature, particle size, and method of generation. Particle size may vary from 100 micrometers to 0.01 micrometers in diameter.

Source: USACHPPM, *Glossary of Terms for Chemical Agents and Chemical Defense Equipment,* December 1994.

alert

Stimulation of one or more of the senses, usually those of hearing and/or sight.

Source: Jacobs Engineering Group. *Emergency Response Concept Plan for the Chemical Stockpile Disposal Program.* Jacobs Engineering Group, 1987.

Army Protective Action Recommendation (PAR)

Protective Action Recommendation provided by the Army to an organization legally responsible for making a protective action decision. A PAR associated with the current work plan is expected to be provided by the chemical stockpile installation to the off post emergency management organizations. A PAR is also expected to be provided by the chemical stockpile installation during a response to a chemical accident or incident.

atmospheric stability (low level)

This is a relative classification of the mixing of the air near the surface. This mixing has been measured as a standard deviation of wind direction changes or, in a more direct way, as the difference in air temperature at two reference heights (temperature gradient between 0.5 and 4 meters). Low stability is associated with smaller downwind hazard distances.

Source: Whitacre, C. Glenvil, et al. *Personal Computer Program for Chemical Hazard Prediction (D2PC)*. Chemical Research, Development and Engineering Center, 1987.

baseline

The original plan or design, plus or minus changes made as a result of changes in scope. It is the standard against which performance is judged.

casualty

A person injured or killed.

chemical accident/incident (CAI)

Chemical events involving chemical surety materiel. A chemical accident refers to a chemical event resulting from nondeliberate acts, where safety is of primary concern. A chemical incident refers to a chemical event resulting from deliberate acts (terrorism or criminal), where security is of concern.

See also: chemical event

Source: Department of the Army. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations.* Department of the Army Pamphlet 50-6, 1991.

chemical agent

A chemical substance that is intended for use in military operations to kill, seriously injure, or incapacitate a person through its physiological effects. Excluded from consideration are riot-control agents, chemical herbicides, smoke, and flame.

Source: Department of the Army. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations.* Department of the Army Pamphlet 50-6, 1991.

chemical event

A term that applies to the following: (a) chemical agent leaks of munitions in the chemical event stockpile; (b) discovery of an actual or suspected chemical agent munition or container that may require emergency transportation and/or disposal; (c) any release of chemical agent to the environment outside of closed systems, facilities, or devices greater than established U.S. Army Surgeon General 8-hour time-weighted average Airborne Exposure Limits (AELs), or release resulting in personnel exhibiting clinical signs or symptoms of chemical agent exposure; (d) any exposure or release of agent that does not exceed established U.S. Army Surgeon General Airborne Exposure Limits, but nonetheless is receiving media attention; (e) any deliberate release of chemical agent resulting from a terrorist or criminal act; (f) loss of chemical surety materiel (other than deliberate destruction by approved, authorized laboratory and demilitarization processes, including training expenditures).

See also: chemical accident/incident

Source: Department of the Army. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations.* Department of the Army Pamphlet 50-6, 1991.

chemical event emergency notification system

A joint (depot/off-post) system of emergency notification of chemical events for off-post response. If a release of chemical agents happens, immediate action must be taken to notify and protect personnel in the predicted hazard area. The decision criteria whether to begin the notification procedure will be based on predicted dosage and distance. The predicted downwind distance of the chemical agent no-effect dosage will be the specific criteria used. The system consists of a minimum of three surety emergency levels and one nonsurety event level. For emergency response purposes, these levels will be identified as nonsurety emergency, limited-area emergency, post-only emergency, and community emergency.

See also: nonsurety emergency, limited-area emergency, post-only emergency, community emergency

Adapted from: Department of the Army. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations.* Department of the Army Pamphlet 50-6, 1991.

chemical operation

A specific action performed on the chemical stockpile. Each operation has an associated set of accidents or incidents that are considered feasible. Several operations constitute one chemical activity. A chemical operation can be described by the following characteristics (not an exhaustive list): name of agent, munition, and quantity of agent/munitions involved. Specific instances of chemical operations may include information on start/end times, location of operation, number of workers involved, and related accidents or incidents.

community emergency

Events are likely to occur or have occurred that involve agent release with chemical effects beyond the installation boundary. The community emergency level will be declared when the predicted chemical agent no-effects dosage extends beyond the installation boundary.

Source: Department of the Army. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations.* Department of the Army Pamphlet 50-6, 1991.

concentration

This is the quantity of a vapor or aerosol suspended in a volume of air.

Source: Whitacre, C. Glenvil, et al. *Personal Computer Program for Chemical Hazard Prediction (D2PC).* Chemical Research, Development and Engineering Center, 1987.

concept of operations

Describes the system of personnel, facilities, and communications through which jurisdictions or installations are able to plan, manage, and exercise to meet emergency management goals. It lists the major entities involved, the relationship of the entities to each other, and the responsibilities assigned to each entity under each emergency management phase. It is important to specify whether the coordination of various entities is through direct control by a specific agency, through Mutual Aid Agreements, or through legislative or administrative rules. The concept of operations should include a broad concept of how operations will be managed, resourced, and conducted. For example, the Army's system is organized along the principles of centralized control and decentralized execution.

Source: Department of the Army. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations.* Department of the Army Pamphlet 50-6, 1991.

CSEPP site

The jurisdictions composing an Army chemical stockpile installation where chemical stockpile munitions are stored, the surrounding counties and cities within the immediate response and protective action zones, and any states that include all or part of the emergency planning zones.

Source: Department of the Army. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations.* Department of the Army Pamphlet 50-6, 1991.

CSEPP site personnel

Emergency management and other personnel involved in planning for and response to chemical accidents or incidents at a CSEPP site.

D2PC

A dispersion model developed by the Army to estimate downwind hazard distances from releases of chemical agents.

Source: Department of the Army, Federal Emergency Management Agency (FEMA), and Oak Ridge National Laboratory (ORNL). *Planning Guidance for the Chemical Stockpile Emergency Preparedness Program.* Department of the Army, FEMA, ORNL, 1996.

daily work plan

A list of planned activities dealing with chemical weapons. These activities will be carried out by the Army chemical stockpile installation. Information contained in the daily work plan is expected to include description of the activity, agent and munition involved, number of persons in the work team, and the start and stop time.

decision matrix

A device designed to organize protective action strategies by using such factors as release characteristics, meteorological conditions, population characteristics, and affected geographic areas.

Source: Oak Ridge National Laboratory. *Functional Requirements for the Chemical Stockpile Emergency Preparedness Program Automated Emergency Management Information System.* Oak Ridge National Laboratory, September, 1992.

decontamination

The process of decreasing the amount of chemical agent on any person, object, or area by absorbing, neutralizing, destroying, ventilating, or removing chemical agents.

Source: Department of the Army. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations.* Department of the Army Pamphlet 50-6, 1991.

demilitarization

The mutilation, destruction, or neutralization of chemical surety materiel, rendering it harmless and ineffectual for military purposes.

Source: Department of the Army. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations.* Department of the Army Pamphlet 50-6, 1991.

disaster

An event that causes much suffering or loss; great misfortune.

Source: Barnhart, Clarence L., and Barnhart, Robert K., eds. *The World Book Dictionary*. Doubleday, 1979.

See also: major disaster

discrete receptor

A location of specific interest for dispersion modeling.

See also: facility

dosage

Dosage is the integration of concentration in mg/m^3 and time in minutes, also referred to as Ct. This is a mathematical concept that makes a useful exposure index to vapors and small aerosols that can be absorbed by inhalation. When the dosage is multiplied by a breathing rate and retention efficiency, the result is an inhaled dose.

See also: dose

Source: Whitacre, C. Glenvil, et al. *Personal Computer Program for Chemical Hazard Prediction (D2PC).* Chemical Research, Development and Engineering Center, 1987.

dose

Dose is the quantity of a substance taken into the body or placed on the body surface or clothing.

See also: dosage

Source: Whitacre, C. Glenvil, et al. *Personal Computer Program for Chemical Hazard Prediction (D2PC).* Chemical Research, Development and Engineering Center, 1987.

electronic plan

An emergency operating procedure in electronic format.

emergency

A rare and unexpected situation with potential for significant loss of life, property, or mission accomplishment.

Source: USACHPPM, *Glossary of Terms for Chemical Agents and Chemical Defense Equipment,* December 1994.

emergency operations center (EOC)

The location or facility where responsible officials gather during an emergency to direct and coordinate emergency operations, to communicate with other jurisdictions and with field emergency forces, and to formulate protective action decisions.

Source: Department of the Army, Federal Emergency Management Agency, and Oak Ridge National Laboratory. *Planning Guidance for the Chemical Stockpile Emergency Preparedness Program.* Department of the Army, FEMA, ORNL, 1996.

Emergency Operations Plan (EOP)

A document that describes how people and property will be protected in disaster or disaster threat situations; details who is responsible for carrying out specific actions; identifies the personnel, equipment, facilities, supplies, and other resources available for use in the disaster; and outlines how all actions will be coordinated.

Source: Federal Emergency Management Agency. *Guide for All-Hazard Emergency Operations Planning*, State and Local Guide (SLG) 101, September 1996.

*Emergency Planning **Zone** (EPZ)*

The geographical area delineated around a potential hazard generator that defines the potential area of impact. Zones facilitate planning for the protection of people during an emergency.

See also: Immediate Response Zone, Protective Action Zone, Precautionary Zone

Source: Department of the Army, Federal Emergency Management Agency, and Oak Ridge National Laboratory. *Planning Guidance for tile Chemical Stockpile Emergency Preparedness Program.* Department of the Army, FEMA, ORNL, 1996.

emergency preparedness plan

See Emergency Operations Plan.

emergency responder

Someone who attempts to protect and restore life, property, and/or the environment in the aftermath of an emergency. Includes full-time and volunteer personnel with specific positions, skills, and training.

enhanced sheltering

Taking refuge in structures in which infiltration has been reduced via weatherization techniques before the occurrence of accidents.

Source: Rogers, G.O., et al. *Evaluating Protective Actions for Chemical Agent Emergencies.* Oak Ridge National Laboratory, 1990.

environment (from the National Contingency Plan [NCP])

The navigable waters, the waters of the continuous zone, and the ocean waters of which the natural resources are under the exclusive management authority of the United States under the Magnuson Fishery Conservation and Management Act; and any other surface water, groundwater, drinking water supply, land surface or subsurface strata, or ambient air within the United States or under the jurisdiction of the United States.

Source: Department of the Army. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations.* Department of the Army Pamphlet 50-6, 1991.

evacuation

A protective action that involves leaving an area of risk until the hazard has passed and the area is declared safe for return.

Source: Department of the Army, Federal Emergency Management Agency, and Oak Ridge National Laboratory. *Planning Guidance for the Chemical Stockpile Emergency Preparedness Program.* Department of the Army, FEMA, ORNL, 1996.

expedient sheltering

Taking refuge in existing structures that are modified at the time of an accident to reduce infiltration by using common resources and materials, such as plastic bags, tape, and wet towels.

Source: Rogers, G.O., et al. *Evaluating Protective Actions for Chemical Agent Emergencies*. Oak Ridge National Laboratory, 1990.

facility

A place built or set aside to provide a special service.

Source: Bamhart, Clarence L., and Barnhart, Robert K., eds. *The World Book Dictionary*. Doubleday, 1979.

facility (from the National Contingency Plan)

Any building, structure, installation, equipment, pipe or pipeline (including any pipe into a sewer or publicly owned treatment works), well, pit, pond, lagoon, impoundment, ditch, landfill, storage container, motor vehicle, rolling stock, or aircraft, or any site or area where a hazardous substance has been deposited, stored, disposed of, or placed, or otherwise come to be located, but does not include any consumer product in consumer use or any vessel.

Source: Department of the Army. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations.* Department of the Army Pamphlet 50-6, 1991.

first responder

The first emergency responders to arrive on the scene of an emergency.

guidance

Information necessary or helpful for the successful completion of a task.

hazard

A chemical or physical condition that has the potential for causing damage to people, property, or the environment.

Source: Center for Chemical Process Safety. *Guidelines for Chemical Process Quantitative Risk Analysis.* American Institute of Chemical Engineers, 1989.

hazard analysis

Identifying the potential hazards associated with, or inherent in, a given process. Qualitative hazard analysis considers events independent of their probability of occurrence. Quantitative hazard analysis considers the relative probability of different catastrophic events.

See also: hazard vulnerability analysis, risk analysis

Source: Greenberg, Harris R., and Cramer, Joseph J. *Risk Assessment and Risk Management for the Chemical Process Industry.* Van Nostrand Reinhold, 1991.

hazard vulnerability analysis (HVA)

A document that identifies how people, property, and structures might be damaged by a disastrous event. A hazard vulnerability analysis considers consequences, whereas a hazard analysis does not.

Source: Federal Emergency Management Agency. *Emergency Program Manager.' An Orientation to the Position.* November 1983.

igloo

An earth-covered structure used to store ammunition.

Immediate Response Zone (IRZ)

The planning zone immediately surrounding each Army installation. This zone encompasses an area requiring less than one hour response time when affected by an

hazard

A chemical or physical condition that has the potential for causing damage to people, property, or the environment.

Source: Center for Chemical Process Safety. *Guidelines for Chemical Process Quantitative Risk Analysis.* American Institute of Chemical Engineers, 1989.

hazard analysis

Identifying the potential hazards associated with, or inherent in, a given process. Qualitative hazard analysis considers events independent of their probability of occurrence. Quantitative hazard analysis considers the relative probability of different catastrophic events.

See also: hazard vulnerability analysis, risk analysis

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Source: Federal Emergency Management Agency. *Emergency Program Manager: An Orientation to the Position.* November 1983.

igloo

An earth-covered structure used to store ammunition.

Immediate Response Zone (IRZ)

The planning zone immediately surrounding each Army installation. This zone encompasses an area requiring less than one hour response time when affected by an agent release under "typical" weather conditions. The IRZ extends to approximately 10 to 15 km (6 to 9 miles) from the potential chemical event source.

impact time

The time at which an area is first affected by a chemical agent release.

in-place sheltering

Also known as in-place protection, in-place sheltering involves taking refuge in various kinds of structures. Five types of sheltering have been identified to be of interest for protection from chemical agents: normal, expedient, enhanced, specialized, and pressurized.

See also: normal sheltering, expedient sheltering, enhanced sheltering, specialized sheltering, pressurized sheltering

Source: Rogers, G.O., et al. *Evaluating Protective Actions for Chemical Agent Emergencies.* Oak Ridge National Laboratory, 1990.

jurisdiction

The territory over which authority extends.

Source: Barnhart, Clarence L., and Barnhart, Robert K., eds. *The World Book Dictionary.* Doubleday, 1979.

limited area

The area immediately surrounding one or more exclusion areas. Normally, the area between the boundaries of the exclusion area and the perimeter boundary.

Source: Department of the Army. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations.* Department of the Army Pamphlet 50-6, 1991.

limited area emergency

Events are likely to occur or have occurred that involve agent release outside engineering controls or approved chemical storage facilities with chemical effects expected to be confined to the chemical limited area. This level will be declared when the predicted chemical agent no-effects dosage does not extend beyond the chemical limited area where the event occurred.

Source: Department of the Army. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations.* Department of the Army Pamphlet 50-6, 1991.

liquid droplets

Agent particles that are larger than aerosol particles, specifically, over 20 microns in diameter.

major disaster

(For the purposes of Public Law [P.L.] 93-288 as amended by P.L. 100-707) "major disaster" means any natural catastrophe (including any hurricane, tornado, storm, high water, winddriven water, tidal wave, tsunami, earthquake, volcanic eruption, landslide, mudslide, snowstorm, or drought), or, regardless of cause, any fire, flood, or explosion, in any part of the United States, which in the determination of the President causes damage of sufficient severity and magnitude to warrant major disaster assistance under this Act to supplement the efforts and available resources of States, local governments, and disaster relief organizations in alleviating the damage, loss, hardship, or suffering caused thereby

Source: P.L. 93-288 as amended by P.L. 100-707

mass care center

A facility for providing emergency lodging and care for people made temporarily homeless by an emergency. Essential basic services (feeding, family reunification, etc.) are provided.

See also: reception center

Source: Department of the Army, Federal Emergency Management Agency, and Oak Ridge National Laboratory. *Planning Guidance for the Chemical Stockpile Emergency Preparedness Program.* Department of the Army, FEMA, ORNL, 1996.

maximum credible event (MCE)

The worst single event that could occur at any time with maximal release of chemical agent from a munition, bulk container, or process as a result of an unintended, unplanned, or accidental occurrence. The event must be realistic with reasonable probability of occurrence.

Source: Department of the Army. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations.* Department of the Army Pamphlet 50-6, 1991.

mg-min/m^3

Milligram minutes per cubic meter. These units are used to measure dosage, which is determined using not only concentration of agent, but also duration of exposure.

mg/m^3

Milligrams per cubic meter. These units are used to measure agent concentration.

model case

The input and output files associated with one run of a dispersion, evacuation, protective action, or other model.

mustard agent

The vesicant agents (H, HD, and HT) that cause blistering. In sufficient quantities, they can be fatal if not quickly removed from exposed skin or if they are inhaled.

Source: Department of the Army, Federal Emergency Management Agency, and Oak Ridge National Laboratory. *Planning Guidance for the Chemical Stockpile Emergency Preparedness Program.* Department of the Army, FEMA, ORNL, 1996.

nerve agent

The nerve agents (GA, GB, and VX) are lethal colorless, odorless, and tasteless agents that can be fatal upon skin contact or when inhaled. These agents attack the central nervous system by inhibiting the production of acetylcholinesterase, which is essential for proper operation of the nervous system.

Source: Department of the Army, Federal Emergency Management Agency, and Oak Ridge National Laboratory. *Planning Guidance for the Chemical Stockpile Emergency Preparedness Program.* Department of the Army, FEMA, ORNL, 1996.

no deaths dosage

The largest dosage that would result in no fatalities to healthy adults.

See also: no effects dosage, 1% lethality dosage

Source: Baronian, Charles, et al. *Chemical Stockpile Disposal Program Final Programmatic Environmental Impact Statement,* Vol. 1 (Sects. 1-8). Department of the Army, Program Executive Officer--Program Manager for Chemical Demilitarization, 1988.

no effects dosage

A calculated dosage from a chemical agent release below which a toxicity level is not expected to have short-term adverse effects on humans.

See also: no deaths dosage, 1% lethality dosage

Adapted from: Department of the Army, Federal Emergency Management Agency, and Oak Ridge National Laboratory. *Planning Guidance for the Chemical Stockpile Emergency Preparedness Program.* Department of the Army, FEMA, ORNL, 1996.

nonsurety emergency

Events are likely to occur or have occurred that may be perceived as a chemical surety emergency or that may be of general public interest, but which pose no chemical surety hazard. This includes nonsurety material emergencies.

Source: Department of the Army. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations.* Department of the Army Pamphlet 50-6, 1991.

normal sheltering

Taking refuge in existing, unmodified buildings.

Source: Rogers, G.O., et al. *Evaluating Protective Actions for Chemical Agent £mergencies.* Oak Ridge National Laboratory, 1990.

notification

Following the alerting phase, information on the nature of the emergency and recommended protective actions are communicated in the notification phase.
Adapted from: Jacobs Engineering Group. *Emergency Response Concept Plan for the Chemical Stockpile Disposal Program.* Jacobs Engineering Group, 1987.

off-post

The area surrounding a military installation or facility.

Source: Department of the Army. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations.* Department of the Army Pamphlet 50-6, 1991.

off-site

The area surrounding the on-site area.

Source: Department of the Army. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations.* Department of the Army Pamphlet 50-6, 1991.

on-post

A military installation or facility.

Source: Department of the Army. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations.* Department of the Army Pamphlet 50-6, 1991.

on-site

An area around the scene of a chemical agent under the operational control of the OSC, technical escort officer, or the commander of the Initial Response Force, or the Service Response Force. It includes any area established as a National Defense Area.

Source: Department of the Army. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations.* Department of the Army Pamphlet 50-6, 1991.

phase

One of the changing states of activity of emergency management. The phases of emergency management are preparedness (also known as readiness), response, recovery, and mitigation.

plume

Effluent cloud resulting from a continuous source release.

Source: U.S. Environmental Protection Agency (EPA), Federal Emergency Management Agency, U.S. Department of Transportation (DOT). *Technical Guidance for Hazards Analysis: Emergency Planning for Extremely Hazardous Substances.* EPA, FEMA, DOT, 1987.

plume/track

The geographic representation of the output of a dispersion model.

post only emergency

Events are likely to occur or have occurred that involve agent release with chemical effects beyond the chemical limited area. Releases are not expected to present a danger to the off-post public. This level will be declared when the predicted chemical agent no-effects dosage extends beyond the chemical limited area but does not extend beyond the installation boundary.

Source: Department of the Army. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations.* Department of the Army Pamphlet 50-6, 1991

Precautionary Zone (PZ)

The outermost zone extending beyond the protective action zone. Theoretically, it has no limits. Practically, its furthest point is that beyond which emergency planning for the CSEPP would not be required under most conditions.

Source: Department of the Army, Federal Emergency Management Agency, and Oak Ridge National Laboratory. *Planning Guidance for the Chemical Stockpile Emergency Preparedness Program.* Department of the Army, FEMA, ORNL, 1994.

preparedness

Preparedness is a phase of emergency management, also sometimes referred to as readiness. It involves planning how to respond in case an emergency or disaster occurs and working to increase resources available to respond effectively.

pressurized sheltering

Consists of people taking refuge in existing or specially constructed structures that are pressurized to replace infiltration of toxic vapors with the infiltration of filtered air.

Source: Rogers, G.O., et al. *Evaluating Protective Actions for Chemical Agent Emergencies.* Oak Ridge National Laboratory, 1990.

Protective Action Decision (PAD)

The protective action(s) chosen to be implemented by an emergency management organization.

Protective Action Recommendation (PAR)

Action(s) recommended by the Army to protect the community from the effects of a chemical accident or incident.

Protective Action Zone (PAZ)

The zone beyond the Immediate Response Zone. The PAZ is in an area that extends beyond the IRZ to approximately 15 to 50 km (10 to 30 miles) from the potential chemical event location, depending on the stockpile and site characteristics. The PAZ is that area where public protective actions may still be necessary in case of an accidental release of chemical agent, but where available warning and response time is such that most people could evacuate.

Quantitative Risk Assessment (QRA)

QRAs are being performed in two phases for each chemical agent disposal facility prior to operation. In Phase 1, the probabilities and public health consequences of potential accidental releases of chemical agent associated with facility operations are being estimated, and the public risk associated with continued storage of chemical munitions is being assessed. The Phase 2 QRAs will be completed when plans for individual sites are finalized. They will be comprehensive assessments of risks, including estimation of worker risks associated with agent operations and explicit evaluation of uncertainty.

Source: Science Applications International Corporation. *Anniston Chemical Agent Disposal Facility Phase 1 Quantitative Risk Assessment.* Report No. SAIC-95/2542, prepared for U.S. Army Program Manager for Chemical Demilitarization, Edgewood, Md., February 1996.

readiness

During the readiness phase, Army emergency response forces prepare and coordinate appropriate response plans. They also establish organizations to execute plans, train personnel and organizations to the required level of proficiency, evaluate the response organization's ability to execute plans, and educate the public to the potential threat, including emergency response procedures.

Source: Department of the Army. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations.* Department of the Army Pamphlet 50-6, 1991.

reception center

There are two primary components of an evacuee support system: reception and mass care. Reception is the process of receiving evacuees, determining their needs (i.e., medical, housing, family reunification, etc.) and assigning them to appropriate resources. The more structured approach calls for evacuees to report to a reception center located on a main evacuation route, have their needs determined, and be referred to a mass care center or other appropriate facility.

See also: mass care center

Source: Department of the Army, Federal Emergency Management Agency, and Oak Ridge National Laboratory. *Planning Guidance for the Chemical Stockpile Emergency Preparedness Program.* Department of the Army, FEMA, ORNL, 1992.

recovery

The final phase of the emergency management cycle. Recovery continues until all systems return to normal, or near normal. Short-term recovery returns vital life support systems to minimum operating standards. Long-term recovery from a disaster may go on for years, until the entire disaster area is completely redeveloped, either as it was in the past or for entirely new purposes that are less disaster-prone.

Source: FEMA. *Emergency Program Manager: An Orientation to the Position.* FEMA, November 1983.

release (from the National Contingency Plan)

Any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment (including the abandonment or discarding of barrels, containers, and other closed receptacles containing any hazardous substance or pollutant or contaminant). For purposes of the NCP, release also means threat of release. Excluded will be any release that results in exposure to persons solely within a workplace, with respect to a claim such persons may assert against the employer of such persons.

Source: Department of the Army. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations.* Department of the Army Pamphlet 50-6, 1991.

respond or response (from the National Contingency Plan)

Remove, removal, remedy, or remedial action, including enforcement activities related thereto, as defined by section 101(25) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

Source: Department of the Army. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations.* Department of the Army Pamphlet 50-6, *1991*.

response

"Emergency response" or "responding to emergencies" means a response effort by employees from outside the immediate release area or by other designated responders (i.e., mutual-aid groups, local fire departments, etc.) to an occurrence which results, or is likely to result, in an uncontrolled release of a hazardous substance. Responses to incidental releases of hazardous substances where the substance can be absorbed, neutralized, or otherwise controlled at the time of release by employees in the immediate release area, or by maintenance personnel are not considered to be emergency responses within the scope of this standard. Responses to releases of hazardous substances where there is no potential safety or health hazard (i.e., fire, explosion, or chemical exposure) are not considered to be emergency responses.

Source: Occupational Safety and Health Administration. "Hazardous Waste Operations and Emergency Response." *Federal Register* 54 (42), 1989.

risk analysis

The development of a quantitative estimate of risk based on engineering evaluation and mathematical techniques for combining estimates of incident consequences and frequencies.

See also: hazard analysis

Source: Center for Chemical Process Safety. *Guidelines for Chemical Process Quantitative Risk Analysis.* American Institute of Chemical Engineers, 1989.

scenario

An accident scenario is a specific sequence of events that causes a release of chemical agent, together with the quantity, mode, and duration of release, and meteorological conditions at the time of release. For purposes of protective action strategy planning, accident scenarios are grouped into accident categories (see Section 8 of this EPG).

scenario table

A table stored by the Integrated Baseline System (IBS), each of whose entries represents a unique combination of D2PC model case, the Interactive Dynamic Evaluation model (IDYNEV) evacuation case, meteorological conditions, and population pattern. An implementing procedure may be selected for each combination in the table.

Source: B. Bailey, et al. *Integrated Baseline System (1BS) Version 2.0 User Guide.* PNL, December 1993.

sheltering

A protective action that involves taking cover in a building that can be made relatively airtight. Generally, any building suitable for winter habitation will provide some protection with windows and doors closed and heating, ventilation, and air conditioning systems turned off. Effectiveness can be increased by such methods as using an interior room or basement, taping doors or windows, and employing other systems to limit natural ventilation.

Source: Department of the Army, Federal Emergency Management Agency, and Oak Ridge National Laboratory. *Planning Guidance for the Chemical Stockpile Emergency Preparedness Program.* Department of the Army, FEMA, ORNL, 1996.

source term

The quantity and mode of chemical agent release.

Source: Center for Chemical Process Safety, *Guidelines for Chemical Process Quantitative Risk Analysis*, American Institute of Chemical Engineers, 1989.

special facility

A facility of particular interest for emergency management, such as a school or hospital.

specialized sheltering

Commercial tents or structures explicitly designed for protection in chemical environments.

Source: Rogers, G.O., et al. *Evaluating Protective Actions for Chemical Agent Emergencies*. Oak Ridge National Laboratory, 1990.

standard

Anything taken as a basis of comparison; level or degree of excellence considered as a goal or as adequate; model.

Source: Barnhart, Clarence L., and Barnhart, Robert K., eds. *The World Book Dictionary*. Doubleday, 1979.

task

An activity that is carried out in an effort to achieve a goal.

time of impact

The time at which an area is first affected by a chemical agent release.

time-weighted average

A time-integral of the instantaneous exposure (such as the cumulative concentration) divided by the length of time for the exposure period. There are basically four methods for estimating time-weighted average exposure. Adequate distribution models must be used to represent the exposure to the target populations using all methods. The four methods are (a) full-period single samples; (b) full-period consecutive samples; (c) partial-period consecutive samples; (d) grab samples.

Source: Department of the Army. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations.* Department of the Army Pamphlet 50-6, 1991.

traffic control point (TCP)

A location that is staffed to ensure the continued movement of traffic inside or outside an area of risk. Traffic control is a temporary function to be implemented at points where normal traffic controls are inadequate or where redirection of traffic becomes necessary due to emergency conditions°

See also: access control point

Source: Department of the Army, Federal Emergency Management Agency, and Oak Ridge National Laboratory. *Planning Guidance for the Chemical Stockpile Emergency Preparedness Program.* Department of the Army, FEMA, ORNL, 1996.

unitary

A single chemical compound that is ready for delivery as an effective chemical agent in its stored configuration.

vapor

Agent occurring as a gas. In particular, vapor particles of agent are less than 2 microns in diameter.

volunteer

A person who serves without pay.

Source: Barnhart, Clarence L., and Barnhart, Robert K., eds. *The World Book Dictionary.* Doubleday, 1979.

VX

See nerve agent.

wedge

An angle centered about the downwind bearing, used to indicate a larger area of concern for emergency planning than that provided by the output of a dispersion model. For example, the D2PC dispersion model assumes that the area surrounding the release is flat and open, and that there will be no changes in wind direction after the release. For this reason, a wedge is often used to account for model limitations.

APPENDIX B:

RATIONALE FOR REEXAMINATION OF PLANNING BASE

The Chemical Stockpile Emergency Preparedness Program (CSEPP) Accident Planning Base Review Group (APBRG) was formed in December 1992 to update the accident planning base for CSEPP. The need for such action was driven by a number of changes in CSEPP and in the Chemical Stockpile Disposal Program (CSDP) since the publication of the original site-specific Emergency Response Concept Plans (ERCPs). Among these changes are modifications in CSDP process design and operations; reassessment of risk; and a movement to base planning on accident categories, source term, time, and distance, instead of on the original accident scenarios. Also, a need was recognized to recalculate the original accident scenarios with more appropriate source characterization (that is, D2PC release types).

B.1 HISTORICAL BACKGROUND

A risk assessment was conducted for the U.S. Army in 1987. The subject of the risk assessment was the proposed destruction of the U.S. inventory of lethal, unitary chemical agents and munitions. The assessment provided input to a *Final Programmatic Environmental Impact Statement* (FPEIS). This risk analysis was based on the Johnston Atoll Chemical Agent Disposal System (JACADS) design at its 60% completion level, as modified by conceptual changes planned for implementation at the eight proposed continental United States (CONUS) facilities. Over 3,000 hypothetical accidents that could occur during storage and destruction and disposal operations at the eight Army depots were identified and analyzed as part of the FPEIS risk assessment. (Many of the 3,000 accidents involved agent and munition combinations not stored at Newport Chemical Depot (NECD), so hence are not applicable to NECD.)

On the basis of this programmatic risk assessment and other relevant information, an initial attempt was made to describe the distribution of accidental releases for the NECD stockpile and to develop planning basis accidents for the NECD area in the *Emergency Response Concept Plan (ERCP) for Newport Army Ammunition Plant and Vicinity* (Carnes et al. 1989).

The accident categories developed in the *ERCP* for the NECD stockpile were based principally on the variation in downwind lethal distance and duration of release found in the distribution of accidental releases for the NECD stockpile. The intent was to ensure that the accident categories were representative of the range of values for variables that could affect the dispersion of chemical agent downwind and any subsequent human health effects for unprotected people. The accident categories identified in the *ERCP* for the NECD stockpile included the following:

- *Category 1:* A small release with no off-site fatalities.
- *Category 2:* A moderate short-term release with fatalities confined within approximately 25 km (15 mi).
- *Category 3:* A moderate long-term release with fatalities confined within approximately 25 km (15 mi).
- *Category 4:* A large, non-earthquake, short-term release with fatalities possible beyond approximately 25 km (15 mi).
- *Category 5:* An earthquake-based continuous release with fatalities possible beyond approximately 25 km (15 mi).

These historical categories are not the same as the current categories described in Section 8. These historical categories were to be used with site topography, meteorology, and population distribution to identify emergency planning zones and appropriate protective actions for populations within those zones. The listing of accident scenarios in the ERCPs led many planners to focus on individual accident scenarios as the basis for developing off-post emergency response plans. The intent of identifying these planning basis accidents, however, was not that planning should take place only for accidents identified in the FPEIS risk analysis, but that the accident distribution in the FPEIS risk analysis could serve as a reasonable range of accidents for which to plan. In fact, it is altogether possible, if not likely, that if there is ever an accident associated with the inventory at NECD (or any of the other CSDP installations), it will not be one of the accidents identified in the risk analysis. The accident should, however, resemble an accident identified in the risk analysis, in terms of cause, source term, and other critical variables. Thus, if planning and preparedness have taken place for accidents in the FPEIS risk analysis or, rather, for the range of critical values found for the accidents in the FPEIS risk analysis, then that planning and preparedness should also address whatever accident might actually happen.

B.2 CHANGES IN ACCIDENT

Although the general approach to developing emergency planning zones and identifying protective actions recommended in the *ERCP* is still sound, changes have occurred since its publication with respect to many of these issues, including the distribution of potential accidental releases for the NECD stockpile, that recommend a reconsideration of accident categories.

Moreover, given the potentially very short decision-making, alert and notification, and response times available for some accidental releases, it is important that the CSEPP planning community move from attempting to develop protective actions and protective action strategy plans for many individual accident scenarios to developing protective action strategy plans for a much smaller number of categories of potential accidental releases.

Since publication of the ERCP, an alternative disposal process to those reviewed in the FPEIS has been identified for the Newport stockpile. Use of this process will result in a different distribution of potential accidental releases for the NECD inventory. Overall public risk for alternative technologies must, however, be demonstrably less than or equal to the baseline method of incineration. Future accident release distributions should therefore continue to fit within categories currently developed.

B.3 CHANGES IN PERTINENT DATA

1990 Census data are now available for all sites. In addition, some sites may have more recent local estimates of demographic data. Hence, the numbers of people potentially at risk and the locations of those people need to be reassessed. Also, some locations have site-specific meteorological data available more locally than the National Weather Service data used in the original ERCPs.

B.4 CURRENT STATUS

Efforts are underway to consolidate the data and results of the analysis of risks associated with design and procedure changes in the CSDP (in support of the site-specific environmental impact statement for each proposed disposal facility) for use in CSEPP planning. When those efforts are completed, the entire and up-to-date distribution of accidental releases identified for storage and disposal of the NECD inventory will be compiled for CSEPP planning purposes.

Since the conclusions of those analyses are already available and indicate that these changes did not result in downwind no-death distances greater than other dominant accidents for the NECD inventory, we can proceed with developing new accident categories for the CSEPP effort for the NECD inventory, then incorporate the full range of information (i.e., quantities released, specific downwind no-effect distances, etc.) regarding the new accidents when it is available.

Because protective action planning in CSEPP should focus on factors other than pre-identified accident scenarios, the accident planning base has been revised to focus on these factors. The planning base still incorporates the full range of credible accident scenarios, but the scenarios are now grouped into categories on the basis of the important decision-making factors. For example, two scenarios that might represent different physical occurrences, happening under different weather conditions, might result in the same distance, time, and level of exposure downwind. Those scenarios could be grouped into the same category for planning purposes. Section 8 of this document contains a complete description of such categories for this site, on which planners should base any new planning efforts or revisions to existing plans.

B.5 APPENDIX B REFERENCES

Carnes, S.A., J.H. Sorensen, G.O. Rogers, B.L. Shumpert, R.L. Miller, A.P. Watson, and C.V. Chester, 1989, *Emergency Response Concept Plan for Newport Army Ammunition Plant and Vicinity*, ORNL/TM-11095, Oak Ridge National Laboratory, Oak Ridge, Tenn.

APPENDIX C:

PART 1 -- APPLYING THE D2PC MODEL TO THE RELEASE SCENARIOS FOR NECD

The following is a detailed description of the method used to apply the U.S. Army D2PC model (version dated October 1993) to the release scenarios for NECD. The downwind distances to the locations where the dosage level corresponds to no deaths (ND) and to no effects (NE) are calculated by using the toxicity levels built into the D2PC model. Two sets of environmental conditions are considered -- one for releases during neutral atmospheric conditions and one for releases during relatively stable atmospheric conditions. Environmental conditions corresponding to the summer season were chosen to be consistent with the application of the D2PC model at other depot sites. Specifically, warmer temperatures associated with summer will tend to result in higher evaporation rates, leading to more conservative (larger) estimates of the potential extent of the downwind hazard.

NOTE: *The calculations described here were made using the stand-alone version of D2PC. The instructions that follow reflect that use. However, Part 2 of this Appendix contains Emergency Management Information System (EMIS) screen captures of two scenarios as visual examples of the inputs used to create the Appendix D results.*

The scenarios, as taken from Appendix A of the *Emergency Response Concept Plan (ERCP) for Newport Army Ammunition Plant and Vicinity* (Carnes et al. 1989), are identified by a five-part code. The first part of the code consists of two alphabetic characters that designate the activity taking place when the accidental release occurs. The codes are as follows:

- SL (Storage, Long-term) represents long-term storage,
- HO (Handling Operation) represents handling for demilitarization,
- HF (Handling, Facility) represents handling at the demilitarization facility, and
- PO (Plant Operation) represents plant operations at the demilitarization facility.

The second part of the code is a single character that indicates the type of munition or container involved. Only one code (K) is applicable because only "ton" bulk containers of VX are stored at NECD. The third character represents the type of agent contained in the munitions, with V representing the nerve agent VX. The fourth part of the code was used in the original analyses of the scenarios to represent the release mode (C=Complex, F=Fire, S=Spill). That code is not explicitly used in the present analyses. The fifth part of the code is a number that represents the specific release event.

When the individual release scenarios were established, the quantity of agent released and the duration of the release event (tR) were estimated for each scenario. The quantity of agent released is expressed in terms of two components. The first component is the quantity spilled (Qs), which represents the amount of agent that is released in such a way as to form a puddle of liquid agent at the location of the munitions involved. This usually will be on a hard surface, such as the concrete floor of the demilitarization or storage facility or on the roadways and aprons. Before the liquid agent is neutralized or otherwise cleaned up, some or all of it will enter the atmosphere through evaporation. The second component of the quantity of agent released during the event is referred to as the quantity emitted (QE). The quantity emitted represents agent that is "violently" released from munitions that rupture due to an accompanying fire. This agent is released directly to the atmosphere but over a finite period of time. Within the D2PC model, this type of release is referred to as a semi-continuous release. The quantities of agent released and the duration of the release event for each of the 14 scenarios contained in Appendix A of the *Emergency Response Concept Plan for Newport Army Ammunition Plant and Vicinity* are included in Appendix D.

If the release event occurs inside a closed building or structure that remains relatively intact, the effective release to the outside atmosphere is moderated by the presence of the building. For example, evaporation will be slowed because the air in the building is relatively still compared to the external atmospheric winds. In the event of a violent rupture of a ton container, agents like VX, which are not particularly volatile, will be deposited on the interior surfaces of the building in the form of liquid droplets. That deposited liquid will then evaporate over time, until it is neutralized or otherwise cleaned up and be released to the outside atmosphere as the air within the building or structure is relatively slowly exchanged with outside air. As a consequence, when applying the D2PC model to a specific release scenario, a different approach must be used for releases that occur inside closed buildings or structures compared with releases that occur outside. The following assumptions concerning inside versus outside releases were made for the purposes of the present analyses. Whenever a particular release event could occur either outside or inside or when the release event most likely would destroy the containment effectiveness of the building or structure, an outside release was assumed. This is considered to be a conservative assumption because no credit is taken for the potential mitigating effects of initial confinement. All the scenarios were assumed to take place outside except

- SL--5, A26; and,
- PO--19,25,26, 29, 42.

The D2PC model contains a database of site-specific, munition-specific, and agent-specific parameter values. To the extent possible, these "default" values were used in the present analyses.

For all applications of the D2PC model in the present analyses, the location was always entered as Newport Chemical Depot and the season was always entered as summer. For neutrally stable atmospheric conditions, an atmospheric stability of D, a wind speed of 3 m/s (6.7 mph), and a temperature of 90°F were always used. For relatively stable atmospheric conditions, an atmospheric stability of E, a wind speed of 1 m/s (2.2 mph), and a temperature of 80°F were used. The munition type and agent type were entered following the second and third parts of the scenario code (always "non-munition" and "VX" at NECD). The rest of the parameter values required by D2PC depend on the specific scenario and the approach used to model that type of scenario

Essentially two basic approaches were used, depending on whether the release was considered to be outside or inside a closed structure. These two approaches are described below in terms of the D2PC model, its parameters, and the parameters that quantify the scenario (Qs, QE, and tR). The particular approach used for each of the scenarios is indicated in Appendix D. The vapor depletion option of D2PC, which accounts for the removal of a portion of the transported vapor from the atmosphere due to contact with the ground surface, trees, etc., was not used in the present analyses. This option only applies to the vapor portion of a release. Because of the way this option is incorporated into the D2PC computer code, incorrect results can be generated when the effects of releases by different release modes are summed by using the built-in dosage summing capability of D2PC. Neglecting vapor depletion will not have a major effect on the model predictions and that effect will tend to be conservative, because all the vapor released will remain in the transported cloud and contribute to the dosage at downwind locations.

C.1 RELEASE OUTSIDE (VO)

The contributions to the downwind dosage resulting from the semi-continuous release of the emitted agent (QE) and the evaporation of the spilled agent (Qs) are calculated separately and then added by using the built-in dosage summing capability of D2PC. The D2PC model includes a two-minute correction to account for the human body's limited ability to deal with nerve agents (such as VX) if the exposure is at a low level over an extended time period (greater than two minutes). This correction can be important when calculating the effective ND dosage but is not used when calculating the NE dosage. Therefore, to obtain the correct result when summing the contributions to the dosage from several sources of VX, the D2PC model must be run with the two-minute correction to calculate the ND hazard distance and then run again with the two-minute correction turned off to calculate the NE hazard distance.

The contribution from the semi-continuous release of the emitted agent is calculated using a munition type of nonmunition and a release type of semi-continuous. For Q and TQ, enter the value of QE for Q and the value of tR for TQ. When calculating the NE hazard distance for VX releases, turn off the two-minute correction.

The contribution from the evaporative release of the spilled agent is calculated using a munition type of nonmunition and a release type of evaporation from a puddle. For QQQ enter the value of Qs. For a surface code enter concrete, and for time of evaporation enter the value of tR or 60 minutes, whichever is larger. A minimum time of 60 minutes is selected because it represents the typical time it takes to respond to a spill and neutralize it or clean it up. If the duration of the release event (tR) is greater than 60 minutes, it is assumed that the circumstances of the event do not allow normal cleanup, and evaporation can continue for the duration of the event. When calculating the NE hazard distance for VX releases, turn off the two-minute correction.

When summing the results from two or more releases (see page 10-30 of *Reference Manuah D2PC and Hazard Analysis* [USANCA 1993]), the user must ensure that the first calculation extends downwind beyond the total hazard distance that will eventually be calculated when the various contributions are summed. This calls for some initial guesswork on the user's part but can be accomplished by setting the dosages parameter to one and entering a small value for the dosage value. A value of 0.01 mg-min/m^3 is generally sufficient, but the user should check to verily that the downwind distance calculated for the first contribution exceeds the final downwind distance that is calculated following the summation. [In *the case of the agent VX, the order in which multiple contributions to the downwind dosage are combined using the built-in summing capability of the D2PC computer code has an effect on the downwind hazard distances predicted. The effect generally results in a difference of less than 20%. In calculating the hazard distances in Appendix D, the order of summation that resulted in the largest predicted downwind hazard distance was used.]*

C.2 RELEASE INSIDE (VI)

The downwind hazard distances resulting from a release inside a closed building or structure are estimated by first calculating the amount of agent that can become airborne and escape the building from the various sources (emitted and spilled). Then the contributions to the downwind dosage resulting from the semi-continuous release of each of the sources are calculated separately and added using the built-in dosage summing capability of D2PC. The D2PC model includes a two-minute correction to account for the human body's limited ability to deal with nerve agents (such as VX) if the exposure is at a low level over an extended time period (greater than two minutes). This correction can be important when calculating the effective ND dosage but is not used when calculating the NE dosage. Therefore, to obtain the correct result when summing the contributions to the dosage from several sources, the D2PC model must be run with the two-minute correction to calculate the ND hazard distance and then run again with the two-minute correction turned off to calculate the NE hazard distance.

The quantity of agent to be released from the closed building resulting from the emitted agent is simply the value of QE.

The quantity of agent to be released from the closed building resulting from the evaporation of the spilled agent is calculated using a munition type of nonmunition and a release type of evaporation in still air. For QQQ enter the value of Qs. For a surface code enter concrete, and for time of evaporation enter the value of tR or 60 minutes, whichever is larger. A minimum time of 60 minutes is selected because it represents the typical time it takes to respond to a spill and neutralize it or clean it up. If the duration of the release event (tR) is greater than 60 minutes, it is assumed that the circumstances of the event do not allow normal cleanup and evaporation can continue for the duration of the event. The quantity available through subsequent evaporation is the value of Q which is the second number in the D2PC output that is printed immediately after the value of TEV is entered. The actual time of evaporation (tev), which may be less than the input time, is the value labeled TEV immediately following the value of Q.

Next, the contributions from the various sources (emitted and spilled) to the downwind dosage are calculated separately using a release type of semi-continuous. For Q and TQ, enter the appropriate quantity from the previous calculation for Q. For the release resulting from the emitted agent, enter a value of tR or 20 minutes, whichever is larger, for TQ. A minimum effective release time of 20 minutes is selected because it is representative of the air turnover time in a storage igloo. For the release resulting from the evaporation of spilled agent, enter the appropriate value of tev from the previous step or 20 minutes, whichever is larger, for TQ. When calculating the NE hazard distance for VX releases, turn off the two-minute correction.

When summing the results from two or more releases (see page 10-30 of *Reference Manual.' D2PC and Hazard Analysis* [USANCA 1993]), the user must ensure that the first calculation extends downwind beyond the total hazard distance that will eventually be calculated when the various contributions are summed. This calls for some initial guesswork on the user's part but can be accomplished by setting the dosages parameter to one and entering a small value for the dosage value. A value of 0.01 mg-min/m^3 is generally sufficient, but the user should check to verify that the downwind distance calculated for the first contribution exceeds the final downwind distance that is calculated following the summation. [by *the case of the agent VX, the order in which multiple contributions to the downwind dosage are combined using the built-in summing capability, of the D2PC computer code has an effect upon the downwind hazard distances predicted. The effect generally results in a difference of less than* 20%. *by calculating* *the hazard distances in Appendix D, the order of summation that resulted in the largest predicted downwind hazard distance was used.]*

C.3 APPENDIX C REFERENCES

Carnes, S.A., J.H. Sorensen, G.O. Rogers, B.L. Shumpert, R.L. Miller, A.P. Watson, and C.V. Chester, 1989, *Emergency Response Concept Plan for Newport Army Ammunition Plant and Vicinity,* ORNL/TM-11095, Oak Ridge National Laboratory, Oak Ridge, Tenn.

USANCA: see U.S. Army Nuclear and Chemical Agency

U.S. Army Nuclear and Chemical Agency, 1993, *Reference Manuah D2PC and Hazard Analysis,* prepared by Innovative Emergency Management, Inc., and U.S. Army Edgewood Research, Development and Engineering Center, for USANCA, Springfield, Va.

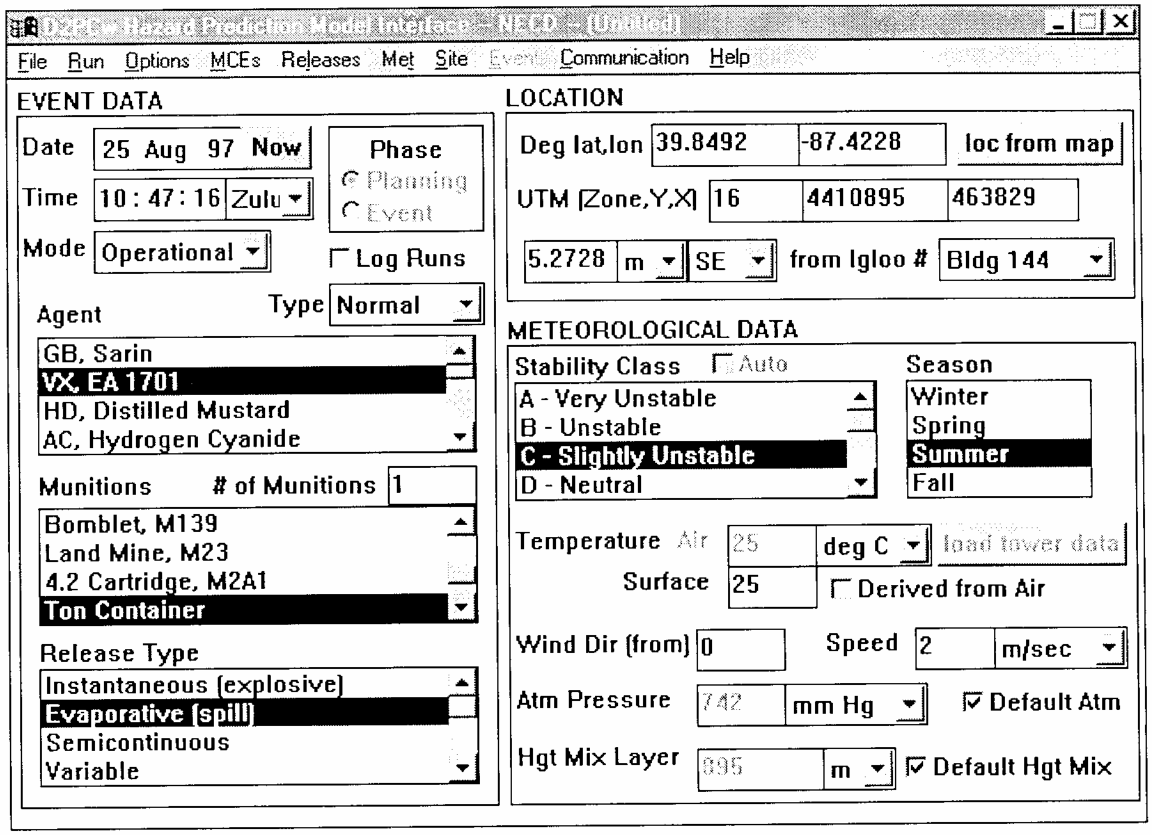
APPENDIX C:

PART 2 -- APPLYING THE D2PC MODEL TO THE RELEASE SCENARIOS FOR NECD

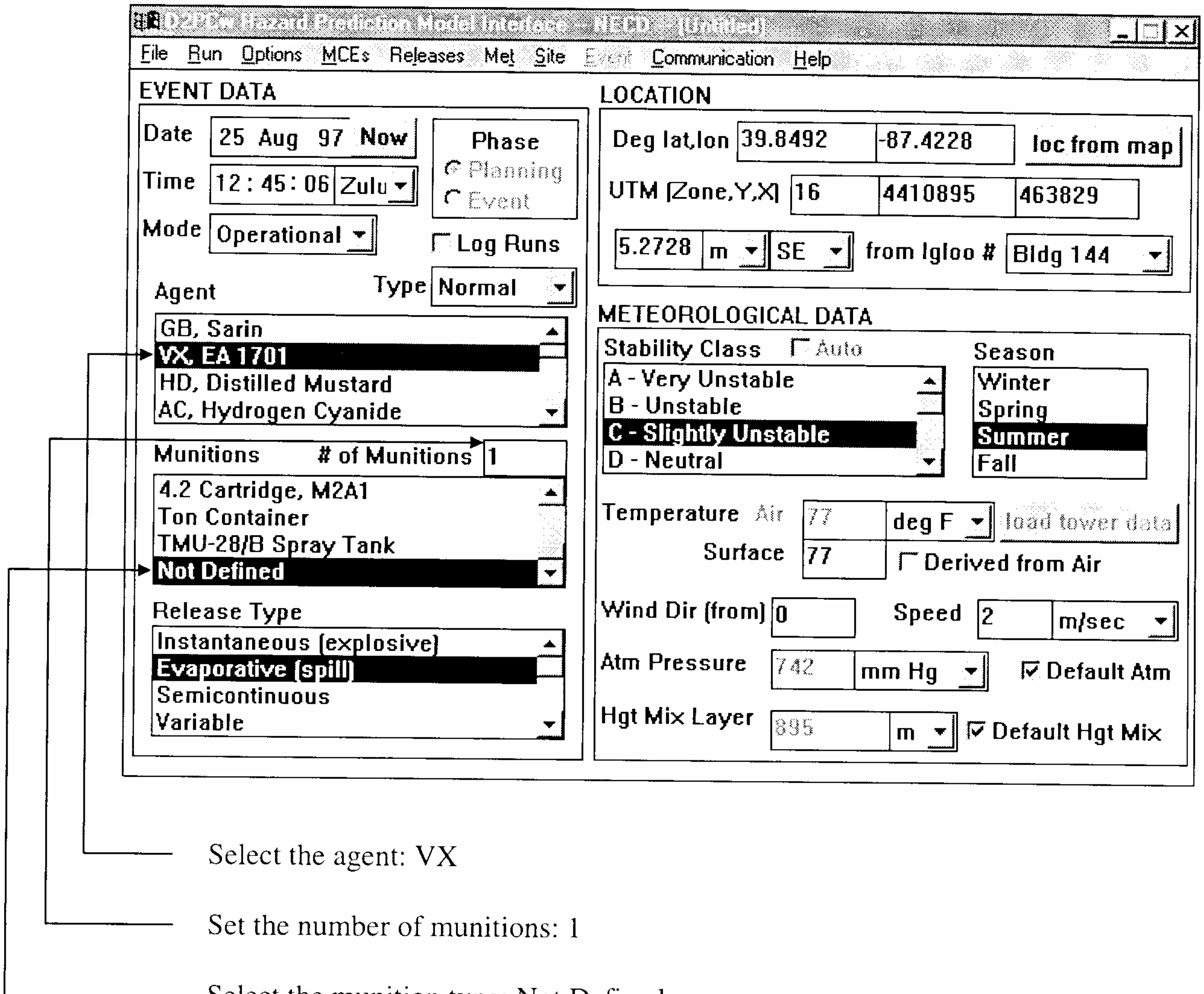
The purpose of the screen captures included here is to guide the user in applying D2PC to the scenarios listed in Appendix D, and to others that the user may wish to study. The screen captures were produced using the approved version of D2PC that is incorporated into the Emergency Management Information System (EMIS), Version 3.0. The two sample scenarios depicted here correspond to two of the scenarios included in Appendix D. By using the inputs depicted here, the user should be able to reproduce the results of those scenarios. Also, by using these samples as patterns, the user should be able to modify the inputs to reproduce the results of the other scenarios in Appendix D. Finally, by again using these samples as patterns, the user may study other scenarios and "what-iF' conditions, with confidence that D2PC is being used in the same way as it was used to model the Appendix D scenarios.

C.1 SCENARIO CODE: PO-KVS-012

During plant operations, a direct crash by a large aircraft damages the munitions demilitarization building (MDB), but no fire occurs. As a result, 8,016.78 lb of VX is spilled on a hard surface and evaporates over a 360-minute period. Because of the expected extensive building damage, it is assumed that the building does not confine the release. The release is into a summer atmosphere of stability category D with a wind speed of 3 m/s and a surface temperature of 90^{o}F. Note that EMIS will force you to enter this temperature as a "surface" temperature (p. C-13) because the spill is onto a hard surface.



This is the initial input screen to D2PCw for the Newport (NECD) site.

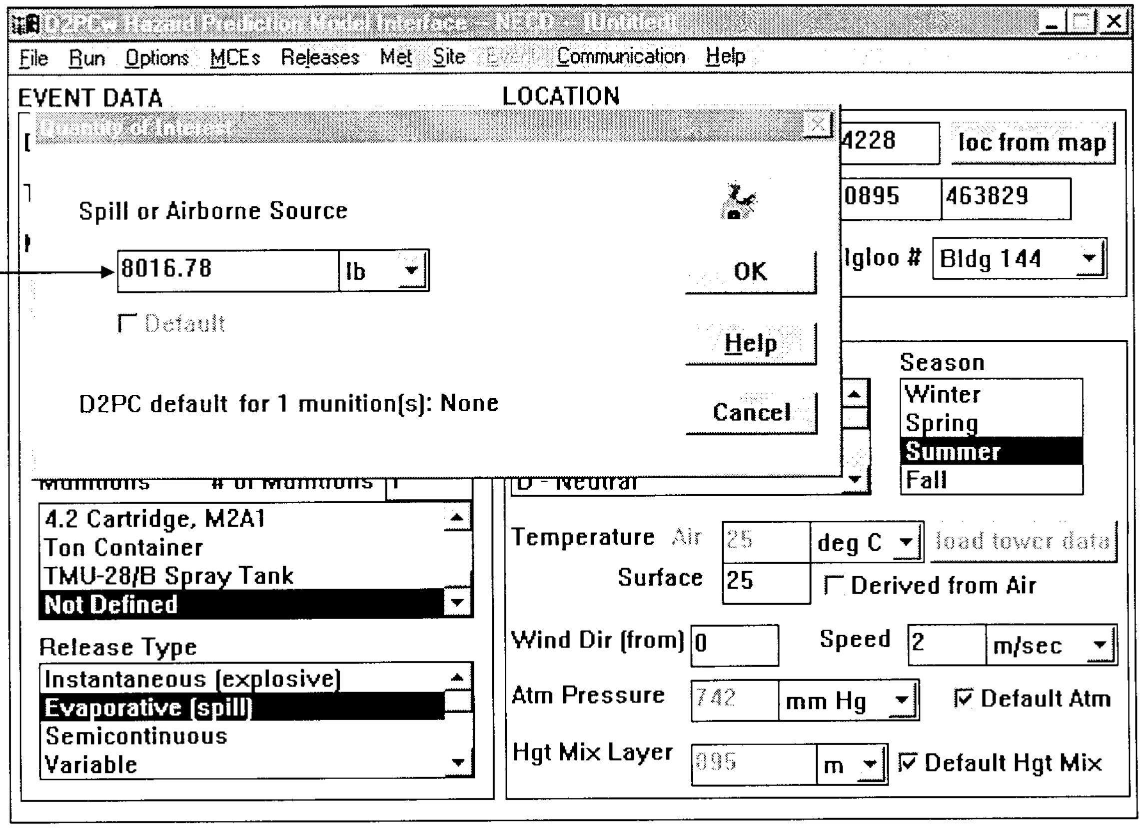


Select the agent: VX

Set the number of munitions: 1

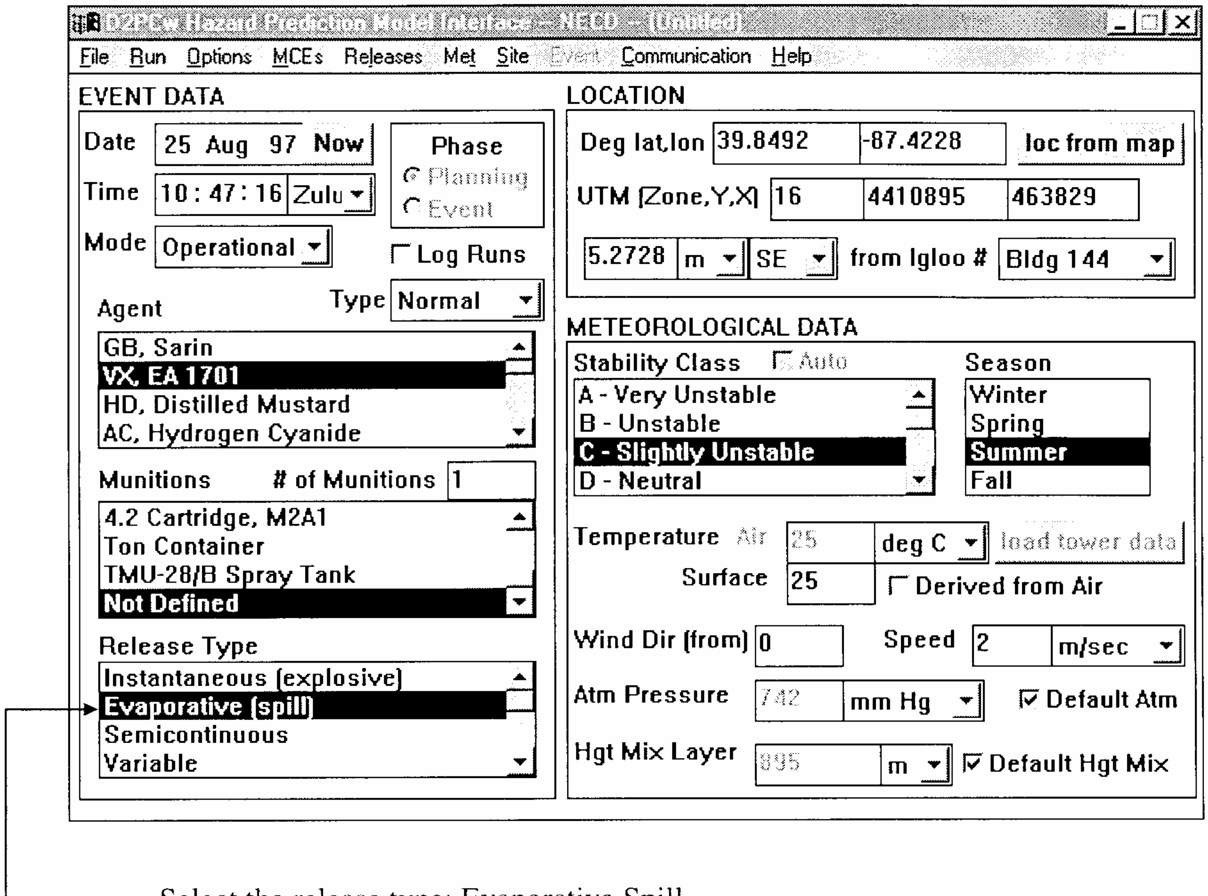
Select the munition type: Not Defined

The "Quantity of Interest" screen will appear when selecting this munition type.



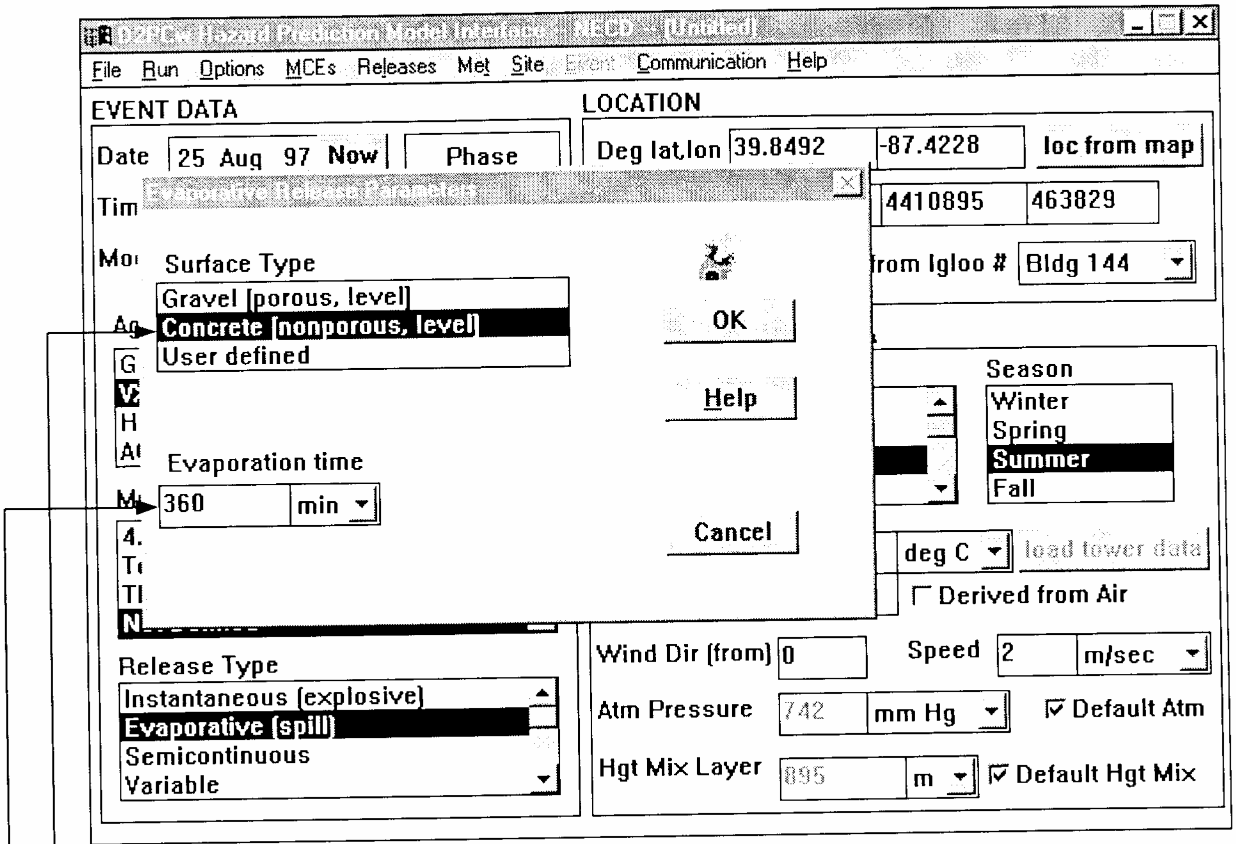
Enter the spill/airborne source: 8016.78 lb

Click on **OK** when entry is completed. Control will return to the main input screen.



Select the release type: Evaporative Spill

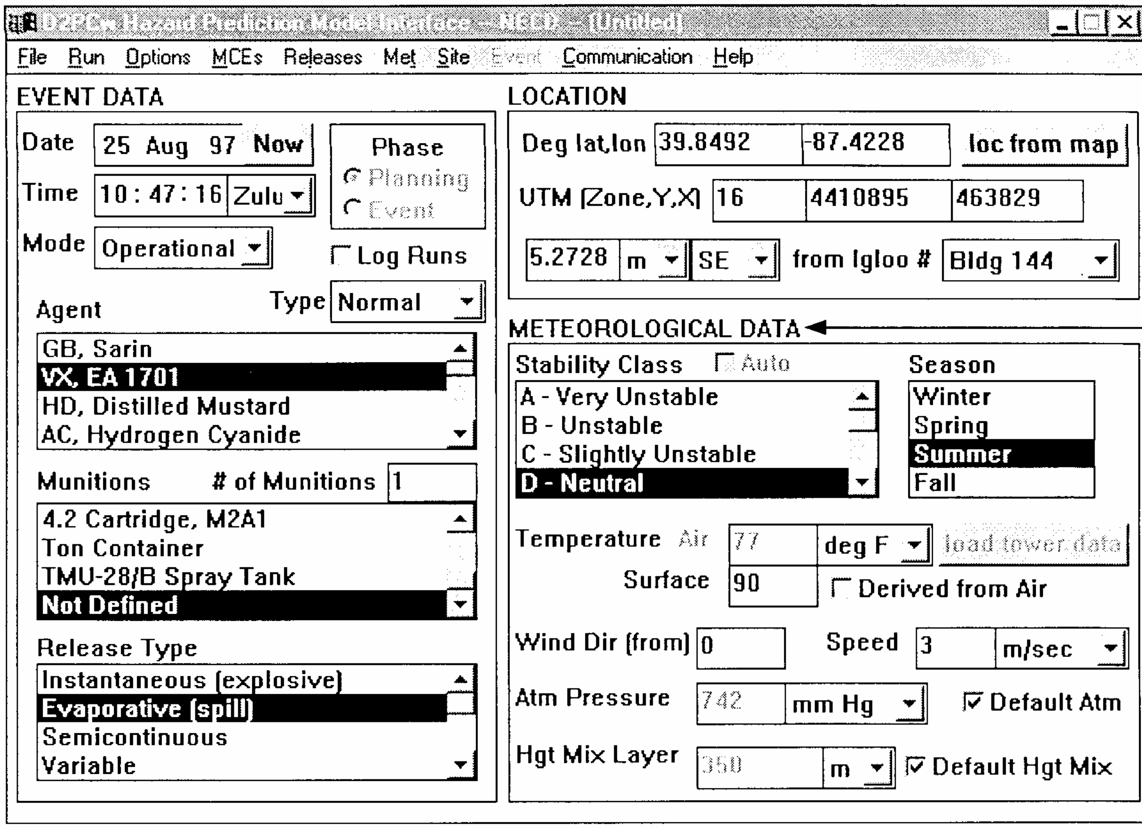
The “Evaporative Release Parameters” screen will appear when selecting this release type.



Enter the surface type: Concrete (nonporous, level)

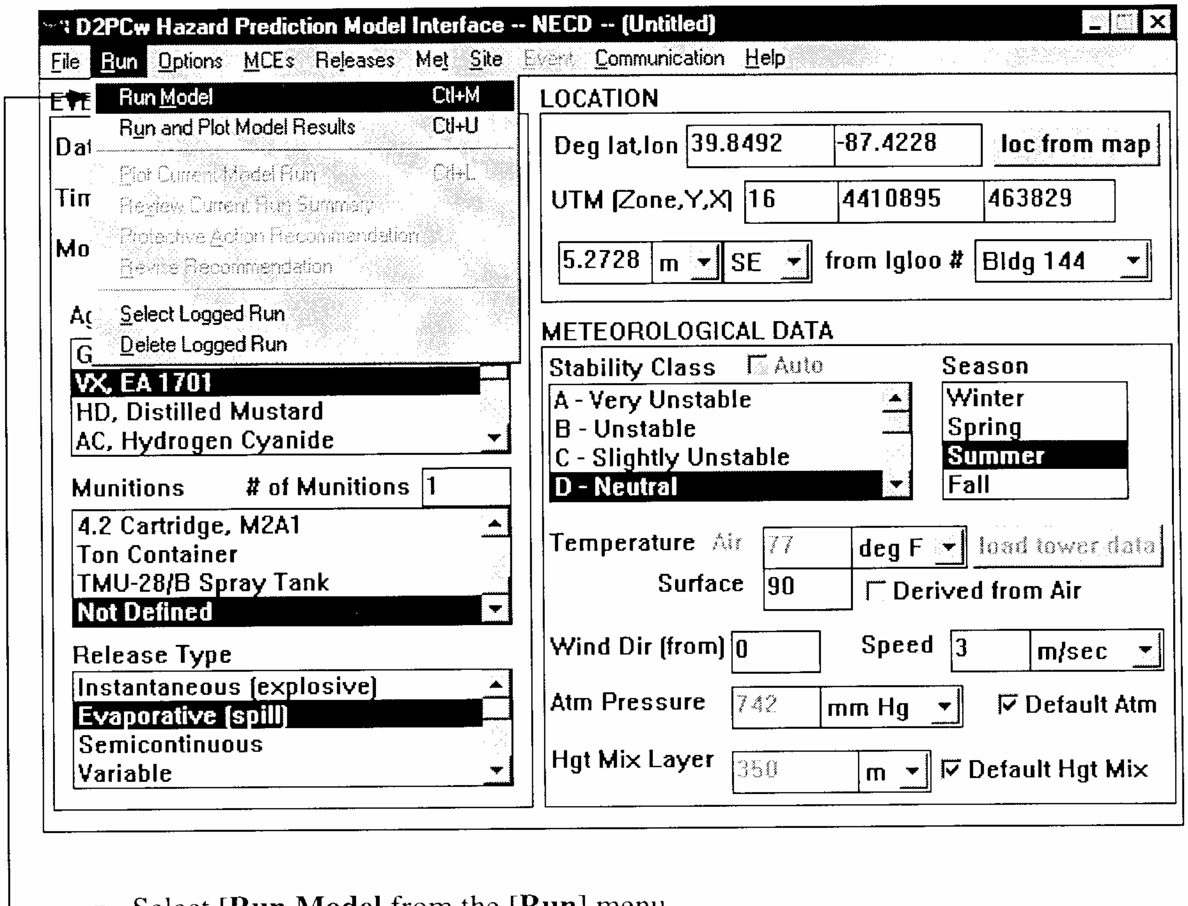
Enter the evaporation time: 360 minutes

Click on **OK** to return control to the main input screen.

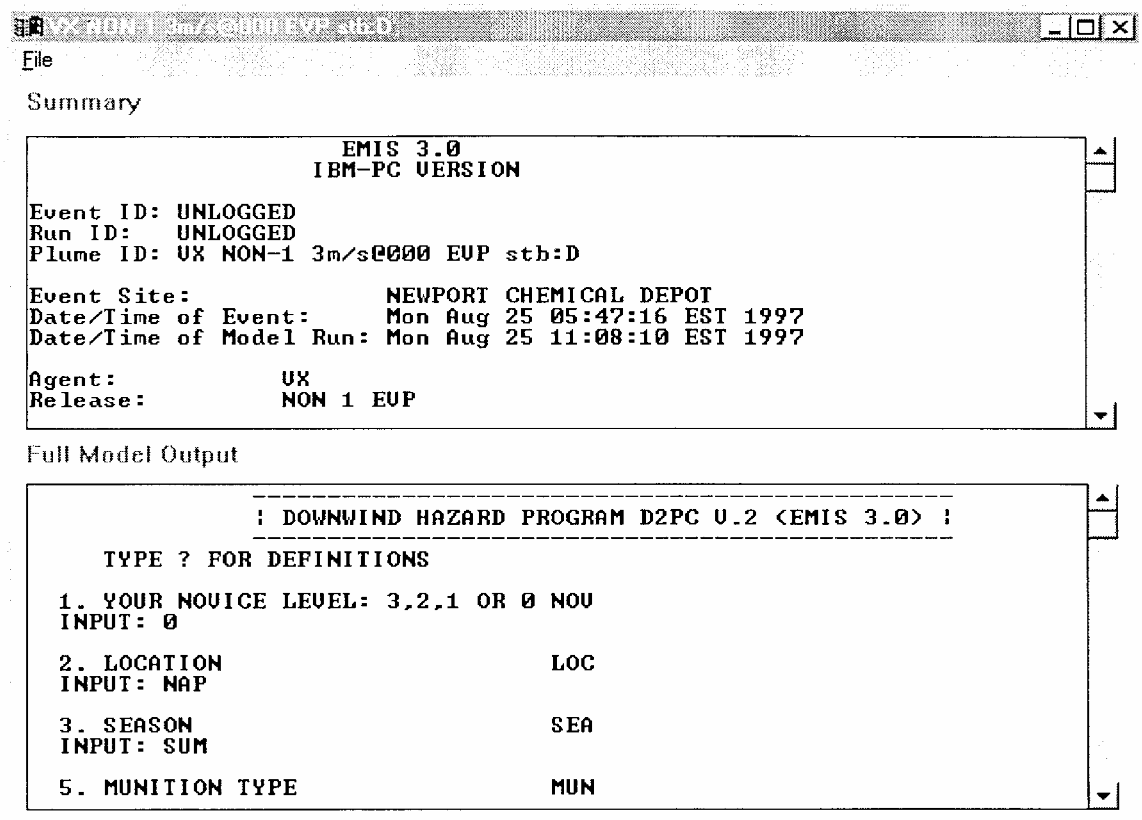


Select the meteorological conditions:

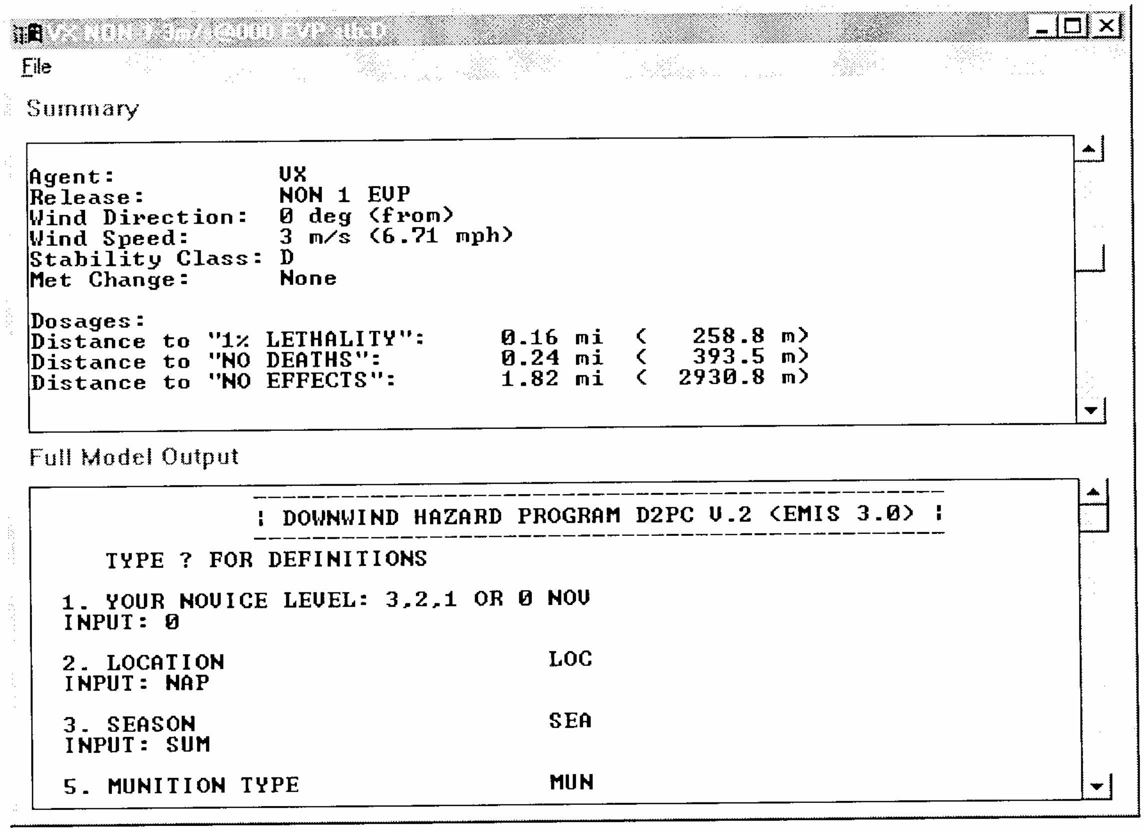
- Stability Class: D – Neutral
- Season: Summer
- Temperature: 90 deg F
- Wind speed: 3 m/sec



Select [**Run Model** from the [**Run**] menu.



When the model is finished running, the output screen will appear.

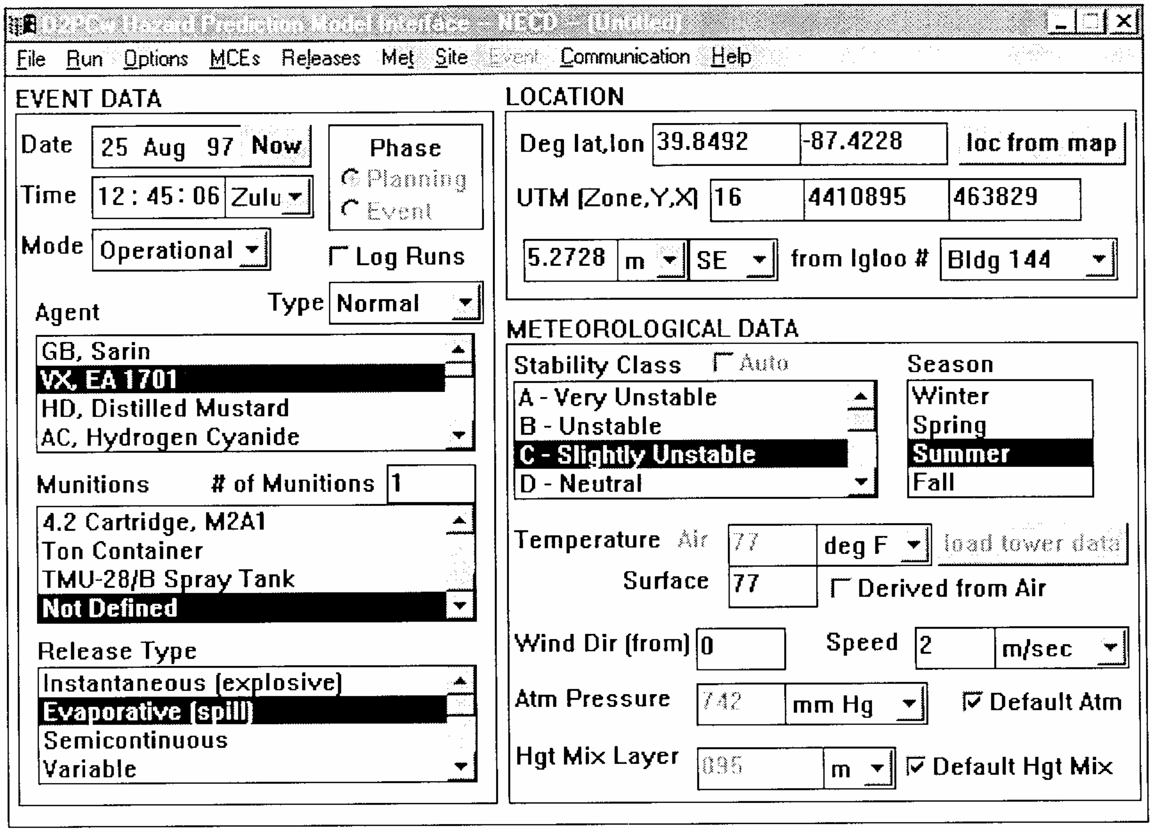


In the "Summary" window, scroll down to obtain distances to:

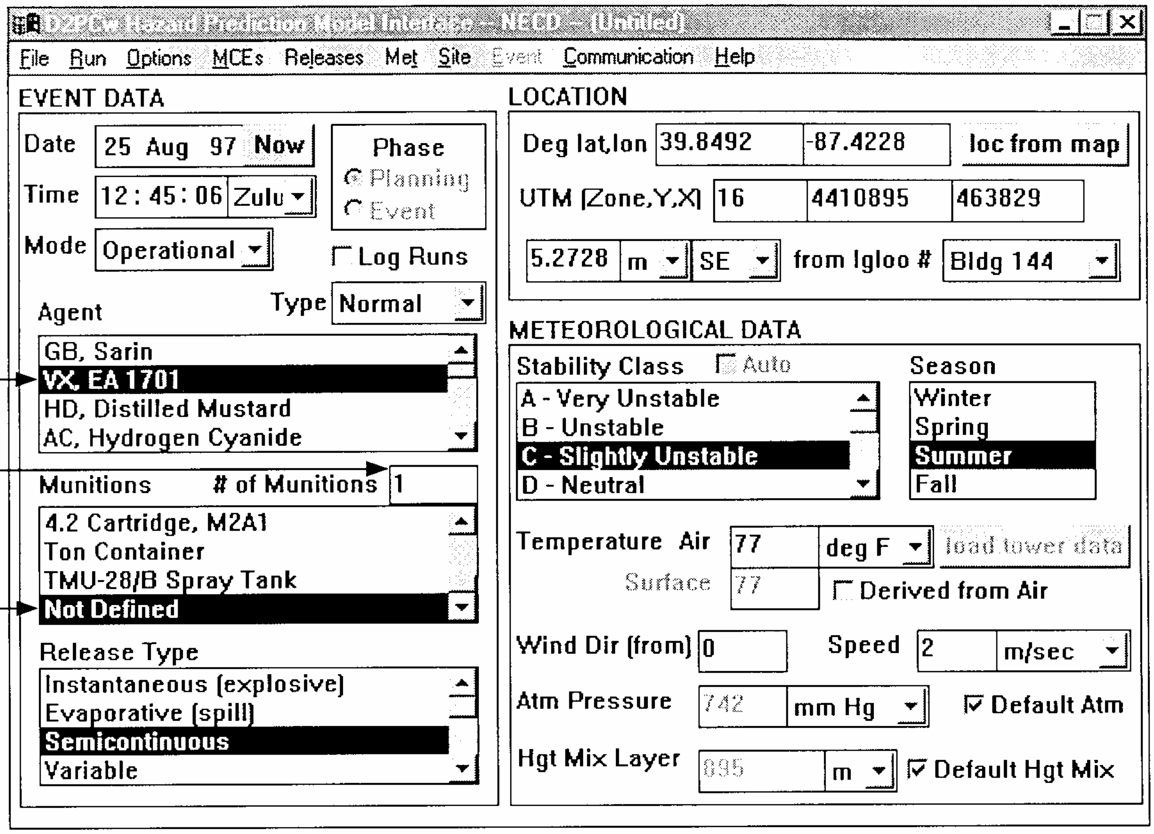
"NO DEATHS":	0.24 mi (393.5 m)
"NO EFFECTS":	1.82 mi (2930.8 m)

C.2 SCENARIO CODE: HF-KVF-003

In the second scenario depicted, a forklift collision accident with a short-duration fire occurs during handling of ton containers of VX outside the MDB. As a result, 1.81392 x 107 mg (39.99 lb) of agent is emitted over 10 minutes. The release is into a summer atmosphere of stability category D with a wind of 3 m/s and an air temperature of 90°F.



This is the initial input screen to D2PCw for the Newport (NECD) site.

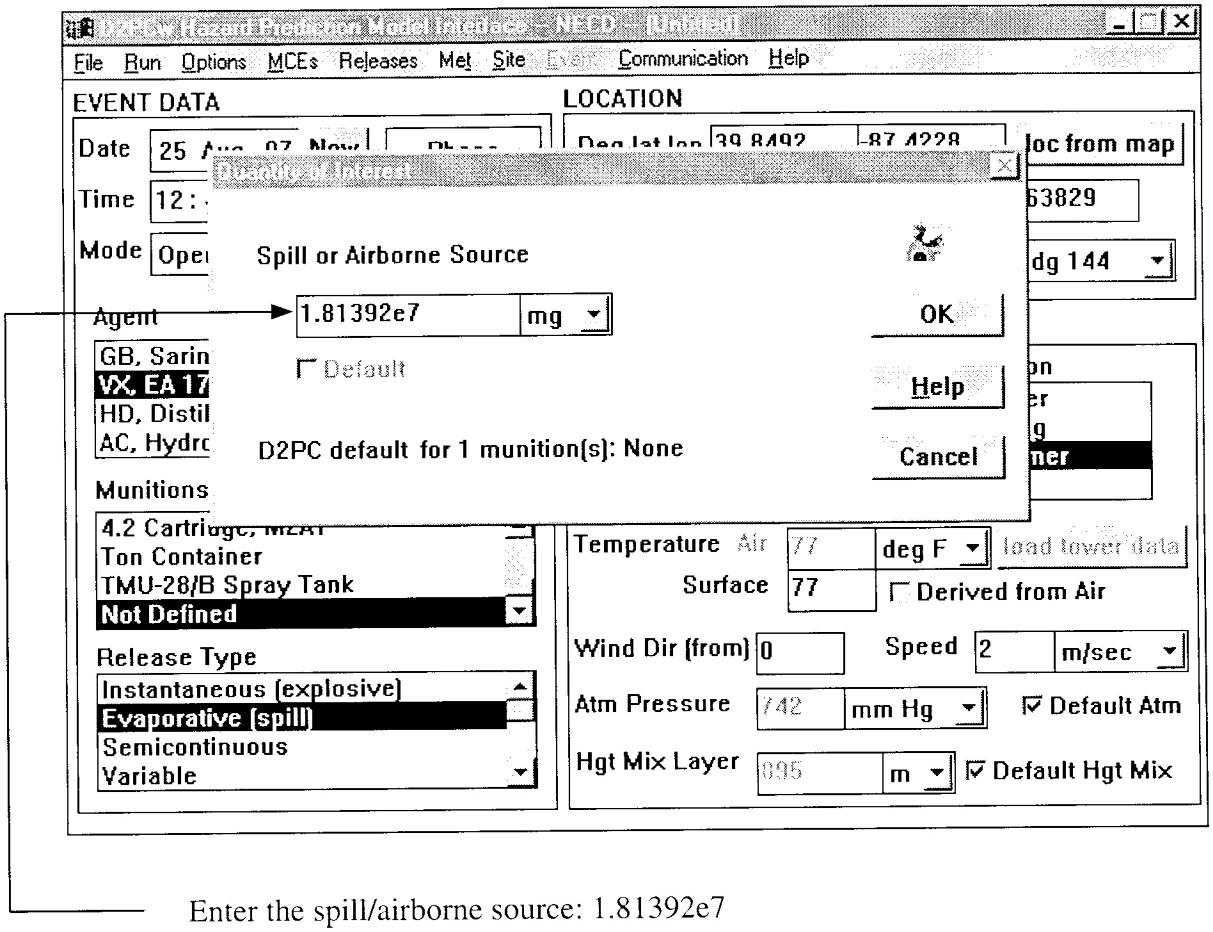


Select the agent: VX

Set the number of munitions: 1

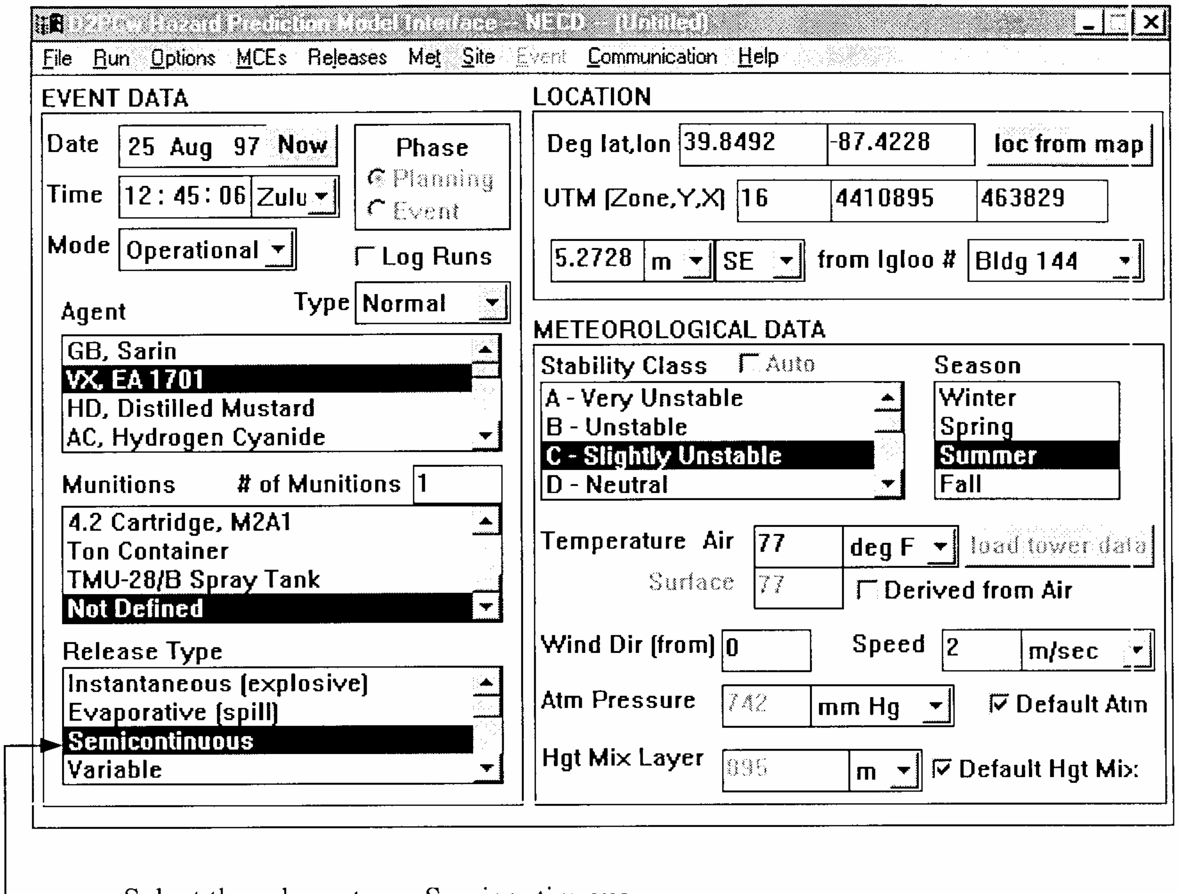
Select the munition type: Not Defined

The "Quantity of Interest" screen will appear when selecting this munition type.



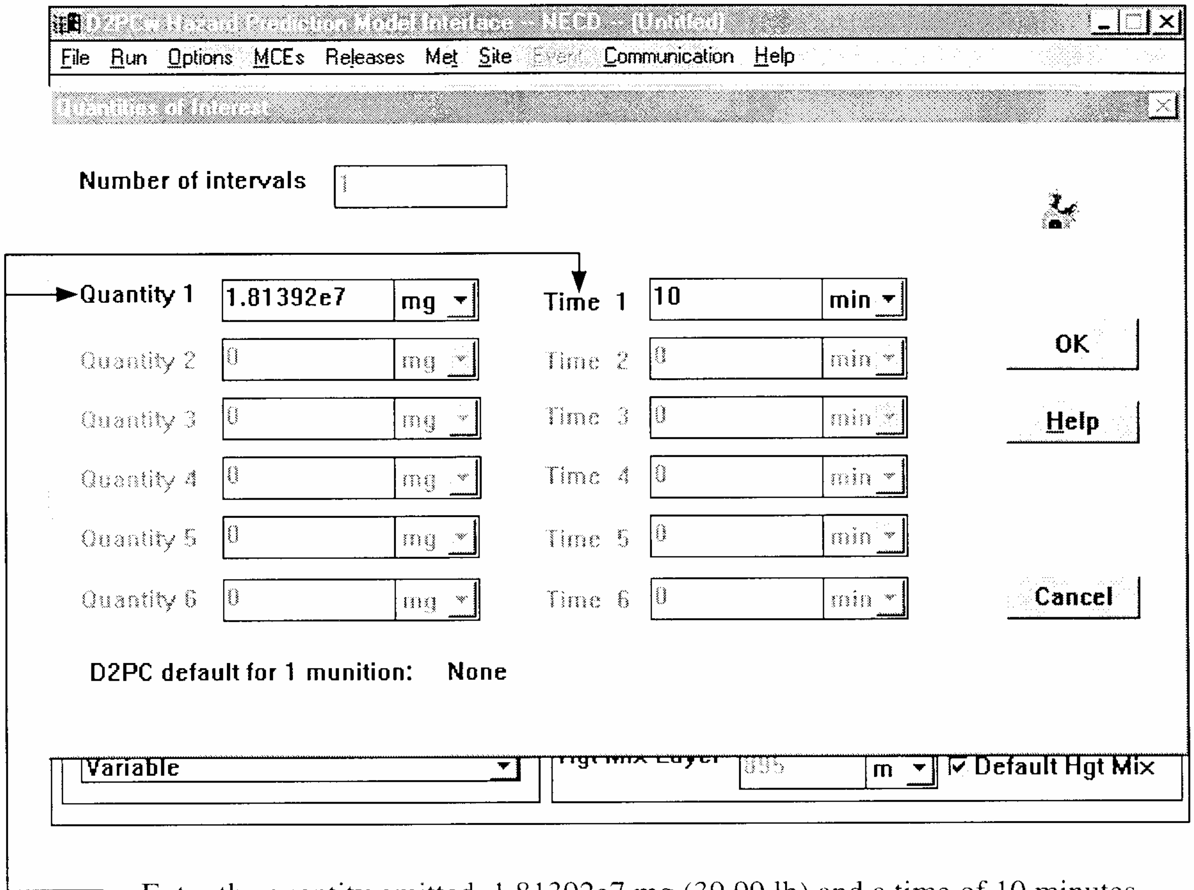
Enter the spill/airborne source: 1.81392e7

Click on **OK** when entry is completed. Control will return to the main input screen.



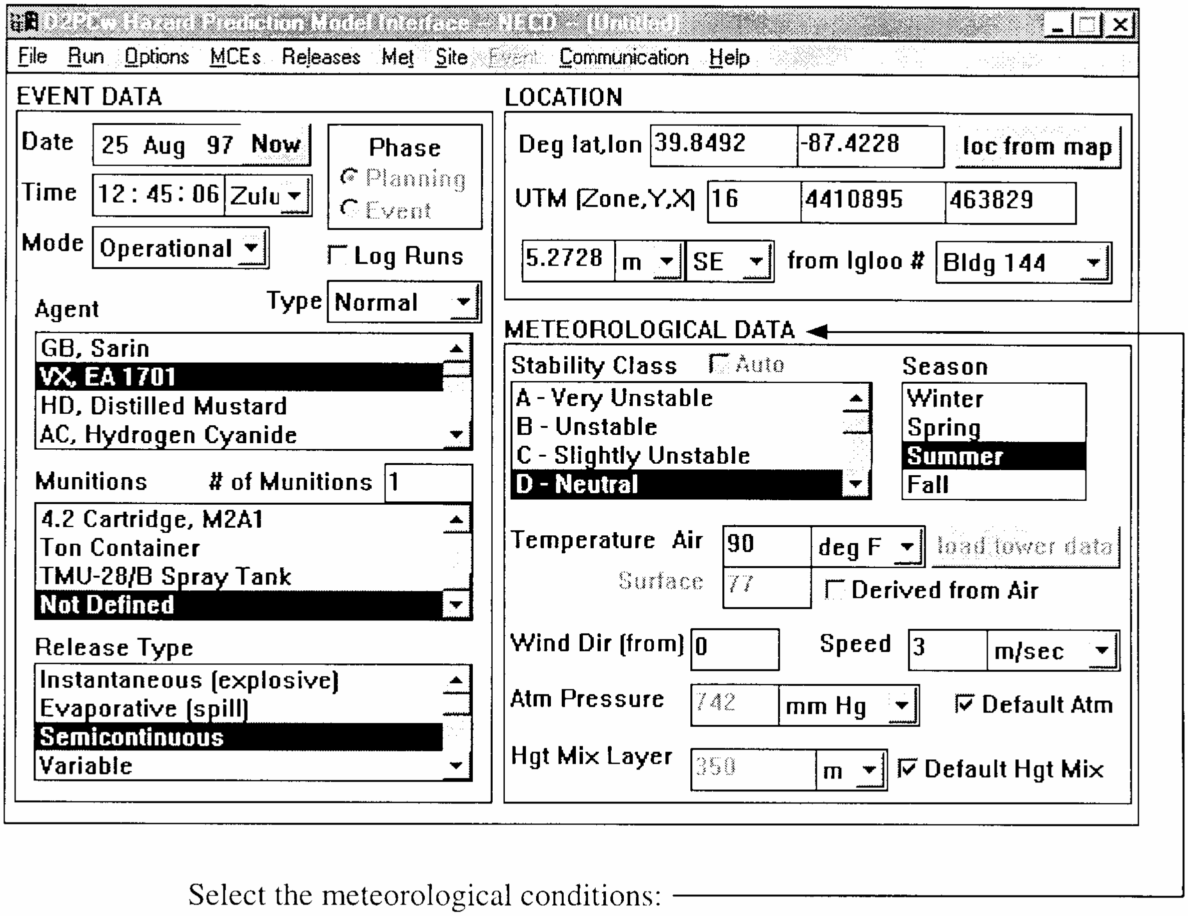
Select the release type: Semicontinuous

The "Quantities of Interest" screen will appear when selecting this release type



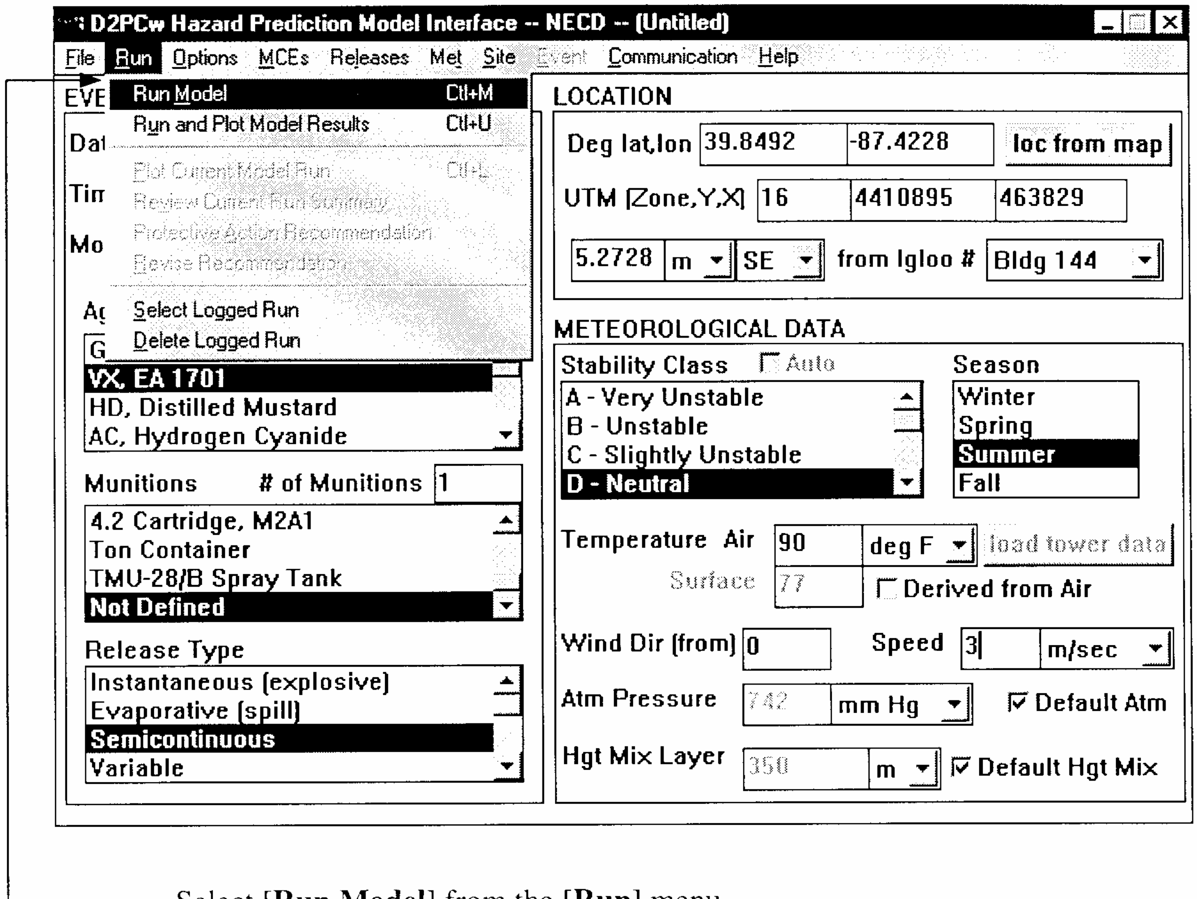
Enter the quantity emitted, 1.81392e7 mg (39.99 lb) and a time of 10 minutes, which is the duration of the release.

Click on OK when entry is completed. Control will return to the main menu.

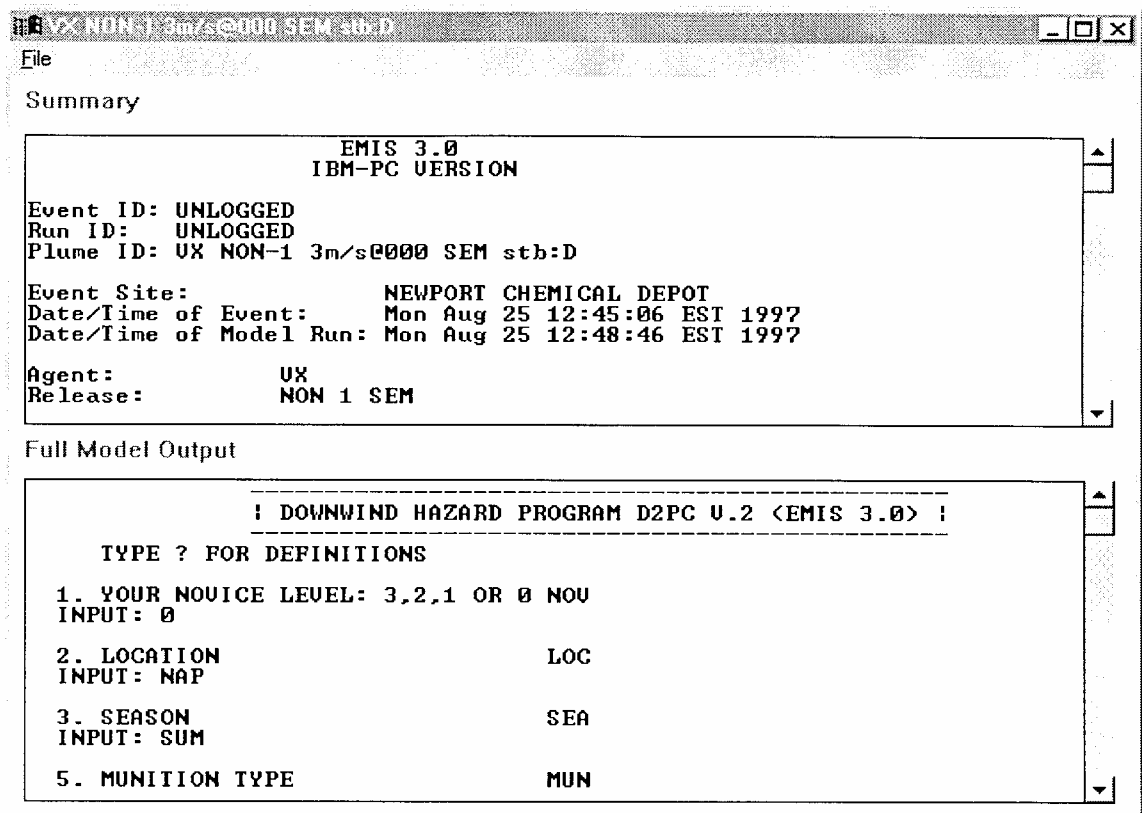


Select the meteorological conditions:

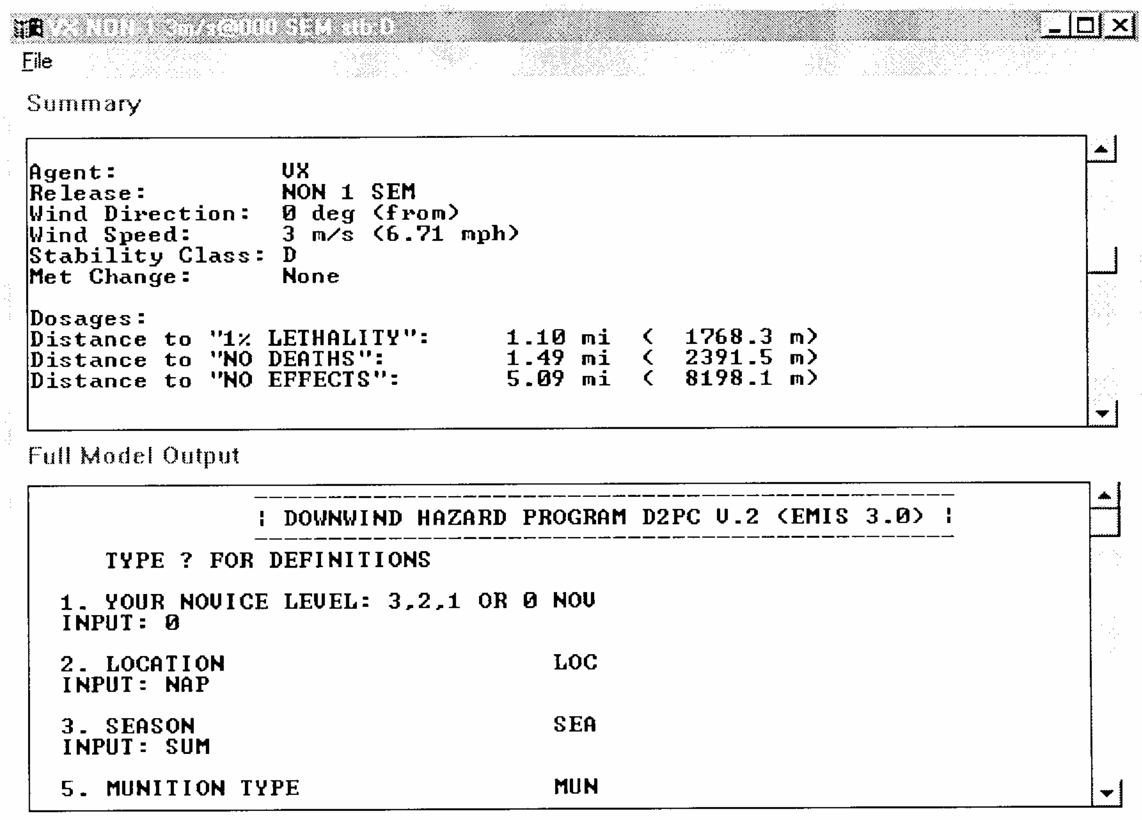
- Stability Class:	D - Neutral
- Season:	Summer
- Temperature:	90 deg F
- Wind Speed:	3 m/sec



Select [**Run Model**] from the [**Run**] menu.



When the model is finished running, the output screen will appear.



In the "Summary" window, scroll down to obtain distances to:

"NO DEATHS":	1.49 mi (2391.5 m)
"NO EFFECTS":	5.09 mi (8198.1 m)

APPENDIX D:

DISTRIBUTION OF ACCIDENTAL RELEASES FOR NECD

D.1 D2PC RESULTS FOR NECD ACCIDENT CATEGORIES

This appendix presents the data used to develop the accident categories in Section 8. Table D.1 lists 14 accidents for which D2PC results have been calculated. Calculations have been performed for two sets of weather conditions: stability D, 3 m/s (6.7 mph) wind speed, and stability E, 1 m/s (2.2 mph) wind speed.

This analysis is based on the same accident scenarios and efficiency factors used in the original Emergency Response Concept Plan (ERCP) for NECD. Upon completion of the Quantitative Risk Assessment (QRA) for NECD, it is possible that different accident scenarios will be identified. Additional calculations should be done for those scenarios at that time. However, the accident categories identified now are believed to be robust enough that they should represent any different scenarios identified in the QRA without a need to redefine the categories.

Table D.1 includes No Deaths (ND) and No Effects (NE) distances for both sets of weather conditions. For convenience, all distances are listed in both kilometers and miles. The accidents in Table D. 1 have been sorted in ascending order by NE distance. The order is the same regardless of which weather conditions are used. Also, the order is the same if the accidents were sorted by ND distance. *More important, however, than the exact numerical distances or tile sorting order, are the categories into which the accidents fall.* These categories are described in Section 8 of this report. The distances in Table D. 1 enable you to see how the scenarios from the previous ERCP match up to the current accident categories. The category concept encompasses all of the accidents from the previous ERCP but is flexible enough to encompass additional accidents identified since the previous ERCP, or yet to be defined.

Note that the same accident may have very different consequences, depending on the weather conditions. If weather conditions are completely unknown at the time of an accident, the conservative decision would be to take action based on relatively stable (stability E) weather. But, if weather conditions are known to be more like the D stability weather, basing decisions on the more conservative weather could lead to costly and unnecessary protective actions.

Note, too, that some of the distances in Table D. 1 are much larger than the distances that D2PC, or any Gaussian dispersion model, can reliably calculate. Distances larger than about 20 km (12.4 mi) are beyond the limits of D2PC to calculate very well, although the model will calculate distances out to hundreds, or even thousands, of kilometers if you let it. In keeping with

TABLE D.1 FPEIS Accidents for NECD Sorted by No Effects Distance

Scenario					Description	Quantity Spilled, Q_S (lb)	Quantity Emitted, Q_E (lb)	Dur. of Release, t_R (min)	No. of Fatalities	Calc. Used	Stability D, 3 m/s Wind, 90°F				Stability E, 1 m/s Wind, 80°F			
											ND Dist. (km)	ND Dist. (mi)	NE Dist. (km)	NE Dist. (mi)	ND Dist. (km)	DB Dist. (mi)	NE Dist. (km)	NE Dist. (mi)
Internally Initiated Accidents																		
PO	K	V	C	51	Ton container spill in MPB, fire	0.00	5.79	34	0	VO	0.67	0.42	2.71	1.69	2.16	1.34	10.25	6.37
PO	K	V	C	42	MPF explosion due to failure to stop fuel	0.00	39.99	12	0	VI	2.19	1.36	8.20	5.09	7.07	4.39	Note 3	Note 3
HO	K	V	F	6	Forklift collision involving container, fire	0.00	39.99	10	0	VO	2.39	1.49	8.20	5.09	7.17	4.46	Note 3	Note 3
HF	K	V	F	3	Forklift collision between MHI and MDB	0.00	39.99	10	0	VO	2.39	1.49	8.20	5.09	7.17	4.46	Note 3	Note 3
Externally Initiated Accidents																		
PO	K	V	S	12	Large aircraft direct crash MDB without fire	8,016.78	0.00	360	0	VO	0.39	0.24	2.93	1.82	0.46	0.29	4.31	2.68
PO	K	V	C	25	Earthquake damages MDB	0.00	39.99	360	0	VI	1.41	0.87	8.20	5.09	4.95	3.07	Note 3	Note 3
PO	K	V	C	26	Earthquake damages MDB, fire	0.00	239.88	360	0	VI	3.91	2.43	39.11	24.30	16.48	10.24	Note 3	Note 3
PO	K	V	C	29	Earthquake damages MDB, fire	0.00	239.88	360	0	VI	3.91	2.43	39.11	24.30	16.48	10.24	Note 3	Note 3
PO	K	V	F	19	Large aircraft indirect crash MDB with fire	0.00	239.88	60	0	VI	5.13	3.19	39.11	24.30	21.23	13.19	Note 3	Note 3
PO	K	V	F	13	Large aircraft direct crash MDB with fire	0.00	240.44	60	0	VO	5.14	3.19	39.21	24.37	21.28	13.22	Note 3	Note 3
SL	K	V	F	A26	Earthquake, warehouse intact, fire	0.00	7,4989.40	360	0	VI	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3
SL	K	V	F	D26	Earthquake, warehouse damaged, fire	0.00	7,4989.40	360	0	VO	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3
SL	K	V	F	5	Large aircraft indirect crash with fire	0.00	7,4644.90	60	0	VI	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3
SL	K	V	F	15	Small aircraft crash onto storage area, fire	0.00	7,4644.90	30	0	VO	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3

Notes:

1. See Appendix C, p. C-1 for explanation of scenario codes and input data.
2. Grayed entries are >20 km (12.4 mi). See discussion in text.
3. Calculations are cut off at 50 km (31 mi). See discussion in text.

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current scientific guidelines (EPA 1986), we have included D2PC results up to 50 km (31 mi). (See the discussion in Section 6.4.) *However, for purposes of emergency planning, you should not take the large printed distances literally*. As a reminder of this caution, distances over 20 km (12.4 mi) are grayed in Table D. 1.

Table D.1 includes several externally initiated accident scenarios from the original ERCP for NECD. As a matter of nationwide policy, the CSEPP planning base currently focuses on internally initiated events. However, for completeness, externally initiated events are listed in Table D.1 with the results of D2PC calculations performed for them. It is apparent that if externally initiated events were included in the planning base, they would fit well into the category definitions based on internally initiated events. The exclusion of externally initiated events is an extension of the policy adopted in the 1989 Emergency Response Concept Plan and is further explained in Section 6.4 of this document. When improved atmospheric dispersion models become available, these external events will be assessed to determine if a different planning policy is needed.

D.2 APPENDIX D REFERENCE

U.S. Environmental Protection Agency, 1986, *Guideline on Air Quality Models* (Revised), EPA-450/2-78-027R, July.

APPENDIX E:

MATERIAL SAFETY DATA SHEETS

A Material Safety Data Sheet (MSDS) has been prepared for each of the chemical agents by the U.S. Army Edgewood Research, Development and Engineering Center (ERDEC). The MSDS for the chemical agent VX stored at NECD is included in this appendix. An MSDS is a set of instructions for the safe use and handling of a chemical. Understanding the information presented in the MSDS will help you protect yourself from the hazards of the chemical agent. The aim of this section of the Emergency Planning Guide is to help you understand the information contained in a chemical agent MSDS.

The header of each MSDS identifies the agent, using its familiar abbreviation (e.g., VX), the publisher of the MSDS (ERDEC), the date of preparation of the MSDS, and emergency telephone numbers at ERDEC. The following data are then listed in 10 sections:

Section 1: General Information
Section 2: Composition
Section 3: Physical Data
Section 4: Fire and Explosion Data
Section 5: Health Hazard Data
Section 6: Reactivity Data
Section 7: Spill, Leak, and Disposal Procedures
Section 8: Special Protection Information
Section 9: Special Precautions
Section 10: Transportation Data

Section 1, General Information, lists the name and address of the manufacturer of the chemical agent (ERDEC). This section also gives the complete chemical name of the agent and alternative chemical names by which the agent may be known. (Because of the rules that govern the naming of organic chemical compounds, the same compound may be called by many different names.) Also in this section, the MSDS lists the National Fire Protection Association (NFPA) ratings for the Health, Flammability, and Reactivity hazards of the agent as a quick method of conveying the most important features of the agent from a safety standpoint. These ratings range from 0 to 4, with higher numbers indicating greater hazards.

Section 2, Composition, lists the chemical formula of the agent. This section also lists the toxicity of the agent. The toxicity rating, known as an Airborne Exposure Limit, or AEL, is expressed as milligrams (rag) of agent in a cubic meter (m^{3}) of air. The AEL rating is based on a time-weighted average. Typically, the standard is for a person exposed to chemical vapor for 8 hours, then to fresh air for 8 hours. The higher the AEL rating, the safer the agent.

Section 3, Physical Data, describes important physical characteristics of the agent, including the following:

- Boiling Point--temperature at which the product will boil.

  Vapor Pressure and Vapor Density--helps to determine the evaporation rate of the agent and whether the resultant vapors will rise or collect in low areas.

- Solubility in Water--usually expressed in words rather than numbers, this tells to what extent the product will dissolve in water.

- Specific Gravity--the ratio of the agent's density compared to water, which has a specific gravity of 1.00.

- Volatility--a measure of how readily a liquid agent will evaporate in air.

- Appearance and Odor--a verbal description of same.

Section 4 contains Fire and Explosion Data. The keystone of this section is Flash Point, which is the temperature at which the chemical gives off vapors that will burn if a source of ignition is introduced. The higher the flash point, the safer the chemical. Flammability Limits state the range of percentages of a chemical's vapors in air in which those vapors will burn. These limits, however, are not available for, or not applicable to, the chemical agents. Extinguishing Media are the recommended types of material to be used to fight a fire involving the chemical agent. If there are unique or notable measures fire fighters should take in a fire involving the chemical agent, they are listed in Special Fire Fighting Procedures. Additional fire and explosion information that fire fighters should be aware of may be listed as Unusual Fire and Explosion Hazards.

Section 5, Health Hazard Data, is a comprehensive description of potential health hazards posed by the chemical agent. It again lists, and explains further, the AEL listed in Section 2. This section describes the effects of overexposure and contains a statement about carcinogenicity and the chemical's potential for it. Finally, under Emergency and First Aid Procedures are listed the common routes of entry into the body--skin or eye contact, inhalation, or ingestion--and describes measures to be taken if a person is exposed to the chemical agent.

Section 6, Reactivity Data, advises the MSDS reader about circumstances under which the agent will undergo a potentially hazardous chemical reaction. Data include

- Stability--the agent's resistance to chemical change.
- Incompatibility--specific materials to avoid.
- Hazardous Decomposition--the substances that will typically be created during a chemical reaction.

  Hazardous Polymerization--reaction that can occur in some compounds when molecules of different chemical components mix and create a hazardous situation. This reaction will not occur with VX.

Section 7, Spill, Leak, and Disposal Procedures, covers general procedures for containing and decontaminating spills of chemical agent. General advice on the proper waste disposal method for the chemical agent is also contained in this section.

Section 8, Special Protection Information, details measures required for adequate personal protection of persons working with the chemical agent. Such protective equipment as respiratory face masks, ventilation (including special requirements for laboratory hoods), protective gloves and clothing, eye protection, and monitoring equipment are listed.

Section 9 lists Special Precautions to be followed when working with chemical agent, such as using the buddy system, not eating, drinking, or smoking in areas containing the agent, and personal cleaning at the end of a work day. Any other special precautions to be taken in handling and storage not covered elsewhere in the MSDS are contained in this section.

Section 10, Transportation Data, lists U.S. Department of Transportation label and placard information to be used in transporting the chemical agent. The section also identifies other precautions to be taken in transporting these materials.

MATERIAL SAFETY DATA SHEET

LETHAL NERVE AGENT VX

SECTION I - GENERAL INFORMATION

DATE: 14 September 1988
REVISED: 28 February 1996

MANUFACTURER'S ADDRESS:
U.S. ARMY CHEMICAL BIOLOGICAL DEFENSE COMMAND

EDGEWOOD RESEARCH DEVELOPMENT, AND
ENGINEERING CENTER (ERDEC)
ATTN: SCBRD-ODR-S
ABERDEEN PROVING GROUND, MD 20101-5423

Emergency telephone #' s: 0700-1630 EST: 410-671-4411/4414
After: 1630 EST: 410-278-5201, Ask for Staff Duty Officer

CAS REGISTRY NUMBERS: 50782-69-9, 51848-47-6, 53800-40-1, 70938-84-0

CHEMICAL NAME:
O-ethyl-S-(2-diisopropylaminoethyl) methyl phosphonothiolate

TRADE NAME AND SYNONYMS:
Phosphonothioic acid, methyl-, S-(2-bis(1-methylethylamino)ethyl) 0-ethyl ester
O-ethyl S-(2-diisopropylaminoethyl) methylphosphonothiolate
S-2-Diisopropylaminoethyl O-ethyl methylphosphonothioate
S-2((2-Diisopropylamino)ethyl) O-ethyl methylphosphonothiolate
O-ethyl S-(2-diisopropylaminoethyl) methylphosphonothioate
O-ethyl S-(2-diisopropylaminoethyl) methylthiolphosphonoate
S-(2-diisopropylaminoethyl) o-ethyl methyl phosphonothiolate
Ethyl-S-dimethylaminoethyl methylphosphonothiolate
VX
EA 1701
TX60

CHEMICAL FAMILY: Sulfonated organophosphorous compound

FORMULA/CHEMICAL STRUCTURE:
C11 H26 N O2 P S

```
  CH3                 CH (CH3)2
     \               /
  O = P-S-CH2CH2-N
     /               \
CH3 CH2O              CH (CH3)2
```

NFPA 704 HAZARD SIGNAL:

```
                 Health - 4              /\
                 Flammability - 1       /  \
                 Reactivity - 1        /    \
                 Special - 0          /\ 1  /\
                                     /  \  /  \
                                    / 4  \/ 1  \
                                    \    /\    /
                                     \  /  \  /
                                      \/ 0  \/
                                       \    /
                                        \  /
                                         \/
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SECTION II - HAZARDOUS INGREDIENTS

INGREDIENTS NAME	FORMULA	PERCENTAGE BY WEIGHT	AIRBORNE EXPOSURE LIMIT (AEL)
VX	C11 H26 N O2 P S	100%	.00001 mg/m3

SECTION III - PHYSICAL DATA

BOILING POINT: 298 DEG C 568 DEG F

VAPOR PRESSURE (mm Hg): 0.0007 @ 20 DEG C

VAPOR DENSITY (AIR=1): 9.2

FREEZING/MELTING POINT: Below -51 DEG C

LIQUID DENSITY (g/cc): 1.0083 @ 20 DEG C

PERCENTAGE VOLATILE BY VOLUME: 10.5 mg/m3 @ 25 DEG C

SOLUBILITY: Slightly soluble in water at room temperature. Soluble in organic solvents.

APPEARANCE AND ODOR: Colorless to straw colored liquid & odorless, similar in appearance to motor oil.

SECTION IV - FIRE AND EXPLOSION DATA

FLASHPOINT: 159 DEG C (McCutchan - Young)

FLAMMABILITY LIMITS (% by volume): Not Available

LOWER EXPLOSIVE LIMIT: Not Applicable

UPPER EXPLOSIVE LIMIT: Not Applicable

EXTINGUISHING MEDIA: Water mist, fog, foam, CO2. Avoid using extinguishing methods that will cause splashing or spreading of the VX.

SPECIAL FIRE FIGHTING PROCEDURES: All persons not engaged in extinguishing the fire should be immediately evacuated from the area. Fires involving VX should be contained to prevent contamination to uncontrolled areas. When responding to a fire alarm in buildings or areas containing VX , fire fighting personnel should wear full firefighter protective clothing (without TAP clothing) during chemical agent firefighting and fire rescue operations. Respiratory protection is required. Positive pressure, full face piece, NIOSH-approved self-contained breathing apparatus (SCBA) will be worn where there is danger of oxygen deficiency and when directed by the fire chief or chemical accident/incident (CAI) operations officer. In cases where firefighters are responding to a chemical accident/incident for rescue/reconnaissance purposes they will wear appropriate levels of protective clothing (See Section VIII).

Do not breathe fumes. Skin contact with nerve agents must be avoided at all times. Although the fire may destroy most of the agent, care must still be taken to assure the agent or contaminated liquids do not further contaminate other areas or sewers. Contact with liquid VX or vapors can be fatal.

UNUSUAL FIRE AND EXPLOSION HAZARDS: None known.

SECTION V - HEALTH HAZARD DATA

AIRBORNE EXPOSURE LIMITS (AEL): The permissible airborne exposure concentration for VX for an 8-hour workday of a 40-hour work week is an 8-hour time weighted average (TWA) of 0.00001 mg/m3. This value can be found in "AR 40-8, Occupational Health Guidelines for the Evaluation and Control of Occupational Exposure to Nerve Agents GA, GB, GD, and VX." To date, however, the Occupational Safety and Health Administration (OSHA) has not promulgated a permissible exposure concentration for VX.

VX is not listed by the International Agency for Research on Cancer (IARC), American Conference of Governmental Industrial Hygienists (ACGIH), Occupational Safety and Health Administration (OSHA), or National Toxicology Program (NTP) as a carcinogen.

EFFECTS OF OVEREXPOSURE: VX is a lethal cholinesterase inhibitor. Doses which are potentially life-threatening may be only slightly larger than those producing least effects. Death usually occurs within 15 minutes after absorption of a fatal dosage.

VX

Route	Form	Effect	Type	Dosage
ocular	vapor	miosis	Ect50	<0.09 mg-min/m3
inhalation	vapor	runny nose	Ect50	<0.09 mg-min/m3
inhalation (15 l/min	vapor	severe incapacitation	Ict50	25 mg-min/m3
inhalation (15 l/min)	vapor	death	Lct50	30 mg-min/m3
percutaneous	liquid	death	LD50	10 mg/70 kg man

Effective dosages for vapor are estimated for exposure durations of 2-10 minutes.

Symptoms of overexposure may occur within minutes or hours, depending upon the dose. They include: miosis (constriction of pupils) and visual effects, headaches and pressure sensation, runny nose and nasal congestion, salivation, tightness in the chest, nausea, vomiting, giddiness, anxiety, difficulty in thinking, difficulty sleeping, nightmares, muscle twitches, tremors, weakness, abdominal cramps, diarrhea, involuntary urination and defecation. With severe exposure symptoms progress to convulsions and respiratory failure.

EMERGENCY AND FIRST AID PROCEDURES:

INHALATION: Hold breath until respiratory protective mask is donned. If severe signs of agent exposure appear (chest tightens, pupil constriction, incoordination, etc.), immediately administer, in rapid succession, all three Nerve Agent Antidote Kit(s), Mark I injectors (or atropine if directed by a physician). Injections using the Mark I kit injectors may be repeated at 5 to 20 minute intervals if signs and symptoms are progressing until three series of injections have been administered. No more injections will be given unless directed by medical personnel. In addition, a record will be maintained of all injections given. If breathing has stopped, give artificial respiration. Mouth-to-mouth resuscitation should be used when approved mask-bag or oxygen delivery systems are not available. Do not use mouth-to-mouth resuscitation when facial contamination exists. If breathing is difficult, administer oxygen. Seek medical attention IMMEDIATELY.

EYE CONTACT: IMMEDIATELY flush eyes with water for 10-15 minutes, then don respiratory protective mask. Although miosis (pinpointing of the pupils) may be an early sign of agent exposure, an injection will not be administered when miosis is the only sign present. Instead, the individual will be taken IMMEDIATELY to a medical treatment facility for observation.

SKIN CONTACT: Don respiratory protective mask and remove contaminated clothing Immediately wash contaminated skin with copious amounts of soap and water, 10% sodium carbonate solution, or 5% liquid household bleach. Rinse well with water to remove excess decontaminant. Administer nerve agent antidote kit, Mark I, only if local sweating and muscular twitching symptoms are observed. Seek medical attention IMMEDIATELY.

INGESTION: Do not induce vomiting. First symptoms are likely to be gastrointestinal. IMMEDIATELY administer Nerve Agent Antidote Kit, Mark I. Seek medical attention IMMEDIATELY.

SECTION VI - REACTIVITY DATA

STABILITY: Relatively stable at room temperature. Unstabilized VX of 95% purity decomposes at a rate of 5% a month at 71 DEG C.

INCOMPATIBILITY: Negligible on brass, steel, aluminum.

HAZARDOUS DECOMPOSITION PRODUCTS: During a basic hydrolysis of VX up to 10% of the agent is converted to diisopropylaminoethyl methylphosphonothioic acid (EA2192). Based on the concentration of EA2192 expected to be formed during hydrolysis and its toxicity (1.4 mg/kg dermal in rabbit at 24 hours in a 10/90 wt.% ethanol/water solution), a Class B poison would result. The large scale decon procedure, which uses both HTH and NaOH, destroys VX by oxidation and hydrolysis. Typically the large scale product contains 0.2 - 0.4 wt.% EA2192 at 24 hours. At pH 12, the EA2192 in the large scale product has a half-life of about 14 days. Thus, the 90-day holding period at pH 12 results in about a 64-fold reduction of EA2192 (six half-lives). This holding period is sufficient to reduce the toxicity of the product below that of a Class B poison. Other less toxic products are ethyl methylphosphonic acid, methylphosphinic acid, diisopropyaminoethyl mercaptan, diethyl methylphosphonate, and ethanol. The small scale decontamination procedure uses sufficient HTH to oxidize all VX thus no EA2192 is formed.

HAZARDOUS POLYMERIZATION: Does not occur.

SECTION VII - SPILL, LEAK, AND DISPOSAL PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED: If leaks or spills of VX occur, only personnel in full protective clothing (See Section VIII) will remain in the area. In case of personnel contamination see Section V for emergency and first aid instructions.

RECOMMENDED FIELD PROCEDURES (For Quantities greater than 50 grams): (NOTE: These procedures can only be used with the approval of the Risk Manager or qualified safety perfessionals). Spills must be contained by covering with vermiculite, diatomaceous earth, clay or fine sand. An alcoholic HTH mixture is prepared by adding 100 milliliters of denatured ethanol to a 900-milliliter slurry of 10% HTH in water. This mixture should be made just before use since the HTH can react with the ethanol. Fourteen grams of alcoholic HTH solution are used for each gram of VX. Agitate the decontamination mixture as the VX is added. Continue the agitation for a minimum of one hour. This reaction is reasonablely exothermic and evolves substantial off gassing. The evolved reaction gases should be routed through a decontaminate filled scrubber before release through filtration systems. After completion of the one hour minimum agitation, 10% sodium hydroxide is added in a quantity equal to that necessary to assure that a pH of 12.5 is maintained for a period not less than 24 hours. Hold the material at a pH between 10 and 12 for a period not less than 90 days to ensure that a hazardous intermediate material is not formed (See Section VI). Scoop up all material and place in a DOT approved container. Cover the contents of the with decontaminating solution as above. After sealing, the exterior decontaminated and labeled according to EPA and DOT regulations. All leaking containers will be over packed with vermiculite placed between the interior and exterior containers. Decontaminate and label according to EPA and DOT regulations. Dispose of decontaminate according to Federal, state, and local laws. Conduct general area monitoring to confirm that the atmospheric concentrations do not exceed the airborne exposure limits (See Sections II and VIII).

If the alcoholic HTH mixture is not available then the following decontaminants may be used instead and are listed in the order of preference: Decontamination solution No. 2 (DS2), Supertropical Bleach Slurry (STB), and Sodium Hypochlorite.

RECOMMENDED LABORATORY PROCEDURES (For Quantities less than 50 grams): If the active chlorine of the Calcium Hypochlorite (HTH) is at least 55%, then 80 grams of a 10% slurry are required for each gram of VX. Proportionally more HTH is required if the chlorine activity of the HTH is lower than 55%. The mixture is agitated as the VX is added and the agitation is maintained for a minimum of one hour. If phasing of the VX/decon solution continues after 5 minutes, an amount of denatured ethanol equal to a 10 wt.% of the total agent/decon will be added to help miscibility. Place all material in a DOT approved container. Cover the contents with decontaminating solution as above. After sealing, decontaminate the exterior of the container and label according to EPA and DOT regulations. All leaking containers will be over packed with vermiculite placed between the interior and exterior containers. Decontaminate and label according to EPA and DOT regulations. Dispose of decontaminate according to Federal, State, and local laws. Conduct general area monitoring to confirm that the atmospheric concentrations do not exceed the airborne exposure limits (See Sections II and VIII).

NOTE: ETHANOL SHOULD BE REDUCED TO PREVENT THE FORMATION OF A HAZARDOUS WASTE. Upon completion of the one hour agitation the decon mixture will be adjusted to a pH between 10 and 11. Conduct general area monitoring to confirm that the atmospheric concentrations do not exceed the airborne exposure limits (See Sections II and VIII).

WASTE DISPOSAL METHOD: Open pit burning or burying of VX or items containing or contaminated with VX in any quantity is prohibited. The detoxified VX (using procedures above) can be thermally destroyed by in a EPA approved incinerator according to appropriate provisions of Federal, State and/or local Resource Conservation and Recovery Act (RCRA) regulations.

NOTE: Some states define decontaminated surety material as a RCRA Hazardous Waste.

SECTION VIII - SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION:

CONCENTRATION	RESPIRATORY PROTECTIVE EQUIPMENT
< or = 0.00001 mg/m3	A full face piece, chemical canister, air purifying protective mask will be on hand for escape. (The M9-, M17-, or M40-series masks are acceptable for this purpose. Other masks certified as equivalent may be used).
> 0.00001 or = 0.02 mg/m3	A NIOSH/MSHA approved pressure demand full face piece SCBA or supplied air respirators with escape air cylinder may be used. Alternatively, a full face piece, chemical canister air-purifying protective mask is acceptable for this purpose (See DA PAM 385-61 for determination of appropriate level)
> 0.02 mg/m3 or unknown	NIOSH/MSHA approved pressure demand full face piece SCBA suitable for use in high agent concentrations with protective ensemble. (See DA PAM 385-61 for examples)

VENTILATION:
Local exhaust: Mandatory. Must be filtered or scrubbed to limit exit concentrations to < 0.00001 mg/m3. Air emissions will meet local, state and federal regulations.

Special: Chemical laboratory hoods will have an average inward face velocity of 100 linear feet per minute (lfpm) +/- 10% with the velocity at any point not deviating from the average face velocity by more than 20%. Existing laboratory hoods will have an inward face velocity of 150 lfpm +/- 20%. Laboratory hoods will be located such that cross-drafts do not exceed 20% of the inward face velocity. A visual performance test using smoke-producing devices will be performed in assessing the ability of the hood to contain agent VX.

Other: Recirculation or exhaust air from chemical areas is prohibited. No connection between chemical areas and other areas through ventilation system is permitted. Emergency backup power is necessary. Hoods should be tested at least semiannually or after modification or maintenance operations. Operations should be performed 20 centimeters inside hood face.

PROTECTIVE GLOVES: Butyl Rubber Glove M3 and M4 Norton, Chemical Protective Glove Set

EYE PROTECTION: At a minimum chemical goggles will be worn. For splash hazards use goggles and face shield.

OTHER PROTECTIVE EQUIPMENT: For laboratory operations, wear lab coats, gloves and have mask readily accessible. In addition, daily clean smocks, foot covers, and head covers will be required when handling contaminated lab animals.

MONITORING: Available monitoring equipment for agent VX is the M8/M9 detector paper, detector ticket, M256/M256A1 kits, bubbler, Depot Area Air Monitoring System (DAMMS), Automated Continuous Air Monitoring System (ACAMS), Real-Time Monitor (RTM), Demilitarization Chemical Agent Concentrator (DCAC), M8/M43, M8A1/M43A1, CAM-M1, Hydrogen Flame Photometric Emission Detector (HYFED), the Miniature Chemical Agent Monitor (MINICAM), and the Real Time Analytical Platform (RTAP).

Real-time, low-level monitors (with alarm) are required for VX operations. In their absence, an Immediately Dangerous to Life and Health (IDLH) atmosphere must be presumed. Laboratory operations conducted in appropriately maintained and alarmed engineering controls require only periodic low-level monitoring.

SECTION IX - SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING: When handling agents, the buddy system will be incorporated. No smoking, eating, and drinking in areas containing chemicals is permitted. Containers should be periodically inspected for leaks (either visually or by a detector kit). Stringent control over all personnel practices must be exercised. Decontamination equipment will be conveniently located. Exits must be designed to permit rapid evacuation. Chemical showers, eyewash stations and personal cleanliness facilities must be provided. Wash hands before meals, each worker will shower thoroughly with special attention given to hair, face, neck, and hands, using plenty of soap and water before leaving at the end of the workday.

OTHER PRECAUTIONS: VX must be double contained in liquid and vapor tight containers when in storage or outside a ventilation hood.

For additional information see "AR 385-61, The Army Toxic Chemical Agent Safety Program," "DA PAM 385-61, Toxic Chemical Agent Safety Standards," and "AR 40-8, Occupational Health Guidelines for the Evaluation and Control of Occupational Exposure to Nerve Agents GA, GB, GD, and VX."

SECTION X - TRANSPORTATION DATA

PROPER SHIPPING NAME: Poisonous liquids, n.o.s.

DOT HAZARD CLASS: 6.1 Packing Group I, Zone A

DOT LABEL: Poison

DOT MARKING: Poisonous liquids, n.o.s. (O-ethyl S-(2-diisopropylaminoethyl) methyl phosphonothiolate)
UN 2810, Inhalation Hazard

DOT PLACARD: Poison

EMERGENCY ACCIDENT PRECAUTIONS AND PROCEDURES: See Sections IV, VII and VIII.

PRECAUTIONS TO BE TAKEN IN TRANSPORTATION: Motor vehicles will be placarded, regardless of quantity. Drivers will be given full information regarding shipment and conditions in case of an emergency. AR 50-6 deals specifically with the shipment of chemical agents. Shipments of agent will be escorted according to AR 740-32.

APPENDIX F:

POTENTIAL FOR SURFACE CONTAMINATION BY DEPOSITION OF CHEMICAL AGENT

In the event of a release to the environment of chemical agent from NECD, the primary hazard for public protective action strategy planning would be the airborne dispersion of agent vapors. However, in addition to the vapor hazard, chemical agent could be released to the atmosphere in the form of a coarse aerosol or small droplets. If the droplets did not evaporate quickly, they could be carried by the wind and dispersed in a manner similar to agent vapors until they are blown onto or settle onto surfaces. This surface deposition could result in a contact hazard, especially for emergency workers whose duties might bring them into a contaminated area.

The Army has studied the potential for surface deposition of chemical agent (Paddock et al. 1994). The chemical agent deposition study is summarized in the following section (F. 1). In Section F.2 a method is described for estimating the maximum potential downwind extent of surface deposition by using the deposition study results. Finally, as an example, the method is applied to an accident scenario at NECD involving a large aircraft crash into the munitions disposal building (MDB) with fire. Generally, the greatest potential for agent to be deposited beyond the NECD boundaries would arise from a release that involves both explosion and fire. An explosion will tend to create droplets of agent. Heat from a fire will tend to carry those droplets upward, where they can travel downwind for significant distances before contacting the ground or other surfaces.

F.1 SUMMARY **OF CHEMICAL AGENT DEPOSITION** STUDY

A relatively simple transport and diffusion model was used to estimate the extent of agent deposition on horizontal surfaces following a release of chemical agent. The U.S. Army's GAPCAP (Generation of Assessment Patterns for Clouds of Airborne Particles) model was used (Wu and Sloop 1986). The model assumes that agent is released into the atmosphere in the form of small droplets that do not evaporate very readily. Thus, they are transported and dispersed like small particles. The model assumes a Gaussian distribution for the cloud of agent particles. Deposition on horizontal surfaces is predicted by assigning a vertical drift or settling velocity to the particles based on their mass and size. The falling particles eventually land, and the resulting average deposition density is calculated.

TABLE F.1 Assumptions of the GAPCAP Model as Used in the Deposition Study

- A uniform wind exists that has a constant direction and a speed that increases with height.
- The ground surface is flat and uniform.
- The concentration profiles of the droplets within the moving, expanding cloud are of a simple Gaussian form
- The standard deviations (widths) of the Gaussian profiles increase as simple functions of downwind distance. (The specific functions depend on atmospheric stability.)
- The droplets behave as particles in that they do not decrease or increase in size due to evaporation or condensation.
- Vertical growth of the cloud is limited by an impenetrable inversion cap at a constant height.
- Within the mixing layer (between the ground and the inversion cap), atmospheric conditions are uniform and constant.
- All droplets are retained on the ground surface upon impact.

The important assumptions that were made in developing and implementing the GAPCAP model are summarized in Table F. 1. Many of these assumptions and other phenomena that are not taken into account by the model tend to make the results of the model conservative. That is, actual deposition densities are likely to be less than those predicted by the model. For example, not all agent released during an accident will become airborne. Some agent may be destroyed or vaporized during the release event; some may be immediately deposited on surfaces near the release. In addition, some of the agent that does become airborne will evaporate as it travels downwind. Also, changes in atmospheric conditions, especially wind direction, will tend to disperse the agent more, diluting its concentration in the atmosphere and resulting in lower deposition densities.

Several variables, such as the size of the droplets, the effective height at which they are released, and atmospheric conditions, are important in determining how the agent is transported, dispersed, and deposited. However, it is very difficult to predict these variables for accidents involving collisions, explosions, and fires, so the deposition study was carried out parametrically. That is, the values of the GAPCAP model's input parameters were systematically varied over ranges judged to span the credible release scenarios and meteorological conditions associated with the various Army stockpile sites. The model was then used to predict the downwind distances to a series of deposition density levels for various combinations of input parameter values.

The input parameters of the GAPCAP model include some that are not readily observable. These parameters include the height of the mixing layer, various atmospheric diffusion parameters, and source dimensions. In order to make the parametric model study easier to understand, these parameters were related to more directly observable parameters. Atmospheric diffusion parameters and mixing layer heights were taken to be functions of atmospheric stability category; values were taken from the database included with the Army's D2PC model. A simple relationship between source size and the quantity of agent released was also developed by using source dimensions from the D2PC database. The resulting parameters and their values used in the parametric model study are listed in Table F.2 and discussed in the following paragraphs.

Agent type. Although NECD stores only agent VX, the deposition study addressed all eight CSEPP sites. The agents considered in the study were the blister agent HD and the nerve agent VX. The nerve agent GB was not included because its high volatility makes it unlikely that this agent will remain in liquid form long enough following a release to travel more than a few hundred meters from the release point.

Mass released. Eight masses of released agent, from 100 lb to 500,000 lb, were used for the study. The values range from the agent content of just a few munitions to the largest credible releases involving earthquake-induced incidents at the NECD bulk storage warehouses.

TABLE F.2 Parameters and Parameter Values Used in the Parametric Model Study

Parameter	Values	Units
Agent type	HD (not applicable to NECD), VX	N/A
Mass released	100; 500; 1,000; 5,000; 10,000; 50,000; 100,000; 500,000	pounds
Droplet diameter	1, 5, 10, 50, 100, 500	micrometers
Effective release height	1, 50, 100, 200, 300, 500, 700	meters
Atmospheric stability	Categories B, D, F	N/A
Wind speed	1, 2, 3, 5, 7, 10, 12, 15, 20	meters/second
Deposition density	1,000,000; 100,000; 10,000; 1,000; 100; 10; 1.0; 0.1; 0.01; 0.001	milligrams/meter^2

Droplet diameter. To cover the range of droplet sizes (diameters) that probably could be transported significant distances downwind, six diameters, from 1 pm to 500 pm, were used for the study. Droplets with diameters of 1 pm or less would tend to behave essentially like vapor even though they contain over a billion molecules of agent each. In contrast, droplets with diameters of 500 pm (about 0.02 inches) or more contain over 125 million times more agent than 1 pm droplets. Such large droplets would rapidly settle out and not leave the immediate vicinity of the release.

Effective release height. The effective height of the release could range from near ground level to several hundred meters in the air, depending on the release scenario. For example, the accidental detonation of a munition during handling by a fork lift would result in a release at essentially ground level; however, a release accompanied by a large fire could result in a large effective release height, because the agent would be carried upward by the heat of the fire. To cover a wide range of possibilities, a series of seven release heights from 1 m to 700 m was used in the study.

Atmospheric stability. Atmospheric stability is a measure of the turbulence or mixing present in the atmosphere. Atmospheric stabilities are classified by meteorologists into categories. One such classification scheme, the Pasquill Stability Categories, consists of six classes designated A through F. The most unstable category, with the greatest amount of turbulence, is A. The most stable category, with the least amount of turbulence, is F. Categories B, D, and F were used in the parametric study to cover the possible conditions, yet limit the number of cases included in the study. Stability category A was omitted because such high levels of turbulence would result in smaller downwind deposition densities than the other stability categories.

Wind speed. The GAPCAP model assumes that the wind is constant in speed and direction for the entire duration of the release and everywhere within the cloud. A series of nine wind speeds from 1 m/s to 20 m/s was used in the parametric study. It is generally believed that 1 m/s is about the lowest speed for which a fairly constant wind can be maintained in nature. Winds stronger than 20 m/s are usually associated with storms or hurricanes, in which constant speeds and directions are not maintained for long periods of time.

Deposition dens?. The GAPCAP model was used to estimate the extent of downwind deposition in densities greater than or equal to ten deposition levels. Deposition density is expressed as mass of agent per unit of surface area; for chemical agents, the units of milligrams per square meter (mg/m^2) are often used. A study by the U.S. Army (Reutter et al. 1994) proposed a no-effects deposition density limit for the general population of 0.002 mg/m^2 for exposure durations of 4 hours to VX, and 0.0009 mg/m^2 for exposure durations of 8 hours or more to VX. However, these limits have not been officially adopted by the Army. Therefore, the deposition study treated this variable as parametric. Deposition levels used in the study ranged from 0.001 mg/m^2 to 1,000,000 mg/m^2. The low end of this range is about the same as the smallest proposed no-effects deposition density for VX. The high end is about the largest deposition density predicted by the GAPCAP model to exist beyond a few hundred meters from the release location for any combination of values of the other six parameters.

In summary, the parametric study included seven parameters. There are 18,144 possible combinations of values of the first six parameters. However, many of these combinations are not physically realistic. For example, atmospheric stability category F would not co-exist for very long with wind speeds over 3 m/s. Restrictions such as this reduce the number of physically realistic combinations of parameter values to 7,200. For each combination, the extent of downwind deposition was estimated to be the farthest downwind distance where the calculated deposition density was at or above the deposition level of interest. Model predictions were only reported to a maximum downwind distance of 20 km because Gaussian dispersion models such as GAPCAP are only considered to be reliable over distances of a few tens of kilometers.

F.2 ESTIMATING THE POTENTIAL DOWNWIND EXTENT OF SURFACE DEPOSITION

It is difficult to predict the true quantity of agent released as droplets, the distribution of droplet sizes (diameters), and the effective release height of the droplets for an actual accident scenario. Therefore, the best that can be done with the present state of knowledge is to estimate an upper bound on the magnitude and extent of agent deposition that might occur. Such estimates can be made using the results in Volume 2 of the deposition study (Paddock et al. 1994) for the agent type, quantity (mass released), atmospheric stability, and wind speed that best describe the accident scenario. The largest downwind distance predicted for each deposition density for any combination of droplet input parameters would be an upper bound on the extent of deposition predicted for that deposition density.

Most accident scenarios at NECD involve less than a few hundred pounds of agent. (Exceptions are a few externally initiated scenarios that involve fire.) Therefore, for most scenarios, the applicable results will be those for agent releases of 100 and 500 pounds. Generally, the predicted deposition density at any downwind location is roughly proportional to the initial mass of agent released. Therefore, the results of the study for 100- and 500-pound releases can be normalized by dividing by the mass released and combining to form a single curve that represents an upper bound of the expected deposition density as a function of downwind distance for a particular atmospheric stability and wind speed.

Results of the study indicate that these bounding curves do not depend strongly on the wind speed (1 m/s through 20 m/s). Therefore, a single bounding curve can be derived for each atmospheric stability category (B, D, and F) that encompasses the results for all droplet diameters, effective release heights, and wind speeds considered in the study. These bounding curves are plotted in Figure F. 1. Figure F.2 is an expanded plot of the first 2,000 m downwind to facilitate extracting numerical values for locations near the release site.

The parametric study did not predict agent deposition within the first 50 to 100 meters of the release. However, the study indicates that the largest deposition densities in this region would come from very large droplets (diameter of 500 pm) released near the ground surface (release height of 1 m). The large droplets would settle to the ground rapidly, resulting in large deposition densities very near the release. In order to extend the bounding curves into the region between the release point and 50-100 m downwind, additional computations using the GAPCAP model were performed. The results are included in Figure F.2.

F.3 APPLICATION TO A SPECIFIC ACCIDENT SCENARIO

As an example of how Figures F. 1 and F.2 can be applied to a specific accident scenario at NECD, consider the scenario designated PO-K-V-F-13 in Appendix D. This scenario involves a large aircraft crash into the MDB with fire. The amount of agent released to the atmosphere is 240 lb. For now, we will assume that the entire amount is released as droplets. In this example, we will consider all three atmospheric stability categories from the parametric study: B, D, and F.

Planners and emergency responders may wish to know the largest agent deposition that might occur on the ground at a particular distance from the release. Section 3 of this guide indicates that the shortest distance from the demilitarization facility to a depot boundary is 1.2 km (0.8 mi). Therefore, we will look at this distance.

From Figure F.2, starting with the curve for stability category B, the largest deposition density that occurs 1,200 m downwind is about 0.4 mg/m^2 per pound of agent released. Multiplying this normalized deposition by the mass released, 240 lb, we get a maximum deposition density of 96 mg/m^2. This calculation is shown in sample worksheet Figure F.3. Similar calculations are shown for stability categories D and F.

The maximum downwind distance to specific deposition densities may also be of interest. For example, consider the same accident scenario with a deposition density of 1,000 mg/m^2. This density, when normalized by the mass released (divide it by 240 lb) becomes 4.2 mg/m2/lb. For stability category B, entering Figure F.2 at 4.2 mg/m2/lb yields a downwind distance of about 370 m. Again, this procedure is shown in Figure F.3. Results obtained in the same way for other deposition densities and stability categories are also shown in Figure F.3.

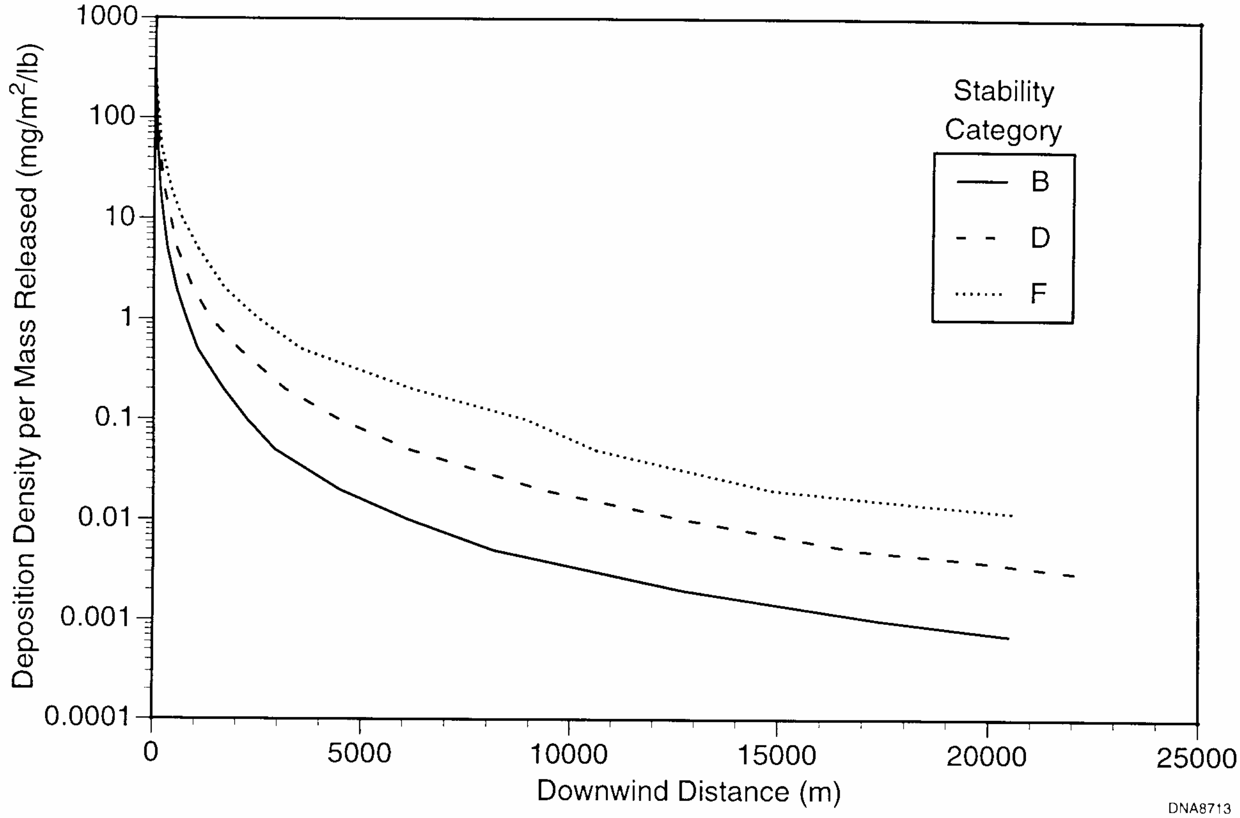

FIGURE F.1 Maximum Expected Deposition Density for Agent Released into an Atmosphere of the Indicated Stability Category: 0 to 20,000 m Downwind

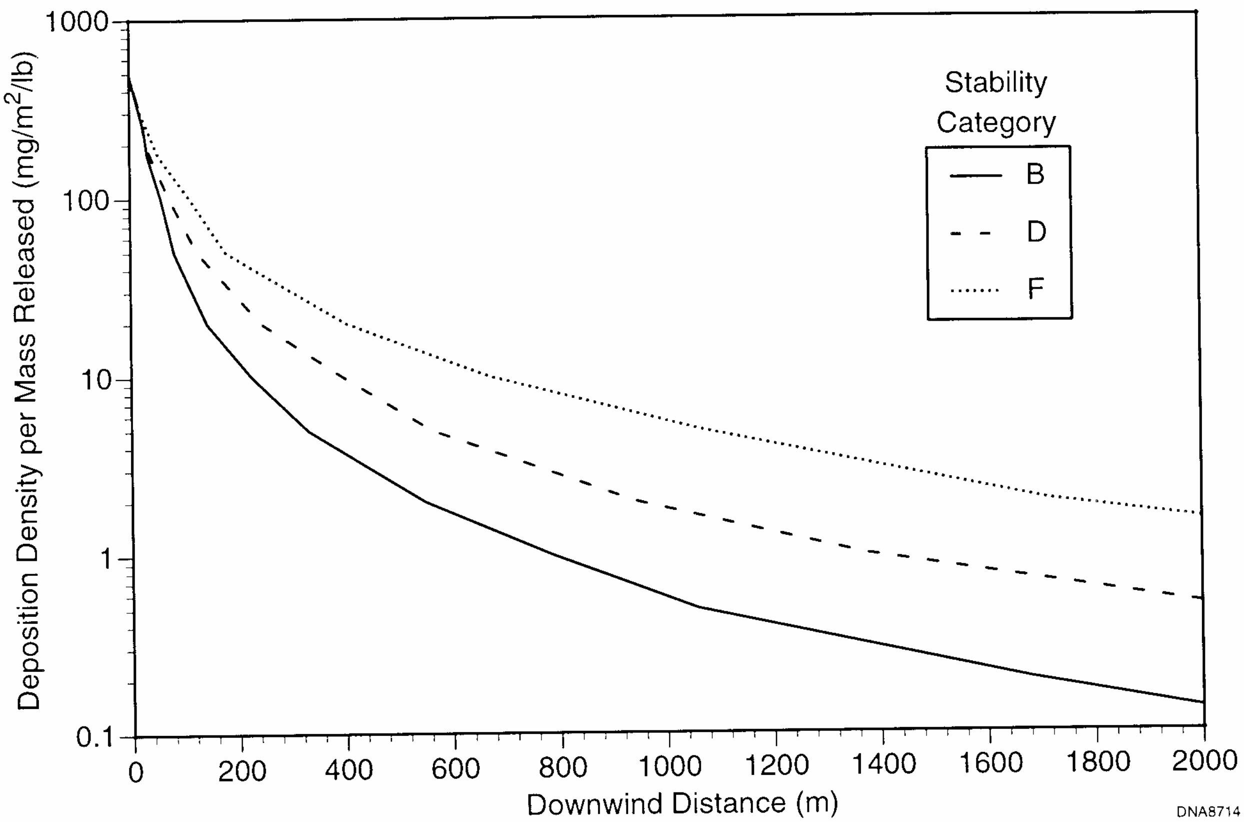

FIGURE F.2 Maximum Expected Deposition Density for Agent Released into an Atmosphere of the Indicated Stability Category: 0 to 2,000 m Downwind

The same procedure can be applied to other accident scenarios to obtain estimates of the largest deposition density that might occur downwind of the point of release. A blank worksheet is provided in Figure F.4 that can be copied and used to make such estimates for other accident scenarios.

Remember that these estimates are only approximate upper bounds. Following an actual release, it would be unlikely for observed deposition densities to approach, much less exceed, these estimates. However, these estimates are based on a limited number of runs of a Gaussian dispersion model. Therefore, it is possible that under just the right release characteristics and atmospheric conditions, observed deposition densities could exceed the estimates. For further discussion of the limitations of Gaussian dispersion models, see Section 7 of this guide.

F.4 APPENDIX F REFERENCES

Paddock, R.A., M.J.G. Absil, J.P. Peerenboom, D.E. Newsom, M.A. Madore, M.J. North, and R.J. Coskey, Jr., 1994, *Potential for Surface Contamination by Deposition of Chemical Agent Following Accidental Release at an Army Storage Depot -- Volume 1: Chemical Agent Deposition Study; Volume 2: Results of Parameter Model Study*, Argonne National Laboratory, Argonne, Ii1., July.

Reutter, S.A., E.J. Olajos, R.J. Mioduszewski, and A. Watson, 1994, *Validation of Contact Hazard Toxicity Estimates for Agents VX and HD -- Phase H*, ERDEC-SP-017, U.S. Army Edgewood Research, Development, and Engineering Center, Aberdeen Proving Ground, Md., Feb.

Wu, D.L., and D.W. Sloop, 1996, *A Package of Transport and Diffusion Models for Biological and Toxin Agents*, CRDEC-TR-86034, U.S. Army Chemical Research, Development, and Engineering Center, Aberdeen Proving Ground, Md., June.

1. Scenario Description: PO-K-V-F-13, large aircraft direct crash MDB with fire

2. Agent Type: VX

Estimated Maximum Deposition Densities at Specified Downwind Locations

Downwind Distance of Interest (meters)	Atmospheric Stability Category (B, D, or F)	Normalized Deposition Density (from Figure F.1 or F.2) ($mg/m^2/lb$)	Quantity Released (pounds)	Deposition Density (Column 3 times Column 4) (mg/m^2)
1200	B	0.4	240	96
1200	D	1.4	240	336
1200	F	3.9	240	936

Estimated Maximum Downwind Distances to Specified Deposition Densities

Deposition Density of Interest (mg/m^2)	Quantity Released (pounds)	Normalized Decomposition Density (Column 1 divided by Column 2) ($mg/m^2/lb$)	Atmospheric Stability Category (B, D, or F)	Downwind Distance (from Figure F.1 or F.2) (meters)
1,000	240	4.2	B	370
10	240	0.042	B	3,200
1	240	0.0042	B	9,000
1,000	240	4.2	D	610
10	240	0.042	D	6,700
1	240	0.0042	D	19,000
1,000	240	4.2	F	1,150
10	240	0.042	F	11,400
1	240	0.0042	F	>20,000

FIGURE F.3 Worksheet Showing Sample Scenario Results

1. Scenario Description: ______________________________

2. Agent Type: VX

Estimated Maximum Deposition Densities at Specified Downwind Locations

Downwind Distance of Interest (meters)	Atmospheric Stability Category (B, D, or F)	Normalized Deposition Density (from Figure F.1 or F.2) ($mg/m^2/lb$)	Quantity Released (pounds)	Deposition Density (Column 3 times Column 4) (mg/m^2)

Estimated Maximum Downwind Distances to Specified Deposition Densities

Deposition Density of Interest (mg/m^2)	Quantity Released (pounds)	Normalized Decomposition Density (Column 1 divided by Column 2) ($mg/m^2/lb$)	Atmospheric Stability Category (B, D, or F)	Downwind Distance (from Figure F.1 or F.2) (meters)

FIGURE F.4 Blank Worksheet