University of Delaware
Disaster Research Center

PRELIMINARY PAPER
#73

ASSESSING LOCAL DIFFERENCES IN CHEMICAL DISASTER PRONENESS: THE COMMUNITY CHEMICAL HAZARD VULNERABILITY INVENTORY*

Thomas Gabor
and
Carlo Pelanda

December, 1981

*The data in this article were partly obtained through National Science Foundation Grant Number PRF 7714445 to the Disaster Research Center, The Ohio State University. However, any opinions, findings, conclusions, or recommendations are those of the authors and do not necessarily reflect the views of the National Science Foundation. The authors are indebted to E.L. Quarantelli, T. Johnson, B. Swisher, and K. Tierney for their comments on earlier drafts of the paper.

Introduction

Recently, a great deal of attention has been focused upon the human and ecological hazards posed by the manufacture, storage, transporation, and disposal of dangerous chemicals. Mass media reports concerning chemical spills and environmental contamination can be observed on a daily basis in the United States, Canada, and Western Europe. Although such incidents may be less salient politically than the cataclysmic threats of nuclear reactor accidents, their cumulative effects, at least, are probably far more damaging.

The threats emanating from hazardous chemicals may develop gradually (chronic events) or they may appear without warning (acute events). The first category is exemplified by incidents such as the finding in the late 1970s of the chemical PCB in the state of Michigan's cattle feed and the contamination of the Love Canal near Niagara Falls, New York by buried toxic wastes. Acute threats, the subject of this paper, may manifest themselves in the form of fires, explosions and/or chemical releases into the air, water, and ground.

The prevalence of acute incidents and their concomitant adverse effects have increased notably in the past several years, if published statistics can be taken seriously. In the realm of transportation, for example, the total number of rail, air, highway, and marine incidents reported to the Department of Transportation has increased from 2,255 to 15,924 (706%) from 1971 to 1977 (U.S. Department of Transportation, 1978a). From 1972 through June of 1978 hazardous materials incidents of an acute nature have been responsible for at least 111 fatalities, 1,460 injuries, and 77.5 million dollars in property damages, with separate evacuations of up to 30,000 persons having occurred (Johnson, 1979). This is not to mention the hundreds of millions of dollars in legal claims that have arisen from these incidents.

Attempts to mitigate the hazards posed by dangerous chemicals have been reactive, with allocations of resources by local or state governments generally being made in response to disasters already underway or as a result of public pressure following a disaster (Benner, 1977). This is partly due to a lack of recognition of the problem's gravity by those responsible for emergency planning. This is to some extent a perceptual problem. A recent study found that safety personnel in industry perceive the threat posed by hazardous chemicals as lower than do persons in emergency organizations (e.g., fire and police departments, civil defense, etc.) (Quarantelli, Lawrence, Tierney, and Johnson, 1979). This is particularly troublesome as most chemical incidents tend to occur while under the control of the private sector. The economic dependency of a community on the chemical industry based therein may constitute another reason for ignoring the problem. On the other side of the coin, unless faced with extreme public pressure, corporations are likely to keep their hazard potentials at a low profile (Gray and Quarantelli, 1981).

Developing a Relevant Inventory

Given the magnitude of the chemical problem, a systematic approach is required to counteract it. The first step in this direction is the determination, at various political levels, of the hazards to which a given jurisdiction is exposed. The objective of this paper is to present an instrument, the

Community Chemical Hazards Vulnerability Inventory (CCHVI), for the assessment of local level vulnerability to chemical incidents of an acute nature. This constitutes an elaboration of a preliminary schema which has been discussed in an earlier paper (Gabor and Griffith, 1979). Before the specifics of this instrument are described, it is necessary to briefly address the issue of vulnerability.

System vulnerability has been conceived of in a diversity of ways. An array of terms such as "proneness", "risk", "hazard", "susceptibility", "fragility", "penetrability", "exposure"; "lack of preparedness, readiness, organization, experience of viability"; "low capability of absorption and normalization"; or "low elasticity, flexibility or stability", have been used to capture the idea of vulnerability. The manner in which the term has been explicitly defined exemplifies this disparity.

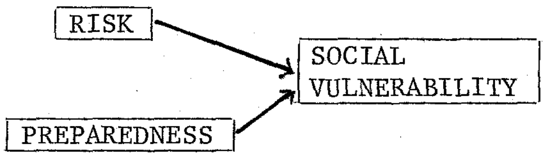
More specifically, disagreement is explicitly present in the distinctions among the meanings of the terms "vulnerability", "proneness", and "risk". Vulnerability has been defined as the degree to which a community is at risk to extreme phenomena (Burton et al, 1978) or as "the susceptibility of population-at-risk to loss when an event of given intensity occurs" (Friedman, 1975: 2). O'Keefe and Westgate assert that the notion of social vulnerability is a combination of both the concepts of proneness and risk. Thus, to them vulnerability is the degree to which a community is at risk from the occurrence of extreme physical or natural phenomena where risk refers to pejorative probability of occurrence, and the degree to which socioeconomic and sociopolitical factors affect the community's capacity to absorb and recover from extreme phenomena (1976: 65).

Our operational definition of vulnerability most closely resembles the latter, with the exception that the probability of an event's occurence is seen as being inversely related to the given area's capacity to respond in the ultimate determination of vulnerability. Thus, vulnerability is seen as comprising two components: 1) Risk (R), the hazards to which a given area are exposed (including the probability of impact and its potential intensity) and 2) Preparedness (P), the area's coping ability in relation to such hazards including physical and human resources, as well as emergency planning. The total Vulnerability of the area is, then, a function of the reciprocal multiplicative relationship between Risk and Preparedness. This can be written as:

$$V = R \times \frac{1}{P} = \frac{R}{P}$$

Hence, it can be seen that vulnerability would be greatest when Risk is high and Preparedness low. This relationship between vulnerability, risk, and preparedness is subsumed within the community vulnerability rating schema to be developed in this paper.

One point that should be made is that the factors of risk and preparedness are not, in reality, independent components of vulnerability (for a more elaborated discussion see, Pelanda, 1981) but have been separated for conceptual and pragmatic reasons. As indicated in an earlier paper (Gabor and Griffith, 1979: 325), this distinction "serves to illustrate the different strategies community planners can pursue according to the relative importance of the two sets of factors in a given situation." Thus, operationally, the relationship of risk and preparedness to vulnerability can be expressed as:



Having provided an operational definition of social vulnerability the units of analysis to which the concept can be applied must be addressed. As mentioned the vulnerability assessment schema to be presented here is designed to be applied at the community (a subsystem) level. Even so, one cannot ignore the legal-political, socioeconomic, organizational, and technological context in which the community must function. The social norms and regulations in a region, as well as the resources and the systems existing for their delivery all impinge upon a community's capability to counteract the threat and avert a crisis.

In ecological and functional terms, vulnerability can be distinguished along, at least three dimensions--the general, the specific, and the typological (Pelanda, 1981). General Vulnerability (GV) refers to the conduciveness of a community's societal context to disaster mitigation. Relevant here, aside from the social and technological contextual factors just mentioned, are the functional linkages between the national (federal) system and the local community under consideration, as well as those involving the international community. Specific Vulnerability (SV) refers to the normative, technological, economic, and organizational capability of a social subsystem (in this case a locality) to counteract a threat. These factors provide a more immediate context than GV for disaster mitigation planning and mobilization strategies. The Typological Vulnerability (TV) of a locality is a function of the concrete measures it has taken or can marshal to directly neutralize a given hazard (e.g., contingency planning). Neutralization here refers to both the prevention of a potential hazard from being actualized or the interruption of an event already in progress so that the most favorable scenario in the event sequence occurs. Since the hazards (both chemical and others) to which a community is exposed are numerous, its vulnerability rating vis-a-vis one hazard may markedly differ from that on another. However, it should be noted that certain communalities exist in preparedness and mobilization procedures across all disaster forms (Dynes, Quarantelli, and Kreps, 1981).

It is our present view, GV directly impinges upon the pre-disaster levels of both SV and TV, as well as upon post-impact recovery. The level of SV, in turn, is a determinant of a community's TV and the response of social units (such as local organizations, families, and individuals) to actual threats. This latter relationship between pre-disaster vulnerability and post-disaster recovery is particularly important as the state of a community before an incident is said to be the best predictor of its subsequent functioning in a crisis (Quarantelli and Dynes, 1977). Finally, the status of a community in terms of TV is the most immediate factor underlying the change a community undergoes as a consequence of crisis.

The community vulnerability assessment schema (CCHVI) to be presented in this paper is oriented primarily toward the typological level--that is, it attempts to probe those community related activities which are most directly related to hazard mitigation. Only one related scheme can be found in the literature. This has been criticized at some length in an earlier paper (Gabor and Griffith, 1979). In short, that scheme appears too cumbersome to be of much use to local authorities with budgetary restrictions.

Characteristics of the CCHVI

Vulnerability analyses can differ in terms of data sources, complexity, and function. Data may derive from experience with a previous incident (Jones, 1973) or may be generated on the basis of theoretically dervied models tested through computer simulations (Silvestro and Mazurowski, 1978). The objective may be to analyze the sensitivity of a single mode or route of transportation (Simmons, Erdmann, and Naft, 1974) or, as in this case, an entire community. Similarly, assessment techniques may be utilized for either pre-, trans-, or post-disaster analyses (Gabor and Griffith, 1979). Futhermore, analyses may be static or processual. The first form involved a quantified definition of the state of an assessed entity at a particular point in time. The second refers to the assignment of probabilities for expected event sequences, with the assessed system continually being re-defined according to changes in the system or the progression of an event.

The method of assessment to be used here in the CCHVI has been termed a "check-list approach" (Griffith, 1979) and roughly falls within the static category. Separate Risk and Preparedness scales are developed (in accordance with our definition of vulnerability). These comprise a list of conditions, the presence or absence of which determine a community's rating of vulnerability to hazardous chemical incidents. These conditions are taken to be independent and additive, rather than synergistic, to facilitate practical application of the instrument. The Risk (Hazard) Scale contains a listing of items regarding the various dimensions of chemical threats to which a community may be exposed. The Preparedness Scale considers community emergency planning, organizational linkages, and resources. The former contains ten items with each possessing a maximum value of one point. The latter contains nine items with their weights ranging from a minimum value of one point to one of four points. The bases for the item weights in the Risk Scale have been discussed in the earlier paper (Gabor and Griffith, 1979). The weights in the Preparedness Scale have been determined by a panel of field researchers at the Disaster Research Center. These should by no means be regarded as the last word but, rather, as preliminary guidelines as to the relative priority of the item in emergency planning.

The Risk Scale constitutes a basic inventory of the magnitude, sources, and types of hazard to which a rated community is exposed. As can be observed in Table 1, the first major set of factors to be considered in assessing community hazards is the density of chemical manufacturing and storage facilities in an area and their proximity to residential or other population centers. Density refers to the concentration of active production sites and warehouses in a community. This factor considers both the likelihood of occurrence and the potential magnitude of an event. Proximity addresses the question of the community's sensitivity, with the focus being the distance of plants from specific population centers.

Density can be computed through calculating the number of non-clerical personnel engaged at chemical sites per the land area of the assessed community. The use of personnel rather than land use data is based on data availability. It also better reflects the volumes of chemicals dealt with in the community, as well as the potential economic impact of disasters on a locality.

The proximity factor examines the extent to which chemical manufacturing and storage facilities are located within a designated distance from the community, posing a direct hazard to the inhabitants and their property. Cities with similar density ratings may differ considerably with respect to the configuration of chemical plants within them. The basic issue is whether industrial plants have been haphazardly constructed and are dispered throughout a city, potentially posing a threat to several neighborhoods, or whether zoning ordinances have confined these plants to industrial parks. The latter situation would result in a threat to possibly only one neighborhood, with protection being provided the remainder of the city.

Although disagreement prevails concerning what constitutes a safe distance from a chemical plant (given the variability of substances produced and their volumes, the importance of climatological conditions and so on), a distance of 2,000 feet has been considered as fatality-free from flying fragments in 99% of plant explosions (U.S. Department of Transportation, 1978b). The same source indicates that a distance of 4,900 feet or over is 100% safe, although the implementation of such a standard would probably not be economically feasible. Proximity could be calculated through the selection of such a standard and the determination (through simple mapping of the area in question) of the percentage of facilities located within that distance from populated areas. A city can be rated on both the density and proximity factors using a nominal scheme (one point for presence or zero for absence of each factor) or it could be scored ordinally according to the degrees of density or proximity.

The next component of the Risk Scale concerns the threat presented by the transporation of hazardous materials through a community. Four major modes of transporation for dangerous chemicals exist, with two, road and rail, constituting the most serious threats and the barge and air cargo modes posing far less serious hazards (U.S. Department of Transportation, 1978a). Due to this difference, the road and rail hazards are accorded a maximum weight of one point in the scheme, with the other two being provided a maximum weight of one-half of a point each. Together, the transporation hazards carry a maximum weight of three points in the ten-point scale, as opposed to only two for manufacturing. This is consistent with the preponderance of transportation incidents, at least in the United States.

Several methods can be used to gauge the extent to which hazards posed by each transportation mode exist in a community. One method involves calculating the total mileage of routes upon which hazardous materials are carried, with consideration being given the population density surrounding these routes and the size of the community as a whole. Another technique involves an attempt to determine the volume of hazardous chemicals passing through a city through monitoring the traffic flow along major arteries. This method is discussed in detail by Zajic and Himmelman (1978). Regardless of the method adopted, some direct observation will be required.

Finally, after the sources and magnitude of community hazards are ascertained, the diversity of these threats must be dealt with. The major forms of hazard to a community are posed by major fires, explosions, and the release of noxious substances into the air, water, or ground. Such substances could include poisons, vapors which irritate or burn the skin and bodily organs through contact or inhalation, substances which may contaminate the soil or water after spills or from run-off following fires, acids which may corrode roadbeds and sewage lines, and so on. The greater the variety of hazards to which a community is exposed, the more difficult the task of emergency planning, as each form of hazard may warrant different preventive and mitigation procedures. Each of the five forms of hazard mentioned are thus provided a maximum weight of one point.

It is recommended that these five items be scored on a presence-absence (0, 1) basis. This is due to the fact that each form of threat, within each of these five categories, requires qualitatively similar resources and procedures to counteract, regardless of the chemical(s) involved. Fires, for example, are contained by several basic agents (water, foam, etc.) irrespective of the properties of the substances involved. In the same way, incidents involving soil contamination, whether caused by a class "A" poison or a corrosive substance, are monitored similarly--soil samples are taken and analyzed, sewage lines and water reservoirs are protected, the possibility of noxious vapors in the atmosphere examined, and preparations for the evacuation of local residents are undertaken. Therefore, for each category of threat, primarily quantitative differences are evidenced in terms of mitigation--i.e., the size of a fire or toxic release. This factor of volume is already taken into consideration in the initial scale items relating to manufacturing and transportation. The second component of the CCHVI, the Preparedness Scale, comprises items totalling twenty points. A city's rating on this scale is placed over a denominator of ten to make it comparable with its hazard rating. The final computation of vulnerability can then be performed according to the formula $V = R(\text{Risk Index})/P(\text{Preparedness Index})$.

The Preparedness Scale consists of nine items probing the comprehensiveness and integration of formal emergency planning in a community, the extent to which efforts have been made to mitigate these and the resources available to the community to perform emergency-related operations. The focus in the scales is the <u>actions of organizations</u> in an assessed community and not the behavior, cognitions, or beliefs of individual persons, be they safety personnel or others.

Futhermore the emphasis is on <u>local</u> activities or those performed within the geographic area assessed. This local emphasis is consistent with the nature of hazardous chemical incident--they most frequently involve brief or no warning at all, thereby necessitating the rapid mobilization of readily available resources (Quarantelli, Lawrence, Tierney, and Johnson, 1979). Also characteristic of such incidents is their shorter duration and less severity, in terms of large-scale property destruction, than some natural disasters. These features indicate the need for greater emphasis on tasks habitually performed in the early minutes of a chemical incident such as the containment of the immediate hazard and evacuation of nearby residents. These tasks would commonly be undertaken by industrial and public safety personnel (Tierney, 1980). Conversely, tasks relating to the long-term feeding, clothing, and housing of great numbers of disaster victims, habitually performed by social and human service organizations, are of a diminished importance. The weighting of items was based on such considerations.

Table 2 contains a listing of all the items in the proposed Preparedness Scale. The first item addresses the issue of the extent of integration of community and extra-community groups in the overall local emergency plan. The industrial and public safety sectors are provided the greatest weight for the reasons mentioned above. Within the public safety sector at least, one fire department, law enforcement, and civil defense agency must be considered in the plan for the community to receive credit on this criterion. These organizations are crucial in both emergency operations and the coordination of the response effort. Other important community organizations include the local executive office (mayor, city manager, or county commissioner(s)) which provides overall guidance for responding groups and legal support for response-related activities; the medical, social, and human service organizations, which provide first aid and subsequent treatment, crisis intervention, and various forms of relief to disaster victims; the media, which perform the tasks of disaster warning and continuous information dissemination to the public; and, of course, the local chemical establishments, which are the first to be involved in a plant incident and normally possess valuable resources for the mitigation of incidents (Gray and Quarantelli, 1981). Finally, the inclusion of extra-local organizations in community disaster planning must be considered as these entities may play a role in supplementing existing services or providing additional ones.

The second scale item provides a listing of ten major task sets conceivably performed in an emergency and addresses the extent of their consideration in the local emergency plan--i.e., whether the tasks have been allocated to specific organizations and whether the conditions under which they are to be performed have been elaborated.

The first two items thus gauge the comprehensiveness of the formal community-wide emergency plan in terms of organizational and task-related integration. Similarly, the fourth item examines formal emergency planning, although, here, the focus is intraorganizational. The distribution of tasks to various agencies in itself is not sufficient for optimal community mobilization. Each organization must develop internal emergency procedures to facilitate the performance of its mandated tasks.

In addition to the comprehensiveness of emergency planning, the extent to which community-wide plans are operational or merely "paper" plans must be determined. Item number three therefore probes the number of sectors involved in community-wide disaster exercises. Also taken into consideration is the form of such drills--i.e., do they involve actual simulations of events or mere chalkboard or communication (telephone, radio, etc.) drills?

Item number five explores the extent to which local officials have assessed chemical hazards in their community. Items number six and seven gauge the preventive measures undertaken in the realm of transportation on the basis of such assessments.

The last two items deal with the community resources existing to counteract the threats presented by hazardous chemicals. Item number eight probes the adequacy of physical resources to neutralize various forms of threat, as well as to protect primary responding personnel. This item also addresses the issue of community expertise to deal with chemical fires, contamination and the human/ecological impact of such events. Item number nine concerns the accessibility of such resources to personnel requiring them--i.e., whether emergency-relevant personnel are aware of existing resources and where they can be obtained. Equally important is whether relevant organizations have made prior arrangements to share equipment and information as these are required.

A Concluding Note

The CCHVI should not be regarded as an ultimate solution to Vulnerability assessment, but as an instrument that can be modified according to user needs with respect to both data input and measurement precision. The check-list approach of the instrument makes it comprehensible to the layman, obviating the need to hire consultants in its application. It can enlighten region planners about the distribution of hazards and the relative susceptibility to disasters of different zones within their jurisdiction. This knowledge permits the formulation of policies regarding acceptable levels of safety and the allocation of funds on an equitable basis. At the same time, the CCHVI could be instructive to local safety personnel, acquainting them with hazards in their area and identifying possible deficiencies in emergency planning.

The overall formulation has primarily been derived from observations and data from the United States and Canada. The CCHVI's applicability to Western European societies and Japan as well as others highly industrialized and urbanized would seem to be a reasonable assumption, but obviously requires empirical testing to see if some item modifications might be necessary. The application of the CCHVI to other social systems, especially Third World and developing countries would seem more problematical, but at worst a variant of the CCHVI would seen useful.

TABLE 1

Risk (Hazard) Scale

	Maximum Weight (Points)
Manufacturing	
a) Density	1
b) Proximity	1
Transportation	
a) Road	1
b) Rail	1
c) Barge	.5
d) Air	.5
Forms of Threat	
a) Major Fire	1
b) Major Explosion	1
c) Noxious Release (air)	1
d) Noxious Release (water)	1
e) Noxious Release (ground)	1
TOTAL	= 10 Points

TABLE 2

Preparedness Scale

Item #1 - A written emergency plan exists in the community incorporating the following sectors:

	Max. Weight			
1) Public Safety (at least one fire and police department and civil defense agency)	.5			
2) Local Executive Office	.3			
3) Medical (at least one major hospital)	.15	.3		
(at least one ambulance service)	.15			
4) Media (at least one radio station)	.3			
5) Social and Human Services (at least one of Red Cross, Salvation Army, etc.)	.3			
6) Industry (all major chemical facilities) or	.8			1.0
(at least one major facility) and/or	.4		.6	
(extra-community facilities)	.2	.2		
7) Extra-Community Non-Industrial Groups (governments, military, etc.)	.3			
Total	3.0			

Item #2 - The community emergency plan clearly outlines the organization(s) or person(s) to perform each of the following tasks sets and the manner in which this is to be done.

1) Overall coordination of emergency response	.3
2) Identification of chemicals	.3
3) Neutralization of chemicals	.3
4) Public warnings and information	.3
5) Stockpiling emergency supplies and equipment	.3
6) Care of injured and deceased	.3
7) Compiling lists of missing persons, search and rescue	.3
8) The maintenance of law and order, traffic control, the establishment of the impacted site's security and an emergency pass system	.3
9) Evacuation	.3
10) Feeding, clothing, and housing victims	.3
Total	3.0

Item #3 - Community-wide emergency drills are conducted at least once annually among the following sectors:

	Max. Weight			
	Simulation		Paper or Communication Drill	
1) Public Safety (at least one fire and police department and civil defense agency)	.6		.3	
2) Local Executive Office	.4		.2	
3) Medical (at least one hospital)	.2	.4	.1	.2
(at least one ambulance service)	.2		.1	

	Max. Weight Simulation	Paper or Communication Drill
4) Media (at least one radio station)	.4	.2
5) Social and Human Services (at least one of Red Cross, Salvation Army, etc.)	.2	.1
6) Industry (all major facilities) or	1.0	.5
(at least one major facility)	.5	.25
Such drills are followed at least once annually by an evaluation of performances in the form of a report or meetings involving participants.	1.0	
Total	4.0	

Item #4 - Internal, written emergency procedures exist for organizations in the following sectors:

1) Public Safety (at least one fire and police department and civil defense agency)	.4	
2) Local Executive Office	.2	
3) Medical (at least one major hospital)	.1	} .2
(at least one ambulance service)	.1	
4) Media (at least one radio station)	.2	
5) Social and Human Services (at least one of Red Cross, Salvation Army, etc.)	.2	
6) Industry (all facilities) or	.8	
(all major facilties)	.4	
(all facilities within 2000' of populated area)	.2	
Total	2.0	

Item #5 - The types and sources of chemical hazards in the community have been identified--i.e., the types of chemicals, specific plants, and transportation routes posing the greatest threat.

1) A recent inventory of major chemicals produced, stored, and transported in the area has been undertaken	.4
2) A recent inventory of chemical plants and storage facilities, including what each stores and produces has been undertaken	.3
3) Major transportation routes through which hazardous materials pass have been identified and contingency plans formulated should incidents occur at any point of such routes	.3
Total	1.0

Item #6 - Hazardous materials traffic on major expressways is diverted from population centers.

The diversion of such traffic is expressly required by local ordinances and such ordinances are enforced by the citation and/or penalization of violators at least twice annually	1
Total	1

Item #7 - Railbeds are upgraded (aligned, leveled and so on) on a bi-annual basis.

Regular inspections are conducted to ensure compliance with FRA regulations and violators are issued citations and/or penalized at least once annually	1
Total	1

Item #8 - Resources are present in the community to counteract existing threats.

1) Basic physical resources exist to contain threats (fire-fighting equipment and foam, heavy equipment for digging operations and dyke construction, neutralizing agents for water or soil decontamination)	1
2) Basic physical resources exist to protect primary responding personnel (air packs, gas masks, acid suits, head, facial, hand and foot gear)	.5
3) The local fire department possesses expertise in combatting chemical fires which is demonstrated by the attendance of at least one member at at least one industrial or academic training seminar in the past two years or the establishment of a specialized hazardous materials division within the department	.5
4) The community possesses experts (academic, corporate, etc.) knowledgeable in hazardous materials and their prevalent treatment modalities to mitigate the impact of exposures. This is evidenced by their specific occuptaitonal role(s), their command and possession of literature in this area, their possession of phone numbers of agencies dispensing information regarding hazardous chemicals (e.g., poison contrl centers and CHEMTREC) and their recognition and involvement in community emergency planning.	.5
Total	2.5

Item #9 - Community resources have been inventoried and arrangements made for their acquisition.

1) A recent inventory of community resources (both human and physical) and their location has been undertaken.	1
2) Call lists are possessed by the essential responding organizations to facilitate the obtainment of additional resources, information, etc..	.5
3) Mutual aid systems exist:	
a) Comprehensive including the major public sector emergency-relevant organizations and chemical plants	1
or	
b) Task-Specific	
1) Among local fire departments	.3
2) Among local fire departments and chemical companies only	.3
3) A medical communications system exists involving the local hospital(s) and ambulance service(s)	.3
Total	2.5
Grand Total	20.0

References

Benner, 1977
L.
"A progress report on risk and analysis." Paper presented to the Division of Chemical Health and Safety, the American Chemical Society.

Burton, 1978
Ian, Robert W. Kates, and Gilbert F. White
The Environment as Hazard. New York: Oxford University Press.

Dynes, 1981
Russell R., E. L. Quarantelli, and Gary Kreps
"A perspective on disaster planning." Report Series #11. Columbus, Ohio: The Disaster Research Center, The Ohio State University.

Friedman, 1975
Don G.
Computer Simulation in Natural Hazard Assessment. Boulder, Colorado: Institute of Behavior Science, University of Colorado.

Gabor, 1979
T. and T. K. Griffith
"The assessment of community vulnerability to acute hazardous materials incidents." Journal of Hazardous Materials 3: 323-333.

Gray, 1981
Jane K. and E. L. Quarantelli (eds.)
"Special Issue: Social Aspects of Acute Chemical Emergencies." Journal of Hazardous Materials 4: 309-394.

Griffith, 1979
R. K.
The transportation of hazardous materials on Columbus roads. Unpublished manuscript.

Johnson, 1979
Q. T.
An Ohio communications network for rail disasters and emergencies involving hazardous materials. Unpublished policy paper. Columbus, Ohio: The Department of Public Administration, The Ohio State University.

Jones, 1973
G. P.
Risk analysis in hazardous materials transportation. Los Angeles, California: Institute of Aerospace Safety and Management, The University of Southern California.

O'Keefe, 1976
P. and K. N. Westgate
Some Definitions of Disaster. University of Bradford Disaster Research Unit, Bradford, England.

Pelanda, 1981
Carlo
"Disaster and sociosystemic vulnerability." Preliminary Paper #68. Columbus, Ohio: The Disaster Research Center, The Ohio State University.

Quarantelli, 1977 — E. L. and R. R. Dynes
"Response to social crisis and disaster." Annual Review of Sociology 3: 23-49.

Quarantelli, 1979 — E. L., C. Lawrence, K. Tierney, and T. Johnson
"Initial findings from a study of socio-behavioral preparations and planning for acute chemical hazard disasters." Journal of Hazardous Materials 3: 77-90.

Silvestro, 1978 — F. B. and M. J. Mazurowski
Computer model for 1NG/LPG risk simulation. Buffalo, New York: Ecology and Environment, Inc.

Simmons, 1974 — J. A., R. C. Erdmann, and B. N. Naft
"The risk of catastrophic spills of toxic chemicals." Los Angeles, California: School of Engineering and Applied Science, The University of California.

Tierney, 1980 — Kathleen J.
A Primer for Preparedness for Acute Chemical Emergencies. Book #14. Columbus, Ohio: The Disaster Research Center, The Ohio State University.

U.S. Department of Transportation
1978a — Hazardous materials incidents reports. Materials Division Bureau, U.S. DOT, DMT-152. Washington, D.C.: U.S. Government Printing Office.

1978b — Emergency action guide for selected hazardous materials. Washington, D.C.: National Highway Safety Administration and Materials Transportation Bureau.

Zajic, 1978 — J. E. and W. A. Himmelman
Highly hazardous materials spills and emergency planning. New York: Dekker.

Preliminary Paper

73

ASSESSING LOCAL DIFFERENCES IN CHEMICAL DISASTER PRONENESS: THE COMMUNITY CHEMICAL HAZARD VULNERABILITY INVENTORY*

Thomas Gabor
and
Carlo Pelanda

Department of Criminology
University of Ottawa
Ottawa, Canada

and

Sociology of Disasters Department
Institute of International Sociology
Gorizia, Italy

December, 1981

* The data in this article were partly obtained through National Science Foundation Grant Number PRF 7714445 to the Disaster Research Center, The Ohio State University. However, any opinions, findings, conclusions, or recommendations are those of the authors and do not necessarily reflect the views of the National Science Foundation. The authors are indebted to E. L. Quarantelli, T. Griffith, T. Johnson, B. Swisher, and K. Tierney for their comments on earlier drafts of the paper.