Too Close To Home

A Report on Chemical Accident Risks in the United States

July 22, 1998

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Executive Summary

Toxic clouds released as a result of chemical accidents respect no boundaries: neither facility boundaries nor city, county or state lines. They seriously threaten the health of workers, communities, and the environment. More than 10 years after an accident at a Union Carbide facility in Bhopal, India released a toxic cloud of methyl isocyanate claiming more than 2,000 lives, chemical accidents with severe environmental and human impacts continue to occur regularly. On average, twenty times per day—or nearly once an hour—a chemical accident is reported in the United States.

Our analysis found that a large percentage of the U.S. population is at risk of suffering the consequences of a chemical accident. Using low estimates, over 41million Americans live in zip codes that contain manufacturing companies with vulnerable zones that extend more than three miles from the facility. **Thus, at least one out of every 6 Americans lives within a vulnerable zone — the area in which there could be serious injury or death in the event of a chemical accident — created by neighboring industrial facilities.**

Accident disaster potential (the sum of vulnerable zones in an area) is highly concentrated in a small number of U.S. states. **Ten states — Texas, Ohio, Louisiana, California, Illinois, Pennsylvania, New York, North Carolina, Michigan, and Georgia — accounted for nearly half of the accident disaster potential in the United States.** However, significant vulnerable zones exist in nearly every county where extremely hazardous chemicals are stored, meaning that the risk of worst-case disasters is very wide-spread across the U.S. Numerous major urban centers are at risk of suffering the impacts of a chemical disaster. **Those cities most at risk include: Houston, TX; Los Angeles, CA; Chicago, IL; Baton Rouge, LA; Cleveland, OH; and Charleston SC**.

Summary of Findings

One in every 6 Americans lives within a vulnerable zone—the area in which there could be serious injury or death in the event of a chemical accident—created by neighboring industrial facilities.

Over 41 million Americans live in zip codes that contain manufacturing companies with vulnerable zones that extend more than 3 miles from the facility.

The top 10 U.S. states ranked by worst-case accident disaster potential are: Texas, Ohio, Louisiana, California, Illinois, Pennsylvania, New York, North Carolina, Michigan, and Georgia.

These ten states account for nearly half (49%) of the vulnerable zones in the United States.

Chemical manufacturing, food products, primary metal industries, pulp and paper and fabricated metal products are the industries with the greatest disaster potential. These industries account for 79 percent of the total disaster potential among all industries.

Fourteen of the top 20 counties in disaster potential were also among the top 20 in frequency of accidents reported between 1993 and 1995.

More than one in every three zip codes contains a company with a vulnerable zone extending more than five miles from the facility. **Companies creating the largest vulnerable zones include: 3M, Dow, DuPont, Monsanto, GE Plastics, Union Carbide, and Bayer Corp.**

This report represents a national overview and ranking of areas in the U.S. that are vulnerable to the impacts of chemical disasters. Using Environmental Protection Agency (EPA) methodology and data on the storage of extremely hazardous chemicals from EPA's Toxic Release Inventory, we calculated "worst-case scenarios" for approximately 7,600 U.S. manufacturing companies. Worst-case scenarios indicate the geographic area (the vulnerable zone) affected by the worst possible accident at a facility, in which people's lives and health would be at risk.

Our analysis is meant to serve as a screening tool for comparative purposes and not a definitive measure of the vulnerable zones or accident risk created by a particular facility. This analysis presents only a limited picture of the size, number, and distribution of vulnerable zones throughout the United States. We used assumptions about facility and atmospheric conditions that would lead to small vulnerable zones. Also, adequate, readily accessible data is lacking on non-manufacturing companies, and on more than 250 toxic cloud forming chemicals, and on populations surrounding industrial facilities. As such, the data contained in this report represent just the tip of the iceberg in terms of populations at risk.

The daily litany of toxic chemical accidents, and the large portion of the U.S. population potentially exposed to their impacts, points to vulnerabilities in industries that handle toxic chemicals and the potential for incidents with disastrous human and environmental consequences. To date, government and industry efforts to protect ecosystems, workers, and the public from toxic cloud releases have focused on preparing for and responding to accidents, rather than preventing them in the first place. Yet, safety systems can fail and toxic clouds travel faster and further than emergency crews can handle.

The best solution is to prevent toxic chemicals spills, fires, and other releases at every stage of toxic chemical production, use, and handling. Prevention can be most effectively achieved through the principle of "Inherent Safety". Inherent Safety measures reduce or eliminate the possibility of an accident through the redesign of production systems, the substitution or reduction of hazardous chemicals at the facility, and increased worker training and involvement.

Progress in the U.S. toward real accident and pollution prevention is painstakingly slow. While some states and local governments have taken substantial steps to implement proactive accident prevention programs, the federal government is failing to uphold legal mandates which require companies to take necessary steps to prevent releases. In addition, citizens are often unaware of the accident risks posed by industries in their neighborhood, creating a barrier to citizen participation in dialogue concerning accident prevention and preparedness, and response.

The Clinton Administration's track record on accident prevention has been poor: from a failure to fund and complete the membership of the Chemical Safety and Hazard Investigation Board to a failure to provide the public with full information on toxic chemical use. Although the Clinton Administration has taken important steps to expand the public's Right to Know about toxic emissions, toxic use reporting is needed to measure and promote accident and pollution prevention. In conflict with their professed commitment to pollution prevention and technology innovation, the EPA failed to require the Clean Air Act 112(r) Risk Management Plan Rulemaking to require industries to consider safer alternatives to current plant operations. And now the chemical industry is lobbying the Administration to keep the Risk Management Plans from the public.

With the goal of significantly reducing chemical accidents and toxic pollution in the United States, we recommend the following:

1. Promote Inherent Safety accident prevention and make readily available to the public all Risk Management Plans (RMPs) including worst-case accident scenarios, as mandated under the 1990 Clean Air Act Amendments

The best way to ensure community safety is to reduce the inherent hazards of chemical operations. Risk Management Plan (RMP) information, including worst-case accident scenarios, will be required for some 66,000 facilities across the country by 1999, as mandated by the Clean Air Act 112(r). The chemical industry is fighting hard to keep these plans from the public. All Risk Management Plans should be made available to the public through an effective national data system. Worst-case accident scenarios can provide a quantitative measurement and evaluation of Inherent Safety at a facility.

2. Expand and improve the public's Right to Know about toxic chemical use and accidents

An expanded Right to Know should include information about the use, storage, and flow of hazardous chemicals within production processes as well as information about past accidents. This information should be made available to the public through easily accessible on-line services such as the Toxics Release Inventory established under the Emergency Planning and Community Right to Know Act.

Legislation is pending in Congress that would fill in many important Right to Know data gaps and help industry work toward real pollution and accident prevention: H.R. 1636, the Children's Environmental Protection and Right to Know Act, and S. 769, the Right to Know More and Pollution Prevention Act.

3. Complete the membership and fully fund the Chemical Safety and Hazard Investigation Board

The Clinton Administration should appoint and the Senate confirm three qualified individuals to complete the membership. Furthermore, Congress should appropriate sufficient funding for the Chemical Safety Board to investigate the underlying causes of chemical accidents and Inherent Safety options for prevention. Insufficient funding and incomplete membership hinder the Board in carrying out its operations mandated under the Clean Air Act Amendments of 1990. This independent board should be a motivating force in the shift toward Inherent Safety.

Introduction

No matter how effective conventional safety devices are, there is a form of accident that is inevitable.

(Dr. Charles Perrow)

On December 13, 1994 an explosion destroyed the Terra Nitrogen Co. fertilizer plant near Sioux City, Iowa killing four and injuring more than 18. More than 2,500 people were evacuated as a result of the 90 square mile toxic ammonia cloud that blanked the area, including a portion of the Winnebago Indian Reservation. A safety audit just six months earlier failed to identify any problems at the facility. Had the explosion and ammonia release taken place near a more densely populated area or an hour later when a new workshift was to begin, the death and injury toll would likely have been much greater.

Toxic clouds released as a result of chemical accidents respect no boundaries: not facility boundaries, nor city, county or state lines.[1] They seriously threaten the health of workers, communities, and the environment. Between 1993 and 1995 over 23,000 toxic chemical accidents were reported in the United States—on average 20 accidents a day—one accident every hour.[2]

The Emergency Planning and Community Right to Know Act (EPCRA) was passed in 1986, in the wake of a tragic chemical accident at a Union

Carbide facility in Bhopal, India. The accident released a toxic cloud of methyl isocyanate that engulfed the city of Bhopal, claiming more than 2,000 lives. EPCRA established some systems to cope with chemical emergencies, including Local Emergency Planning Committees (LEPCs) to actively involve businesses and communities in emergency planning and chemical safety decision-making. One of the specific duties conferred on LEPCs is to prepare comprehensive emergency plans outlining local chemical hazards and emergency response procedures. For these plans, the Environmental Protection Agency (EPA) recommends that LEPCs either prepare or require facilities in their jurisdiction to prepare "worst-case accident scenarios". Worst-case scenarios indicate the geographic area (the vulnerable zone) affected by the worst possible accident at a facility, in which people would be at risk of life and health. The scenarios typically consider the almost instantaneous release of the entire amount of a chemical stored at a facility and assume the failure of mitigation and safety systems. In 1987, EPA established and disseminated a standard methodology to the Nation's 4,100 LEPCs to use in computing vulnerable zones.[3] Unfortunately, few LEPCs have completed or published such estimates.

Since the passage of EPCRA, **government and industry chemical safety efforts in U.S. have focused primarily on limiting and responding to chemical accidents, rather than preventing them in the first place**. Meanwhile, chemical accidents continue to occur regularly, with disastrous human and environmental consequences. Government agencies have failed to emphasize the importance of Inherent Safety technologies and processes for preventing chemical accidents. They are only beginning to recognize the links between chemical safety programs and existing pollution prevention programs, which seek to reduce routine pollution at the source.

While worst-case accident scenarios have typically been used by government agencies and industry for emergency planning, they are also critical for the purpose of preventing accidents.[4] For example, the scenarios are one way to indicate the degree of Inherent Safety progress at a facility. Regulations developed under the Clean Air Act Amendments of 1990 will require companies to prepare these Risk Management Plans (RMPs), including worst-case scenarios, by 1999 and make them publicly available. When publicly available, the analyses can lead to dialogue between companies and communities on ways to prevent accidents and reduce accident risks. To date, only a few government agencies, environmental organizations and media outlets have used these analyses to inform the public of the risks associated with chemical storage at industrial facilities. Citizens are still uninformed about potential accident risks throughout most of the United States, and workers and community members still have incomplete information on chemicals used in the workplace and transported through the community. The chemical industry is fighting to keep the public in the dark, including keeping these worst-case scenario plans from ready public access.

The first chapter of this report presents an estimate of the populations at risk from worst-case chemical accidents and the geographic distribution of vulnerable zones throughout the United States using EPA's Technical Guidance methodology. It describes the unique vulnerability to chemical accidents and their impacts faced by the Great Lakes Region, as well as the link between vulnerable zones and actual accidents. The report provides a ranking of the areas with the largest and greatest number of vulnerable zones. The report should provide useful information to government agencies, local emergency planning committees, labor and citizens' groups, and industries working to prevent accidents.

The second chapter of the report examines the need for Inherent Safety to reduce the potential for toxic cloud forming accidents and the shortcomings of federal programs. The report also discusses how Inherent Safety and Source Reduction can be achieved through an expanded Right to Know law about toxic chemical use, Risk Management Planning including disclosure of worst-case accident scenarios, Local Emergency Planning Committees, and the Chemical Safety and Hazard Investigation Board.

Chapter I: Worst-case disaster potential in the United States

This report represents a national overview and ranking of some of the areas in the U.S. vulnerable to the impacts of worst-case chemical accidents. While some localities and counties have estimated and mapped vulnerable areas and the companies that create these areas, there has been no national level effort to quantify and rank worst case disaster potential.[5] Worst-case scenarios are rarely accessible to the public or used for Inherent Safety accident prevention purposes.

This report estimates the size of areas at risk from the impacts of worst-case chemical accidents, referred to as "disaster potential" areas or "vulnerable zones." These zones are created by the storage of extremely hazardous substances (EHS chemicals) at U.S. manufacturing facilities.[6] The worst-case estimate is the radius of a potentially exposed area; the exact area affected by a worst case accident would depend on such factors as wind direction, speed, and landscape (see Figure 1). The analysis was completed using EPA standard methodology and data on chemical storage obtained from EPA's 1995 Toxics Release Inventory (TRI).[7]

This analysis is meant to serve as a screening tool for comparative purposes and not a definitive measure of the vulnerable zones or

accident risk created by particular facility. Precise facility estimates would be impossible given the lack of readily available data (on a local or national level) about individual facilities.[8] As a result, the analysis requires assumptions about chemical storage conditions, chemical concentration, passive containment measures, and facility location.[9] Carefully selected assumptions provide low estimates of vulnerable areas.The data contained in this report represent just the tip of the iceberg in terms of populations at risk. Some zip codes in NELC's analysis were facility-specific zip codes and as such had no population statistics, yet facilities are often surrounded by substantial populations. Thus, substantial populations contained within vulnerable zones are not covered by this report. Also, adequate chemical storage data is nationally available only for a limited number of chemicals and industries. **As a result, this report presents only a limited picture of the size, number, and distribution of vulnerable zones throughout the United States**. A more complete description of the methodology used in this report is contained in the Methodology section.

Populations at risk

Using low estimates, more than **41 million** Americans live in zip codes that contain manufacturing companies with vulnerable zones that extend more than three miles from the facility.[10] **Thus, at least one out of every 6 Americans lives within a vulnerable zone — the area in which there could be serious injury or death in the event of a chemical accident — created by neighboring industrial facilities**. Industrial facilities are often situated in close proximity to residential neighborhoods, placing whole communities at risk from the impacts of worst-case accidents. Over 54 million people live in zip codes with companies that have a single vulnerable zone extending more than 1 mile.

It is clear that to fully estimate the extent of populations at risk, more in depth studies are needed to calculate and map vulnerable zones under location specific conditions, and then identify sensitive sites (schools, hospitals, nursing homes) and ecological areas within those zones.[11] Few companies have provided this information to plant neighbors.

Worst-case disaster potential

=

Total of the radii of all vulnerable zones within a geographic area

Geographic distribution of potential disaster areas
NELC analyzed the geographic distribution of vulnerable zones, to better understand which areas of the country are most at risk from the potential impacts of worst-case chemical accidents. NELC ranked states, counties, and zip codes by worst-case accident disaster potential, a term used for the cumulative total of the radii of all vulnerable zone

estimates (by facility and chemical) within that geographic area.

As demonstrated in Table 1, **the top ten U.S. states ranked by worst-case accident disaster potential are: Texas, Ohio, Louisiana, California, Illinois, Pennsylvania, New York, North Carolina, Michigan, and Georgia**. These ten states account for nearly half (49%) of the vulnerable zones in the United States. This ranking of states does not directly correspond to the amount of EHS chemicals that facilities in the state store because some chemicals are more acutely toxic or create larger toxic clouds than others.

Table 1: U.S. States (and Puerto Rico) ranked by worst-case disaster potential

Rank	State	Worst-case "disaster potential"	Number of facilities	Number of vulnerable zones	% of vulnerable zones above 5 miles	EHS chemical storage (lbs.)	Population affected
1	TX	3,469	475	1,107	24.3	950,000,000	2,573,910
2	OH	2,005	471	773	16.8	160,000,000	3,120,503
3	LA	2,002	163	483	36.2	2,300,000,000	967,869
4	CA	1,952	633	992	12.7	190,000,000	3,962,188
5	IL	1,732	444	741	14.8	240,000,000	2,920,731
6	PA	1,611	358	587	19.1	120,000,000	2,150,406
7	NY	1,304	264	464	20.7	47,000,000	1,447,032
8	NC	1,286	274	456	20.2	92,000,000	1,513,451
9	MI	1,270	312	534	16.1	30,000,000	2,262,783
10	GA	1,238	263	482	18.7	380,000,000	1,568,064
11	AL	1,162	188	384	23.2	140,000,000	788,992
12	IN	1,004	257	388	18.3	34,000,000	1,281,703
13	SC	981	183	388	17.3	140,000,000	1,273,801
14	WI	923	309	514	11.3	62,000,000	1,350,141
15	TN	914	181	347	19.3	110,000,000	1,017,827
16	VA	910	159	271	27.7	53,000,000	777,959
17	FL	838	175	314	20.7	330,000,000	1,076,263
18	NJ	789	211	364	12.9	240,000,000	1,141,140
19	AR	762	123	236	25.8	190,000,000	634,811
20	MO	734	170	280	18.6	76,000,000	890,225
21	KY	699	141	251	21.5	540,000,000	633,956
22	WV	675	55	163	35	80,000,000	197,472
23	IA	623	127	198	24.2	190,000,000	380,810
24	MS	613	102	193	25.4	180,000,000	625,687
25	WA	588	104	209	21.1	20,000,000	661,346
26	OR	510	105	190	18.4	33,000,000	525,927
27	MN	483	158	241	12.4	15,000,000	493,764
28	KS	482	84	156	22.4	250,000,000	413,565
29	OK	384	81	128	26.6	210,000,000	328,565
30	MA	321	181	255	4.3	4,000,000	672,204

31	NE	320	62	97	26.8	120,000,000	195,553
32	MD	314	73	110	20.9	60,000,000	329,240
33	AZ	289	76	132	15.2	56,000,000	577,924
34	CT	272	123	183	6.6	5,000,000	342,959
35	PR	245	69	110	12.7	5,000,000	--
36	UT	235	59	90	21.1	110,000,000	284,778
37	ME	228	41	89	19.1	6,000,000	183,385
38	DE	178	32	52	26.9	160,000,000	104,158
39	ID	172	36	69	20.3	34,000,000	162,643
40	CO	160	72	110	4.5	2,000,000	377,329
41	NV	135	13	29	44.8	6,000,000	113,614
42	NH	133	35	60	15	4,000,000	146,804
43	WY	117	18	41	24.4	55,000,000	73,298
44	RI	116	51	75	5.3	2,000,000	253,900
45	MT	104	18	37	18.9	14,000,000	128,908
46	NM	97	19	37	16.2	150,000,000	161,922
47	AK	47	6	13	30.8	100,000,000	24,435
48	ND	39	13	20	15	160,000	21,809
49	VT	26	11	15	13.3	160,000	19,499
50	HI	25	9	11	9.1	1,000,000	33,269
51	SD	11	10	12	0	63,000	0
Total		**35,527**	**7,597**	**13,481**	**--**	**8,200,000,000**	**41,188,522**

EHS storage is the cumulative amounts of the minimum of the indicated ranges for 94 extremely hazardous substances that companies store in the U.S., as reported to the Toxics Release Inventory (TRI). 79 of the 94 chemicals had at least one report in the 1995 TRI.

Population affected refers to the total population of zip codes that contain 3 mi. vulnerable zones.

Source: Toxics Release Inventory 1995 provided by RTK-Net. Data analyzed by NELC using EPA methods. See Methodology Section.

NELC found that more than one half (891 of 1,660) of the counties analyzed had facilities with vulnerable zones of more than five miles. Significant vulnerable zones exist in numerous U.S. county where EHS chemicals are stored by manufacturing facilities. **Thus, the risk of worst-case disasters is very wide-spread across the United States** However, accident disaster potential appears to be concentrated in relatively small a number of counties that contain a large percentage of the U.S. population. Table 2 demonstrates that 50 counties in the United States account for more than one quarter (27.8 %) of the worst-case accident disaster potential.

Among the cities with the greatest worst-case disaster potential are: Houston, TX; Los Angeles, CA; Chicago, IL; Baton Rouge, LA; Cleveland, OH, and Charleston, SC . While we did not rank cities themselves, Figures 2 through 6 present pictures of the vulnerable zones that blanket several large cities in the U.S. Numerous other major cities are within the vulnerable zones of industrial facilities. One in every three zip codes with facilities reporting storage of EHS chemicals under the Toxic Release Inventory (1,495 of 4,576) contain companies with vulnerability zones of more than 5 miles, further demonstrating the wide-spread nature of disaster potential across the United States (see Table 3). About 16 percent of these zip codes contain facilities that have vulnerable zones of more than 10 miles.

Risky industries

NELC estimated and ranked the cumulative vulnerable zone sizes for manufacturing companies in the United States. In the event of a chemical accident, approximately 25 percent (1,881 of 7,602) of the manufacturing facilities that store EHS chemicals, according to TRI filings, could potentially create a zone of injury and death extending 5 miles from the facility. More than 20 percent of these facilities create vulnerable zones of 10 miles or greater.

Some of the companies that pose the greatest worst-case disaster potential are large scale chemical producers and users such as: 3M, Dow, DuPont, Monsanto, GE Plastics, Union Carbide and Bayer Corp. Table 4 presents 50 of the top U.S. facilities in disaster potential, in alphabetical order. As previously indicated, this report presents a rudimentary estimate of worst-case vulnerable areas for facilities using generalized assumptions; as such, follow-up analysis should be completed with facility-specific information. Though these companies pose some of the greatest worst-case disaster potential due to their large storage of EHS chemicals, they also tend to have some of the most sophisticated safety controls and emergency response capabilities to manage risk. These safety systems may reduce the probability of an accident, but cannot prevent or eliminate accident risk. Smaller and medium-sized companies, with less resources dedicated to chemical safety may actually have a higher probability of experiencing a worst-case disaster.

Using Standard Industrial Codes (SIC codes), NELC analyzed worst-case disaster potential by industry sector. NELC found that the industries with the greatest disaster potential include: chemical manufacturing, food products, primary metal industries, pulp and paper, and fabricated metal products. These industries account for 79 percent of the total disaster potential among all industries. The chemical manufacturing industry accounts for almost half of the total worst-case disaster potential.

Information on non-manufacturing facilities should be made available so that further analysis can include all facilities that store EHS chemicals and thus potentially create vulnerable zones.

Hazardous chemicals

When extremely hazardous substances are released in accidents, the size of the resulting toxic cloud depends on several conditions, such as: toxicity; storage amount; storage conditions; atmospheric conditions like wind speed and air density, and where the facility is located (rural or urban setting).[12] Thus, chemical storage at a facility alone is not a sufficient indication of the potential for a disastrous air release. However, high quantity toxic chemical storage can be an indicator of worker exposure risk and the potential for spills to land and waterways.

NELC found that manufacturing facilities in the U.S. store more than 8 billion lbs. of EHS chemicals.[13] While NELC's analysis includes some of the most frequently used toxic chemicals in the U.S., it is a severe underestimate of EHS chemical storage in the U.S., as federal data is not available for more than 250 EHS chemicals, and it excludes many storage and non-manufacturing sites.

The top ten chemicals ranked by worst-case disaster potential are: ammonia, chlorine, hydrochloric acid, hydrogen fluoride, formaldehyde, phenol, ethylene oxide, phosphorous, nitric acid, chloroacetic acid (see Table 5). These chemicals account for approximately 95 percent of the cumulative vulnerable areas in the U.S. Chlorine, anhydrous ammonia, and hydrogen fluoride are well-known for their ability to form ground-hugging toxic clouds that travel long distances. All of these chemicals have known adverse acute and/or chronic health effects. Several of these chemicals are among the chemicals most frequently reported in chemical accidents from 1993-1995. These chemicals would be logical priorities for chemical safety and pollution prevention efforts, though **it**

Chemical Exposure

Acute health effects:

skin ailments
nausea
respiratory infection
death from burns
or asphyxiation

Chronic health effects:

bronchitis
chronic lung disease
kidney and liver
ailments
reproduction
dysfunction
cancer

makes sense for companies to identify ways to substitute or reduce their storage or use of all EHS chemicals.

Accident potential and reality

More than 23,000 toxic chemical accidents were reported in the United States between 1993 and 1995, according to NELC's report Accidents Do Happen.[14] One out of every twenty accidents was serious enough to cause immediate injuries, evacuations or deaths. The report found that the severity of the accident picture is gravely under stated in the federal Emergency Response Notification System database, as many accidents go unreported and it contains incomplete information on the chemicals involved and human and environmental impacts.

Do counties that have the greatest potential for toxic cloud disasters also have the most accidents? In general, the answer to this question is yes. Fourteen of the top 20 counties in disaster potential were also among the top 20 in frequency of accidents reported between 1993 and 1995. **The correlation between high disaster potential and accident frequency points to the strong potential for accidents with catastrophic impacts**.

It is instructive to look at counties where accident potential and frequency do not correlate. For example, facilities in counties with low disaster potential and high frequency of accidents may store less hazardous chemicals but have ineffective prevention systems. Since catastrophic accidents are rare events at an individual facility, the fact that a company has not had an accident does not mean that the potential does not exist or that workers, communities, or the environment are adequately protected.

The Great Lakes region at risk

The Great Lakes region is especially vulnerable to the impacts of toxic chemical accidents. The Great Lakes represent the largest contiguous bodies of fresh water in the world and are home to countless species of wildlife and millions of people. However, the Great Lakes ecosystem is under siege from the continuous routine and accidental loading of persistent and bioaccumulative chemicals which threaten the Lakes' very existence. Some species of waterfowl are unable to reproduce due to eggshell thinning and hormone disruption, cancer rates among humans are unusually high, and many species of fish are so contaminated by these substances that they should not be consumed. Chemical accidents involving persistent and bioaccumulative substances are of major concern in the Great Lakes Basin, as they can undo years of progress in preventing routine pollution. EPA identified accidental releases as one of the five main sources of the indirect loading of persistent toxic chemicals to the Great lakes.

The Great Lakes Basin includes counties in the eight states of Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, Pennsylvania, and New York. The Great Lakes region is at serious risk from the impacts of worst-case chemical accidents; notably, counties in the Great Lakes Basin account for approximately 14 percent of worst-case accident disaster potential in the United States. In addition, five of the states bordering the Great Lakes are in the top 10 states in chemical accident disaster potential.

Just 10 Great Lakes counties accounted for almost 42 percent of the worst-case disaster potential in the Basin: **Cook County, IL; Cuyahoga County, OH; Wayne County, MI; Niagara County, NY; Lake County, IN; Erie County, NY; Milwaukee County, WI; Lucas County, OH; Midland County, MI; and Ashtabula County, OH.** Five of these ten counties were also among the top 50 counties in the country in frequency of chemical accidents from 1993-1995. Seven Great Lakes Basin counties are among the top 50 U.S. counties in worst-case accident disaster potential.

About 31 percent of the Great Lakes vulnerable zone zip codes contain facilities with vulnerable zones of greater than five miles. These zip codes cover most of the major Great Lakes cities, including: Chicago, Detroit, Buffalo, Cleveland, Toledo, Rochester, and Milwaukee. Five of these zip codes are among the top 50 in the U.S. in disaster potential.

A chemical accident may produce a toxic cloud as well as releases to waterways and land. This report does not address the potential impacts of toxic chemical accidents releasing pollutants directly to waterways, which accounted for nearly 20 percent of the accidents reported in the Great Lakes region from 1988 to 1992.[15] For example, an accident at a Shell Co. plant in Belpre, OH in May, 1994 released hundreds of thousands of pounds of styrene and other toxic chemicals into the Ohio River, shutting down water treatment plants downriver. Toxic materials released during accidents can also reach the Great Lakes through land or air. Land releases can affect groundwater supplies and reach surface waters through runoff.

Toxic chemicals released to waterways, especially those that persist or bioaccumulate, can affect humans and the environment in both the short and long-term. In the short term, an accidental release may kill fish and wildlife, disrupt drinking water systems, and cause illnesses in humans that either drink or swim in the waterway. In the long-term a release may cause tumors, reproductive dysfunction, and other disease in fish and wildlife, and pollutants may concentrate in the food chain from fish to humans.

Another consequence of accidental fires and explosions is the deposition of toxic materials from combustion to the Great Lakes. EPA identified air deposition of toxic materials as a significant source of toxic pollution to the Great Lakes.[16] Of special concern are accidents involving the combustion of chlorine-containing materials (e.g., PVC plastic, PCBs), which may create dioxins, one of the most toxic chemicals known, which persist in the environment for long periods of time. EPA has linked exposure to small concentrations of dioxins to health effects such as cancer, reproductive disorders, immune suppression, and hormone disruption.[17]

Reports by the Institute of Terrestrial Ecology in the United Kingdom, as well as Dr. Barry Commoner et. al. and EPA indicate that the combustion of chlorinated compounds (from accidents, fires, or incineration) release large quantities of dioxins into the environment, potentially in equal or greater amounts than other known sources.[18] For example, an accident involving the common antiseptic, trichlorophenol in Seveso, Italy in 1976 released significant amounts of dioxins into the surrounding environment, and led to the establishment of European Union legislation designed to prevent accidents. Thus, any chemical accident involving chlorine or chlorinated materials has the potential to form dioxins, potentially leading to chronic health problems for humans and wildlife.

Chapter II: Avoiding the worst-case

A large percentage of the U.S. population, as documented in the previous section, is at risk from the impacts of catastrophic chemical accidents. Chemical accidents result in the toxic pollution that scientists believe may be linked to increasing rates of cancer, reproductive dysfunction, and birth defects in humans and wildlife.

More than 10 years after an accident at a Union Carbide facility released a toxic cloud of methyl isocyanate (MIC) that engulfed the city of Bhopal, India, chemical accidents with severe environmental and human impacts continue to regularly occur in the United States. The Bhopal disaster claimed more than 2,000 lives and injured as many as 200,000. Interestingly, Middleport, NY suffered the effects of MIC just 18 days before Bhopal when the FMC Corp. accidentally released 50 gallons of the chemical just 400 yards from an elementary school, where it was sucked into the school's ventilation system. While many children and teachers were treated at local hospitals for respiratory problems after being overcome by MIC fumes, had the temperature been 20 degrees higher, the results would have been catastrophic.

As the following examples demonstrate, chemical accidents often occur with unforeseeable circumstances:

Williamsport, PA — On January 4, 1996 a thick cloud of chlorine gas blanketed the city of Williamsport sending 26 people to the hospital. Victims suffered headaches, eye irritation, and breathing problems. The cloud formed as a result of a chlorine leak from a railroad tanker at the Lonza Chemical Plant.

Rodeo, CA — August 22 - September 6, 1994. A **16 day release** of 125 tons of a caustic catalyst including heavy metals and organics sickened and injured 1500 people living near the Unocal plant. Victims experienced vomiting, headaches, memory loss, brain damage, and other cognitive disorders. Some residents remained sick for well over a year after the Unocal accident.

Richmond, CA — On July 26, 1993 a three hour leak of oleum (pure sulfuric acid) from an overheated railroad tank car at the General Chemical Corp. sent approximately 24,000 people to the hospital from having inhaled acid mist. The highly concentrated acid vapors, which were not captured by safety systems, formed a toxic plume and drifted about 15 miles from the site. However, the company's "credible" worst-case estimate predicted an acid cloud extending less than a mile from the site (Figure 7).

Superior, WI — A June 30, 1992 rail tank car accident caused the release of more than 20,000 gallons of benzene and other hazardous materials into the Nemadji river on the Minnesota-Wisconsin border, 17 miles from Lake Superior. More than 40,000 people were evacuated as the result of a 20 mile long cloud that engulfed the Duluth/Superior metropolitan area. Significant numbers of fish and wildlife, including beaver, mink, rabbits, and numerous species of birds, died as a result of the accident.

Sparks, NV _ In January a deadly explosion at Sierra Chemical Co. set off 10,000 pounds of a highly sensitive material called PETN. The blast killed four workers just one day after the EPA removed high explosives from the list of chemicals that trigger Risk Management Planning requirements.[19]

West Helena, AR - On May 8, 1997 an explosion and fire in a building containing 200,000 pounds of pesticides killed three firefighters and injured 16 people. The pesticides, their combustion products, and even chemicals formed during firefighting activities, formed a highly toxic cloud forcing the regional hospital to be evacuated, along with residents in a 3-mile radius.

These events remind us that toxic chemical accidents frequently occur in this country and need to be prevented. An accident the magnitude of the one in Bhopal can happen in the U.S.

A 1990 study commissioned by EPA found that since 1980 there were at least 15 accidents in the U.S. which exceeded Bhopal in volume and toxicity of chemicals released. Only circumstances such as wind conditions, containment measures, rapid evacuations, and facility siting prevented disastrous consequences from taking place.[20]

As experience demonstrates, toxic clouds can travel much further than one would expect. Amoco, for instance, showed that a 1,000 gallon release of hydrogen fluoride from a refinery can cause a ground-hugging toxic cloud that would be lethal for five miles downwind. The New York Attorney General's office estimated that a major chlorine gas release (possible from railroad tank car or sewage treatment facility) might be poisonous for 25 miles downwind. According to that office, even a 300 lb. chlorine gas release can be poisonous as far as 5 miles downwind.[21]

Toxic clouds can also travel faster than emergency response teams can handle. Some toxic clouds can cover about one mile in 17.6 minutes. Yet, it can take up to 20 minutes for a facility to detect an accidental release. Up to an hour can pass before a facility notifies authorities and the public of a release. Evacuation of neighbors may take even more time.[22] Authorities may rely on response measures, such as "shelter-in-place" during a toxic cloud release. However, some experts say that "shelter-in-place" produces an ineffective facade of security and is unreliable. For example, neighbors to General Chemical, in Richmond, California who were told to "shelter-in-place" ended up in the hospital due to toxic fumes that leaked through gaps in windows, doorways, and walls.

Reducing the risks through Inherent Safety prevention

The daily occurrence of toxic chemical accidents, and the large portion of the U.S. population potentially exposed to their impacts, points to vulnerabilities in industries that handle toxic chemicals and the potential for incidents with disastrous human and environmental consequences.

Industry officials frequently downplay the message that the high frequency of chemical accidents and "near misses" provides. For example, following the chemical explosion and fire at the Napp Chemicals Corp in Lodi, New Jersey which killed five workers, injured dozens others, and released toxic phenol into a local river, a chemical industry spokesman stated emphatically, "these things happen, just as planes go down."[23]

To date, government and industry efforts to protect ecosystems, workers and the public from toxic cloud releases have focused on add-on safety systems, emergency response and clean-up. While state-of-the-art safety controls — such as leak detectors, double-walled vessels, supplemental temperature and pressure controls, high-tech valves, sprinklers, and emergency flares or scrubbers — may limit an accidents impacts, they do not prevent incidents from occurring and may even make an operation more prone to accidents. Add-on safety systems can fail, as was the case in Bhopal, India, where five separate safety systems failed to neutralize or contain the release of deadly methyl isocyanate gas. Following the Bhopal disaster, Union Carbide added state-of-the-art enhancements to its Institute, WV facility. However, an August, 1985 accident at the facility highlighted the lesson that add-on safety systems are not as reliable as front-end prevention. Sociologist Charles Perrow noted the problems with a reliance add-on safety systems in Normal Accidents, stating "if a system is so complex and integrally meshed as to require superhuman operators to constrain the process within safe limits, then it needs some modification."[24]

"Inherent Safety" activities reduce or eliminate the possibility of an accident occurring through the fundamental redesign of production systems or products, reductions in chemical inventories, or substitution of hazardous chemicals at the facility.

The best solution is to prevent toxic chemical spills, fires, and other releases at every stage of toxic chemical production, use, and handling. Prevention can be most effectively achieved through the engineering design principle of "Inherent Safety". As shown in Figure 8 Inherent Safety eliminates or reduces the possibility of an accident by modifying key aspects of the production system, such as technologies, products and raw materials (e.g., substitution of less hazardous chemicals or reductions in their use).

Inherent Safety is advocated by experts from industry, government, labor, and environmental groups as a truly preventive approach to reducing chemical accident risks. The Transnational Resource & Action Center recently conducted an interview with Edward A. Munoz, former Managing Director of Union Carbide, India. Union Carbide officials claim that the Bhopal accident was an unusual event, and possibly a result of sabotage. Munoz agreed that it may well have been an unusual event, but that "it doesn't exonerate the guy who built the tank." "If you do something that is inherently dangerous and somebody does something foolish with it, **still you are responsible for doing what was inherently dangerous**."[25]

Dr. Trevor Kletz, a leader in promoting Inherent Safety, states, "whenever possible hazards should be removed by a change in design...rather than by adding on protective equipment."[26] Bringing the concept of Inherent Safety down to understandable terms, Dr. Kletz notes, "If the meat of lions was good to eat, our farmers would be asked to keep lions and they could do so, though they would need cages around their fields instead of fences. But why keep lions when sheep or cattle will do instead?"

To be inherently safer and cleaner, companies should analyze the hazards associated with the use of certain chemicals, products, and production processes and search for benign alternatives. An EPA study completed by Nicholas Ashford, et. al. of the Massachusetts Institute of Technology recommends that toxic chemical producers and users be required to undertake a Technology Options Analysis (TOA), a concerted effort to identify safer and cleaner alternatives, which forms part of a continuous technology improvement process.[27] Through TOA planning, the facilities adopt inherently safer technologies with appropriate cost and performance characteristics and explain why any technically feasible options were not selected. Information contained in the TOA could be available to the public and could likely lead to dissemination of innovative technologies.

Technology Options Analysis is similar to its counterpart dealing with "routine" toxic hazards: pollution prevention planning. Facilities planning for pollution prevention customarily analyze their hazardous chemical flows and identify cost-effective ways to reduce the use of toxic chemicals and generation of toxic waste. Both Inherent Safety and pollution prevention share a similar goal: changes in technologies, products, and raw materials to reduce toxics-related hazards at the source.

Risk Management Plans (RMPs)

Worst-case accident scenarios can provide a quantitative measurement and evaluation of Inherent Safety at a facility. In 1990 as a part of the Clean Air Act Amendments Section 112(r) the U.S. Congress required industrial sites that use extremely hazardous substances to disclose Risk Management Plans (RMPs). Starting in 1999, some 66,000 facilities that use large amounts of extremely hazardous chemicals will publicly disclose worst-case accident scenarios as part of larger RMPs. The RMPs have three parts: First, a hazard assessment describes release scenarios, potential off-site consequences, and a five-year accident history. Second, a prevention program addresses basic safety procedures such as training, maintenance, and safety audits. Third, an emergency response program covers response plans, drills, and coordination with local planners. By law, the RMPs are public information; by EPA rule, they are accessible to "any person" .[28]

However, some industry representatives oppose a national, public data system that includes all parts of the RMP on the Internet. Chemical industry lobbyists, argue that publicizing worst case scenarios will lead to terrorist attacks targeted at their facilities. Their solution to ensuring the public's safety is **keeping the information off the Internet and keeping the public in the dark**. To better protect workers and community members, industry should be taking steps to reduce the *actual hazards* posed by their facilities, instead of being preoccupied with public disclosure. As they have done for years, the chemical industry continues to lobby to limit the public's Right to Know, and is urging the EPA and other public officials to withhold these worst-case accident scenarios from a national public database.

The recent debate over the public availability of worst-case accident scenarios is just one example of the industry opposition to the 1990 Clean Air Act Amendments. Throughout the Rulemaking process to implement the Risk Management Plans industry pressured EPA to weaken the requirements. EPA missed opportunities to require companies to identify inherently safer technologies, and ignored comments made by a coalition of environmental and labor organizations calling for a requirement that companies undertake Technology Options Analyses to identify inherently safer technologies.

EPA also failed to fully acknowledge several state and local chemical safety programs which focus on Inherent Safety prevention:

- The New Jersey Toxic Catastrophe Prevention Act (TCPA) requires regulated facilities to undertake "state-of-the-art" analysis of design alternatives. When the NJ Department of Environmental Protection finds a facility risk management program unacceptable, the agency can require the facility to identify "any alternative processes, procedures or equipment which might reduce the risk of a release..." The state reported a 40% reduction in the amount of materials registered under the program in 1993, just five years after the program went into effect.
- The New York City Right-to Know law requires regulated companies to undertake Technology Options Analysis to identify inherently safer alternatives. The law states, "A responsible party shall make the following considerations...an examination of alternative substances and equipment to reduce the use of extremely hazardous substances or regulated toxic substances, and a timetable for implementing alternatives that are technically and economically feasible." Companies began to submit their risk management plans and options analyses in early 1995.
- The governments of Washtenaw County, Michigan and Cuyahoga County, Ohio have taken large strides in encouraging companies to prevent chemical accidents and routine pollution. The Washtenaw County Local Emergency Planning Committee (LEPC) obtains

information on chemical hazards from facilities, conducts inspections, and assesses chemical storage fees. The Washtenaw County program has spurred some companies to streamline their operations and reduce inventories of hazardous chemicals. The Cuyahoga County LEPC requires facilities to prepare hazard analyses and submit the results of these to the public. Through its chemical accident prevention program, a technical advisor has visited numerous facilities to identify Inherent Safety options. The LEPC also hosted a risk reduction recognition award for facilities.

Exposing the risks: the importance of the citizen's right to know

Citizens are often unaware of the toxic risks posed by industries in their neighborhood. They have little access to information on chemical inventories, past accidents, and accident potential at a facility. This lack of information is a serious barrier to communication about emergency response and accident prevention between a facility and its neighbors.

Public information has had a profoundly beneficial effect on environmental protection efforts in the U.S. The biggest success has been the federal Right to Know program's Toxics Release Inventory (TRI)—the first publicly accessible on-line database on routine toxic releases to the air, land and water. Public attention to this information has prompted voluntary corporate decisions to reduce the use of toxics, enabled government agencies to target resources, and strengthened citizen activism on prevention.

However, citizens have little access to useful data on toxic accident risks. Ironically, the Emergency Planning and Community Right to Know law passed in the wake of the Bhopal tragedy, but it does not include the very chemical use and flow quantities that are the source of accident hazards. The Toxics Release Inventory does not even include the most basic data about the quantities of toxic chemicals that are transported through the community, stored in factories, manufactured onsite, or used in chemical reactions.

Box 1: Inherent Safety and Source Reduction strategies for Local Emergency Planning Committees (LEPCs)

The Great Lakes Pollution Prevention and Chemical Safety Project Team recommends that LEPCs:[29]

Adopt and implement a policy, goal, or mission statement of working toward Inherent Safety and Source Reduction.

Make it a high priority to network with providers of prevention-based technical assistance for industry.

Introduce Inherent Safety/Source Reduction concepts to industry during Risk Management Rule review, plant tours—either themselves or by working with other local agencies such as fire prevention or pollution prevention officials.

Create opportunities to impart expertise to industry, including better economic analysis methods.

Publish (or otherwise present to their members, industry, labor, the public, and government agencies) information from footprints/vulnerable zones, Tier II inventories, and TRI in order to track and improve Inherent Safety and Source Reduction progress.

Network or form partnerships with compliance and enforcement agencies and others, such as insurance companies, both in providing incentives for compliance and "beyond compliance," and in enforcement (e.g., increasing the rigor of fire department or other agencies' inspections of uncooperative facilities).

Understand and, where appropriate, take a role in compliance assistance and enforcement. This may involve such activities as LEPC reviews of emergency response plans, working creatively with State Attorney Generals' offices, and Supplemental Environmental Projects (SEPs) in settlements. An example would be the Milwaukee LEPC's SEP which provided funding for Risk Management Plan workshops.

Use community pressure by publicizing which facilities have made progress towards Inherent Safety, as well as instances of noncompliance or non- cooperation.

Obtain more (and sustainable) funding for Inherent safety and Source Reduction, and we recommend facility fees as an appropriate mechanism. Other funding mechanisms include creative enforcement settlement, networking with other agencies and organizations to use their resources, including "in-kind" donations of equipment or services.

Encourage public awareness and participation, including recruitment of LEPC members from community groups, community colleges or school districts, labor, pollution prevention agencies, etc.

The collection of chemical use information, also referred to as "materials accounting" data helps industries identify ways to reduce toxic pollution at the source, and work toward real pollution prevention. Far-reaching state laws in Massachusetts and New Jersey, require companies to report materials accounting, or toxic chemical use information. Industries in those states show reductions in toxic chemical waste generation and overall toxic chemical use, while numbers for the rest of the country continue to increase. Between 1990 and 1996, Massachusetts manufacturers decreased their total toxic chemical use by 24 percent, their waste generation by 34 percent, and their toxic releases to the environment by 73 percent.[30]

The EPA issued and Advance Notice of Proposed Rulemaking to expand the federal Right to Know program to include materials accounting information. They collected public comment on the issue last year, but have yet to finalize any rulemaking. Legislation is also pending in Congress that would fill in many of the gaps in the public's Right to Know: H.R. 1636, the Children's Environmental Protection and Right to Know Act, and S.769, the Right to Know More and Pollution Prevention Act would expand the public's Right to Know about toxic threats and help industry work toward real pollution and accident prevention. Both bills would improve public access to information on chemical use and information on particularly hazardous substances like lead, dioxin and mercury that currently escape reporting requirements.

The Chemical Safety and Hazard Investigation Board

In 1990, Congress mandated a promising approach to chemical accident prevention: a Chemical Safety and Hazard Investigation Board.[31] The Board, modeled after the influential National Transportation Safety Board, which investigates airline accidents, would investigate the causes of major chemical accidents, critique regulatory and industry inaction, and recommend measures to prevent accidents. President Clinton named three qualified individuals to the independent, non-regulatory Board, but unilaterally diverted the Board's funding in February of 1994.[32]

Since then, environmental and labor groups have fought to reinstate the Chemical Safety Board, and establish sufficient funding for its operation. Last fall Congress appropriated and initial 4 million dollars to fund the Chemical Board, and the Clinton Administration began the process of appointing the remaining Board members.

So far the Chemical Safety Board has made a fast start, but only two of the five seats are filled. Currently, Congress is considering appropriating only 6.5 million dollars of the 8.2 million requested for the Board's funding. Without sufficient resources, the Board will hardly be able to function as an investigative body, let alone play a significant role in the necessary shift toward Inherent Safety planning.

Transportation risks

Transport of hazardous chemicals poses some of the most serious chemical accident risks, as the 1992 Superior, WI accident demonstrates. In the Great Lakes, almost one million tons of hazardous chemicals are transported by highway and rail through the metropolitan Chicago area each day. Yet, information on what, how much, how often, and where toxic chemicals are being transported is generally inaccessible and unexplored. As such, vulnerable zones resulting from transportation accidents are not covered in this report's data analysis, though, according to NELC's report Accidents Do Happen, these accidents may constitute upwards of 25% of chemical accidents.[33]

The National Institute for Chemical Studies (NICS) recently estimated the flow of toxic materials in transport in the Kanawha Valley, West Virginia using various data collection methods. The study documented the high vulnerability of communities to accidents involving the transport of toxic chemicals and the lack of information on transport of hazardous materials available to local emergency preparedness organizations.

Public Participation

By harnessing the power of public accountability, facility information on vulnerable areas and toxic chemical operations could prove to be a valuable tool in the area of accident prevention. This information can serve as a mechanism to identify problem areas (e.g., with sensitive populations), priorities for Inherent Safety intervention, indicate the relative safety of a facility, lead to a prevention dialogue, and inform zoning decisions. For example, California state law requires formal consideration of worst-case scenario risks if schools are situated close to industrial facilities.

Examples of innovative projects using worst-case accident estimates and other facility information on toxic chemicals to convey information about chemical accident risks to the public include:

1. Kanawha Valley, WV. In response to citizen activism, in 1994 chemical manufacturers in the Kanawha Valley, WV publicly disclosed vulnerable zone analyses, as well as information on past accidents, and prevention activities as part a widely publicized model project. While the Kanawha Valley project did not focus primarily on accident prevention, it made public the sentiments of many citizens, such as Pam Nixon, who stated,

"Responding to accidents isn't what communities want. They don't want accidents in the first place."[34]

2. Contra Costa Times, Contra Costa, CA. The Contra Costa Times published both worst-case and "credible" worst-case accident scenarios as well as information on the hazardous chemicals contained at each facility in December, 1993. As Denny Larson of Citizens for a Better Environment stated, "It gives you a realistic look at how much damage could be caused by an accident at that facility when humans and machinery fail." [35]

3. New York State Attorney General's (AG) Office. The AG's office prepared a 1989 report entitled New York Under a Cloud: The Need to Prevent Toxic Chemical Accidents that provided a clear picture of potential disaster areas and sensitive populations, including the World Trade Center, universities, hospitals, and airports. The AG's office focused mainly on two chemicals, ammonia and chlorine and plotted the vulnerable areas on a state map. A subsequent report by the Consumer Policy Institute found 365 facilities in the five boroughs of New York that pose toxic cloud risks. Of these, 13 were identified as posing significant risks to the more than 8 million inhabitants of New York City in the case of a worst-case accident.[36] Other state and local examples of the public use of worst-case scenarios include: Providence, RI, Buffalo, NY, Minneapolis, MN and Fort Huron, MI. In Washington, DC, the Local Emergency Planning Committee demonstrated that a toxic chlorine cloud released from a water treatment facility would potentially blanket the White House. As a result, the water treatment facility studied the possibility of switching to less hazardous sodium hypochlorite. These examples demonstrate that the potential for public information to stimulate Inherent Safety is enormous.

Recommendations

The storage and use of extremely hazardous chemicals poses significant risks to workers, communities, and the environment. Accidents producing far-traveling toxic clouds *can* and *do* happen in this country, adversely affecting significant populations and ecosystems. Chemical accidents are preventable. The following measures should be taken to prevent toxic chemical accidents, to reduce the impacts of toxic accidents and improve chemical safety in the United States:

1. Promote Inherent Safety accident prevention

The best way to ensure community safety is to reduce the inherent hazards of chemical operations. "Inherent Safety " accident prevention eliminates or reduces the possibility of an accident by modifying key aspects of the production system, such as technologies, products and raw materials.

- Risk Management Plan (RMP) information, including worst-case accident scenarios, under the Clean Air Act 112(r) should be made readily available to the public through an effective national data system. EPA should ensure meaningful public access to information on worst case toxic cloud estimates, other hazard assessments, complete information on past accidents, and a full prevention plan. Worst-case accident scenarios can provide a quantitative measurement and evaluation of Inherent Safety at a facility.
- Consistent with the EPA agency-wide focus on pollution prevention and technology innovation., companies should be required to prepare a Technology Options Analysis (TOA) to identify inherently safer alternatives. At a minimum companies should prepare Technology Options Analysis when undergoing process re-design. Particular emphasis should be placed on those chemicals that pose the greatest hazards to humans and the ecosystems, including those that persist or bioaccumulate in the environment. State and local governments should integrate Inherent Safety into existing programs for pollution prevention and chemical safety, such as technical assistance and prevention planning.
- Local Emergency Planning Committees, established under the Emergency Planning and Community Right to Know Act, should use the RMPs when available and emphasize accident prevention and Inherent Safety as an integral part of their activities. To date, most of the LEPC efforts across the country have focused on responding to accidents after they have occurred, rather than looking for ways to prevent them in the first place. A series of appropriate Inherent Safety strategies for LEPCs is listed in Box 1.

2. Expand and improve the public's Right to Know about toxic chemical use and accidents

An expanded Right to Know should include information about the use, storage, and flow of hazardous chemicals within production processes as well as information about past accidents and "worst case" accident hazards. This information should be made available to the public through easily accessible on-line services such as the Toxics Release Inventory established under the Emergency Planning and Community Right to Know Act.

Citizens, government agencies and industries themselves need complete and accurate information on toxic chemical production and use, chemical accidents, and sources of toxic pollution to play a meaningful role in preventing pollution and toxic chemical accidents. Until we have a clearer understanding of where toxic chemicals are in production, transportation, and commerce, it will be difficult, if not impossible, to prevent the majority of toxic chemical accidents and adopt the principle of Inherent Safety.

Legislation is pending in Congress that would fill in many important Right to Know data gaps and help industry work toward real pollution and accident prevention. H.R. 1636, the Children's Environmental Protection and Right to Know Act, and S. 769, the Right to Know More and Pollution Prevention Act would provide the public with:

- toxics use data on chemicals used in facilities, transported through communities, and contained in consumer products;
- information on occupational exposure to toxic chemicals;
- and information on highly toxic substances that persist in the environment, such as lead, dioxin, and mercury.

3. Complete the membership and fully fund the Chemical Safety and Hazard Investigation Board

The Clinton Administration should appoint and the Senate confirm three qualified individuals to complete the membership of the Chemical Safety and Hazard Investigation Board. Furthermore, Congress should appropriate sufficient funding for the Chemical Safety Board to investigate the underlying causes of chemical accidents and Inherent Safety options for prevention. Insufficient funding and incomplete membership hinder the Board in carrying out its operations mandated under the Clean Air Act Amendments of 1990. This independent board should be a motivating force in the shift toward Inherent Safety.

Table 2: Top U.S. Counties ranked by worst-case disaster potential

Rank	County	State	Worst-case "disaster potential"	Number of facilities	Total EHS storage (lbs.)	Total number of vulnerable zones	% of vulnerable zones above 5 mi.
1	HARRIS	TX	1,112	135	361,676,300	356	24.4
2	LOS ANGELES	CA	586	196	20,946,300	312	11.9
3	COOK	IL	572	186	71,755,880	283	10.6
4	ASCENSION	LA	354	16	283,995,320	78	41
5	MOBILE	AL	326	24	18,332,540	71	39.4
6	JEFFERSON	TX	298	25	84,026,700	78	35.9
7	CUYAHOGA	OH	272	82	4,151,660	128	10.9
8	BRAZORIA	TX	264	14	120,845,240	58	39.7

9	ST CHARLES	LA	245	9	36,963,220	40	57.5
10	WAYNE	MI	244	53	7,999,720	100	15
11	NIAGARA	NY	237	20	10,356,280	49	42.9
12	CONTRA COSTA	CA	219	26	71,114,420	55	36.4
13	CALCASIEU	LA	211	16	529,458,140	49	38.8
14	IBERVILLE	LA	209	11	180,776,520	41	48.8
15	GALVESTON	TX	188	10	85,459,440	50	30
16	MARICOPA	AZ	186	52	1,411,140	93	12.9
17	SHELBY	TN	176	24	17,398,920	63	22.2
18	LAKE	IN	164	21	6,075,220	40	32.5
19	POLK	FL	162	24	148,805,520	45	31.1
20	NUECES	TX	161	10	21,856,240	37	40.5
21	DALLAS	TX	155	62	1,282,660	88	8
22	ST JAMES	LA	155	9	62,375,040	20	75
23	EAST BATON ROUGE	LA	148	15	67,597,520	46	26.1
24	SAINT LOUIS CITY	MO	147	25	2,259,300	42	28.6
25	HAMILTON	OH	147	36	25,357,520	65	13.8
26	KANAWHA	WV	142	14	26,418,480	48	25
27	ERIE	NY	138	29	23,171,580	51	19.6
28	MADISON	IL	137	15	3,184,240	31	38.7
29	WILL	IL	134	18	14,984,560	46	21.7
30	SANTA CLARA	CA	132	69	1,326,920	113	2.7
31	MARION	IN	129	36	2,748,920	53	15.1
32	ANNE ARUNDEL	MD	127	17	57,087,080	34	29.4
33	MIDDLESEX	NJ	126	39	4,645,640	65	9.2
34	GLOUCESTER	NJ	124	14	14,788,260	33	30.3
35	RICHMOND	GA	120	20	64,954,360	39	25.6
36	UNION	AR	117	10	19,613,420	35	28.6
37	SAN BERNARDINO	CA	116	25	1,887,640	37	27
38	ALLEGHENY	PA	116	19	2,215,360	34	23.5
39	JEFFERSON	KY	113	30	5,298,160	55	10.9
40	KERN	CA	111	23	2,246,400	30	33.3
41	ST CLAIR	IL	111	11	28,641,120	24	41.7
42	CALHOUN	TX	110	6	36,355,340	26	38.5
43	LINN	OR	109	12	2,742,440	29	27.6
44	MULTNOMAH	OR	108	22	13,532,140	34	26.5
45	NEW CASTLE	DE	107	16	157,762,300	30	30

46	MECKLENBURG	NC	107	22	3,512,440	40	20
47	MASON	WV	107	3	5,262,000	15	66.7
48	MILWAUKEE	WI	106	47	1,115,860	70	8.6
49	ROCKINGHAM	VA	105	7	456,000	15	66.7
50	BERKS	PA	103	21	11,817,400	37	18.9

EHS storage is the cumulative amounts of the minimum of the indicated ranges for 94 extremely hazardous substances that companies store in the U.S., as reported to the Toxics Release Inventory (TRI). 79 of the 94 chemicals had at least one report in the 1995 TRI.

Source: Toxics Release Inventory 1995 provided by RTK-Net. Data analyzed by NELC using EPA methods. See Methodology Section.

Table 3: Top U.S. Zip codes ranked by worst-case disaster potential

Rank	Zip code	City	County	State	Worst-case "disaster potential"	EHS chemical storage	% of vulnerable zones above 5 mi.
1	70734	GEISMAR	ASCENSION	LA	271	81,635,240	38.7
2	77536	DEER PARK	HARRIS	TX	189	86,494,180	46.2
3	77571	LA PORTE	HARRIS	TX	166	38,915,200	35
4	77507	PASADENA	HARRIS	TX	155	27,461,160	15.9
5	77541	FREEPORT	BRAZORIA	TX	141	105,892,200	34.3
6	77590	TEXAS CITY	GALVESTON	TX	138	64,086,400	36.4
7	70669	WESTLAKE	CALCASIEU	LA	121	506,773,140	42.3
8	71730	EL DORADO	UNION	AR	114	19,612,420	29.4
9	21226	BALTIMORE	ANNE ARUNDEL	MD	106	55,886,040	27.6
10	36505	AXIS	MOBILE	AL	106	11,561,180	58.8
11	70805	BATON ROUGE	EAST BATON ROUGE	LA	105	66,263,280	28.1
12	70057	HAHNVILLE	ST CHARLES	LA	105	13,532,100	66.7
13	70776	SAINT GABRIEL	IBERVILLE	LA	101	5,421,100	76.9
14	90670	SANTA FE SPRINGS	LOS ANGELES	CA	95	1,094,200	20.6
15	36582	THEODORE	MOBILE	AL	95	2,031,080	52.9
16	44004	ASHTABULA	ASHTABULA	OH	89	15,522,000	53.3
17	97321	ALBANY	LINN	OR	88	2,722,140	25
18	77015	HOUSTON	HARRIS	TX	87	27,212,120	47.1
19	94565	PITTSBURG	CONTRA COSTA	CA	87	2,851,000	50
20	42029	CALVERT CITY	MARSHALL	KY	85	24,452,220	38.1

21	25515	GALLIPOLIS FERRY	MASON	WV	84	5,231,000	72.7
22	77520	BAYTOWN	HARRIS	TX	83	17,552,140	31.8
23	14304	NIAGARA FALLS	NIAGARA	NY	78	1,701,040	31.6
24	70346	DONALDSONVILLE	ASCENSION	LA	78	202,330,080	61.5
25	26155	NEW MARTINSVILLE	MARSHALL	WV	77	40,410,100	36.8
26	48667	MIDLAND	MIDLAND	MI	77	8,523,040	31.6
27	52404	CEDAR RAPIDS	LINN	IA	71	2,432,140	53.8
28	23860	HOPEWELL	HOPEWELL CITY	VA	71	31,752,440	21.7
29	77651	PORT NECHES	JEFFERSON	TX	71	15,420,040	53.8
30	28456	RIEGELWOOD	COLUMBUS	NC	70	3,212,140	70
31	77506	PASADENA	HARRIS	TX	69	1,733,200	43.8
32	36553	MC INTOSH	WASHINGTON	AL	69	52,520,160	42.9
33	30906	AUGUSTA	RICHMOND	GA	69	3,563,080	31.6
34	47905	LAFAYETTE	TIPPECANOE	IN	68	4,712,080	37.5
35	72501	BATESVILLE	INDEPENDENCE	AR	68	101,530,000	63.6
36	14302	NIAGARA FALLS	NIAGARA	NY	66	5,312,040	50
37	48192	WYANDOTTE	WAYNE	MI	65	4,541,000	35.7
38	78407	CORPUS CHRISTI	NUECES	TX	64	20,342,120	42.9
39	77511	ALVIN	BRAZORIA	TX	64	13,511,000	54.5
40	89015	HENDERSON	CLARK	NV	64	3,520,220	42.9
41	77640	PORT ARTHUR	JEFFERSON	TX	63	551,180	42.9
42	25112	INSTITUTE	KANAWHA	WV	62	10,743,100	31.3
43	71753	MAGNOLIA	COLUMBIA	AR	62	4,440,100	46.2
44	29405	CHARLESTON	CHARLESTON	SC	61	4,502,000	45.5
45	70070	LULING	ST CHARLES	LA	61	10,501,000	85.7
46	25143	NITRO	PUTNAM	WV	60	841,000	38.5
47	28401	WILMINGTON	NEW HANOVER	NC	59	12,461,100	33.3
48	55068	ROSEMOUNT	DAKOTA	MN	59	12,142,680	27.8
49	19706	DELAWARE CITY	NEW CASTLE	DE	58	104,130,140	45.5
50	70079	NORCO	ST CHARLES	LA	58	12,630,080	35.7

Disaster potential refers to the sum of vulnerable zone radii for all EHS chemicals and facilities analyzed in the zip code.

EHS storage is the cumulative amounts of the minimum of the indicated ranges for 94 extremely hazardous substances that companies store in the U.S., as reported to the Toxics Release Inventory (TRI). 79 of the 94 chemicals had at least one report in the 1995 TRI.

Source: Toxics Release Inventory 1995 provided by RTK-Net. Data analyzed by NELC using EPA methods. See Methodology Section.

Table 4: Top 50 U.S. manufacturing facilities in worst-case disaster potential*Note: Facilities listed in alphabetical order not in order of ranking.*

Facility Name	Parent Company	City	State
3M	3M	KEARNEYSVILLE	WV
AKZO NOBEL CHEMICALS INC.	AKZO NOBEL INC.	GALLIPOLIS FERRY	WV
ALBEMARLE CORP.	ALBEMARLE CORP.	ORANGEBURG	SC
ALBRIGHT & WILSON AMERICAS INC	ALBRIGHT & WILSON PLC	CHARLESTON	SC
ALLIED-SIGNAL INC.	ALLIED-SIGNAL INC.	HOPEWELL	VA
AMOCO PETROLEUM PRODS.	AMOCO CORP.	TEXAS CITY	TX
ARISTECH CHEMICAL CORP.	MITSUBISHI CORP.	HAVERHILL	OH
BASF CORP.	BASF CORP.	GEISMAR	LA
BAYER CORP.	NA	NEW MARTINSVILLE	WV
BAYER CORP.	BAYER CORP.	KANSAS CITY	MO
BAYER CORP. BAYTOWN	NA	BAYTOWN	TX
BORDEN CHEMICALS & PLASTICS	NA	GEISMAR	LA
CIBA GEIGY CORP.	CIBA GEIGY CORP.	MC INTOSH	AL
CIBA-GEIGY CORP.	CIBA-GEIGY CORP.	SAINT GABRIEL	LA
CONDEA VISTA CO.	NA	WESTLAKE	LA
CYTEC IND. INC.	NA	WESTWEGO	LA
DEGUSSA CORP.	DEGUSSA CORP.	THEODORE	AL
DOW CHEMICAL CO.	DOW CHEMICAL CO.	FREEPORT	TX
DOW CHEMICAL CO.	DOW CHEMICAL CO.	LA PORTE	TX
DOW CHEMICAL CO.	DOW CHEMICAL CO.	PLAQUEMINE	LA
DOW CHEMICAL USA	DOW CHEMICAL CO.	MIDLAND	MI
DU PONT	E.I. DU PONT DE NEMOURS	BELLE	WV
DU PONT	E.I. DU PONT DE NEMOURS	DEEPWATER	NJ
DU PONT	E.I. DU PONT DE NEMOURS	BEAUMONT	TX
DU PONT	E.I. DU PONT DE NEMOURS	VICTORIA	TX
DU PONT	E.I. DU PONT DE NEMOURS	LA PORTE	TX

DU PONT AGRICULTURAL PRODS.	E.I. DU PONT DE NEMOURS	AXIS	AL
EASTMAN CHEMICAL CO.	EASTMAN CHEMICAL CO.	BATESVILLE	AR
EASTMAN CHEMICAL CO.	EASTMAN CHEMICAL CO.	LONGVIEW	TX
ELF ATOCHEM N.A. INC.	ELF ATOCHEM N.A. INC.	RIVERVIEW	MI
FMC CORP.	FMC CORP.	NITRO	WV
GE PLASTICS CO.	GE CO.	MOUNT VERNON	IN
HULS AMERICA INC.	VEBA CORP.	THEODORE	AL
MONSANTO	MONSANTO CO.	ALVIN	TX
MONSANTO CO.	MONSANTO CO.	LULING	LA
MONSANTO CO.	MONSANTO CO.	SAUGET	IL
MONSANTO CO.	MONSANTO CO.	BRIDGEPORT	NJ
MONSANTO CO.	MONSANTO CO.	MUSCATINE	IA
OCCIDENTAL CHEMICAL CORP.	OCCIDENTAL PETROLEUM COR	NIAGARA FALLS	NY
PFIZER INC.	PFIZER INC.	GROTON	CT
PHARMACIA & UPJOHN CO.	PHARMACIA & UPJOHN INC.	PORTAGE	MI
RHONE-POULENC INSTITUTE PLANT	RHONE-POULENC INC.	INSTITUTE	WV
RUBICON INC.	RUBICON INC.	GEISMAR	LA
SHELL OIL CO.	SHELL OIL CO.	DEER PARK	TX
STERLING CHEMICALS INC.	NA	TEXAS CITY	TX
STONE-HODGE INC.	STONE CONTAINER CORP.	HODGE	LA
TELEDYNE WAH CHANG ALBANY	TELEDYNE IND. INC.	ALBANY	OR
TENNESSEE EASTMAN DIV.	EASTMAN CHEMICAL CO.	KINGSPORT	TN
UNION CARBIDE CORP.	UNION CARBIDE CORP.	TAFT	LA
ZENECA AG PRODS.	ZENECA HOLDINGS INC.	BUCKS	AL

Disaster potential refers to the sum of vulnerable zone radii for all EHS chemicals analyzed.

Source: Toxics Release Inventory 1995 provided by RTK-Net. Data analyzed by NELC using EPA methodology.

Methodology

Worst-case vulnerable zone estimates depict the area in which people would be at risk of serious injury or death in the event of a major chemical accident at a facility. NELC calculated these estimates using the EPA's standard "Green Book" Methodology (Technical Guidance for Hazards

Analysis, 1987). The methodology serves as a screening tool for facilities and local emergency management agencies to estimate potential immediate human impacts of worst-case accidents. The methodology does not consider long-term human health impacts or the environmental impacts of worst-case accidents. This methodology assumes failure of all safety any mitigation systems and the entire release of a storage tank's contents. Maximum vulnerable zone radius (extending from a facility) that can be estimated under this methodology is 10 miles.

Vulnerable zone estimates are calculated based on the storage of extremely hazardous substances (EHS chemicals), identified under the Emergency Planning and Community Right to Know Act (EPCRA). There are currently 356 chemicals on the EHS list. Companies storing EHS chemicals are required under EPCRA to report storage under the Tier Two program. This information is typically kept on file by the Local Emergency Planning Committee or county emergency management office. The Tier Two data is less often compiled on a statewide basis (though some states do compile this information and others are beginning the process) and is not available on a region-wide or national basis.

As Tier Two data is not available on a national basis, NELC obtained data on the storage of EHS chemicals from the 1995 Toxics Release Inventory (TRI), through the RTK-NET database. The TRI Form R (Section 4) contains a field named "Maximum Amount On-site," and companies record storage data one of 11 ranges (e.g., 10,000-99,000 lbs or 50,000,000-99,000,000lbs). There are currently 94 EHS chemicals on the TRI list, 79 of which had at least one report in 1995 TRI.

As a result, more than 250 EHS chemicals were not included in the analysis, including numerous pesticides and other extremely toxic chemicals. The 1995 TRI database included 13,487 separate reports of EHS chemicals stored onsite at 7,602 facilities.

NELC sent letters to confirm storage quantities to those facilities that reported storage of more than 50,000,000 lbs. of a given EHS chemical (approximately 65 companies). We corrected a few reporting errors thanks to company responses.

The EPA methodology takes into account the following: (1) Whether the chemical is a liquid, solid, or gas; (2) the rate of release of the chemical (calculated according to the assumptions listed below); and (3) the level of concern (LOC) for the chemical. The level of concern is a measure of the toxicity of a chemical and is equal to 1/10th the exposure level which is immediately dangerous to life and health.

The size of each vulnerable zone depends on: the amount of the chemical; location of the facility (rural or urban); whether a liquid is released at or above ambient temperature; and the presence of a dike. NELC calculated 16 different vulnerability zone estimates using combinations of the following assumptions:

	Smaller zones	Larger zones
Storage amount:	Minimum of storage range	Midpoint of storage range
Location:	Urban	Rural
Liquid state:	Ambient	Above ambient (boiling)
Diking:	Dike	No Dike

Each of these assumptions affects the vulnerable zone estimates to different degrees. A greater amount of storage will result in greater release of EHS chemical and larger vulnerable zones. Rural assumptions will also lead to larger vulnerable zones, as clouds can move unobstructed by buildings. Boiling liquids will generally be more volatile and lead to larger vulnerable areas. A dike will serve to hold liquid and keep it from volatilizing, thus reducing the vulnerable area.

NELC also used the following underlying assumptions in its calculations of worst-case scenarios: (1) F Atmospheric stability (stable weather), low wind speed, 3.4 miles per hour; (2) release time, 10 minutes; (3) percent solid less than 100 microns, 30%; (4) complete storage quantity released; (5) liquid concentrations of 100%; and (6) Dike size 2,000 feet. A computer program and assistance provided by the New York State Emergency Response Commission (Vulzone) provided basic information on assumptions and calculation of vulnerable zones.

For most of its estimates, NELC chose the set of assumptions for its analysis and ranking which provided the smallest vulnerable zones of the 16 estimates. This set contained the following assumptions: minimum point of storage range; urban area; ambient temperature; and diked area. NELC assumed that the amount of the chemical stored onsite was the minimum of the indicated range; i.e. 100 pounds if the range was listed as 100-1000 pounds. Out of the 13,487 EHS chemicals at facilities listed in 1995 TRI, 10,557 had vulnerable zones calculated using these assumptions.

Some vulnerable zones were calculated using other assumptions. Facilities reported no minimum for the amount on-site in two circumstances: they estimated in 640 records that the lowest range was 0 - 100 lbs. (N.B. zero is the minimum) and they filed a Form A for 1, 099 records. The Form A is a new "streamlined" certification allowed by EPA, in lieu of the TRI Form R filing, that fails to disclose the amount on-site even if the amount is in millions of pounds. For the purpose of calculating zones, we treated these 1,739 records as if 40 lbs. were the amount on-site. In addition, a rural rather than an urban area assumption was used for the 1,324 records (216 with a minimum amount set to 40 lbs.) from facilities located in Zip codes that had 100% rural population, according to the 1990 U.S. Census. Lastly there were83 records that had zero radius vulnerable zones under the usual set of assumptions. These had their assumptions varied slightly within a reasonable range in order to provide a minimal but non-zero radius.

NELC ranked facilities, zip codes, counties, states, chemicals, sectors and industries by cumulative vulnerable zone radii. Cumulative vulnerable zone radii are the sum of all vulnerable zone estimates within a geographic area (zip code, county, state). Great Lakes Basin counties were identified according to a list provided by the U.S. EPA Great Lakes National Program Office in Chicago. Vulnerable zone rankings were then compared to population, according to the 1990 Census, on a zip code basis and to frequency of chemical accidents from 1993-1995 on a county basis. Data on the frequency of toxic chemical accidents was obtained by NELC from the EPA's Emergency Response Notification System Database and reported in NELC's Accidents Do Happen.

Total affected populations within this report are the sums of 1990 U.S. Census populations of zip codes that contain three mile vulnerability zones. In some cases, the vulnerable zone will not cover the entire zip code, and in many cases the vulnerable zone will extend into other zip codes, but this method provides a very understated way of estimating potentially affected population at a national level. In order to do this, we needed to find the population of each zip code listed by each TRI facility reporting EHS chemicals. For 12,107 of the 13,487 TRI EHS chemical records, the associated zip code had a population in the 1990 U.S. Census. The remaining records did not, usually because the facility had their own zip code for mail delivery purposes that covered only the facility and not the surrounding area. We matched the remaining zip codes to existing zip codes within the same city that had either the same initial four or three digits. Then we assigned the population of the first matching zip code to the problem zip code. In this way we estimated the population of zip codes for 742 TRI records by 4-digit match and for 136 TRI records by 3-digit match. 502 remaining records were left with zero population estimates.

This analysis provides only an approximate, baseline ranking of communities, counties, and states with regards to potential worst- case accident impacts so as to create dialogue on accident risks and prevention. This ranking should be followed up by greater discussion and more in-depth analysis of facility specific accident risks using computer modeling programs. Also, this analysis does not estimate the potential vulnerable areas and populations from spills directly to bodies of water. An analysis of this type is extremely important and necessary in the Great Lakes basin.

Additional information on the methodology may be obtained by contacting the authors.

[1] Toxic clouds form when chemicals that are heavier than air are released during an accident. An accident is a non-routine chemical release, spill, explosion, or fire at an industrial facility or during transport.

[2]Phillips,L. and H. Gray. 1996. Accidents Do Happen: Toxic Chemical Accident Patterns in the United States. Second Edition, Boston, National Environmental Law Center.

[3] See U.S. EPA. 1987. Technical Guidance for Hazards Analysis: Emergency Planning for Extremely Hazardous Substances. Washington, DC. (Also known as the "Green Book".)

[4] Some companies use worst-case scenarios for accident prevention planning and use more "credible case" (considering the function of some safety systems) scenarios for emergency planning. The scenarios are also used to insurance purposes, to determine off-site liabilities.

[5] This report represents the second report by NELC and the state PIRGs ranking areas based on worst-case accident scenarios. The first report, Nowhere to Hide, was written by Joel Tickner and Hillel Gray in August, 1995.

[6] Extremely Hazardous Substances are chemicals that cause severe toxic effects in humans who are exposed to them due to an accidental release. They pose an immediate risk to life and health.

[7] Data from the TRI, which covers only 94 of 356 EHS chemicals, was used instead of data from the Tier II EHS reporting program (EPCRA section 311), which is not accessible on a federal or often state basis.

[8] For example, NELC assumed that EHS chemicals were stored in a single vessel or multiple interconnected vessels (and thus entirely released during an accident) when a certain chemical may be stored and used in several different locations throughout a facility. A worst-case scenario is generally considered the immediate release of the entire contents of a single vessel or multiple interconnected vessels.

[9] Passive containment measures are non-mechanical safety systems designed to limit accident effects (e.g., dikes and settling ponds).

[10] NELC used assumptions that would produce small vulnerable zone sizes. See Methodology for complete information.

[11] Sensitive sites are those that either contain individuals which are affected by toxic exposures to a greater degree or where evacuation in the event of an accident would be difficult. Sensitive ecological areas are those that are already threatened by toxic pollution or contain a delicate ecosystem balance (e.g., wetlands).

[12] For example, when under "boiling" conditions (above ambient temperature), numerous liquid chemicals have substantially greater potential for forming large vulnerable zones as they vaporize much more readily. Sulfuric acid, the most commonly used and stored EHS chemical in the U.S., is stable and creates very small vulnerable zones under ambient conditions. When above ambient conditions (during a fire or heating operations), sulfuric acid becomes magnitudes of order more volatile and creates large vulnerable zones.

[13] 8.3 billion lbs was calculated by using the minimum point for every range reported for each EHS chemical. This calculation only includes those EHS chemicals reported under TRI (94 of 356 total). Thus, 8.3 billion lbs is a very low estimate.

[14] See Phillips, L. and H. Gray. 1996. Accidents Do Happen: Toxic Chemical Accident Patterns in the United States. Second Edition. Boston: National Environmental Law Center.

[15] See Tickner, J. and H. Gray. 1994. Accidents Do Happen: Toxic Chemical Accident Patterns in the United States. Boston: National Environmental Law Center.

[16] See U.S. EPA. 1994. Deposition of Air Pollutants to the Great Waters. Washington, D.C., EPA-453/R-93-055.

[17] See U.S. EPA. 1994. EPA calls for new dioxin data to complete reassessment process. EPA Environmental News. Press release packet to announce the release of EPA's draft dioxin health assessment, September, 13.

[18] See Mehard, A. and D. Osborn. 1995. The need to consider accidents when regulating the environmental sources of dioxin-like compounds. Nature. May 25, 1995.

[19] 63 FR 640

[20] Potter, J. 1993. Chemical accident prevention regulation in California and New Jersey. Ecology Law Quarterly, vol.20:755-813.

[21]See Jaffe, S. and P. Skinner. 1989. New York Under a Cloud: The Need to Prevent Toxic Chemical Accidents. Albany: New York Attorney General's Office.

[22] See Jaffe and Skinner, 1989, which describes an EPA study on toxic cloud movement and an Oak Ridge National Laboratory study on accidental release detection, notification, and evacuation times.

[23] See The Bergen Sunday Record. April 23, 1995. Chemicals and New Jersey: often a perilous mix.

[24] Perrow, C. 1984. Normal Accidents: Living with High-Risk Technologies. New York: Basic Books.

[25] A conversation with Edward A. Munoz, former Managing Director of Union Carbide, India, Limited. Interview conducted by Joshua Karliner, Executive Director of the San Francisco-based Transnational Resource & Action Center, in association with the Bhopal Action Resource Center of the Council on International and Public Affairs.

[26] Kletz, T. 1994. What Went Wrong. Houston: Gulf Publishers.

[27] Ashford, N., et al. 1993. The Encouragement of Technological Change for Preventing Chemical Accidents: Moving Firms from Secondary Prevention and Mitigation to Primary Prevention. Boston: Massachusetts Institute of Technology. Call EPA's EPCRA Hotline at 1-800-535-0202 for a copy.

[28] 61 FR 31717

[29] A project team of governmental, industry, academic and public interest representatives have worked together in NELC's Great Lakes Pollution Prevention and Chemical Safety Project. The Project Team developed a set of recommendations for LEPCs.

[30] Massachusetts Department of Environmental Protection press release 4/22/98

[31] The Board was mandated under the 1990 Clean Air Act Amendments.

[32] President Clinton diverted the Board's funding into EPA and OSHA, the very agencies the Board was supposed to oversee. The Board was designed to be independent to enable it, for instance, to criticize the actions of these agencies.

[33] See Tickner, J. and H. Gray. 1994. Accidents Do Happen: Toxic Chemical Accident Patterns in the United States. Boston: National Environmental Law Center.

[34] Contact Pam Nixon, People Concerned about MIC 304-766-6313, or, NICS .1-800-282-2796

[35] Citizens for a Better Environment and the West County Toxics Coalition later published "A Toxic Tour of Richmond, CA" which described the hazardous facilities of that city and their impacts. Contact Denny Larson, CBE.

[36] Contact Peter Skinner, NY Attorney General's Office, 518-474-2432.