COPING WITH CONFLICTING PERCEPTIONS OF RISK IN HAZARDOUS WASTE FACILITY SITING DISPUTES

by

MICHAEL LAWRENCE POIRIER ELLIOTT

B.S., Urban Studies, Massachusetts Institute of Technology
(1974)

B.S., Architecture, Massachusetts Institute of Technology
(1974)

M.C.P., University of California, Berkeley
(1978)

Submitted to the Department of
Urban Studies and Planning
in Partial Fulfillment of the Requirements
of the Degree of

DOCTOR OF PHILOSOPHY

in

URBAN AND REGIONAL STUDIES

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

June, 1984

Signature of Author ____________________
Department of Urban Studies and Planning
May 22, 1984

Certified by ____________________
Lawrence E. Susskind
Thesis Supervisor

Accepted by ____________________
Lawrence E. Susskind
Chairman, PhD Committee

COPING WITH CONFLICTING PERCEPTIONS OF RISK IN HAZARDOUS WASTE FACILITY SITING DISPUTES

by

Michael Lawrence Poirier Elliott

Submitted to the Department of Urban Studies and Planning of the Massachusetts Institute of Technology on May 24, 1984 in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Urban and Regional Studies

ABSTRACT

Public officials are frequently required to make choices that will have uncertain consequences. Particularly in public health and environmental policymaking, decisions are made with information that leaves much room for conjecture. This difficulty can be seen readily in the siting of hazardous waste facilities. Despite a nationwide call for better management of hazardous chemical wastes, few treatment facilities have been sited in the past ten years. Whenever sites are proposed, disputes erupt among various publics and experts over the likelihood of adverse impacts and the margins for safety that are appropriate in light of uncertainty. This thesis seeks to explain why divergent perceptions emerge in facility siting disputes and to prescribe how agreement might be achieved in the face of these differences.

A range of government interventions capable of shaping risk perception in hazardous waste facility siting are examined. Siting of these facilities raises concerns about (1) predictions: do we know enough to forecast the likely effects of a hazardous waste disposal plant? (2) detection: if hazardous conditions develop, will we be able to detect them quickly? (3) prevention: can we design and manage systems for effectively reducing the potential risks? and (4) mitigation: if serious hazards are detected, do we know how to reverse the dangers and the negative impacts? Strategies for coping with differing perceptions of risk currently focus on information exchange about physical properties, technological systems, and safety

estimates. The efficacy of these prediction and prevention strategies are compared with alternative detection and mitigation strategies. In addition, the research compares improvements in technical safety relative to innovations in social control as devices for coping with risk perceptions.

Gaming-simulation research was used to evaluate the usefulness of these different frameworks for understanding risk perceptions. Particular strategies for implementing a risk management system based on each of these frameworks were simulated by providing participants with appropriate materials. The study points to several findings. From the perspective of local residents, the risks of hazardous waste treatment are most effectively controlled through improved detection and mitigation of hazards and through better management of facilities. Perceptions of risk are not easily altered by changes in technological systems for predicting and preventing hazards. Moreover, these perceptions circumscribe the effectiveness of compensation as a tool for increasing the acceptability of potentially hazardous facilities.

Dynamics of risk perception depend significantly on the perceiver. Participants in risk management disputes generally hold one of three distinct positions: that of sponsors, of guardians, or of preservationists. Sponsors value business activity and judge proposals by their benefits. Guardians value orderly change that protects and promotes the public interest and judge proposals by evaluating tradeoffs. Preservationists value stability and a traditional life and judge proposals by their potential disruption and uncertainty. Sponsors generally believe that the risks of hazardous waste treatment facilities are insignificant and manageable, guardians believe they are significant but potentially controllable, and preservationists believe they are significant and highly unpredictable. The consequences of these underlying values and perceptions are explored in depth.

The dissertation develops a rationale for each of these findings, and examines their potential implications for social risk management policy. The thesis supervisor was Professor Lawrence Susskind. The dissertation committee also included Lawrence Bacow, Gary Hack, Michael O'Hare, and Howard Raiffa.

Biographical Note

for

Michael L. Poirier Elliott

While a doctoral candidate in the Department of Urban Studies and Plannning at the Massachusetts Institute of Technology, Michael Elliott has focused on issues of environmental and land use policy, emphasizing processes for resolving technologically based environmental disputes. His previous degrees include a M.C.P. from the Department of City and Regional Planning at the University of California, Berkeley (1978), a B.S. from the Department of Architecture at M.I.T. (1974), and a B.S. from the Department of Urban Studies and Planning at M.I.T. (1974).

The work of this disseration was conducted while he was a research fellow with the Joint Center for Urban Studies of M.I.T. and Harvard (1981 - 1984). While in residency at M.I.T., he has been an Instructor with the M.I.T. Department of Urban Studies and Planning (1980-81 and 1983-84) and with the continuing education program of the Harvard Graduate School of Design and the M.I.T. Laboratory for Architecture and Planning (summers, 1979 - 1981). He has served as assistant project director for a German Marshall Fund sponsored study of citizen participation in Europe (1978 - 1980). Before coming to M.I.T., he also served as Executive Assistant to the Director of Business Services in the New York City Mayor's Office of Economic Development (1977 to 1978).

Recent publications include: Co-editor (with Lawrence Susskind), Paternalism, Conflict and Co-Production: Learning from Citizen Action and Citizen Participation in Western Europe, (New York: Plenum Press, 1983). Author, "The Impact of Growth Control Regulations on Housing Prices in California," Journal of the American Real Estate and Urban Economics Association (9:2), 1981, pp. 115 - 133. Author, "Pulling the Pieces Together: Amalgamation in Environmental Impact Assessment," Environmental Impact Assessment Review, (2:1), 1981, pp. 10 - 38. Author (with Lawrence Susskind), "Learning from Citizen Participation and Citizen Action in Western Europe," The Journal of Applied Behavioral Science (17:4), 1981, pp. 497 - 517. Co-editor (with Marc Draisen), special issue on "Citizen Participation: The European Experience," Planning and Administration, (1981:2). Author, "Evaluating Citizen Participation: Illustrations from the European Experience," (Presented at the Symposium on Citizen Participation in Western Europe, Washington, D.C., May, 1980). Author (with Lawrence Susskind), "A Survey of Local Growth Policy Committees and Their Impacts," (Cambridge, MA: MIT Laboratory for Architecture and Planning, 1977).

Preface

This dissertation is about perceptions of risk, how these perceptions alter public policymaking disputes and how consensus might be developed when these perceptions vary widely. In many policymaking disputes, disagreements over the likely consequences of a decision erupt among experts and various publics. Planners, policy analysts, engineers and scientists commonly argue that risks are best estimated using special analytic skills. Subjectively held perceptions, when they differ markedly from analytically derived perceptions, are thought to be irrational or biased by comparison. The problem of diverging risk perceptions is defined as one of lay "misperceptions" or "self-interestedness." Consequently, in their search for solutions, the professionals most closely linked to these disputes tend to focus on ways of reeducating the lay public, of overriding their political voice, or of changing their primary motivation.

In the course of examing this problem, this dissertation presents a fundamentally different conception of why perceptions diverge and what policies are most likely to create effective public risk management systems. The dissertation focuses on policymaking for siting hazardous waste treatment facilities. Siting disputes are generated in large part by conflicting perceptions of risk. Analysis of these disputes suggests that lay perceptions diverge from expert opinion not simply because the lay public distorts the process of information search and analysis (because of irrational or self-serving biases), but more fundamentally because they use different criteria for what constitutes a significant risk. These criteria are not measured by technical indices of risk, and hence important elements of the risk management problem (as defined by laypeople) are overlooked by technical analysis.

The dissertation does not seek to answer the epistomological question of whether expert perceptions are, in some absolute sense, more realistic appraisals of uncertain risks than are lay perceptions. Rather, it seeks to answer the more pragmatic question of how we might best manage these risks when perceptions fundamentally differ. To this end, the dissertation examines the sources and dynamics of lay and expert risk perceptions, explores the effects of each pattern of perceiving on public policy disputes, and suggests a process by which the difficulties of coping with conflicting perceptions of risk might be better managed.

Acknowledgements

The study would not have been possible without the support of a number of research centers and foundations. The study was initiated and conducted at the Joint Center for Urban Studies of the Massachusetts Institute of Technology and Harvard University. For three years the Center has been my work home and its staff my colleagues. The William and Flora Hewlett Foundation (through the Harvard Program on Negotiation) and the Andrew W. Mellon Foundation (through the M.I.T. Center for International Studies) provided needed financial support. I am grateful to these organizations for their help.

The work of this dissertation is deeply imbedded in years of learning and exploration, for which I owe many people thanks. In my dissertation committee, I was fortunate enough to bring together several of my most valued advisors. Thirteen years ago, Gary Hack first introduced me to planning, and has nurtured and helped discipline my thinking since that time. My association with Michael O'Hare has been equally long and fruitful. The ideas he developed as Assistant Secretary of Environmental Affairs and through his extensive research into facility siting and public policy information dissemination have been particularly provocative. In like manner, Lawrence Bacow has helped me with his considerable experience in environmental conflict resolution and interest in the Massachusetts Hazardous Waste

Facility Siting Act. His ongoing encouragement of my work is particularly appreciated. Joseph Ferreira first introduced me to the problems of the public management of risk and has continued to challenge my thinking in this area. Howard Raiffa, always mindful of both the larger implications of my work and the intellectual rigor of its details, has shared his experience in both areas.

I offer my deepest appreciation to Lawrence Susskind. In this project and virtually all my recent work, he in particular has devoted endless attention and insight. For six years, he has been a teacher and mentor in all areas of my professional development. He has challenged me with ever new projects and goaded me with his tireless energy, offered me opportunities and demanded excellence.

The real heros of this study must remain anonymous. They are the 34 individuals who each gave me between five and seven hours of their time, simply because they thought the problems I was addressing were important (or at least interesting). This dissertation is based on the reflections and concerns of these residents of Worcesterville and Essexton.

In many real ways, the topics of this dissertation emerge from real life experiences. The thesis is in part about preserving qualities of the social, natural, and built environments which I value deeply. In discussions with Julia Wondolleck, Steven Yaffee, Connie Ozawa, and my friends at the Fairmont House Collective, I have been frequently reminded of this basic value. More fundamentally, the thesis is about coping with uncertainty and risk, which none of us can avoid though many of us try. While struggling in this study with issues of how individuals cope with potentially catastrophic risks, I

suffered through the death of my father and several close relatives. While trying to understand the communal hopes and visions of residents in small towns, I was married and thereafter conceived a child. Uncertainty and risk are life, and in Larry Elliott, Rita Fleming, and John Poirier, this reality is made tragically personal. Hope is also life, and through numerous friends and relatives, but particularly Shirley Elliott, Fran Fleming, Elaine Poirier, and a as yet unborn child, I am given the support I need to cope with the vagaries of living and working, in full partnership with their joys.

Table of Contents

Foreword

It was summer, and the evening breezes tempered the gloriously bright day. My drive from Cambridge had taken me beyond the urbanized finge of Boston and into its still rural edge. Here, in the gently rolling town of Worcesterville,* I had organized a meeting with town officials and residents.

The town center in Worcesterville is organized along a common, with the town hall, fire and police departments, schools, and churches in close proximity. The center is small yet spacious, a place of meeting for Worcesterville's 5,000 residents. This evening, we were gathering in the Community House. At one time a private residence, the house had been donated to the town. It housed a kitchen, a living room large enough to fit a small group, and numerous other small rooms.

By 5:30, we had gathered on the porch over cider, crackers and cheese. I was the only stranger, and so was introduced around. Most served on the Board of Selectmen, Town Planning Board, Conservation

---

* The name of the town and its residents, as well as descriptive details about both, have been changed to protect the identity of the respondents. The town is located in Worcester County, Massachusetts. The county stretches from New Hampshire to Rhode Island. It generally demarks the end of the urbanized area in the eastern portion of Massachusetts, and the beginning of the more rural portions. A second exercise was conducted in a town north of Boston. Located in Essex County, I call this town Essexton.

Commission, Industrial Development Commission, Zoning Board of Appeals or Town Finance Commission. Several were town employees: the police chief, the fire chief, the assistants to the Selectmen and the Board of Assessors, a fireman (with a specialty in hazardous waste and chemical fires), and the local Hazardous Waste Coordinator. Still others were politically active local residents involved in the League of Woman Voters or local business associations. Altogether: sixteen residents of Worcesterville representing government, business, landowner and environmental interests found in the town. All participants were from the community in which the simulation was run and shared a commitment to and experience with the political life of the town.*

I had invited these particular individuals to attend because I was interested in simulating the make-up of a Local Assessment Committee. The Massachusetts Hazardous Waste Facility Siting Act mandates the formation of this committee in any community in which the siting of a hazardous waste facility has been proposed. The law dictates the make-up of the committee and gives authority over local hazardous waste facility siting issues to this group.** The committee is designed to represent the range of local interests affected by a

* In Essexton, eighteen residents participated, including three selectmen; the director of Public Works; members from the Board of Health, Planning Board, Solid Waste Study Committee, Historic Commission, Finance Committee, Water Study Committee, and Conservation Commission; and five additional residents representing landowner and business interests.

** The Hazardous Waste Facility Siting Act requires that within thirty days of proposal to site a hazardous waste treatment facility in a town, the chief executive officer of that community will establish a local assessment committee, to be comprised of the local chief executive officer; the chairs of the local Board of Health, Conservation Commission and Planning Board; the fire chief; and eight local residents (O'Hare, et al., 1983: 201).

facility. I wished to study how people perceive the risks associated with the siting of hazardous waste treatment facilities, by gathering with residents who might be central to this process. I designed the meeting to help me understand how perceptions affect their decisions when the consequences of choices are uncertain, and to explore the policy changes that might facilitate an alteration of these perceptions.

The individuals present in Worcesterville, then, were selected because it is they who would make the policy choices if a developer ever proposed to site a hazardous waste treatment facility in their town. They had come together to simulate this decision making process in as realistic a setting as possible. Before the evening was over, they would hear proposals, argue their merits, and negotiate among themselves. They faced a difficult task, for they would need to accomplish in one five-hour meeting what usually takes place over many months.

I began the meeting by presenting a hypothetical proposal to site a hazardous waste treatment facility in Worcesterville. On the wall were pictures and flow charts describing the operations of such a facility. The plant would be a rotary kiln incinerator, designed to burn hazardous organic wastes.* By using temperatures high enough to decompose wastes into gases and ash, incinerators convert change highly noxious wastes to relatively benign compounds. For the most part, the end products of incineration are carbon dioxide and water,

* A rotary kiln incinerator was selected because it is largely self-sufficient and requires little infrastructure support from the community. Hence, it could be located in virtually any community.

but thirteen percent of the original waste remains as a hazardous ash, and toxic gases must be cleaned from the air before it was released out the smoke stack.

Using diagrams and pictures (see Appendix A), the characteristics of the facility were described in detail. Information about probable hazards of these processes, plant design, safety features and aesthetics were presented. The facility was designed to meet all state and federal safety standards, but had no additional safety features. Costing $35 million to build, it would provide $850,000 in property taxes each year.

I described not one, but three companies that were competing for permission to build a rotary kiln incinerator in Worcesterville. While each company offered the same basic design (sufficient to meet state and federal standards), each had a different system in mind for further reducing risk. Waste Technology Incorporated stressed technological improvements: more stringent vehicle safety standards, additional spill prevention and containment measures, oversized pollution control systems, a buffer zone -- the best and most advanced technologies currently available. WTI argued that by careful attention to prevention, the facility could be made relatively risk-free.

The Pollution Control Corporation argued that nothing could be technologically risk-free, but by carefully monitoring material flows, ambient environmental conditions, and routine operations, problems could be corrected before they became serious. Pollution Control proposed to use standard technology, but to also implement evaluation systems for detecting problems (e.g., systems for monitoring air quality, combustion flows, groundwater quality, and neighborhood conditions), vehicle inspections, and a strengthened system for tracking the shipment of wastes from generators to the treatment facility. To deal with problems as they might develop, PCC would adopt mitigation and spill containment measures, organize an emergency response corps, and prepare detailed contingency response plans. The company argued that through such measures they could remain on top of any hazard that might develop.

Finally, Environmental Management Incorporated's position was presented. Environmental Management argued that the risks of hazardous waste treatment developed not so much because of inadequate technology, but because of less-than-ideal management practices. They offered to open the operations of the company to public scrutiny and to subject safety decisions to community review. The core of their proposal was a safety board on which community residents would sit. The board would oversee the safety of the plant, manage its own annual budget for making improvements, and have emergency powers should hazards develop. The facility and its records would be inspected by an engineer hired by the town. Payments would be made to the town fire department so that it would have the specialized equipment and training to cope with emergencies. Agreements on how to resolve disputes would also stipulate the creation of emergency action trust funds to ensure the availability of necessary funds. Finally, EMI indicated that it would own all delivery trucks, specifying the routes they could travel and the hours they could operate. By careful attending to issues of liability, accessibility, and open management, Environmental Management offered reassurances that no shortcuts would be taken that might undermine the safety of the plant.

When the presentations were over, we broke for a quick dinner. In little over an hour, everyone had been given more information than some companies ever reveal. Numerous visual displays helped keep information about the companies straight. The dinner revived spirits and gave a needed respite.

By 7:30, we were back in the meeting room. Participants now needed to select the company with the package they felt would be safest. Objections came quickly: "We don't want to choose, we want all three." Since each offered a different strategy for reducing risk, all three together would undoubtedly reduce risk the most. The discussion shifted to the advantages and disadvantages of each company. "Is it advantagous to incorporate only the best available technology or should we rely on what has proven the most reliable in the past?" "Will monitoring data do us much good if it remains in the hands of the company?" "If we accept authority over the plant, doesn't that mean we accept liability as well?" After 45 minutes and despite a continued desire to form a new company out of parts of all three companies, a bare plurality of Worcesterville residents voted to select Pollution Control as the company with whom they would most like to do business.*

After a brief break, we reconvened for the final (and probably most enjoyable) phase. The committee of town residents now had a negotiating partner, and needed to decide what they should demand from the company. They were free to ask for anything that any of the other

* In Worcesterville, 43% voted for Pollution Control, 36% for Environmental Management, and 21% for Waste Technology. In Essexton, 56% of participants voted for Environmental Management, 37% for Pollution Control, and 7% for Waste Technology.

two corporations had offered. In addition, they could insist on compensation of various kinds: community service improvements, trust funds to cover damage caused by accidents or to guarantee the value of land and the supply of water, technical assistance, free local hazardous waste disposal, facility landscaping, or direct cash compensation (over and above property taxes).

I imposed one restriction: their requests could not exceed three million dollars annually. This was the amount that by my estimate a private corporation with net revenues of $30 million per year could afford to pay (above what its competitors paid). Thus, unless the plant was heavily subsidized by the state or federal government (a possibility I precluded in this exercise), $3 million annually was a realistic restriction.

To enforce the budget, I provided the participants with prices for each possible form of compensation. Each option had a price tag: this option costs $70,000 per year; that one costs $210,000. The proposals for the three companies were designed to cost approximately $1.9 million each. In addition, a compensation package of $2.5 million was available. All told, then, $3 million would buy somewhat less than half of everything that had been proposed. A game board was used to facilitate discussion of possible tradeoffs. The price of each option was designated on the board. The initial position of the board included $1.9 million annual budget for safety features offered by Pollution Control* and $1.1 million in annual cash payments to the town treasury.

* In Essexton, the initital position of the board included $1.9 million annual budget for safety features offered by Environmental Management (since EMI had been chosen by the participants) and $1.1 million in annual cash payments.

Participants broke up into three groups of approximately six individuals. Each group was free to make tradeoffs among the remaining safety and compensation features as they wished (see Appendix A for more details).

The arguments resumed: "Let's give up some of this monitoring to buy this technology... Don't you think we should have more authority over the plant? After all, the greatest risks emerge from situations where operators are trying to cover up... Perhaps we should move money currently earmarked for general revenues into an emergency trust fund. If we don't, the selectmen will use it on some pet project... Isn't safety more important than compensation? Let's move money out of community revenues into a safety board."

Finally, over an hour later, the three groups had reached a resolution of one kind or another. By now, each group had cut funds reserved for Pollution Control's initial safety package in half, and reduced unrestricted compensation to near zero. With the released money, one team bought two-thirds of Waste Technology's risk reduction package and one-third of Environmental Management's ideas. The other two teams divided their redistributed money evenly between the safety devices of Waste Technology, the participatory management of Environmental Management, and restricted compensation funds designed to guarantee land values, water supplies, and liability payments.*

---

* In Essexton, the results were more varied. One team (which by coincidence included most of the participants who had voted for Pollution Control) shifted the Environmental Management budget entirely into Pollution Control and left unrestricted compensation largely untouched. The other two teams left Environmental Management's initial safety budget 80% intact, but reduced unrestricted compensation to near zero in one case, and in half in the other. (Footnote continued on next page.)

It was after 10:00 pm. The excitement carried some individuals, but others were obviously weary. We talked about differences between the teams for a few minutes, and adjourned the meeting. Some stayed to talk and help clean up, others drifted out into the cool night.

I met with each of the participants within a week and a half for an interview. My findings are based in large measure on the revealed perceptions and hopes of these 16 men and women from Worcesterville and a similar group of 18 men and women from Essexville. My gaming simulation had three purposes. It was an experiment, a probe, and a school. As an experiment, it was designed to test how people develop arguments and form perceptions about the risks of hazardous waste and how they would react in a relatively realistic decision making settings. As a probe, it was designed to raise questions which could be pursued in the interviews that followed. And, as a school, it was designed to inform a divergent group of local decision makers about the risks of hazardous waste, the potential for managing such risks, and the process for siting hazardous waste facilities in Massachusetts. With this knowledge, and the experience of trying to make such decisions, these individuals had become informed spokespersons for the position of local residents in the siting process.

I completed extensive interviews (between 60 and 90 minutes), with each participant. The interviews were relatively unstructured. A general list of topics were covered: What are the most important aspects of these facilities that causes you to oppose them? In what

* (continued from previous page) The released money was evenly divided between restricted funds for covering damage due to accidents and the monitoring features of Pollution Control. Virtually no funds were redirected into the safety equipment of Waste Technology by any of the three teams.

way are the risks of these plants different from other risks you now face? Independent of the structure of the game, how might the risks of these plants to the town be most readily reduced? What role should private enterprise, the town, the state and the federal government play in the siting process? How do you feel about the use of compensation to promote the siting of hazardous waste facilities? How do you make trade-offs between expenditures for safety and those for compensation?

These interviews explored with participants their perceptions of and feelings about the hazards of chemical waste, their hopes for their communities, and ideas for improving the siting process. From this, a story emerged. Better yet, three stories emerged. The people of both towns tended to cluster into three categories: sponsors, guardians and preservationists.

This thesis examines the structure of these risk perceptions and the patterns of risk acceptance in local public policymaking. The first three chapters provide a context for understanding the problems of risk and uncertainty in public choice. Chapter 1 provides an overview of problems of perceptions in the context of siting hazardous waste treatment facilities. Chapter 2 describes the historic problem of improper disposal practices and suggests that scientific understanding of the consequences of these practices are neither so precise nor so reliable as to preclude controversy from developing. As seen in the example of Love Canal, the scientific uncertainty and the controversy it engenders has important implications for how people perceive risk. In Chapter 3, opposition to the siting of new hazardous waste facilities is examined. While new processes for managing hazardous waste are far superior to those used in older, existing facilities, residents do not believe that these newer facilities are safe enough to be located in their town. These perceptions have effectively blocked all attempts to promote hazardous waste management through replacement of outdated treatment systems with better designed facilities. Without these facilities, application of more stringent safety standards is not feasible, and policymaking for hazardous waste is stalemated.

Why do perceptions of risk have such widespread implications? To understand the links between perceptions and opposition, we next examine perceptions and values as revealed by the participants of the simulation. Chapter 4 presents these stories in detail, and discusses differences between three types of individuals: sponsors who value business activity or safe waste management, believe risks to be insignificant, and judge proposals by their potential benefits; guardians who value orderly change that protects and promotes the public interest, believe risks to be significant but controllable, and judge proposals by their potential impacts; and preservationists who value a traditional life style with autonomous decision making, believe risks to be highly significant, and judge proposals by their potential disruption and the uncertainty they engender.

In the final four chapters, we consider the implications of these perceptions on public policymaking and propose how society might better cope with the siting of potentially hazardous facilities. Chapter 5 examines the dynamics behind the perceptions of sponsors, guardians and preservationists. Two aspects of perception are given particular attention: the intellectual and cultural frames used to define risks, and the cognitive and social processes used to evaluate risks. Based on an understanding of these dynamics and data derived from this study, Chapters 6 and 7 argue that particular strategies of risk management are likely to be more effective than others, and that these strategies will more readily promote acceptance of potentially noxious facilities than will preemptive or compensatory strategies currently being used. We close with a discussion of principles for improving the siting of potentially hazardous facilities in Chapter 8.

Chapter 1

Perception and Acceptance in the Resolution of Hazardous Waste Facility Siting Disputes

Public policymaking frequently requires elected and appointed officials to make choices that will have uncertain consequences. Policy choices likely to affect environmental quality and public health, in particular, must be made with less than perfect information in hand. Disagreements can erupt among experts and various publics over the likelihood of adverse impacts, the margins for safety that the government ought to ensure, and the appropriate government response in light of uncertainty. Such disputes are now quite common and they are straining our regulatory and policymaking system.

The difficulties of coping with conflicting perceptions of risk are readily seen in the hazardous waste facility siting disputes that have arisen throughout the country. Former EPA administrator Douglas Costle has called hazardous waste managment the single greatest environmental challenge of the next few decades (Morell, 1982:1). The call for better managment of hazardous chemical wastes is nationwide, but few treatment facilities have been sited in the past ten years (U.S. EPA, 1979). From the perspective of policymakers, new treatment plants can help reduce illegal dumping and permit the government to clean up dangerous landfills. From the standpoint of potential abutters of these new facilities, however, the risks associated with these plants are often unacceptable. What is generally good for the majority seems bad for a minority. While waste disposal plants are regionally desirable, they are invariably opposed once particular sites are selected.

The failure to develop workable hazardous waste facility siting policies is significant. Each year, approximately 43 million metric tons of nonradioactive hazardous wastes are generated in the United States (Morell, 1982:5). These wastes are generated in the normal course of industrial production. The demand for chemicals, drugs, metals, energy, textiles, petroleum products and other goods is growing. While processes may become more efficient, the production of these products ensures the continued generation of hazardous wastes.

The continued production of these wastes, combined with the perceptions of risk they evoke, has led to a potentially dangerous stalemate. The EPA estimates that only 10 percent of these wastes are properly disposed (Epstein, 1982:7). More effective disposal requires better designed facilities. However, we are a nation that does not trust centralized power. We have empowered individuals and localities to oppose the imposition of new facilities. The use of administrative and judicial review as a delaying tactic is widespread. Costly delays can certainly be reduced with more efficient procedures, but workable hazardous waste facility siting policies will require a more comprehensive approach.

Government and industry have attempted to streamline the hazardous waste facility siting process by altering perceptions of likely impacts (U.S. EPA, 1979). Most frequently, agencies try to convince potential abutters that the adverse affects are not really so bad as the abutter thinks. Sometimes the government or industry will even promise to take steps to minimize or mitigate some adverse effects if they do indeed occur. These efforts have been haphazard and ineffective.

Workable public policies for handling hazardous wastes are not likely to be forthcoming at the federal, state, or local levels in the absence of a new consensus (or at least a workable detente) over what is desirable. Risk perceptions play a dominant role in numerous hazardous waste facility siting controversies, a role which at times overpowers all other difficulties. The siting of hazardous waste and other regionally necessary but locally noxious facilities requires that government develop approaches for coping with environmental risk perceptions. While basic research into the perceptions of individuals making isolated decisions has been conducted, the effort to understand risk perception in the context of social decisions and to develop strategies for coping with these perceptions in a public policymaking context is only just beginning.

This thesis is aimed at clarifying the patterns of risk perception that emerge in facility siting policy disputes, the sensitivity of these patterns to various public policies aimed at ameliorating hazards, and the possibility of developing consensus when risk perceptions vary widely. By pinpointing differences in the perceptions of various groups and by exploring key public policies that may enhance the ability of government to develop consensus around these differences, I have sought to understand ways to better structure the siting process when perceptions of risk are widely divergent. I emphasize the social or group aspects of risk perception, aspects which are potentially alterable within the public sector. These publicly conditioned aspects of perceptions are a legitimate concern of public policy, and the conflicts they generate require public policy solutions.

I. Hazardous Waste Facility Siting Disputes

The Hazardous Waste Controversy

The problem of chemical contamination of land and underground water supplies is of recent concern. Twelve years ago, when Earth Day was first celebrated, hazardous waste was hardly mentioned. Perceptions changed with the generation of new information about toxic substances and a few highly publicized tragedies involving hazardous waste.

Love Canal is of course the most infamous of the modern hazardous waste dumps. Love Canal defined the image of "hazardous waste" more than any other single event, but numerous local waste sites have fueled widespread concern. In Massachusetts, which generates approximately two percent of the nation's hazardous waste, the state Department of Environmental Quality has closed 70 public and private wells in 30 communities due to chemical contamination. Thirty-six communities are known to have hazardous waste sites within their boundaries

(Blake, 1982a). Nationally, up to one third of the 100,000 known hazardous waste disposal sites may possibly cause future problems (Senkan & Stauffer, 1981:36).

The threat to public health and to the environment posed by these wastes is stongly dependent on the quantity and characteristics of the wastes involved. Problems often arise in attempting to manage hazardous substances because many of the substances involved are neither qualitatively nor quantitatively well understood. Regulation of substances with obvious properties such as reactivity, corrosivity, ignitability or acute toxicity can be developed relatively easily, but questions about chronic toxicity, changes in a chemical's health impact at various concentrations, its potential for degrading into toxic products, its persistence in nature, and its potential for bioaccumulation are considerably more controversial (Senkan and Stauffer, 1981:40).

Controversy begins when public health standards are first proposed. The problems of determining the response of an organism to pollutants are enormous. The National Research Council's Board on Toxicology and Environmental Health Hazards has noted difficulties in deciding which pollutants to measure, how to ensure that they are adequately measured, what corrections to make for widely differing exposure patterns and sensitivities, and how to relate measured pollutants to health effects. Investigators are further restrained by their limited success in replicating models of human disease in animals (in order to examine the response of more vulnerable elements of the population) (National Research Council, 1978; Trieff, 1980). Under these conditions -- where absolute proof of chronic disease induction can not be traced to exposure to specific substances -- overall assessment of risk based on available epidemiologic and experimental animal investigations is subject to widely varied interpretations (Lee and Mudd, 1979; President's Science Advisory Committee, 1973; NAS, 1975).

Equally controversial is the safety of technologies developed to handle these wastes. Where economical, new technologies have been used to recycle and otherwise reprocess chemicals. But chemicals with no economic worth have frequently been discarded with few safeguards. Generally, today's problems emerge from these lax (and sometimes illegal) disposal procedures. Public perceptions about hazardous waste are based on some of the worst case examples of waste handling. How common these practices were remains unclear.

Improvements in waste handling will depend largely on industry's willingness and ability to innovate. The development of technically sophisticated approaches to handling individual waste streams is time consuming, but necessary. In trying to innovate, however, industry will create new uncertainties. To date, public perceptions of the risks associated with hazardous waste treatment and disposal have not been quieted by technological improvements. Unless new disposal facilities can be sited, these improvements will be of little use.

Siting Hazardous Waste Facilities

The political impasse over the siting of hazardous waste treatment and disposal facilities has been amply documented nationally (US EPA, 1979). Local perceptions of the risks involved seem to be the limiting constraint. Construction of a plant is visible and location specific. The plant, and its treatment activities, will become a permanent neighbor when built and operational. In light of this permanence, perceptions of potential risks gain local prominence.

Almost invariably, impasses develop over the siting of locally noxious but regionally beneficial projects. Because siting policies are redistributive, potential host communities have little incentive to support such policies. Benefits of a hazardous waste facility are spread widely across a region; no single beneficiary feels especially well rewarded. At the same time, the risks and costs are concentrated in a very small area of the host community. Diffuse regional support is counteracted by concentrated local opposition. The resulting conflict in interests is aggravated by traditional regulatory systems because they give complete authority to central governing bodies to enforce siting decisions and fail to acknowledge the power and insights of local governing bodies.

The Massachusetts Experiment

In July of 1980, the Massachusetts Legislature adopted the Hazardous Waste Facility Siting Act (Bacow, 1982). The new law vested primary authority for siting hazardous waste facilities with local communities; established a process of negotiation and compensation involving the community, the developer and the state; and mandated a broad public information program on hazardous waste management practices. By enabling those who stand to lose from a project to share in the gains of those who benefit, the state hoped to ameliorate local opposition.

Three years into the process, however, no siting process has reached the stage where local residents have negotated with developers over compensatory benefits. Using the siting law, four waste management companies (IT Corporation, SRS, Liqwacon Corporation, and General Chemical Corporation) have tried to locate a treatment facility in Massachusetts. The experience of General Chemical is most dramatic. After successfully operating a treatment plant in Framingham for more than a decade, General Chemical sought to locate a second chemical recycling plant in the nearby industrial city of Gardner. After a stormy debate, the company agreed to accept as binding the results of a local referendum on the acceptability of its proposal. Gardner voters turned the plant down almost three to one. Moreover, Framingham residents, alerted to the hazardouse waste processing capability of the existing plant, began work to revoke General Chemical's license to operate its Framingham plant (Lewis, 1982). Both Liqwicon and SRS withdrew their proposals under equally intense local pressure. IT Corporation is continuing in the process despite a non-binding local vote of six to one against the proposal (Linda Smith, 25 January 1984 interview). In each case, potential host communities have argued that the risks involved are too great to even permit bargaining over appropriate compensation and mitigation measures.

The Massachusetts experience underlines how little we know about effecting agreements among disputing parties when their positions are based on widely divergent perceptions of risk. The Siting Act instituted a system of negotiation and compensation for managing risks. On the surface, the system is quite capable of coping with differing risk perceptions. However, the Act and the disputants who have come under it rely heavily on traditional approaches to regulatory decision making. Massachusetts has relied on information dissemination as a means of improving the quality of the debate and has sought to design a process of bringing about a convergence in perceptions of risk through technical studies. Policies for more creatively coping with risk perceptions are needed if improvements in the decision making process (such as negotiated dispute resolution) are to be effective.

II. The Dynamics of Risk Perception

Uncertainty and Risk in Public Choice

"Risk" is an elastic and multipurpose word. Technical definitions tend to emphasize the gamble and venture connotations of the word risk; randomness and probability of loss are the most important features. In everyday use, however, risk has more subjective meanings. To the lay person, the connotations of danger (the possibility of loss or injury) and hazard (a perilous situation) are psychologically powerful associations.

These associations are important in public policymaking. In hazardous waste facility siting and similarly high risk ventures, perceptions are crucial to decision making. Estimates of risk are not strictly objective because the range of probable events is not known and the probability distribution of those events that are known is subject to significant disagreement. We have what Rowe (1977:17) calls descriptive and measurement uncertainty. Questions of fact associated with environmental risk management cannot be answered by the scientific method either because their answers require impractically expensive research, their subject matter is too variable to allow strictly scientific rationalism, or their implications are essentially incomplete unless coupled to moral and aesthetic judgments (Weinberg, 1972:213).

The uncertainty that results frequently cripples public decision making. These uncertain risks lead to predictable behaviors. In many public policy debates, uncertainty is systematically denied or treated as a predictable effect, an inadequate theory is claimed as most appropriate in light of no clearly adequate alternative, or action is prevented in the absence of greater certainty. Hazardous waste management debates have all these characteristics.

Improved risk management, therefore, depends on improved treatment of risk perceptions. Public systems function to provide services, and perceptions influence the demand for, opposition to, and satisfaction with those services. As a basis for knowledge, perceptions are most important when public policy has no firm factual foundation upon which to rest. Perceptions of risk can overpower any analysis that is attempted if the analysis and its supporting theory are subject to dispute. As a basis for behavior, perceptions constrain the range of feasible risk management strategies. Perceptions can generate substantial opposition to proposed facilities. As a basis for experience, the fears generated have demonstrable psychological and social costs. (Kasper, 1980). Perceived risks, even when not substantiated by analytic estimates, can cause considerable distress. If we are to break out of the cycle of denial, claiming, and inaction associated with uncertain and risky public policies, we must learn to cope with risk perceptions in the face of uncertainty.

Current research into risk perceptions in public policymaking is based largely on studies of individual perceptions. This research helps explain individual predispositions toward risk. Yet, risk perceptions are not incorporated into policymaking by individuals in isolation from others, but rather as part of a larger bargaining process. Hence, in addition to studies of individual perceptions, an understanding of interactive risk perceptions is essential.

Studies of Individual Risk Perceptions

As currently practiced, risk analysis is based largely on engineering theories. The analysis builds on prescriptive theories about how we ought to measure risk and make decisions when uncertainty exists. The indicator of overall hazardousness generally preferred by risk analysts is "expected outcomes per unit time" (e.g., expected increase in deaths per year). By estimating the probability of various potential futures and amalgamating the data into a single measure of expected outcome, the essential characteristics of risk and uncertainty that are of interest to engineers can be incorporated into the analysis. Use of this scale as a measure of hazardousness, however, blurs the distinction between risk estimation and risk preference. Not only does the scale imply that fewer deaths are to be preferred to more (an opinion against which few would disagree), but because expected outcome is presented as the only significant indicator of risk, the scale also implies that other characteristics of outcomes which have not been estimated (e.g., the manner of death or the degree of uncertainty) are less important.

This implicit link between estimations of and preferences for particular characteristics of hazards is more explicitly recognized in expected utility theory. By encouraging decision makers to state preferences for many possible pairs of potential outcomes (each with some subjectively held probability of occuring), the decision analyst can derive a more refined understanding of tradeoffs over the entire range of possible alternatives. The resulting estimate of expected utility, however, is highly subjective. Utilities cannot be compared among individuals. Moreover, only measurable characteristics that are amenable to probability analysis can be incorporated.

In observing patterns of lay perceptions, psychologists have concluded that laypeople do not perceive risks as prescribed by technical analysts. Laypeople are as concerned with the range of possible consequences as they are with expected value or utility. In portfolio theory developed by Coombs and associates (1975) the psychological importance of three different forms of variability are emphasized: the range of outcomes, probability of extreme outcomes and variance for any given expected value.

Additionally, in complex decision making, information is frequently processed sequentially (Schoemaker, 1980). Perceptions about the consequences of particular alternatives are constrained by comparisons with other alternatives. Alternatives are evaluated by tightening criteria until the subset of acceptable alternatives is managable. Criteria are used to eliminate options below thresholds of acceptability. Thresholds are established for probabilities (e.g., the chance of failure exceeds a critical value) or consequences (e.g., an option has the possibility of exceeding a specified maximum cost).

Rejection rules are more frequently applied to potential losses than to potential gains because losses more strongly alter minimum aspiration levels than do gains. (Slovic, 1967; Slovic and Lichtenstein 1968; and Andreissen 1971). Kahneman and Tversky (1979) suggest that losses become increasingly important while gains become decreasingly important the further removed they are from an individual's point of psychological neutrality.

Perception theorists have further demonstrated that individuals use simplifying procedures to analyze complex problems of probability and consequences. Representativeness (similarity to other objects or events along some dimension) is usually used to classify a new object or event into an existing, subjectively held class or process. Availability (ease with which instances can be brought to mind) is used to assess the frequency of a class or the plausibility of a particular development. Adjustments to an anchor (re-evaluation of an initial estimate) is employed to make predictions when a relevant value is available (Tversky and Kahneman, 1974).

The hazardous waste debate provides ample opportunity for systematic bias to enter through each of these heuristics. To illustrate: an individual's estimate of the likelihood of a hazardous waste catastrophe is likely to depend on whether hazardous waste is perceived to be more similar to nuclear waste, to recycling, or to city dumps (representativeness); whether the individual can easily visualize potential catastrophes because of news coverage (availability); and whether the individual's initial estimate is colored by the estimates of advocates or opponents to the project (anchoring).

Estimates of risk based on these heuristics, once formed, are difficult to change because they are based on inherently subjective processes of classifying objects, correlating events, and imagining consequences. Both laypeople and sophisticated experts are typically overly confident in these intuitively based judgments (Slovic et al., 1980; Nisbett & Ross, 1980), and hence are generally resistant to alternative analyses. Inconsistencies within subjectively derived judgments are difficult to pinpoint, and no compelling argument for changing opinions can be made unless a subjective estimate can be shown to be inconsistent with a person's total system of beliefs.

If laypeople evaluate the riskiness of an event by the range of potential outcomes, paying more attention to potential losses than gains and systematically simplifying complex problems in ways which are highly subjective, it is little wonder that their evaluations differ from those of professional risk analysts. However, the differences between lay and technical perceptions run deeper than these alternative approaches to information processing would suggest. When consequences are potentially catastrophic, the social context accentuates differences between lay and technical perceptions of risk.

The Social Context of Risk Perceptions

Differences between lay and professional perceptions of risk are rooted in the social and cultural environment in which the individual perceives and decides. This social context is eclipsed in most studies of individual risk perceptions. In these studies, the outcomes are monetary, the solution set is discrete and well defined, the consequences of risk taking are immediately apparent, and the decision maker is an individual. Models of risk perception and preference such as these are of limited relevance when the decision maker, the risk bearer, and the beneficiary are different; when associated risks and benefits can be used to compensate losses, trade risks, or otherwise plan for contingencies; or when consequences are potentially catastrophic.

Nonetheless, a key to understanding how the lay public perceives large scale technological risks can be found in these germinal studies. Even more so than when choosing among small gambles, laypeople focus on variability in potential outcomes and the possibility of loss when faced with large scale risks. This focus is not simply a consequence of shifts in statistical reasoning and risk averseness. Laypeople's approach to large scale risk is not probabilisitic (that is to say, quantitative). The riskiness of large scale technologies appears to be evaluated by characterizing potential effects rather than evaluating probable effects. In assessing accidents, neither the annual number of lives lost nor the lives lost in one mishap are indicative of the perceived seriousness of the risk. Innumerable car accidents go unnoticed and plane crashes are given only passing concern because they occur as part of a familiar and well-understood system. A small accident in a poorly understood system, however, is frequently perceived as a harbinger of catastrophy (Slovic, 1982b:88), and consequently is viewed as having great importance.

The subjectivity of evaluations based on qualitative characteristics helps create enormous discrepancies between technical and lay risk perceptions. Research is increasingly suggesting that the perceived risks of large scale technologies are built on perceptions of both knowledge and consequences. Risks are perceived as greatest when an individual believes that little is known about and little can be done to prevent potentially catastrophic consequences. Currently, public policy relies most heavily on improved information about technologies and physical systems to reconcile divergent opinions about risk. Because information about rare events is not definitive, however, risk perceptions are not easily altered by such information (Nelkin et al, 1980:189). Moreover, disputants argue less about information than about how to interpret such information (Schon, 1971:13). The result has been partisan use of analysis to "prove" what is really perceived through more basic qualitiative characteristics. The debate is not compelling because it fails to address issues of fundamental concern.

Even more importantly, public policymaking is stalemated by this failure to accept the potential validity and to actively engage lay as well as technical patterns of risk perception. In the absence of active engagement, risk management strategies developed by the technical community are increasingly resisted by organized communities of lay publics. Our policymaking process is strained. We are unable to cope with risks that we recognize as endangering our environment.

If we are to develop public consensus around perceptions of risk, we cannot do so by altering each person's psychology, group identity or culture. We must do so by altering factors that are rooted in the social context and are legitimately part of public decision making. We need to explore the patterns of lay perceptions and their sensitivity to alternative policies of risk reduction. We need also to explore patterns of lay risk acceptance and their sensitivity to policies of compensation. Through such exploration, in the context of policymaking, we might design policies for better coping with risks.

III. Strategies for Coping with Risk Perceptions

Perception research underscores the importance of variability as a determinant of perceived riskiness. What seems to place large scale technical facilities in a class by themselves is their perceived unpredictability and potential for extreme outcomes. Images of catastrophes and cancer dominate. Small accidents seem less important because they are familiar and controllable. Social mechanisms for coping with small hazards, of defining and limiting their effects, are widely trusted. Similar mechanisms for coping with large scale hazards are given little credance.

The task of designing better ways for coping with risk requires a fundamental shift in risk management techniques. We must devise systems for reducing the variability, for limiting the potential for extreme outcomes. Moreover, these systems must be percieved as reliable and trustworty. Otherwise, they will make little difference to the siting process.

Whether risk is estimated quantitatively or qualitatively, questions about four aspects of risk management must be answered to the satisfaction of participants in the decision making process. These include:

- **Prediction:** Do we know enough to forecast the likely effects of a hazardous waste treatment facility? Is this knowledge being impartially examined and presented?

- **Prevention:** Can we design systems for effectively reducing the potential risk? Will these systems be reliably managed?

- **Detection:** If hazardous conditions develop, do we have the means to detect these changes? If so, will that data be collected and scrutinized so as to detect changes quickly? and

- **Mitigation:** If serious hazards are detected, do we know how to reverse the dangers and the negative impacts? Will these mitigation measures be applied with sufficient speed and skill to be effective?

Perceptions of risk depend not just on predictive knowledge, but also on detective knowledge; not just on efforts to prevent consequences, but also on efforts to mitigate them should they occur. A preoccupation solely with technical definitions of risk lead us to emphasize prediction-prevention strategies for managing those risks. Technical analysis focuses most readily on events in the planning and construction phases of risk management: on technologies being installed and systems being built. Because built systems and infrastructures are difficult to alter, the risk management strategy is limited to the adequacy of our current knowledge. Unfortunately, this adequacy is at the core of the hazardous waste facility siting debate.

Detection-mitigation models, with their focus on the operating phase of risk management, are more future oriented and adaptable. They do not limit control to present actions, but offer a way of integrating new concerns through time. Inasmuch as problems evolve toward extreme outcomes by building on lesser problems, variability can be greatly reduced though detection and mitigation of these lesser problems. By bargaining over methods of detection and mitigation, we can reduce feelings of uncertainty, increase perceived control, and hence alter perceptions of risk.

But our current emphasis on improving technology and learning more about the resilience of natural systems is still too limiting. We need new approaches to risk management aimed directly at reconciling opposing perceptions of risk. As Clark (1980:308) notes, when knowledge is incomplete and the future uncertain, mistakes and surprise are inevitable. Effective policy must rely on a strategy of recognizing mistakes, learning from them, and modifying future actions accordingly. Our problem is not just of knowledge, but also of learning; not just of consequences, but also of coping. To effect changes in perception, efforts to manage risk must extend beyond a focus on technology and physical systems to the design of organizational learning and control strategies.

Alternative approaches to risk management can be illustrated by the experience of IT Corporation in Warren, Massachusetts (Blake, 1982b). In June of 1981, IT announced plans for a $100 million hazardous waste treatment plant. The firm currently operates 26 plants in California with a combined total output 10 times that of the proposed Massachusetts plant. The proposed plant is larger than any single plant it now operates.

IT is simultaneously proposing to build large plants in Louisiana, Texas and Massachusetts. In all three states, the arguments both for and against the proposal are essentially based on perceptions of risk. Proponents feel that without these or similar plants, illegal dumping will continue posing significant health hazards. Opponents feel that the proposed plants are too large, use untested technologies, and present health hazards themselves. In Massachusetts, the state Secretary of Environmental Affairs and a statewide public interest group, the Coalition for Safe Waste Management, promoted consideration of the project while a local citizen's group, STOP IT, expressed strong opposition.

The groups involved in the IT siting process tried to affect the perceptions of members of the state mandated Local Assessment Committee as well as the public-at-large. For the most part, each group relied on analysis of the safety record of IT and on predictions of likely consequences to convince others of the rightness of its position. Information, propaganda and documentary evidence were exchanged. IT claimed to have a good waste management record. STOP IT pointed out numerous code violations in existing plants. IT countered that it had rectified problems whenever they become apparent.

Information was adapted by both sides to convince specific audiences. As O'Hare (1981) has noted, users of information vary. Because factual information is difficult to analyze, most individuals rely on the interpretation of others. For these people, the problem of information analysis is reduced to the task of selecting appropriate advocates and adopting their view. Recognizing this, IT tried to convince opinion leaders, especially environmental organizations, of their view. STOP IT responded with charges that the firm was saying different things to different audiences.

The two strategies used in the Warren debate represent the most common approach to altering risk perceptions. But bargaining need not be restricted to an exchange of views. Alterations of physical systems is a second often used approach to risk perception management.

Traditional regulatory and permitting processes frequently require alterations such as redesigning the plant or adding back-up safety features. Bargaining over preventive physical systems, however, can increase a sense of risk as well as decrease it. Large expenditures in prevention is frequently cited as evidence of a plants fundamental lack of safety. IT claims its plant is safely designed. STOP IT counters that the possibility of leaks is not infinitesimal. The bargaining stances are predictably opposed.

A third stance is possible. Agreement might be reached on the appropriate systems for detecting breakdowns in the system and for mitigating and managing the effects if breakdowns occur. Wells could be sunk to monitor changes in water quality and pump systems added to confine leachate should it be detected. Candor about the possibility of accidents and a willingness to commit resources to detect and mitigate damage are at the core of this bargaining strategy.

Contingency planning, however, has not been present in past hazardous waste facility debates. By itself, it does not resolve disputes based on risk perception because future events signal very different possibilities to individuals who perceive risks differently. In the absence of a trusted arbiter to enforce contingency agreements, differences in risk perceptions will remain.

The impossibility of fail-safe design underlines the importance of developing reliable mechanisms for coping with hazards (Clark, 1980; Thompson, 1980). Our willingness to believe that certain institutions or organizations can and will function effectively shapes our perception of risk. We evaluate private organizations by their willingness or ability to invest in the necessary technology, attract and retain competent workers, enforce appropriate work practices, and develop and implement effective managment procedures. We evaluate public agencies by their willingness or ability to investigate potential hazards and, if necessary, enforce changes in operating procedures, capital investments or mitigation measures. Thus, managers and public officials can alter perceptions of risk through the sense of competence and trustworthiness they create.

Governmental and organizational arrangements determine who wields control. The major social system for managing risks today is owner onsite management coupled to a regulatory and permitting overview. This system entrusts the greatest control to those with the greatest vested interests: the owners. Uncertainty is largely shifted onto host communities. With permission to site the facility, the community gives up its ability to alter an important aspect of its future while openning itself to the vagaries of the facility's operation. Public control is largely limited to a priori permit reviews.

Changes in this system of control may well be the key to coping with differences in risk perceptions. Prescribed arrangements for the detection and mitigation of hazards could include the establishment of overseers or review boards with contingent powers to manage or close plants under certain specified conditions. For example, IT Corporation or the state of Massachusetts could provide funds to Warren to hire an industrial engineer who would help co-manage the plant, or they might create a trust fund to limit local liability should an accident occur.

Surprising as it may seem, innovative modifications to systems of management have rarely been an item of negotiation in siting disputes. Instead, bargainers have focused on the acceptability and distribution of perceived risks. Strategies for minimizing adverse consequences if hazardous conditions do arise have been given little or no attention.

Under these circumstances, the efficacy of these approaches will not be easily tested. There are no case studies to be done because none exist. But experiments are possible, experiments in which individuals confront their perceptions in light of these risk management policies. Real life decision making can be simulated. Such research can explore the structure of opposition to hazardous waste facilities, examine risk perceptions in the context of siting these facilities, and experiment with the impact of systems of contingency planning and management on risk perceptions.

IV. An Overview of the Research Approach and Methods

Using Gaming Simulation in Research

The analysis was aimed at clarifying the patterns of risk perception that emerge during facility siting disputes, the sensitivity of those patterns to various actions of public officials, and the possibility of developing consensus when perceptions of risk vary widely. Gaming simulation provided a structure for exploring siting disputes in both their wholeness and in detail. Because simulations are holistic, they provide a laboratory for studying linkages otherwise left uncovered, linkages which appear only when interactions actually take place. Because simulations are controllable, specific alternatives can be introduced, tested, and probed.

Other research methods were inadequate for my purposes. Single person behavioral studies allow for highly focused experiments, but cannot be used to analyze the interactions between and among competing interest groups that are an essential feature of siting disputes. Survey studies elicit an individual's perceptions but do not impose a shared context through which perceptions are shaped. Case studies and other field studies reflect on a stream of events, but leave little room for understanding what might have been. Finally, mathematical modeling and computer-based simulations require a prior understanding of system features that are precisely the object of the research. Each of these research methods is important to the study of risk perceptions and siting disputes, but gaming simulation is the logical choice for the questions I seek to raise.

The simulation was designed to learn more about resolving conflicts that grow out of differing perceptions of risk. How are these perceptions fine tuned? Do conflicts in risk perception stem mostly from disagreements about the ability (or willingness) of government and industry to accurately predict impacts, to detect harmful impacts before they reach crisis proportions, to prevent adverse impacts, or to mitigate harmful impacts if they do occur? Are we more concerned with proposed technological improvements that limit the likelihood of hazard or with organizational arrangements for coping with the risks inherent in all technological systems?

The simulation was used to compare the efficacy of prediction and prevention strategies with alternative detection and mitigation strategies, and technological systems of control with alternative management systems. To facilitate this comparison, the simulation needed to accomplish three purposes: to communicate information about hazardous waste in an educational format, to promote dialogue about and careful consideration of this information, and to extract information and opinions from the participants (Duke, 1974; Greenblat and Duke, 1981).

The communities in which I ran the simulation were ones in which a hazardous waste dispute had not occurred. I assumed that the details of an individual's perceptions can be quickly submerged in the rhetoric of a dispute. In struggles, people become strategic. The language they use for communicating their concerns is hard to separate from their position in the dispute. I wished to examine perceptions in light of disputes, but before the language for describing those perceptions had become stylized by the debate. By choosing participants naive to the struggles of hazardous waste disputes but sophisticated in the politics of local governance, I hoped to tap this level of perception.

Because most participants had no professional experience with hazardous waste, however, I needed to present information within a context they could quickly grasp and integrate into their thinking. Strategies for coping with the risks of hazardous waste needed to be specified and simulated by the materials and information provided the participants, and by the structure of the decision making process. The simulation also needed to promote dialogues and interactions by which the participants' initial impresssions could be tested in a realistic decision making setting. From this dialogue and decision making, I hoped participants would frame an understanding of their concerns and perceptions about hazardous waste facility siting. Through observation of behavior in the context of the simulation, questionnaires and interviews, I would then be able to explore these perceptions and concerns with each participant.

The Simulation

The gaming exercise was mounted in two Massachusetts communities. The communities were selected based on a few minimal criteria applicable to the siting of hazardous waste treatment facilities. Each community must be readily accessible to an interstate highway and contain large tracts of undeveloped land. Densely populated cities, highly sensitive ecologies, and towns in which a hazardous waste controversy had occured were excluded. I have named the two communities Essexton and Worcesterville.

Essexton is located in the coastal county of Essex, north of Boston. With a population of 6,000 and development concentrated along the main road and town center, Essexton is a tightly developed commercial and residential community. The town has only one heavy industry and very little light industry. Income levels in the town are slightly below state averages, while unemployment and educational levels are slightly above. Because development has been concentrated, half the town remains wooded and undeveloped. Railroad tracks cut through this undeveloped area, and a major interstate highway cuts along one of its edges. The town draws its water from a shallow aquifer that underlies most of the town.

Worcesterville is located in Worcester County, west of Boston. While the county contains considerable industry, large sections are rural residential. Worcesterville, with a population of 5,000, is predominantly residential. Low density development is scattered throughout the town, but large tracts of undeveloped land remain. The town has some light industry. Residents are relatively affluent. Income and educational levels are above state averages. Almost half the working population are employed in professional, technical or managerial positions. Interstate highway and railroad transportation to the town are excellent.

Participants from these two communities were identified from four interest groups: public officials, businesses, environmentalists, and landowners. Eighteen and sixteen participants each took part in the Essexton and Worcesterville simulations. All participants were from the community in which the simulation was run and shared a commitment to and experience with the political life of the town.

As discussed in detail in the foreword, the participants were selected to mirror the make-up of a Local Assessment Committee. The Massachusetts Hazardous Waste Facility Siting Act requires that towns form these committees whenever a facility is proposed for siting in their community. The law dictates the make-up of the committee and gives authority over local hazardous waste facility siting issues to this group. By mirroring this committee in the simulation, participation need not involve difficult role playing. Each of the public officials, business people, environmentalists and landowners were making a decision very much akin to one they might make in real life. With the roles of the developer's spokesperson and the town's expert consultant being played by research associates and simulated in the materials provided to the participants, the simulation was designed to provide as realistic a setting as possible for making siting decisions.

The foreword also described in detail the simulation as conducted in Worcesterville. Essexton closely parallels this experience. Each simulation had three phases: presenting the siting proposals, discussing and selecting a negotiating partner, and making tradeoffs. The researcher presented participants with a proposal for a rotary kiln incinerator to be sited in their community. Using diagrams and pictures, the characteristics of the facility were described in detail. Three hazardous waste management firms were then presented as competing for permission to build this facility. Incorporated into each package was one of the three major approaches to risk management discussed above. Waste Technology Incorporated offered additional technical hazard prevention features. Pollution Control Corporation offered detection and mitigation features. Environmental Management Incorporated offered alternative management and power sharing features. Finally, participants were presented with a range of possible compensation proposals, divided into groups of approximately six individuals, and given the freedom to make tradeoffs among the safety and compensation features as they wished. Details of these stages are presented in the foreword. The materials used in the simulations are presented in Appendix A.

The Research Tools

Close observation and documentation of the simulations provided an important component of the research data. However, detailed descriptions of participants behavior are difficult to interpret.

Research tools are needed to understand the perceptual basis for this behavior. This study incorporated three research tools specifically designed to explore perceptions that motivated observed behavior. Each individual was given a pre-simulation test of general perceptions about and preferences for risk and hazardous waste treatment, two questionnaires probing changes in their perceptions (to be answered as the simulation proceeded), and a post-simulation interview.

Before commencement of the simulations, the attitudes and perceptions of each participant were evaluated using a simple questionnaire. The questionnaire was aimed at determining attitudes towards hazardous waste, industrial development, environmental protection, the state and federal governments, and public regulation of industry. Beliefs about risk management options and knowledge about hazardous waste were also explored (see Appendix B). The questionnaire was designed to facilitate evaluation of group behavior in light of individual preconceptions.

During the simulation, each individual was provided with two voting questionnaires. The form was designed as a simple recording device to assist the individual in reflecting on his or her ongoing perceptions of the siting process. The record was confidential, and was used as a basis for exploring perceptions that public statements did not reveal.

After the simulations were completed, each individual was interviewed privately. The sixty to ninety minute interviews were used to integrate the results of the questionnaires and observed behavior. The interviews were designed to provide a time for "picking the minds" of the participants. The simulations had greatly enhanced the understanding of these city officials, business people, environmentalists and land owners about hazardous waste facility siting. Interviews probed the trade-offs that participants made during the simulation and examined the relative importance of the various factors that shaped their risk perceptions. Participants were questioned about perceptions, decision making, discrepencies between perceptions and behavior, the relative value of different approaches to risk management, the suggestions they had for improving the siting process, and their reaction to other, untested proposals.

The realism of the simulation and its ability to elicit meaningful comments are difficult to evaluate. It can only be truly experienced from within -- as it was by the researchers and the participants -- for it is essentially a sophisticated form of communication and interaction among these individuals. But fully a third of the participants made spontaneous comments about the simulation. The flavor of these comments can be summarized with the statements of three individuals.

> I take this exercise seriously. I've tried to give you input, to tell you what you need to hear because it is what I as an official feels really reflects what is best for the town without shirking responsibility for the problem. But it's really hard to grapple with a problem that's so damned important.
>
> A Selectman

> The game was marvelous. It really put put us in places where we had to push and think about these problems. The things that individuals felt were most important were really brought out into the foreground and discussed.
>
> A Conservation Commissioner

> Is anyone really considering putting a hazardous waste treatment plant in Essexton? We talked about this in our group. Yes, we have the land. Yes, we have the wind currents that would carry any air pollution away

> from populated areas. There's 400 acres of open land available in close proximity to a railroad, with a super highway coming right in. A plant like this could conceivably be sited here. The proposal was very realistic.
>
> An Industrial Process Engineer

Before examining the outcomes of these simulations, however, we need to first understand the dynamics of existing and past hazardous waste controversies. The next chapter focuses on problems historically associated with hazardous waste disposal and treatment facilities. Two questions are addressed. First, what are the causes and how widespread are the impacts of improper management of hazardous waste? Second, how unequivocally can the hazards of an existing treatment or disposal problem be determined once a condition of hazard is known to exist? We explore these issues because they form the historic base on which prediction of potential impacts of new facilities will be based, and inasmuch as the consequences of hazardous conditions remain uncertain even after the condition exists, these examples clearly demonstrate the limits to our predictive and analytic capabilities.

CHAPTER 2:

HAZARDOUS WASTE IN THE 1970s: THE PAST AS PROLOGUE TO AN UNCERTAIN PRESENT

In biblical Jerusalem, Christians redefined the meaning of hell. Fire and brimstone replaced the cold subterranean darkness of Hades. The Valley of Gehenna, filled with the burning and stench of Jerusalem's wastes, proved a powerful metaphor for this new hell. Garbage heaps, it would seem, are graphic embodiments of undesirable places.

As the urban landscape has evolved over the last two centuries, waste has become even more ubiquitous. Waste repositories, however, have become cleaner. Sanitary landfills and engineered incinerators have replaced the firey pit. For the most part, notorious city dumps are now merely unpopular neighbors (see Wilson, 1977). In their stead a new waste problem has emerged. Not smoldering wastes but chemical waters are now a serious cause of concern.

Love Canal is the most infamous of these chemical landfills. Love Canal has set the image of "hazardous waste" more than any other single place or event. Throughout the country, however, local hazardous waste sites have fueled widespread concern. In Massachusetts alone, the state Department of Environmental Quality has closed 70 public and private wells in 30 communities due to chemical contamination. Thirty-six communities are known to have hazardous waste sites within their boundaries (Boston Globe, 3/20/82:1). The contamination of water, land, and air with chemical wastes stem from lax (and sometimes illegal) procedures widely used for the last 40 years.

Whether the chemical industry can reverse public perception through more appropriate management procedures remains unclear. To date, public perceptions of the risks associated with hazardous waste treatment and disposal have not been quieted by technological improvements. In trying to improve the technology of waste management, the industry can hardly help but create new uncertainties. These uncertainties, when coupled with widespread contamination from older facilities, have led to an impasse. Local communities have become universally opposed to the siting of a hazardous waste treatment facility within their borders. Despite nation-wide support for improved treatment facilities, no major facility has been successfully sited in the past eight.*

This chapter examines hazardous waste controversies caused by treatment practices of the past. These controversies have done much to color the current debate. They also pinpoint uncertainties that will influence virtually all hazardous waste siting disputes in the future. This chapter focuses on the nature of uncertainty and its impact on perceptions of risk.

* Between 1976 and 1984, several facilities for onsite treatment of hazardous waste by the generators of those wastes have been constructed in this time period, but to the best of my knowledge, no commercial facility designed to accept multiple waste streams from many different generators has been constructed.

I. Emerging Problems Due to Improper Disposal Practices

Fourteen years ago, when Earth Day was first celebrated, hazardous waste had few detractors. Until the debates over the 1976 Resource Conservation and Recovery Act (RCRA), the public was most attentive to industrial pollution of the air, water, and ocean. Perceptions changed rapidly with the availability of new information about toxic substances and with several highly publicized tragedies involving hazardous waste. Love Canal is the most famous, but national concern was based less on this one incident than on the widespread discovery of more localized problems. By 1979, EPA had documented approximately 700 "damage incidents" caused by hazardous waste. Many hundreds more were suspected. While remedial action was considered necessary in most of these cases, cleanup had been attempted in only a few (US Senate, 1979a:IV-37).

The extent of damage in these incidents varies considerably. Widespread contamination of all three major Long Island aquifers has affected 54 public wells serving 100,000 residents (US Senate 1979a: IV-32) and could eventually affect the water of the three million Long Island residents who rely on ground water (US Congress, 1982:II-J-5). In another locale, trichloroethane found in the groundwater aquifer of Grey, Maine, affected only 750 families, but to those families forced to use trucked water and to the municipality forced to spend $600,000 to extend the water system to them, the cost remains high.

Damage created by the Rocky Mountain Arsenal, located near Denver, is more typical. Use of unlined holding ponds to store pesticide wastes began in 1943. Contamination of the soil became apparent with repeated crop damage on adjacent farms starting in 1951. The contamination was traced to the holding ponds in 1954. The pesticide wastes had also infiltrated into the shallow water table aquifer. The unlined ponds were used for three more years. The wastes were then transferred to lined ponds, but contamination continued to spread. By 1975, when the Colorado Department of Health issued a cease and desist order, contamination had spread to 30 square miles of aquifer and six and a half square miles of farmland. Sixty-four domestic, stock, and irrigation wells were abandoned. The estimated cost of decontaminating the Arsenal property is 78 million dollars. Full decontamination has not been attempted (US EPA, 1975).

These and scores of similar cases have given rise to a growing local consciousness about the risks of hazardous waste. In Massachusetts, one-third of the state's 351 communities have chemical contaminants in their well water in excess of state and federal health standards. Private and public wells have been closed or restricted in 22 towns, including all municipal wells in two of these towns (US Congress, 1982:II-J-6). Four waste sites have serious enough problems to warrent inclusion on EPA's first list of 115 superfund sites (Epstein, 1982:448-449). A well publicized dispute exists between the W. R. Grace Company and the town of Acton over waste migration from lagoons. The wastes are contaminating a major aquifer supplying 40 percent of the town's drinking water (Epstein, 1982:441). In the industrial city of Lowell, Massachusetts, the waste processing firm of Silresim Chemical declared bankruptcy in 1977. Some 20,000 barrels, many rusted and leaking and containing over a million gallons of toxic waste, were left behind (US EPA, 1980a:21). The runoff from storms carried high concentrations of wastes into both the Lowell sewer system and into a stream that flows into the Merrimack River. The cost of cleanup exceeded 1.5 million dollars (Hanrahan, 1979:22). As Figure 2.1 shows, hazardous waste and related chemical pollution are a state-wide problem in Massachusetts.

Problems associated with past processing and disposal practices have led to widespread concern throughout the United States. While each instance of contamination is unique, residents and abutters share several common concerns: fear of health effects (even in the absence of supportive data); anger over the turmoil (and in some cases economic loss) generated by uncertainty; and frustration at the failure of public institutions to eliminate the hazards. A closer look at one case will illustrate these concerns.

II. Risk and Relief in Love Canal

The Love Canal controversy is a story of uncertainty and competing interests. The story is described in detail here because it is indicative of more local but less well documented disputes across the nation. A close look at the Love Canal controversy reveals a range of uncertainties and competing interests, as well as the inability of institutions to reconcile the resulting disputes. (The major sources for this account include Brown, 1981; Levine, 1981; and Epstein, 1982).

Ironically, Love Canal was born of a grand vision. William Love began excavating a canal in the 1880s as part of a plan to build a

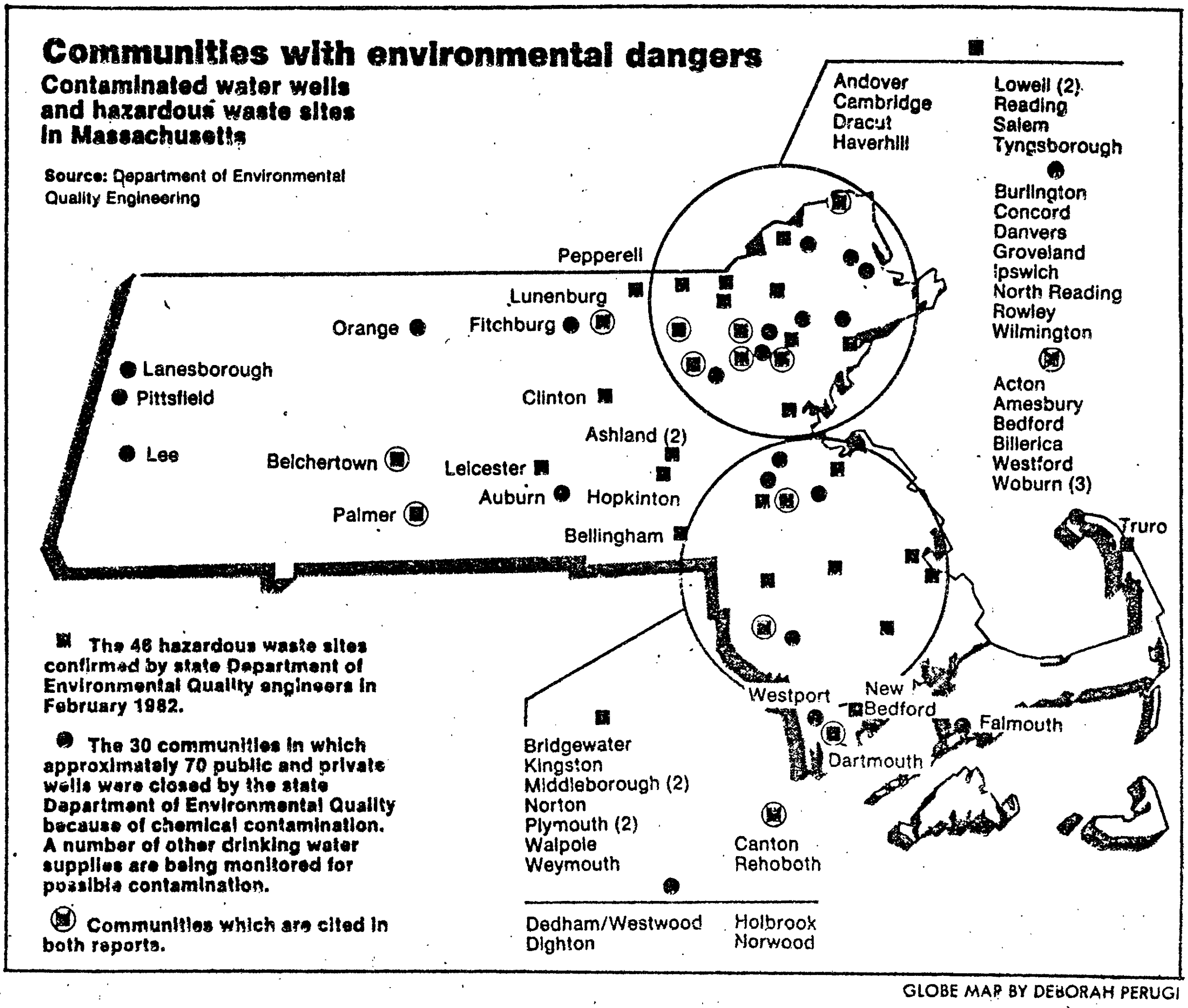


Figure 2.1: Massachusetts communities with hazardous waste sites or chemical contamination of well water. (Source: The Boston Globe, 20 April 1982, p. 20)

model city. The economy of the city was to be based on the plentiful supply of direct current electricity. By connecting the river from above Niagara Falls to the water below via a canal, water power could be distributed along the entire length of the canal. The discovery of alternating current electricity destroyed the raison d'etre for the canal and the new town because, unlike direct current, alternating current could be easily transmitted over distances. Industry no longer needed to be located adjacent to sources of water power. The canal was abandoned until the Hooker Chemical company purchased it for use as a dump site. Between 1947 and 1952, Hooker used the canal to legally disposed of 20,000 metric tons of chemical waste containing 300 different chemicals (US EPA, 1980b:1). They thereafter donated the land to the Niagara Board of Education. The 99th Street Elementary School was built over the chemical landfill in 1954. Housing developments soon followed.

By the mid-sixties the production and migration of leachate from the landfill caused odors and visible problems in the surrounding neighborhood. Huge holes and lagoons filled with brown-black liquid. Children came home with chemical burns. Only dandelions grew where the chemicals were present. In the early seventies, basements nearest the canal began to flood, carrying leachate into homes after each heavy rainfall.

The first state sponsored investigation, conducted in 1977, discovered heavy contamination of both ground and surface water. It was not until May of 1978, however, that a resident named Lois Gibbs petitioned the neighborhood to close the school. At the same time, the New York State Departments of Health and of Environmental

Conservation conducted a series of tests to determine the level of contamination. Fears long held but never openly voiced by local residents were confirmed by the investigation. News announcements, official inquiries and meetings led to feverish discussions among neighbors.

What had once been covered was now open: as a community, residents feared that something "ominous, huge, and destructive might be in store" (Levine, 1981:25). When the state health commissioner ordered the school closed and the evacuation of pregnant women and young children, the streets were filled with the crying and shouting of residents left behind. When dioxin was found on the site, violence erupted.

By the summer of 1978, residents of Love Canal felt a sense of abandonment, isolation, and loss of control (Levine, in NY Times, 16 May 1980). The loss of control stemmed from decisions made long ago in which the residents had not participated. Official disorganization in developing a rescue plan deepened these feelings. The agencies to which residents looked to find solutions were unable to act decisively. Responsibility was divided among Hooker Chemical, which had deeded the land to the school board with specific provisions absolving it of all future liability; the school board, which had in turn deeded the land to the city in 1960 and had neither the expertise nor the resources to generate a solution; and the city, which owned most, but not all of the land, but had never managed the site.

In the end, the state and federal governments bore most of the investigative and cleanup costs. The State Departments of Health, Environmental Conservation, Transportation, Housing, Social Services, Banking, and Insurance, the Office of Disaster Preparedness, and the Division of Equalization and Assessment worked with the federal Environmental Protection Agency and Federal Housing Administration and a host of local agencies to provide disaster relief and develop a management plan for the Canal (Worthley, 1981:152). In the absence of clearly delineated lines of responsibility, many of these efforts were counterproductive.

One hundred families were temporarily relocated during remedial construction. Conditions were cramped, families were separated, meals were unavailable, and people were moved from room to room. Three months later, the homes of these relocated residents were deemed safe enough for habitation. The residents returned to find that the Federal Housing Administration had instituted new regulations effectively forbidding FHA insurance in the area. The reason given: homes were potentially too hazardous for habitation. *Ad hoc* decisionmaking and shifting responsibility continued until the final evacuation of 550 families from a 30 block area in 1980.

Uncertainty in Managing the Process of Relief

With local government and Hooker Chemical either ignoring the situation or denying responsibility, conflict between these parties and Love Canal residents was inevitable. The state's willingness to assume at least some responsibility for the cleanup should have helped, but its relationship with the residents also broke down. As Levine (1981:24) notes:

> The more that officials met with residents, the more negative feelings and relationships developed. When professionals presented raw data, it confused people. When they tried to interpret the data in down-to-earth

> terms, describing risks as some number of deaths in excess of the usual number expected, people interpreted that to imply their deaths and their children's deaths. When they tried to calm people by saying that, despite all the serious possibilities, there was no evidence of serious health effects, the officials were seen as covering up.... What officials thought of as privileged advisory conferences were viewed as conclaves that excluded affected citizens. What officials saw as preliminary studies conducted to assess the situation were viewed by residents as wasting resources on repetitious research projects rather than doing something helpful. When they took action quickly or tried to do everything at once, for everyone, they overloaded facilities, made errors, and were faulted for bungling.

The conflict separated not just resident from outsider, but resident from resident. No one could be held solely responsible for the contamination. Frustration and anger were therefore diffuse; the victims felt themselves to be at the mercy of the state and federal government. Legitimate claims for relief did not translate easily into politically effective demands for action. Residents viewed their plight as personal and economic rather than as communal and political. Groups of victims felt themselves to be in direct competition for money (Moldenhauer, 1982:220-221), and bitter arguments divided the Love Canal Homeowners' Association. Those living nearest the chemicals formed a splinter group to demand that they be the first to go (Brown, 1981:36). Homeowners and renters did not work to meet their common interests.

The psychological stability of the residents and the social fabric of the community deteriorated under the strain. Many remained at home, unable to cope with jobs. Children experienced nightmares of death. Among the 237 families evacuated in 1978, 40 percent of married couples became divorced or separated before 1980 (Holden, 1980:1243). Residents felt like "hostages" (NY Times, 16 May 1980) and "American refugees" who had been "pushed, frustrated, pulled, hauled" and left homeless (Epstein, 1982:107). Finally, when residents were removed from the neighborhood, the community dissolved.

The alienation and emotional turmoil that the residents of Love Canal experienced need not have been so dramatic. Much of it stemmed from the fact that no political institution had both a mandate and the means to act in the interests of the residents. The United States has a well rehearsed disaster relief system that is triggered by natural disasters. These systems are not designed to respond to slowly evolving tragedies.

Particularly for those responsible for the problem -- Hooker Chemical, the school board and the city -- the risks associated with accepting any liability were enormous. By 1981, over 125 million dollars had been expended, mostly by the state and federal governments, to bring the wastes under control and to relocate the families (Worthley, 1981:160). From 1978 to 1979, out of a total city budget of 45 million dollars, seven million was spent on remedial work in the canal area. Claims against the city for personal injury and property damage amounted to three billion (Epstein, 1982:110 & 103). Hooker Chemical has been sued for 15 billion dollars* (US Congress, 1982:II-J-8). In late 1977, a Love Canal study group was formed including representatives of Hooker Chemical, the city, the county and the school board. The group cooperated with the state to develop an

* These costs should be compared to the cost of constructing and sealing a secure hazardous waste facility. According to Douglas Costle, EPA's administrator in 1979, the equivalent of four million dollars in 1979 funds would have covered the cost of closing Love Canal in 1952. (Source: US Senate, 1980:1).

engineering plan for rehabilitating the site. Cooperation broke down in mid-1978 as the question of financial responsibility loomed.

While competing interests of different parties helps explain their actions, an important element of the problem remains. Much of the alienation and emotional turmoil sprang from differences in the perceived risks of Love Canal. Because the risks remained highly uncertain, even after repeated scientific study, perceptions became a central force in the debate.

Love Canal: The Scientific Debate

The more than 20,000 metric tons of chemicals buried at Love Canal (US EPA, 1980:1) created problems from the beginning. When excavation for the 99th Street school uncovered barrels of wastes in 1954, the school was moved and the planned basement was eliminated. When a number of children were burned by chemicals that surfaced in the late 1950s, parents called Hooker's health dispensary for information about treatment. When a child fell into a pit filled with a muddy black liquid and became sick in 1965, residents fought to have the city fill the hole. When basements flooded with the same liquid in the early 1970s, parents sent their kids outside to play. When vegetable gardens, shrubs and lawns refused to grow, residents with green thumbs planted hardier varieties, or gave up.

Throughout this period, many of the children developed chronic health problems, especially asthma, liver damage, hepatitis, hyperactivity, rashes, loss of hair, bronchitis and gastroenteritis. In the first nine houses of a block adjacent to the Canal, five women had miscarriages. Neighboring women had given birth to six children with birth defects, a still born, and two chilren who died in their cribs (Epstein, 1982:100). Most of these parents considered these health problems as a quirk of nature. The burns and property damage clearly caused by the chemicals were seen as unrelated to problems of chronic health deterioration (Brown, 1979:7).

In May of 1978, two residents reshaped local perceptions. As part of a petition drive to close the 99th Street school, Lois Gibbs and Debbie Cerrillo interviewed residents door-to-door. They uncovered a pattern of widespread illness. In 1977, the city of Niagara Falls hired an engineering consulting firm to analyze the disposal site. The firm concluded that massive leakage had occurred from drums located near the surface of the canal, contaminating both groundwater and surface topsoil.

The State Departments of Health and Environmental Conservation had collected samples from Love Canal in 1976. Because funds to finance the necessary tests were not available, testing was delayed more than a year (Wothley, 1981:153). In 1978, the departments initiated more extensive sampling of groundwater, soil and air contamination and began a survey of local health problems for residents living adjacent to the Canal. Contamination was found to be widespread and highly toxic. Miscarriages were four times the normal rate among some populations of women (Epstein, 1982:101). Based on these data, a first ring of homes was evacuated.

The stage for the scientific debate was now set. In the fall of 1978, the Love Canal Homeowners Association designed its own health survey under the direction of Beverly Paigen, a cancer researcher. The Association believed the health problems of Love Canal were more extensive than the state survey showed. Eleven hundred residents were contacted by phone. Participants were not screened nor were medical records collected (US HOR, 1979:60; Paigen, 1981). But from this survey grew a theory of contamination that had not been considered before. By examining the historic topography of the area, residents identified old marshes and streambeds. These "wet" areas highly correlated with the incidences of miscarriages, asthma, birth defects and nervous disorders identified in the survey. Nine of sixteen children born in these areas in the previous five years had birth defects.

The State Department of Health conducted its own limited survey. It also found a higher incidence of problems in wet areas.* In early 1979, the state authorized a limited evacuation of pregnant women and children under the age of two, but did not believe that a general evacuation was warranted. The Home Owners' Association asked to review the state's data, but the request was denied on the grounds of confidentiality.

In the ensuing uproar an independent panel of scientists was established to review the results of both studies. Chaired by David Rall, director of the National Institute of Environmental Health Sciences, the panel concluded that both studies demonstrated the existence of health problems adjacent to the canal and in wet areas, but that disagreements over interpretation of the data were inevitable. Rall observed (Epstein, 1982:105):

* The study documented adverse effects in liver function, low birth weights, spontaneous abortions, and possibly congenital defects (N.Y. Department of Health, 1981).

> We don't have the appropriate tools or even the appropriate background with scientific knowledge to evaluate these problems. Scientists probably don't even know what the short term effect of half to a third of each of the chemicals found in the canal have on laboratory animals. Without this basic knowledge, assessing the immediate effect on people is almost impossible. We have even less understanding of what each of the chemicals may do over a long period of time (or) the effect of combinations of chemicals.

By the summer of 1979, the city began its remedial efforts designed principally to reduce further leakage (not to remove wastes). Removal was prohibitively expensive and no host site was willing to receive the wastes. The process of reconstruction created additional problems. Trucks working on the site contaminated new areas with material on their tires. The work stirred up dust and odors. New holes opened as the ground subsided. Residents feared that the chemicals might explode.

In January of 1980, the EPA contracted with Biogenics Corporation to conduct a pilot study of chromosome abnormalities in 36 Love Canal residents. The study was designed to determine whether chromosome damage could be detected. Residents with the greatest likelihood of suffering such damage were selected as subjects. With limited funding, the study relied on published data to establish background levels of abnormalities in healthy populations. No control group was established (Picciano, 1980a). If abnormalities were detected, EPA planned to conduct additional studies to establish a causal link between injuries and the chemicals, and to more systematically survey residents throughout the Love Canal area. The data would then be used by the U.S. Department of Justice in a suit against Hooker Chemical, the city of Niagara Falls, the Board of Education and the county Health Department.

Biogenics concluded that 11 of the 36 residents had major chromosomal abnormalities and that this rate was well above normal. In the absence of a control group, Biogenics stressed the need for cautious interpretation of the results. When the report was leaked to the New York Times, the EPA held an impromptu Saturday press conference to head off confusion. In the news stories that resulted, the limitations of the study were quickly lost amid the more spectacular news of chromosomal damage. By the following Wednesday, after a violent confrontation between two EPA experts and Love Canal residents, EPA announced that the approximately 550 families remaining would be evacuated.

The chromosome study was heavily criticized in scientific circles (Kolata, 1980). It also received some support (Picciano, 1980b). The scientific community did agree on one point: the study was certainly insufficient for assessing the general health dangers to Love Canal residents. In addition to the sampling limitations of the study, chromosomal damage has not been causally associated with genetic damage. The author of the study, however, pointed out the potential seriousness of health effects (Picciano, 1980b:754). Of the last 18 pregnancies among the residents included in the study, two births were normal, nine chilren had birth defects, four spontaneously aborted and three were stillborn.

In response to the scientific controversy, New York Governor Hugh Carey organized a second scientific panel to review the available health data. In a series of stinging criticisms, the panel concluded that the Department of Health studies lacked proper control groups, that the Paigen studies were impossible to interpret, and that the

Picciano chromosome study was so poorly designed that it should not have been launched in the first place. The report emphasized how little evidence had actually been accumulated to document health damage, and suggested that the studies had done more to fuel public anxiety than to resolve scientific questions (Thomas, 1980). To prevent further scientific controversy, the panel recommended that (1) only government-sponsored surveys be conducted in the future; and (2) an advisory panel of distinguished experts be established to review the results of such studies but not make public its disagreements (Levine, 1981:168). Thus would the public be protected from its own anxiety! As Judge Bazelon (1979) has noted:

> In reaction to the public's often emotional response to risk, scientists are tempted to disguise controversial value decisions in the cloak of scientific objectivity, obscuring those decisions from political accountability.

The technical debate over health effects will probably never be settled. The objectivity of the panel report has also come under serious question. Some biostatisticians and public health specialists independently checking the studies reviewed by the panel have claimed that the evidence of serious health damage is strong (Epstein,1982: 117). Canal residents have refused to cooperate with further attempts to study their health.

The controversy underscores the difficulty of using science to resolve politically volatile problems. The controversy over health effects at Love Canal was caused not just by the political turmoil and fears of residents, but also by inherent scientific limitations. The scientific method is ill equipped to produce unequivocal answers to questions regarding the likelihood of health effects from hazardous waste.

III. Uncertainty in Evaluating Toxic Chemicals and their Consequences

Evaluations of Love Canal health and environmental problems vary considerably. To some, Love Canal is one of the worst public health tragedies in recent years -- in all likelihood accounting for numerous miscarriages, birth defects, and probably the death of at least one child (Epstein, 1982:89-91). To others, Love Canal is an example of mass hysteria in which no physical health effects were ever proven, and the psychological trauma was caused by fumbling bureaucrats, overzealous scientists, anxious residents, and the mass media (Levine, 1981:169). It is not at all surprising that Lois Gibbs holds the first opinion while Armand Hammer holds the second: Ms. Gibbs headed the Love Canal Home Owners' Association and Mr. Hammer is chairman of the board of Hooker's parent company, Occidental Petroleum.*

Differences in the perception of risk are not always so easily associated with differences in self-interest. Disagreements exist among similarly trained experts with no stake in the dispute. Any system of ranking potential hazards is sure to be fraught with ambiguity given the gap in knowledge that exists. The hazardousness of many substances is neither qualitatively nor quantitatively well understood. Regulatory standards for substances with obvious physical properties (e.g., reactivity, corrosivity, or ignitability) or acute toxicity can sometimes be easily delineated, but questions of chronic toxicity, changes in a chemical's health impact at various concentrations, its potential for degrading into toxic products, its

* In late 1979, Dr. Hammer told a national audience on Meet the Press that the danger of Love Canal was minimal and "has been blown all out of context." (Source: Epstein, 1982:132.)

persistence in nature, and its potential for bioaccumulation are considerably more controversial (Senkan and Stauffer, 1981:40).

The siting of hazardous waste dumps pose particularly complex problems. Although general agreement exists among most scientists that hazardous waste disposal poses great risks, the manner in which the risk of exposure and the potential health effects are to be determined is the subject of considerable debate (US Congress, 1982:I-28). To effectively determine potential health risks would require data on waste constituents, environmental transport pathways, exposure and absorption pathways, and toxicity. Collection of these data are problematic.

Waste Constituents

The easiest task is usually identification of constituent chemicals (US Surgeon, 1980:45-50). At Love Canal, chemicals migrated into basements and topsoil, where they were easily collected for analysis. Leachate, however, is not a reliable sample of the stored chemicals. To sample these chemicals is difficult. Chemicals are typically stored in containers and dispersed among innocuous material. Except in the very worst cases, in which significant leaching has occurred across all sectors of a site, many chemicals may remain hidden from all but the most systematic field sampling.

Identification of most organic substances, if available in sufficient concentrations, is possible using mass spectrometry. The results of this test can be compared to data published for most industrial chemicals. Since many industrial wastes are by-products of organic synthesis, the spectral characteristics will not have been published. These by-products can be identified only through their similarity to industrially useful chemicals.

Existing methods for sampling and identifying wastes have not been standardized or validated. Most were developed for analyzing specific chemicals in a particular medium, and consequently are expensive and time consuming to apply to heterogeneous waste mixtures (US GAO, 1981a:17). Further difficulties exist in preserving samples at onsite concentration levels, preparing samples for analysis, and identifying interference effects when the presence of some compounds are hidden by the effects of others. These limitations can be overcome, but the costs are substantial (US GAO, 1981a:20).

Detecting certain substances in highly dilute leachate poses still other problems. The EPA currently lists 387 compounds as hazardous. The US Office of Technology Assessment (1982:251) has concluded that current capabilities for detecting a majority of these compounds is questionable, either because appropriate analytical protocols are not available for waste constituent analysis or because analysis is limited by the concentrations of constituents in waste.

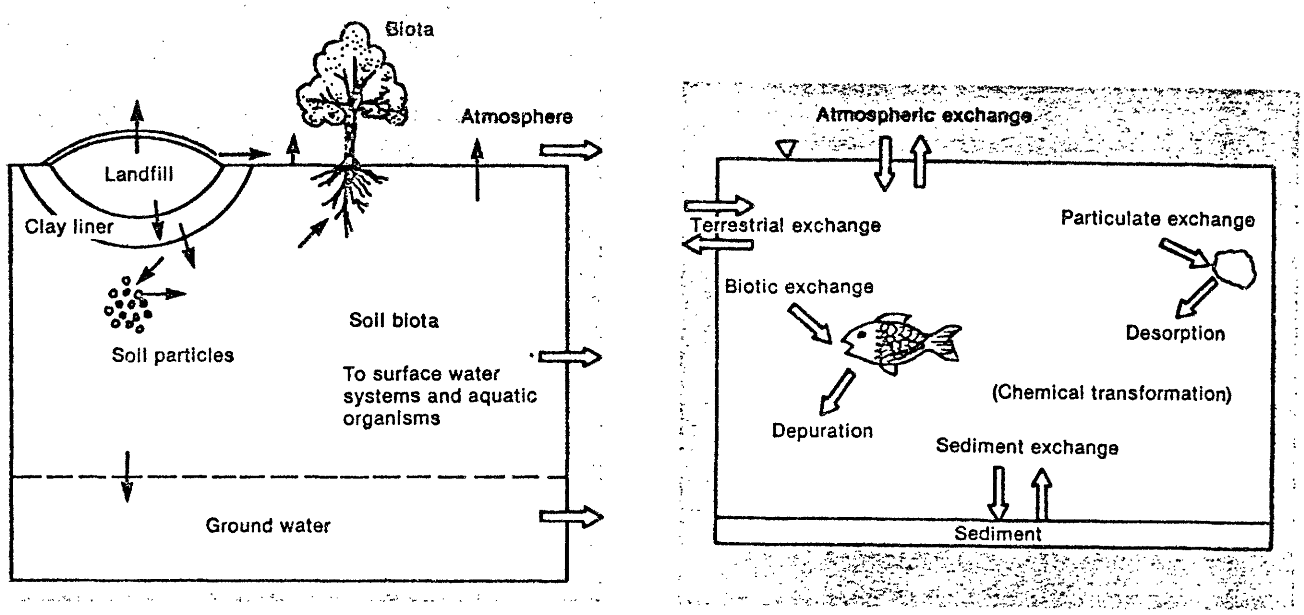
Finally, detection of pollutants in water or soil may not be indicative of problems stemming from a hazardous waste site. Not all contamination stems from hazardous waste. Many household products, pesticides, fertilizers, and industrial solvents find their way into the environment (US CEQ, 1980:83-100). These contaminants can mask the chemical sources as well as distort their apparent concentrations by creating anomalies in the levels of background contamination.

Environmental Transport Pathways

The fate of any released hazardous waste depends on its affinity for particular elements of the environment. Chemicals disperse along four major pathways: water soluble chemicals are transported by runoff to groundwater and streams; volatile chemicals evaporate and are swept away by the wind; most chemicals can adhere to or be absorbed by dust and soil; and chemicals that bind to organic material move through the food chain. Chemicals rarely are found in only one medium, but shift through one to another over time, as shown in Figures 2.2a to 2.2b. The fate of waste constituents is difficult to predict because of the complexity of physical, chemical, and biological properties that determine pathways in the environment.

For most dump sites, the critical dispersion medium is water. An EPA study (1977:11-12) showed that 60 percent of all documented hazardous waste damage cases involve groundwater contamination, with over half of these causing contamination in water supply wells. Forty percent cause surface water pollution. Groundwater, once polluted, remains contaminated for decades. Since over half of all United States drinking water is from ground water and 40 million people depend on untreated domestic well water (Maugh, 1982a:491), the potential for problems is extensive.

The determination of pollutant pathways in underground water is frequently difficult to either predict or detect. How wastes move through soils to groundwater, how groundwater moves, and what happens to both along the way are not well understood (US GAO, 1981a:23). Because of the uniqueness of each site, consensus does not exist on drilling methods, sampling frequency or protocol, standard quality



SOURCE: Modified from G. F. Lee and R. A. Jones - A risk assessment approach for evaluating the environmental significance of chemical contaminants in solid wastes, "Environmental Risk Analysis for Chemicals," R. A. Conway (ed.), 1981.

SOURCE: Modified from G. F. Lee and R. A. Jones - A risk assessment approach for evaluating the environmental significance of chemical contaminants in solid wastes, "Environmental Risk Analysis for Chemicals," R. A. Conway (ed.), 1981.

Figure 2.2: Potential transport and points of transformation (a) for land contaminants and (b) in aquatic systems. (Source: U.S. Office of Technology Assessment, 1983)

assurance procedures, or the number and location of wells needed to define problems (US Congress, 1982:I-29). Costs for estimating groundwater contamination of a disposal site typically range from $50,000 to $250,000. Plume shapes, rates of movements, and concentrations over time cannot always be predicted accurately, even with extensive study (Maugh, 1982a:491).

In about 12 percent of the documented damage cases, poisoning occurs through direct contact with chemicals (US EPA, 1977:11-12). At Love Canal, children came into direct contact with leaching chemicals that had migrated into basements and top soil. These pathways are easily identified when the point of contact is adjacent to the source of contamination and the concentrations are high. When chemicals are widely dispersed by air, water, or biotic transport mechanisms, however, the source cannot always be traced. Identifying toxic substances in small concentrations and isolating the effects of contamination from a particular disposal site from other sources of environmental pollutants is difficult. In industrialized areas, the problems may be insurmountable. At Love Canal, despite extensive contamination from the landfill, early identification of hazardous substances found in well water could not be reliably tied to the waste site bacause of inadequate information about pollutant pathways (US GAO, 1981a:23).

Exposure and Absorption Pathways

Health effects of chemical exposure depend not just on the nature of the chemical, but also on the quantity and duration of exposure. Chemicals acting in large doses over short periods of time produce acute effects; small doses administered over long periods of time produce chronic or latent effects. Since contamination from hazardous waste dumps generally produces exposures at low concentration that may go undetected for years, a major difficulty exists in estimating the actual exposure and absorption pattern for individuals living in a contaminated area.

The most reliable ex post facto tool for monitoring exposure to chemicals is direct measurement of chemical content in the body. Direct measurements, however, have serious shortcomings. Water soluble chemicals, easily detected in blood or urine, are quickly washed from the body. No trace may be found on the day of examination despite continuous exposure. Chemicals that bind to fat, bone, or tissue accumulate within the body. Most require minor surgery to obtain samples for examination. Milk is an easily accessible body fat, but milk can be obtained from only a small subgroup of women within a narrow age range. These women may not be representative of the population and milk can easily be contaminated during collection of samples. Moreover, studies conducted on milk, adipose tissue, urine, and blood indicate that almost everyone carries significant quantities of DDT, DDE, PCBs, dieldrin, heptachlor epoxide, and other chemicals (Maugh, 1982a:492-493). Estimating exposure caused by a particular hazardous waste site therefore would require extensive baseline studies with controls.

An alternative to direct measurement of a body's chemical content is to study chromosome abnormalities. Damage to chromosomes can be caused by toxic chemicals, but their detection is difficult. The number to be expected from even high doses of chemical contamination will be less than one in 300 cells, so extremely large numbers of cells are needed to observe a statistically significant increase. Since people are exposed to many agents that can cause chromosome damage -- such as x-rays, caffeine, viruses, and other environmental pollutants -- a proper control group is essential. Moreover, the presence of such aberrations does not necessarily indicate a potential health problem, the absence of visible aberrations does not indicate the absence of nonvisible mutations, and an individual whose sample showed an aberration on one occasion might have none later (Maugh, 1982b:643).

Analysis may also be misleading. Analysis requires strict quality control to insure the integrity of the samples. Heat, light, dissolved oxygen, water, biological activity, and the container itself can all cause chemical alterations (NAS, 1975b:304). The Center for Disease Control has shown that quality control is often poor. Samples of lead nitrate tainted blood are consistently evaluated correctly (that is, measurements within 15 percent of actual value are obtained on more than 70 percent of the samples) by only 35 percent of labs. When PCB tainted blood was sent to labs for testing, only 10 percent produced values within two standard deviations of the correct value. Since lead and PCB contamination has been widely studied and should be readily measurable, analysis on less well known substances may be much worse (Maugh, 1982a:492).

Toxicity Assessment.

The causal link between environmental pollutants and health problems is very difficult to establish. The usual methods of toxicology, clinical examination, and epidemiology are difficult to apply to hazardous waste sites. In toxicological assessment, dose-response curves are traditionally used to relate an organism's reaction to various concentrations of pollutants. Ideally, dose-response curves are predictive and can be translated into technical standards. Unfortunately, the problems of determining dose-response relationships for a widely diverse population are enormous. The National Research Council's Board on Toxicology and Environmental Health Hazards has noted difficulties in deciding which pollutants to measure, how to ensure that they are adequately measured, what corrections to make for widely differing exposure patterns and sensitivities, and how to relate measured pollution to health effects.

The cause-effect relationship between toxic substance in the environment and human health is highly uncertain. Long term tests of chemical toxicity are usually conducted on specially bred animals. Rodents are almost always selected, not on any biochemical, physiological or anatomical basis, but rather because rodents are relatively inexpensive and short lived. Even so, long term bioassays now cost a half million dollars per compound (US EPA, 1980c). Extrapolations of results to humans must be done cautiously: rodents generally give reliable identification of carcinogenic and other toxic effects, but tumors in other species are not necessarily found in the same tissues (NAS, 1975b:135) and dose response may vary significantly. Humans, for examples, are 60 times as sensitive to the effects of thalidomide (a tranquilizer that caused birth defects) as are mice, 100 times as sensitive as rats and 700 times as sensitive as hamsters (US EPA, 1980c). Investigators are further restrained by their limited success in replicating models of human disease in animals so as to examine the response of more vulnerable elements of the population (National Research Council, 1978; Trieff, 1980).

Because of the very large number of animals needed to test the relatively rare effects associated with very low doses of chemicals, risk values at low doses are not generated directly from data. Rather, they are extrapolated from the dose response relationships found in higher doses. A combination of biological theories, some experimental evidence and statistical conventions have yielded several extrapolation models. As Figure 2.3 shows, the choice of model can

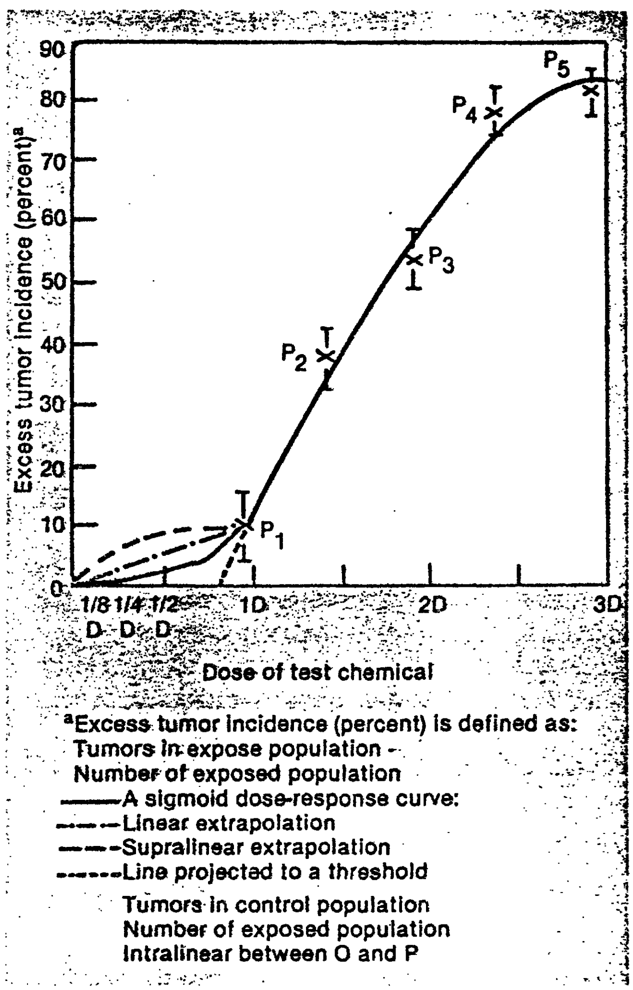


Figure 2.3: Stylized dose-response curve with extrapolation to low doses using different models. (Source: US Office of Technology Assessment, 1983:224)

make enormous differences in estimates of low dose toxicity. At one-half a standard dose ("1/2 D" in the figure), predicted excess tumors range from zero to ten percent. In a population similar to Love Canal's 4,000 residents, estimates of the number of people who might get tumors might range from zero to four hundred. Under these circumstances, overall assessment of risk based on available experimental animal investigations is subject to widely varied interpretations (Lee and Mudd, 1979; President's Science Advisory Committee, 1973; NAS, 1975b).

The continual production of new chemical substances makes the careful testing of our chemical environment even more difficult. The number of chemical compounds recognized in the United States exceeds three million and approximately 3,000 new ones are being added per year. Present chronic assay methods require at least three years at substantial cost to test one chemical (Task Force, 1978:4).

The most prominent strategies for overcoming these difficulties rely on short term tests. Cell transformation _in vitro_ can provide preliminary evidence of the need for further testing _in vivo_, but they cannot, in and of themselves, indicate potential carcinogenesis (NAS, 1975b:144-147). Furthermore, the tests measure only one type of biological effect (i.e., damage to genetic material) and are not sensitive enough to show the effects from very low levels of waste (US GAO, 1981a:26).

Moreover, the measurement of effects in the laboratory only approximates the effects in the environment. The complex combinations of chemicals found in most hazardous wastes are even more difficult to evaluate. Experience in testing and predicting health effects of these mixtures is limited. Yet the potentiation of toxic effects of one chemical by another, the enhancement of latent neoplastic change, and even the elimination of carcinogenic properties have all been demonstrated with chemicals found in the Love Canal waste site (US Surgeon, 1980:39).

Clinical examinations are conducted to diagnose individual diseases. While some acute effects such as burns and allergic reactions might be directly traceable to exposure, many chronic and latent effects are not so directly correlated. Exposure to chemicals may produce effects which are sub-clinical or similar to commonly experienced ailments such as headaches, fatigue, irritability, and depression. Respiratory discomforts, miscarriages, and birth defects are likely to be a cumulative response to long term exposure.

Moreover, since clinical exams require considerable labor by trained professionals, such exams are very difficult to conduct on large populations. When the state Department of Health expanded its Love Canal study in late 1978, it sent a medical team to take blood samples from families. The makeshift clinic was overwhelmed with hundreds of residents. The technicians gave up, telling the people to go home and fill out a health questionnaire (Epstein, 1982:102). The chromosomal damage study discussed above relied on clinical exams of blood samples, but limited its attention to 36 residents and used no control population.

Epidemiological studies are more useful for correlating disease patterns with exposure to hazardous substances when many individuals have been exposed. The studies examine the health and exposure histories of a particular population group. A control group is used to determine general environmental and social influences on health problems. In Love Canal, all studies, excluding the chromosomal damage study, were epidemiological.

Well designed epidemiological studies are expensive, time-consuming, and complex. Most past studies have been conducted on specific pollutants. In these studies, special problems exist in obtaining good historical health and exposure data, obtaining a representative control population, controlling for other influences, and collecting and analyzing data from large numbers of people (US GAO, 1981a:25). These problems are compounded in hazardous waste cases because the mixture of chemicals is unknown, the effects are spread over years of exposure, and many changes are difficult to detect.

Since most toxic waste dump exposures involve small populations, the efficiency of methods for establishing potential health hazards are also of considerable importance. Reproductive dysfunctions, such as sterility, spontaneous abortion and low birth weight, are considered to be the most sensitive indicators of health effects due to chemical exposure. Sterility and abortion are not easily studied because, despite their high incidence, a large number of cases are never brought to the attention of the medical profession. Birth weights, however, are routinely recorded on hospital records. Low birth weight babies are, therefore, generally the most convincing indicators of reproductive dysfunction. Low birth weight, defined as less than 2500 grams, occurs in approximately seven percent of all live births in the United States. Depending on age, race, previous pregnancy history, weight at conception, alcohol consumption, and smoking habits, the background incidence of low birthweight can range from five percent to fifteen percent. Assuming that these variable characteristics could be accounted for with appropriate analysis, it would still take at least 200 births to detect as statistically significant a 50 percent increase in the proportion of low weight birth babies. Even if a clearly comparable group were available for determining the average birth weight for a particular area, 100 births would be needed to detect as significantly different a three percent shift in average birth weight (US Surgeon, 1980:30). These large samples frequently cannot be obtained among the limited populations exposed to hazardous waste contaminants.

The difficulty of showing significant increases in disease generation is nowhere more pointedly demonstrated than in studies of Hiroshima and Nagasaki. In these cities, no significant increase in birth defects and miscarriages were detected. Given the high doses of ionizing radiation, which is known to cause both defects and miscarriages, the effect was undoubtedly present. However, 11 percent of all children have genetic defects and an estimated 50 percent of pregnancies end in spontaneous abortions. Given these high normal incidences and the small populations available for study, significant increases could not be shown (Kolata, 1980:1240).

Many of the diseases associated with hazardous waste are common. Moreover, survey instruments which are resistant to the emotional issues of hazardous waste are difficult to design. Clinical endpoints are not specific enough for any chronic ailments like headaches and depression. The use of physician records and other verifiable data may be the best that can be done, but such data clearly varies among individuals. Moreover, even if a change is detected in a population, it will be almost impossible to isolate out individuals actually affected by chemical exposure from individuals not directly affected.

The difficulties with toxicology, clinical diagnosis, and epidemiology as methods of establishing causality are even more apparent when a disease like cancer is considered. The relatively high background incidence, long latency, nonspecificity of cancer type to chemical source, and mobility of the population make causal linkages difficult to establish in the best of circumstances.

The public health debate that grew up around Love Canal underscores these problems. Love Canal had one of the most direct exposure pathways of any dump discovered to date. The chemicals had migrated into the basements of homes. The dump had been around since the 1940s and the school that breached the clay barrier since the 1950s. EPA identified over 200 chemicals, many of them with known acute and latent effects. Yet the toxicological information on most chemicals was deficient or missing. Of 241 chemicals actually identified, one-third had been tested for mutagenicity and slightly less than that for carcinogenicity. In each case, approximately half of the tested chemicals had shown positive results in at least one published study (US Surgeon, 1980:95-132). Many of the chemicals had never been tested because they were not commercial products but rather their precursors or process intermediates. None had been tested in combination with other chemicals (US Surgeon, 1980:19-20).

The epidemiological studies were similarly inconclusive. No other hazardous waste site has been studied as much as Love Canal.

The cost for EPA's and the Center for Disease Control's study was five million dollars, but science remains unable to link the health effects experienced by Love Canal residents conclusively to the chemicals found at the site (US GAO, 1981a:26-27). A close examination of the health effects could not unambiguously answer the most important questions: who was actually affected and to what degree, and hence who should be compensated and who should not. Neither the overriding issues setting the locus of responsibility for analysis and action, nor the detailed issues of designing protocols for defining the area of impact, method of analysis, apportionment of costs, and criteria for relief have since been resolved.

IV. Implications of the Uncertainties of Love Canal

This chapter has examined the risks associated with past hazardous waste disposal practices and the uncertainties involved in analyzing these risks. The Love Canal case and others like it bring four principles into sharp relief: hazardous waste disputes are marked by divergent perceptions of risk; differences in perceived risk place considerable strain on the policymaking process; differences in perception spring from underlying uncertainties in the scientific understanding of the health effects of hazardous waste; and these uncertainties are further exacerbated by ambiguities in the assignment of organizational responsibility for disaster relief.

Hazardous waste disputes are marked by divergent perceptions of risk. Risk springs from the randomness of future events. New information is almost always useful in reassessing risks. Our estimates of risk shift as we act, gain new insights, and learn from our mistakes. But when our strategies yield no results and our theories are implausible explainers of crisis situations, then we can no longer account for nor control the risks we will face. We are lost, as Don Schon (1971:12-14) notes, with more information than we can handle. Sorting through the array of social, technological, and theoretical signals becomes difficult. Many claims are plausible because no claim is dominant. This uncertainty is often irresolvable.

Differences in perceived risk place considerable strain on the policymaking process. In Love Canal, these differences led to behaviors that are inconsistent with effective policymaking. Denial of the uncertainty led to sharply delineated perspectives. This denial took on many forms. Hooker Chemical, the School Board, and the City of Niagara systematically denied the significance of the risks long after early relief actions showed substantial problems. The Governor's review panel set up to study the problems of Love Canal recommended that uncertainty by kept from the public and out of the decision making process by using experts to provide the best available estimate of risk which would then be used as if it were certain. In a similar vein, inadequate theories were claimed by both the Love Canal Home Owners' Association and the State Department of Health as most appropriate in light of no clearly adequate alternative. This cycle of denial and claiming exacerbated the strains resulting from divergent perception of risk. Action became impossible for virtually everyone.

Differences in perception spring from underlying uncertainties in the scientific understanding of the health effects of hazardous waste. Risk management under uncertainty hangs on questions which can be asked but not strictly answered by science. These questions "transcend" the scientific method because their answers require impractically expensive research, their subject matter is too variable to allow strictly scientific rationalism, or their implications are essentially incomplete unless coupled to moral and aesthetic judgments (Weinberg, 1972a:213).

The environmental health risks of hazardous waste have all of these characteristics. The subtlety of public health changes that can be detected and attributed to hazardous waste contamination depends on the amount of resources expended. Small changes can be detected only if large resources are expended. But, as we have seen, variability is introduced into the assessment of the effects of hazardous waste at every stage of the analysis: identifying waste constituents, environmental transport pathways, exposure and absorption pathways, and toxicity assessments. This variability cannot be adequately controlled, especially within the time and resource constraints imposed by a crisis.

Ultimately, the interpretation of data must be a choice about what type of error is most important to avoid. Scientific norms guard against the acceptance of a false conclusion because such conclusions mislead future research. In the context of a hazardous waste controversy, application of the norm would tend to support conclusions that the community continues to be safe. Only in rare circumstances would a scientist be able to determine with near certainty that a community was significantly at greater risk. To residents of the community, however, the most important error is the failure to recognize a health problem before it becomes serious. Avoidance of this error (the failure to recognize as true something which is actually true) is in direct opposition to the scientific norm. The first errs on the side of protecting public health and safety even if relief is given to some communities unnecessarily; the latter errs on the side of protecting the substantial resources that would be needed to correct a problem that might not be serious. Risk assessments which are precise enough to overcome divergent perceptions of risk are therefore not currently possible. The scientific debate in Love Canal did not lead to consensus, but rather to greater dispute.

These uncertainties are further exacerbated by the ambiguities in the assignment of organizational responsibility for disaster relief. In the absence of clear responsibility at Love Canal, all decisions became risky. The resources needed to carry out decisions were substantial. Any decision made by a public official or private manager was open to criticism by people with greater authority as inappropriate or unnecessary. Small actions became complicated because they might serve as a precedent for the resolution of bigger problems. In the resulting disarray, decisions were *ad hoc*, slow in being made, and difficult to justify.

The uncertainties and ambiguities that exist in past hazardous waste disputes are a basis upon which people evaluate proposals for siting new hazardous waste treatment facilities in a community. As several of the participants in the simulation study remarked:

> My biggest concern is the uncertainty. We've all become better educated and made more aware of the problems of hazardous waste. Love Canal made all the headlines not for just a short period of time but over quite a while. It's imbedded in our minds: hazardous waste has many problems, it can cause birth defects and other problems,

> its long lasting, and nobody can make the problem go away once the land is contaminated. What's worse, what we've learned from Love Canal may only be the beginning of it. A lot of everyday items have been found to be carcinogenic. Certainly hazardous waste must be. The unkown risks may well be worse than those we know.

The next chapter focuses on how perceptions of risk and concern for uncertainty are translated into opposition to the siting of new hazardous waste treatment facilities.

Chapter 3

Opposition to the Siting of Hazardous Waste Treatment Facilities

In the wake of growing public concern about the impacts of hazardous waste, the federal government enacted two major pieces of legislation. To prevent deterioration of active treatment and disposal sites, Congress authorized the Environmental Protection Agency (EPA) to regulate hazardous waste under the Resource Conservation and Recovery Act of 1976. In 1980, Congress also enacted the Comprehensive Environmental Response, Compensation and Liability Act of 1980. This "superfund" bill provides funding and assigns responsibility for the cleanup of improperly designed hazardous waste disposal sites. If sites can not be upgraded, wastes must be removed (for treatment or disposal) to alternative sites.

The design and siting of improved facilities for treating and disposing of hazardous waste is integral to any cleanup strategy. Neither cleanup nor effective regulation is feasible until facilities exist for safely handling waste. Proposed new facilities, however, have met strong opposition whenever sites have been selected. As a consequence, virtually no new chemical waste facilities have been built since the mid-1970s.

This chapter examines the dynamics of opposition to the siting of new hazardous waste facilities. New processes for managing hazardous wastes are far superior to those available in older facilities. Local residents, however, believe that new facilities are not "safe enough" to be located in their communities. Moreover, competition from loosely regulated and relatively inexpensive existing facilities has restricted the apparent cost-effectiveness of risk management features incorporated into new facilities. The twin forces of local opposition to the risks of new facilities and corporate concern about cost-effectiveness have created a stalemate in which no new facilities can be sited. Yet, unless new facilities are built, the capacity to cleanup existing dumps or treat newly produced waste will not exist.

This chapter examines the social impact and causes of this stalemate. Are hazardous waste treatment facilities needed? Will these facilities improve the managment of hazardous waste? Why is opposition to their siting so vociferous? The chapter argues that despite the regional benefits that accrue from siting these facilities, communities will continue to oppose local sitings because the impacts of a facility on a host community are undesirable. In particular, divergent perceptions of risk catalyze and intensify this opposition.

I. Existing Practices for Managing Hazardous Waste

Methods of Disposal and Treatment

The last chapter focused on the potential dangers of improperly disposed hazardous waste. Improper disposal, unfortunately, is far from unique to the cases sited. EPA studies of 17 major industries indicate that 90 percent of the wastes generated in the late 1970s were being disposed of by environmentally unsound methods and failed to meet the RCRA standards proposed in 1979 (EPA, 1980a:21).* Most disposal sites used unlined surface impoundments or landfills that would not prevent migration of chemicals. EPA estimated that in the late 1970s, 173,000 surface impoundments (pits, ponds and lagoons) and 94,000 landfills were used for the disposal of hazardous waste (USGAO, 1980:3).

Estimates prepared by the EPA regional offices suggest that between 30,000 and 50,000 sites contain potentially dangerous amounts of hazardous waste (US Surgeon, 1980:22-23, citing Hart, 1978:66-74). Eighty percent of all hazardous waste is disposed of at small sites located on the generator's property (US Senate, 1980:1). More than 75 percent of all landfill sites are located in wetlands, flood plains or over major aquifers. A 1977 EPA study of 50 industrial waste landfills indicated that in 47 of these sites, hazardous substances had migrated beyond the boundaries of the disposal area (US Senate,

* The breakdown is as follows: the 10% sound disposal consisted of 6% controlled incineration, 2% secure landfills and 2% recovery; the 90% unsound disposal consisted of 48% unlined surface impoundments, 30% land disposal, 10% uncontrolled incineration and 2% other (EPA, 1980a:21).

1979a:IV:33-34). All told, between 1,200 and 2,000 sites may cause serious danger to health (Hart, 1978: 66-74).* Of the 115 sites selected in 1981 as high priority for superfund consideration, EPA identified 24 as being potentially worse than Love Canal (Epstein, 1982:448-449). EPA has further estimated that 1.2 million Americans are currently exposed to health hazards from hazardous waste disposal sites (Lennett, 1980:7).

The quantity of hazardous waste disposed of in these sites is subject to wide speculation. A Congressional survey of the 53 largest chemical manufacturers showed that between 1950 and 1979, 765 million tons of processed chemicals were deposited in 3,383 sites (US Surgeon, 1980:19). Because of inadequate records, a more systematic analysis of past waste disposal practices has not been attempted.

The cost of remedial action for these sites is enormous. Emergency containment of waste is expected to cost $3.6 million a site, while permanent remedies will average $25.9 million. These second level remedies must provide for excavation of wastes and contaminated soils and for proper disposal offsite at a safe facility. If 1,200 to 2,000 problem sites require remedial action, the total cost for first level treatment would be 3.6 to 6.1 billion dollars, while second level treatment would cost 26.2 to 44.1 billion. These estimates do not include compensation for property damage, direct or consequential economic loss, or personal injury (US Senate, 1979a:IV:

* These figures (like much of what is known about the hazardous waste problem) are subject to dispute. In reporting estimates, some EPA regional offices reported that all landfills may contain hazardous waste, while others omitted sites that could pose serious risk. Only 232 sites were actually inspected. Estimates of potential problems were extrapolated from these numbers (US Congress, 1982: I:22).

37-38, citing Hart, 1978). Second level treatment is, of course, only possible if safe offsite facilities exist to receive the wastes.

The Generation of Hazardous Wastes

Despite some efforts to reduce hazardous waste generation through new production processes and recycling, the volume of waste increases yearly. Quantities of hazardous waste generation are difficult to estimate, both locally and in total. Neither community nor industry-wide inventories exist for several reasons. Industries generally regard production and waste stream information as proprietary. Commercial establishments and domestic households are numerous and frequently do not know the hazardousness of their waste streams. Hazardous waste is itself not clearly defined.

Estimates of annual volumes can consequently differ by a factor of ten within a single industry (see Murray, et al., 1981:36-41). EPA estimates hazardous waste production at 35 to 60 million metric tons (10 to 17 percent of all chemical wastes produced by the 17 industries studied by EPA). Net increases in production and reclassifications of wastes as hazardous results in a 5 to 10 percent yearly growth rate. These numbers only include wastes specifically regulated by EPA. The Association of State and Territorial Solid Waste Management Officials, in a survey of state data based on state definitions of hazardous waste, estimated the rate of hazardous waste generation to be 265 million metric tons per year (US OTA, 1983:120).

Hazardous waste cannot be isolated from air and water pollution. With the enactment of the clean air and water acts, pollutants cleaned from air and water emissions were disposed of as hazardous waste.

Consequently, hazardous waste volumes increased rapidly in the 1970s.

The chemical and petroleum industries currently account for 62 percent of the chemical wastes produced. The primary metals electroplating industry accounts for an additional 10 percent. Hazardous wastes generated in the production of paper, coal products, fabricated metals, electronics and transportation each exceeds a million metric tons per year, while rubber, leather, agriculture, and railroad transportation industries exceed a half million metric tons each (Booz-Allen, 1980:III-2). Other sources of hazardous waste can include, in addition to these industries, battery shops, car washes, chemical and paint storage warehouses, city equipment yards, research and hospital laboratories, construction companies, dry cleaners, electric utilities, electronic and radio repair shops, almost any industrial plant, pest control agencies, photographic processing facilities, newspapers, and service stations (Tchobanoglous, et al., 1977:384).

EPA estimates the number of hazardous waste producers to be 760,000. Of these, 67,000 produce waste streams that exceed 1,000 kg per month and account for 99 percent of the total waste (Murray, et al., 1981:47). Sixty percent of waste is generated in just ten industrial states,* while twenty percent is generated in eight

* The 10 states that generate the most hazardous waste (and the percentage of U.S. waste they generate) are: New Jersey (8.0%), Ohio (6.8%), Illinois (6.8%), California (6.6%), Pennsylvania (6.5%), Texas (6.3%), New York (6.2%), Michigan (4.6%), Tennessee (4.4%), and Indiana (3.6%) (US EPA, 1980a). These states account for 60% of the waste generated and 55% of the national population (1981 Statistical Abstract of the United States).

others.** Excluding California and Texas, all are located east of the Mississippi. These figures, while suggesting a regionalization of hazardous waste problems, in fact closely parallel the population distribution of the United States. New England accounts for 4 percent of the wastes and 6.3 percent of the waste generators (Senkan and Stauffer, 1981:37). Half of this activity is in Massachusetts, the state in which the simulations used in this study were conducted.

II. The Possiblity for Improved Treatment of Hazardous Waste

In 1982, EPA assessed 929 hazardous waste disposal and treatment sites that had caused environmental damage and on which information had already been collected. Fifty-six percent of these facilities were still active. Most of the contamination sites were discovered between 1979 and 1981 as a result of growing federal and state enforcement activity. The typical site according to the report,

> was undesigned, with little information on file to suggest that adequate operating and maintenance procedures were routinely employed. Most sites contained no liners, leachate or runoff collection systems and/or containment facilities and inactive sites almost invariably received inadequate closure. In addition, most of the sites evaluated were located in poor hydrogeologic/ environmental settings. For example, in the majority of

** The eight states that generate between two and three percent of the national total are Massachusetts, Missouri, Wisconsin, Florida, North Carolina, South Carolina, Virginia, and Louisiana (US EPA, 1980a). These states account for 20% of the waste generated and 20% of the national population (1981 Statistical Abstract of the United States).

> cases, the facility was located in moderate to highly permeable soils within 10 feet of groundwater and 100 feet of a surface water body. In many cases the facility was also located within one-half mile of shallow drinking water wells (US EPA, 1982b:xi).

Clearly, when the design of disposal sites is this faulty, damage is likely to occur. The methods for selecting and operating such sites were fairly standard in the years before RCRA was enacted. How much better can we do with new facilities?

Advances in the Treatment and Disposal of Wastes

Many technical options exist for managing hazardous wastes. Waste can be treated using a number of physical, chemical, and biological processes. The waste stream can be reduced at the source by altering feedstocks or modifying industrial processes. Recycling is an increasingly viable alternative as the price of raw materials and waste treatment both increase rapidly.

Process modification and source separation are the most preferred methods of waste reduction. Source separation, in particular, is being used increasingly. Many production processes can be easily modified to isolate hazardous constituents in concentrated waste solutions, and thereby prevent contamination of large volumes of nonhazardous waste. The more efficient uses of toxic substances also offers potentially great reductions as new process technologies are adopted. Estimates of the quantity of hazardous waste that will be produced by new industrial plants range from 30 to 80 percent of the amount now produced by existing plants. Waste cannot be so easily reduced in existing plants (US OTA, 1983:142).

Resource recovery and recycling, while highly desirable, has numerous obstacles to effective implementation. When in-plant recovery is relatively easy, the savings can be substantial. But controlling the consistency of deliveries and the composition of the wastes deliverd to offsite recovery facilities is difficult. Different firms using different processes create variations in the waste streams that cause problems. Waste exchanges are also unpopular because generators must assume all liability in transferring wastes (USOTA, 1983:139). Currently, only six percent of all hazardous waste is recylced (Booz-Allen et al, 1980).

Approximately 80 percent of hazardous wastes is currently disposed of in landfills (Krag, 1982a:7). Modern secure landfills are designed to overcome the problems of early sanitary landfills. Chemicals are isolated from each other and from the environment. Sites are lined with impermeable clay and are designed to allow runoff to drain in a controlled manner. Under the provisions of RCRA, EPA has required ground water monitoring and leachate entrapment and treatment for 30 years. These landfills are a significant improvement over older "sanitary" landfills, but the longevity of many chemicals suggests that they are not a final solution. While new disposal technologies are likely to perform better than their earlier counterparts, experience with these more advanced designs is insufficient to predict their performance. The effectiveness of disposal techniques relies on the continued integrity of the engineering structures and operating procedures over many decades and potentially for centuries.

By comparison, waste treatment technologies destroy or detoxify wastes. This permanent reduction in risk is an overwhelming advantage when wastes are toxic, persistent, and bioaccumulative. Many chemical, biological and physical treatments are designed specifically to destroy or neutralize particular waste streams. For example, bacteria can be selected from nature, acclimated to live in particular substances, and mutated to accomplish particular tasks. As a general technique for destroying or degrading organic hazardous materials, incineration offers the greatest range of options. By decomposing wastes at high temperatures, these technologies are designed to achieve destruction efficiencies of up to 99.99 percent (USOTA, 1983:159). The advantage of this very high destruction is substantial. While difficulties remain in monitoring methods, knowledge about toxic by-products of incomplete combustion, and uncertainties of long term performance capabilities, these systems of treatment provide clear benefits relative to disposal options.

The option used by the waste producer, however, is likely to be the least costly within options acceptable to government regulations. At the high end, incineration of solids costs up to $800 per metric ton, while either incineration or engineered storage of liquids costs up to $240 per metric ton. The cost of most processes ranges between 50 and 150 dollars per metric ton. At the low end, deep-well injection, aerated lagoons, land treatment, and illegal dumping can cost as little as $5 per metric ton (US OTA, 1983:196; Senkan and Stauffer, 1981:43). Figure 3.1 displays costs in greater detail. These costs provide powerful motivation to resist adoption of more sophisticated technologies.

The Hazardous Waste Industry

Improvements in hazardous waste handling will depend largely on the hazardous waste industry's willingness and ability to innovate. The size and nature of the market, however, is not obvious. The Booz-Allen study (1980:V-26) of the hazardous waste treatment industry concluded that current offsite treatment capacity has not been exhausted. National capacity utilization ranges from 17 percent for deep well injection to 59 percent for incineration. Landfills for handling 10 years of hazardous waste generation are currently permitted. Aggregate national capacity, however, may not be indicative of the need for new capacity. Aggregate capacity is estimated based on the maximum utilization rate technically possible for each treatment process. Local restrictions on when facilities can operate, the management of the flow and mix of wastes into the facility, and technical limitations and equipment failures make maximum utilization

Type of waste management	Type or form of waste	Price 1981	$/tonne[b] 1981
Landfill	Drummed	$0.64-$0.91/gal ($35-$50/55 gal drum)	$168-$240
	Bulk	$0.19-$0.28/gal	$55-$83
Land treatment	All	$0.02-$0.09/gal	$5-24
Incineration clean	Relatively clean liquids, high-Btu value	$(0.05)[c]-$0.20/gal	$(13)[c]-$53
	Liquids	$0.20-$0.90/gal	$53-$237
	Solids, highly toxic liquids	$1.50-$3.00/gal	$395-$791
Chemical treatment	Acids/alkalines	$0.08-$0.35/gal	$21-$92
	Cyanides, heavy metals, highly toxic waste	$0.25-$3.00/gal	$66-$791
Resource recovery	All	$0.25-$1.00/gal	$66-$264
Deep well injection	Oily wastewater	$0.06-$0.15/gal	$16-$40
	Toxic rinse water	$0.50-$1.00/gal	$132-$264
Transportation		$0.15/ton mile	

[a]Interviews were conducted in May of 1980 and February of 1982.
[b]Factors used to convert gallons and tons into tonnes are described in the appendix.
[c]Some cement kilns and light aggregate manufacturers are now paying for waste.

SOURCE: Booz, Allen & Hamilton, Inc.

Figure 3.1: Comparison of quoted prices for nine major hazardous waste firms in 1981. (Source: US Office of Technology Assessment, 1983:196)

rates unachievable (Krag, 1982a:3).

Moreover, the Booz-Allen study does not examine the capacity of onsite treatment. As we have seen, this capacity accounts for 80 percent of all treatment. Neither does the study take into account the need to clean up many old waste sites. Perhaps most importantly, the study does not specify the environmental adequacy of existing treatment processes, many of which are expected to be closed down as hazardous waste regulations become increasingly stringent. State and industry officials have consequently argued that the report underestimates capacity shortfall (BNA, 1981:872). Finally, the Booz-Allen report indicates that 75% of the nation's excess capacity is located in the three states of Louisiana, Texas and Oklahoma (Booz-Allen, 1980:IX-3 and IX-20). Half the states, accounting for over 40 percent of the demand for offsite capacity, are located in regions with net capacity deficits. The New England region, for example, has a projected demand for 580,000 wet metric tons of offsite capacity with only 218,000 tons available. The remainder must be transported to places as far away as Alabama. The transportation not only greatly increases costs, but also increases the potential for accidental spills and illegal disposal.

Demand for the services of treatment facilities depends largely on the generation of waste and hence on the market for primary products and the efficiency of production techniques. Demand is also critically linked to the requirements for safe waste managment, and hence to regulation and potential liability. Demand will shift towards more sophisticated techniques as regulations and liabilities increase. But, EPA cannot enforce tougher regulations unless the capacity exists for legally disposing of wastes. In 1980, EPA estimated that only 120 existing disposal sites would meet the requirements of the law (Epstein, 1982:246). A hazardous waste siting committee established in EPA further estimated that 40 new offsite storage and disposal facilities and 60 new treatment facilities would be needed between 1980 and 1985 (BNA, 1980).

Increases in demand for offsite treatment have been slow in coming (BNA, 1982:66), as have effective regulations. Congress gave EPA 18 months to develop regulations for RCRA. Two and a half years after that deadline, in November of 1980, the first of these regulations went into effect. The regulations defined hazardous wastes, created an accounting system for tracking these wastes from the generator to ultimate disposal, established recordkeeping and financial requirements for operators of hazardous waste treatment facilities and set interim standards to be met by disposal facilities until permanent standards could be set and a certification process established. The interim regulations, however, were largely administrative and did not set technical, design and operating standards needed to protect health and environment. Moreover, the application process was not designed to determine compliance with the regulations. Inspection occurred in only 12 percent of the sites within the first 12 months, and despite the fact that 97 percent of these facilities did not comply with the regulations, compliance orders were issued to only 14 percent (US GAO, 1981b). Not until January 26, 1983 did permanent land use regulations become effective and standards for treatment facilities have still not been promulgated.

Given these circumstances, the onsite treatment processes of hazardous waste generators are only now coming under review and regulation. Whatever effect the RCRA regulations will have on shifting onsite treatment to offsite facilities has yet to be seen. The industry is nonetheless growing rapidly. Total revenues for the hazardous waste management business were estimated at $60 million in 1970, at $300 million in 1980, and to reach $1.5 billion by 1985 (Krag, 1982a:1).

In essence, the main service of the hazardous waste industry is risk managment. The process of developing technical solutions for individual hazardous waste streams is a time consuming task. Risk management, however, goes beyond the design of technologies. The very high capital costs of new technologies and the long lead time required to site a facility means that technological sophistication alone will be insufficient to ensure corporate success. The market for waste management services is complicated by uncertainties surrounding federal and state regulations and their enforcement; instability in the demand for offsite services due to source reductions and onsite management of waste streams; the emergence of new competitors; and continued improvements in technology (Krag, 1982a:24). The United States treatment facilities are neither as sophisticated nor as plentiful as that of some Western European countries (Krag, 1982a:3). We have capacity shortfalls in many sections of the country. The capacity that exists causes considerably greater environmental and public health damage than would new treatment facilities. Much will need to be replaced. Existing capacity is also predominantly disposal capacity. Over time, the effective management of hazardous waste requires that waste be detoxified or destroyed to the maximum extent possible. The successful management of hazardous waste therefore depends on the industries' ability to bring new technologies on line, and that in turn is heavily dependent on siting a facility.

III. Opposition to Locally Sited Hazardous Waste Treatment Facilities

Krag, in his analysis of the hazardous waste management industry conducted for the Harvard Business School, concluded with this remark:

> The political rather than economic nature of the hazardous waste problem becomes most evident when we consider what should be a crucial focus of government regulation, namely site permits. The most stringent enforcement of RCRA will be ineffectual unless facilities can be created. Everyone desires the good that could be produced by the industry, risk avoidance; everyone is willing in a general sense to pay for that good since the costs are not readily seen. No cost, that is, until a particular community has its attention brought to the most important costs by a proposal to locate a facility in its midst -- that is, when it is suddenly realized that society's risk aversion propensities might be achieved by placing all (or what is seen as all) of the risk in a particular locale. In the long run this strategically critical problem may only be solved, or mitigate, by public credibility achieved by particular operators at specific facilities. Given adequate government regulation to determine the market and to enforce voluntary compliance with the regulations, firms should evolve in the industry that can demonstrate, through operation, the legitimacy of capable hazardous waste disposal. But this will not be done overnight nor simply. (Krag, 1982b:103).

Perceptions about the risks associated with siting a facility may well be the limiting constraint facing a hazardous waste managment firm. The strategy proposed by Krag is the careful management of risks such that over time some firms are perceived to be reliable. For Krag, risk management is the core service that the industry can provide as well as the crux of its ability to survive the facility siting process.

Krag is not alone in his assessment. EPA and state government officials concur with representatives of the National Solid Waste Management Association that "the siting of hazardous waste facilities is the biggest and most difficult obstacle to safe management of hazardous wastes" (BNA, 1981:871). Opposition to hazardous waste facilities has forced abandonment of proposed projects and restrictions or closure of existing facilities. Between 1978 and the end of 1981 (and to my knowledge since that time), no new offsite commercial waste management facilities were approved (BNA, 1981:872).

Dynamics of a Hazardous Waste Facility Siting Dispute

Opposition to the siting of hazardous waste facilities is almost unanimous in potential host communities. Centaur Associates conducted a major study of local opposition to hazardous waste facilities for the EPA. Of the ten cases selected as examples of successful siting, only four were offsite facilities sited after 1974 and one of these failed in the year following the study. All successful plants were sited before the Love Canal controversy (US EPA, 1979c).

Based on the experience described in these reports, Centaur concluded that local opposition is critical to both the siting of new facilities and the continued operation of existing facilities. Public opposition often arises as soon as a facility is announced. The community, including "grandmothers and U.S. Congressmen, factory workers and university scientists, those who never graduated from high school and those with doctorates in ecology and physical sciences," (US EPA, 1979c:iii) are united in their opposition to hazardous waste facilities in their community. Centaur notes that these controversies

> have reached levels of stridency impossible to convey in reports such as this one. In one case studied, an angry

> mob was prepared to blow up a facility... There were two reports ... of threats of death or physical harm to key individuals or their families (US EPA, 1979c:iii).

Facility sponsors are often surprised by the vehemence of this opposition. While technical studies show that proposed facilities will meet all regulations, opponents frequently acquire technical expertise to refute the sponsors' claim. When state regulatory agencies support claims made by sponsors, they are frequently viewed with the same suspicion and hostility.

Underlying community opposition is usually a dispute over risks and fairness. As Centaur notes:

> Throughout this process the community talks in terms of risks and fears, the facility sponsor in terms of regulation and technology. The terms of one are often not understood by the other...
>
> The community envisions few benefits from the proposed facility -- a few jobs and perhaps some tax revenues. Risks are often seen as overwhelming -- a "Love Canal" in their community, polluted water supplies threatening the entire community, decades of uncertainty, hundreds of trucks carrying thousands of drums of hazardous waste on local roads. The industries that produce these wastes may be hundreds of miles away... Opponents question the fairness of having their town bear such a large share of the environmental costs of modern industry. Facility sponsors rarely, if ever, address this question of equity (UA EPA, 1979c:iii).

Centaur concludes:

> National publicity concerning abandoned sites has made citizens and local officials increasingly aware of hazardous waste problems. They are also likely to be increasingly aware of actions taken by others to stop sitings. Opposition will, in all likelihood, become more widespread and sophisticated. Even if not ultimately successful, opponents may increasingly turn to the courts and delay siting for months or years with costly law suits (US EPA, 1979c:iv).

In reaction to local opposition to private hazardous waste facilities, some states have tried to preempt land control over the siting process. Minnesota is a striking example of the difficulties associated with this strategy. In 1975 the state's Pollution Control Agency, in conjunction with the Minneapolis - St. Paul Metropolitan Waste Control Commission (MWCC), received $3.7 million from the US EPA to site and demonstrate the safety of a state-of-the-art secure landfill. Three attempts were made to select a site. Despite MWCC's power to override local zoning, each attempt failed.

The agency had first selected 45 sites based on land use, hydrologic, topographic and geologic data. These sites were narrowed to four through further technical analysis. All four sites were on rural agricultural land. Persistent public opposition forced a reevaluation of the siting criteria (supposedly to accomodate regional and local land use and development plans). All lands in Commercial Agricultural Regions (a metropolitan council designation for preserving agricultural land) were therefore excluded. Use of this criterion eliminated the four preferred sites. Six more were selected that were less geologically desirable. Extensive opposition within these communities emerged, in part because the criteria for evaluating sites were changed halfway through the process. The process was postponed until 1978, when after a third attempt to find a site, the agencies abandoned the project and returned the grant to EPA (US EPA, 1979c: 190-206).

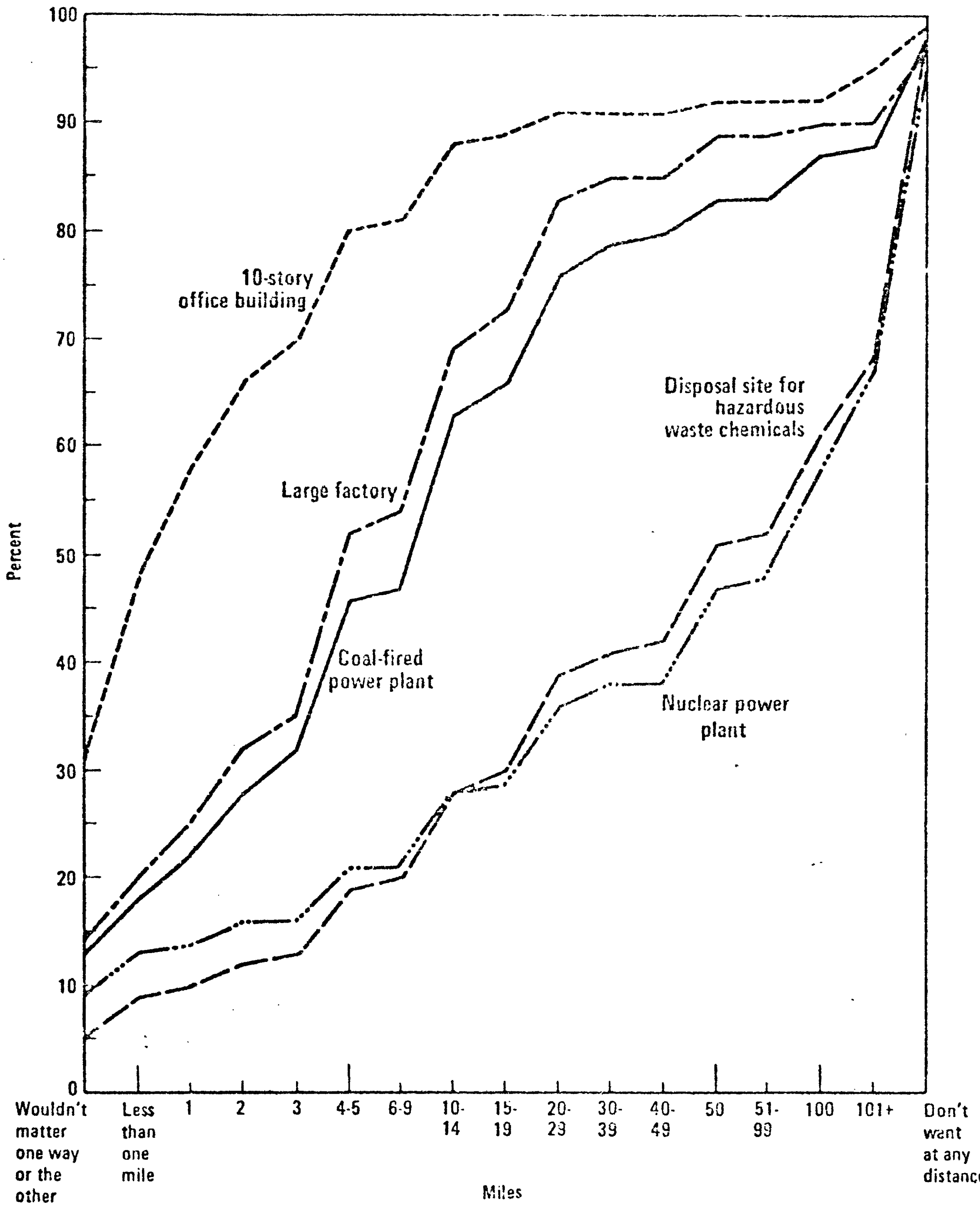
Extent of Opposition to Locally Sited Facilities

A number of surveys have indicated just how extensive concern about hazardous waste has become. In 1980, 64 percent of the respondents to a Roper survey indicated that they were worried a great deal about the disposal of hazardous industrial chemical wastes. In similar polls throughout the 1970s, concern about air and water pollution had never reached this level (US CEQ, 1980b:26-27). A Harris poll, released in the same year, suggests that 93 percent of Americans want to see stricter hazardous waste regulations, 86 percent give the problem a "very high priority," and 83 percent want disposal sites cleaned even if it costs more than $10 billion in the process (Harris, 1980).

While individuals are worried about hazardous waste and its regulation, however, they are even more adament about resisting the siting of improved waste treatment facilities. A Resources for the Future survey asked 1,576 individuals to indicate how near to their homes five facilities could be sited before they would either want to move or to actively protest the siting. Four installations (a ten-story office building, a large factory, a coal-fired power plant, and a nuclear power plant) were mentioned with a general assurance that they would be built and operated according to government environmental and safety regulations. The fifth installation (a disposal site for hazardous waste chemicals) was listed with an additional assurance that "disposal could be done safely and that the site would be inspected regularly for possible problems." As shown in Figure 3.2, only 17 percent accepted a disposal site within five miles of their home, less than any other type of facility.* By comparison, 80 percent would accept a ten story office building, 50 percent a large

* In Massachusetts, where the average community is 24 square miles in area, few sites exist in which a majority of a community's residents would not live within 5 miles.

Figure 3.2: Cumulative percentage of people willing to accept new industrial installations at various distances from their homes. (Source: U.S. Council on Environmental Quality, 1980b)



factory, 45 percent a coal powered factory, and 20 percent a nuclear power plant. Neither the hazardous waste facility nor the nuclear power plant reached majority acceptance until the distance exceeded 100 miles (US CEQ, 1980b:29-32). The similarity between public attitudes toward nuclear power and hazardous waste facilities is striking for several reasons. Nuclear reactors have long been considered the facility that is hardest to site.* Moreover, the survey took place less than a year after the Three Mile Island incident and only shortly after the Kemeney Commission report on the causes of the problem was released with considerable fanfare. Seventy-four percent of the respondents were able to correctly associate Three Mile Island with an accident at a nuclear power reactor. By contrast, only twenty-two percent could associate Love Canal with hazardous waste. National media attention on hazardous waste was relatively low. The original Love Canal evacuation occurred two years before the survey and the second evacuation had not yet taken place (US CEQ, 1980b:36-37). It would appear that opposition to hazardous waste facility siting was extensive, even before the media focused on a particular national disaster.

Sources of Opposition Within Communities

At the heart of community opposition are two immutable facts: once sited, a facility is difficult to move, and within even the best

* National fascination with nuclear power led to 84 separate surveys of attitudes toward nuclear power in the years 1974 through 1976 alone. All together, over 100,000 Americans were surveyed in these studies (Melber, 1977:8-14). By comparison, national surveys of hazardous waste were not conducted until the 1980s.

facility lies the possiblity (albeit small) of tragedy. Construction of a treatment plant is literally a concrete act. Construction is visible and fixed in location. The plant, and its treatment activities, becomes a permanent neighbor. The siting decision is the most significant control a community has over this neighbor.

While support for better treatment processes and improved hazardous waste management facilities is almost universal, local opposition to specific sites is equally widespread. Hazardous waste facilities, like prisons and power plants, are locally noxious but regionally beneficial. However, because the location of the benefits is isolated from the location of the risks, interjurisdictional disputes are likely to emerge. A local constituency which will benefit from a large facility seems a necessary precondition for local support. In hazardous wastes facilities, however, only facilities that treat wastes onsite for a local firm will be of strictly local benefit.

This political reaction to hazardous waste plants has crippled traditional regulatory approaches to the siting process. As the key to facility siting, regulation is based on the notion that improvements in the design and safety of facilities will reduce opposition to their siting. Regulations are designed to promote regionally beneficial facilities by weeding out those facilities that are undesirable. Social optimality can best be ensured by establishing site selection, design and operating standards, and promoting facilities that meet these criteria. Based on this notion of social optimality, opposition to facilities ought to continue only if proposals are inadequate (and hence not socially optimal) or misperceived (and hence mistakenly thought to not be socially optimal). A strict standard and permitting process will improve inadequate proposals, while a well-informed public debate will correct misperceptions. In either case, an unbiased and thorough technical research program coupled with a strict permitting process is a necessary, and hopefully sufficient, step in resolving such siting disputes. Once a technically competent and impartial review of a facility has been conducted, the continual inability to site the facility is generally believed to grow from developer or resident attempts to bend the siting process to their own ends for purposes inconsistent with the public interest. Based on this assessment of the problem, reforms to enforce regulation or to forestall delay in site permitting are generally attempted.

In my view, the impasse over the siting of locally noxious but regionally beneficial projects will continue because siting policies are redistributive. That is, benefits of a hazardous waste facility are spread widely across a region -- no single beneficiary feels especially well rewarded -- while at the same time, the risks and costs are concentrated in a very small area of the host community (O'Hare, 1977). Diffuse regional support is counteracted by concentrated local opposition. The resulting conflict in interests is aggravated by traditional regulatory systems. The regulatory approach presupposes common public values and an appropriate technical solution to the problem of how to achieve those values. Neither exists in hazardous waste disputes. While complete authority can be given to central governing bodies to make decisions which are in the interest of the region, these bodies will have insufficient power to prevent opposition when disagreement over means and ends undermines the acceptability of the regulatory solution.

Over the last seven years, research on large scale facility siting (O'Hare et al., 1983; Susskind et al., 1978, and 1984; O'Hare, 1977; and Morell et al., 1983) has led to the design of new siting processes involving face-to-face negotiation and compensation. Those who benefit can, on a project by project basis, share the gains with those who stand to lose. In July of 1980, the Massachusetts Legislature adopted a new siting process based in part on this research (Bacow, 1982). Called the Hazardous Waste Facility Siting Act, the new law vested primary authority for siting hazardous waste facilities with local communities; established a process of negotiation and compensation involving the community, the developer and the state; and mandated a broad public information program on hazardous waste management practices. The National Governor's Association has endorsed a similar approach to hazardous waste facility siting.

The Siting Act instituted a system of negotiation and compensation for managing risks. On the surface, the system is quite capable of coping with differing risk perceptions. However, the State and the developers that have attempted to site facilities under the Act have relied heavily on traditional approaches to regulatory decision making. Massachusetts has used technical analysis and public education as the primary means of improving the quality of the debate and bringing about a convergence in perceptions of risk. In four years since the law's enaction, no negotiation in Massachusetts has reached the stage where local residents have openly negotiated over compensatory benefits. In three cases (the SRS proposal for Andover, the General Chemical proposal for Gardner, and the Liqwacon proposal for Freetown), potential host communities have successfully argued that the risks involved are too great to even permit bargaining over appropriate compensation and mitigation measures, and have forced the developer to withdraw. In one case (the IT Corp proposal for Warren), two years of negotiation have settled little about the risks of the facility, and active negotiations over benefits has yet to begin. This emphasis on risks early in the process suggests that risk perceptions is of considerable import to a successful facility siting process. Changes in benefits may have little power to alter perceptions about what risks are acceptable. It would seem that policies for more creatively coping with risk perceptions are needed if improvements in the decision making process (such as negotiated dispute resolution) are to be effective. The next chapter examines the perceptions of and attitudes about risk revealed by the residents of Worcesterville and Essexton.

Chapter 4

The Variety of Local Perceptions: Sponsors, Guardians and Preservationists

Local opposition to the siting of the hazardous waste facilities is widespread, but neither as universal nor as monolithic as would first appear. In both Essexton and Worcesterville, participants in the simulated hazardous waste facility siting dispute generally held one of three distinct patterns of perception about and approaches for siting hazardous waste facilities.

Participants within each of these three groups perceive risks and value outcomes consistent with other members of the group. I call these three groups sponsors, guardians, and preservationists. While differences among sponsors, guardians and preservationists are most clearly demonstrated using interview data, the general outline of these differences are also revealed through the questionnaires.*

* The designations of sponsors, guardians and preservationists emerged from analysis of the interview data. Participant attitudes and perceptions were of three distinct types, and almost all individuals fell clearly into one category or another. The study was exploratory, in that while I expected differences to exist within communities, I had little basis for predicting the characteristics and strength of those differences.

(Footnote is continued on the next page.)

Sponsors (to which 29 percent of the designatable participants belong**) value the tax revenue or waste management benefits that such a plant would bring, and at least tacitly promote facility proposals. As shown in Figure 4.1, they perceive the risks of hazardous waste treatment facilities to be relatively minor (question 2) and controllable (question 6). They are more trusting of expert knowledge, private industry, and technology than are guardians and preservationists (questions 5, 3, and 7), and generally resist community control over those facilities (question 4).

Guardians (to which 38 percent of the designatable participants belong) value orderly change that protects and promotes the public interest and judge proposals by their potential impacts. They perceive the risks of hazardous waste treatment facilities to be significant (question 2) but potentially controllable (question 6). Guardians emphasize the managerial aspects of safety (question 7), do

---

* (Footnote continued from previous page). The validity of these designations is to some extent independently confimed by analysis of the responses to the questionnaires. The questionnaires, shown in Appendix B, were administered before the simulation began. Answers to the questions were therefore in no way influenced by the simulations. Moreover, all answers were scaled and quantitatively analyzed, and hence served as a counterpoint to the more qualitative analysis of interview data. While the small number of participants (16 in Worcesterville and 18 in Essexton) do not allow for a statistical test of the significance of these designations, the attitudes and perceptions revealed are consistent with those obtained from the interviews. A summary of findings is shown in Figures 4.1 to 4.3.

** Seventeen percent of the participants in the Worcesterville and Essexton simulations could not be classified as a sponsor, guardian or preservationist, either because interviews could not be completed (11%) or no clear preference was revealed in the interview that was held (6%). Excluding these individuals, Worcesterville participants consisted of 23% sponsors, 46% guardians and 31% preservationists. Essexton participants consisted of 35% sponsors, 30% guardians and 35% preservationists.

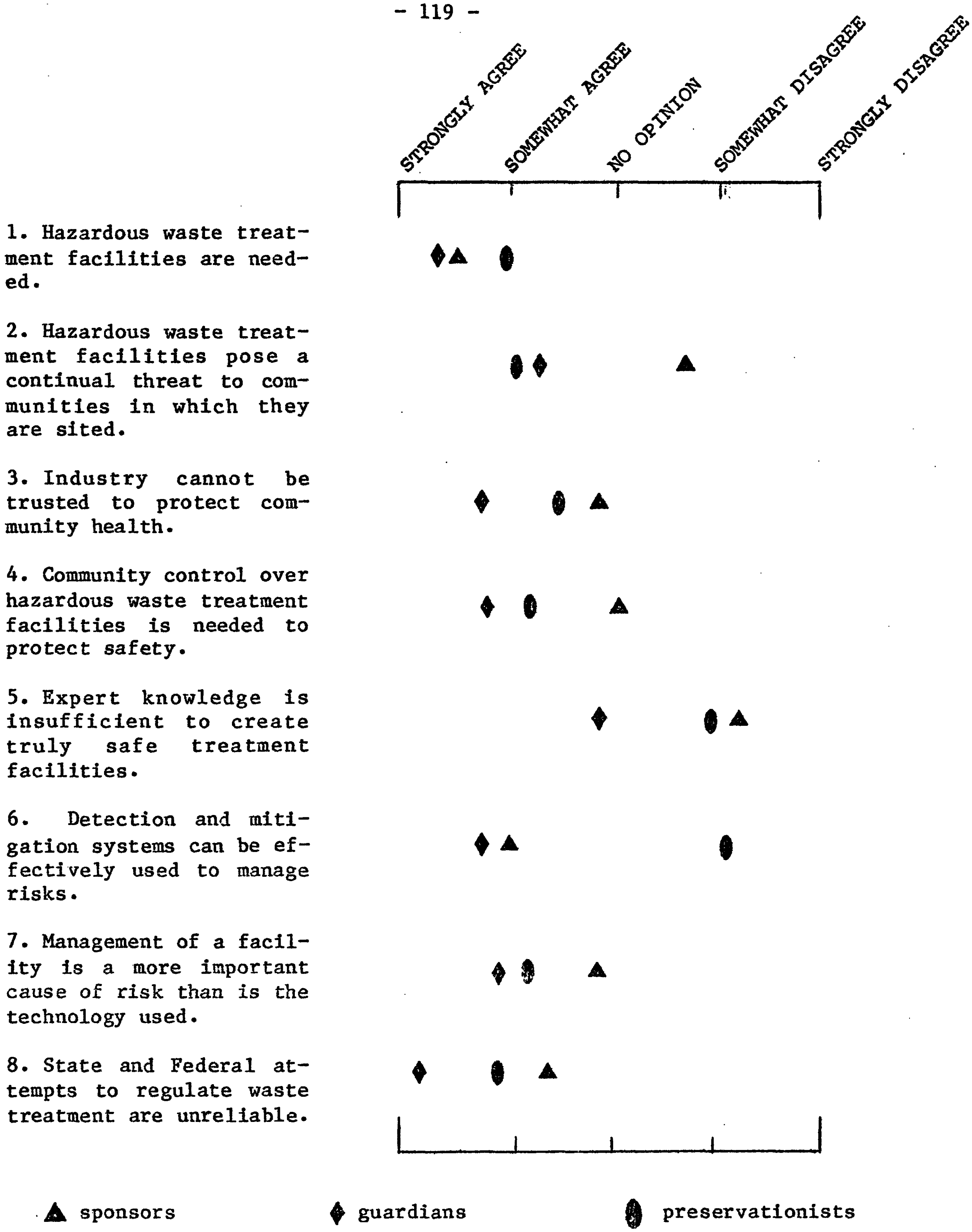


Figure 4.1: Attitudes about the Risks of Hazardous Waste Treatment, by Type of Participant. Each scale is the amalgamation of data from several questions. The questionnaire is presented in Appendix B.

not trust technical expertise, industry, or higher levels of government to ensure proper waste management (questions 5, 3, and 8), and hence promote consideration of community participation in the management of hazardous waste treatment facilities (question 4).

Preservationists (to which 33 percent of the designatable participants belong) value stability, a traditional life style, and control over their own environment. They judge proposals by their potential disruption and the uncertainty they engender, and perceive the risks of hazardous waste treatment facilities to be significant (question 2) and highly unpredictable (question 6).

Surprisingly, the position that an individual adopts is only weakly related to traditional political and public interest demarcations. As a group, sponsors are somewhat more conservative and guardians somewhat more liberal than are preservationists, but the differences are slight and exceptions common. Environmentalists exist in all three groups, and the pro-environmental stand of guardians is only slightly stronger than that of the other two groups. As shown in Figure 4.2, small but consistent differences exist in attitudes about industrial development, environmental protection, and governmental activism.

Employment and income seem a somewhat more important determinant, with self-employed businessmen tending to be sponsors, moderate-income professionals to be guardians, and well-paid professionals to be preservationists. Service workers, and surprisingly engineers, are scattered somewhat equally through the groups. In addition, guardians tend to be younger, to have resided in the town for fewer years, and to be considerably more active in local politics than either sponsors

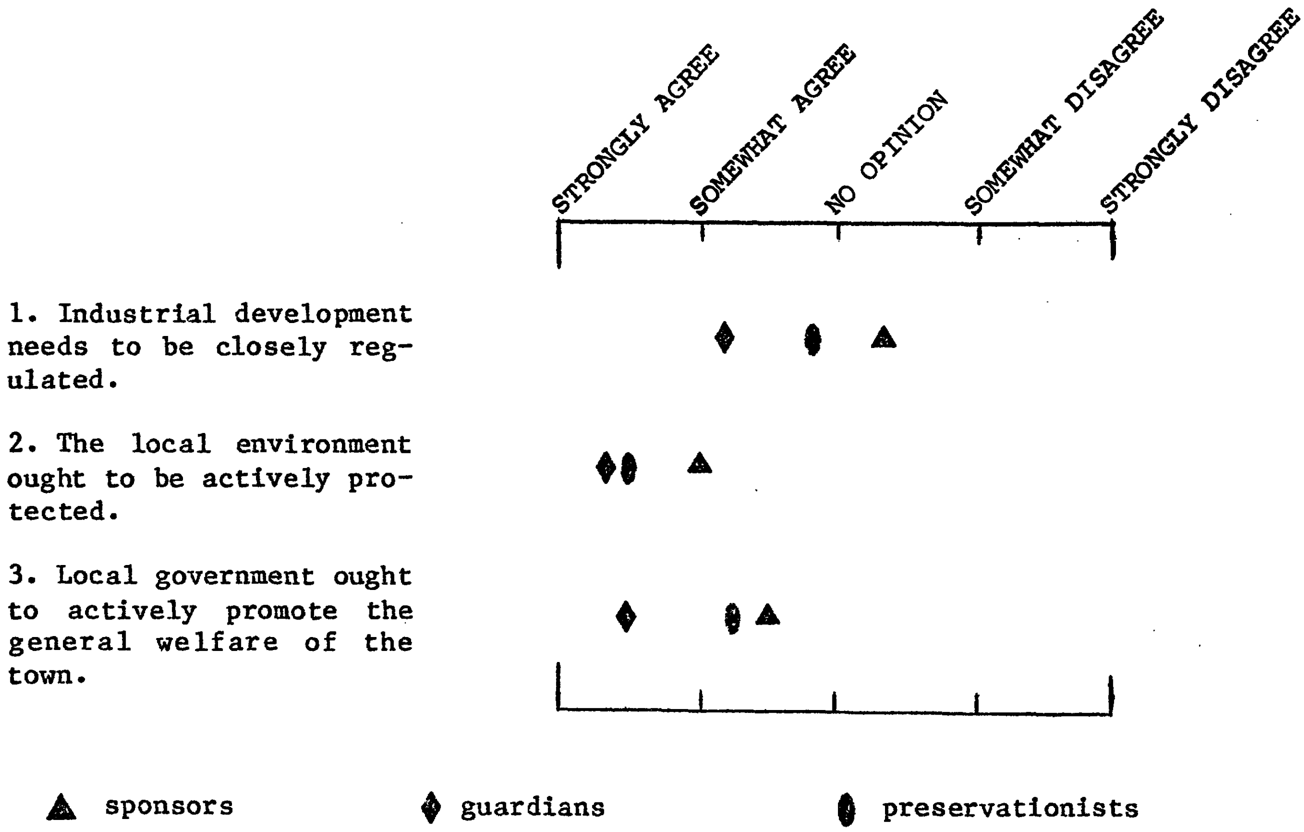


Figure 4.2: General attitudes about industrial development, the environment, and government activism, by type of participant. Each scale is the amalgamation of data from several questions. The questionnaire is presented in Appendix B.

---

or preservationists. The specifics of these differences are shown in Figure 4.3a to 4.3e.

These differences only begin to suggest the complex perceptions and values used in evaluating the acceptability of a proposed hazardous waste treatment facility. In the next three sections, we will examine the perspective of each of these three groups. For each group, we will explore perceptions and values associated with the character of the town, and the effectiveness of technical expertise, monitoring and management as techniques for controlling risk.

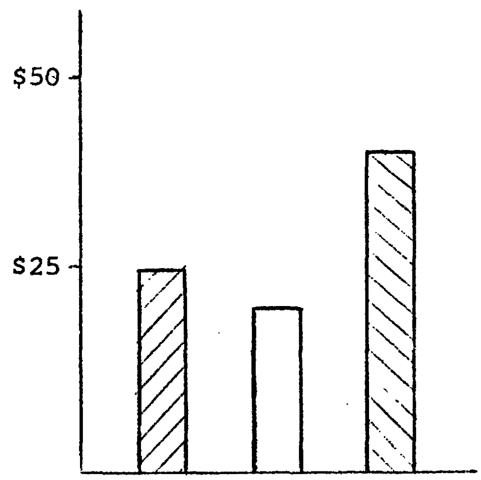


Figure 4.3a: Average income, in thousands of dollars.

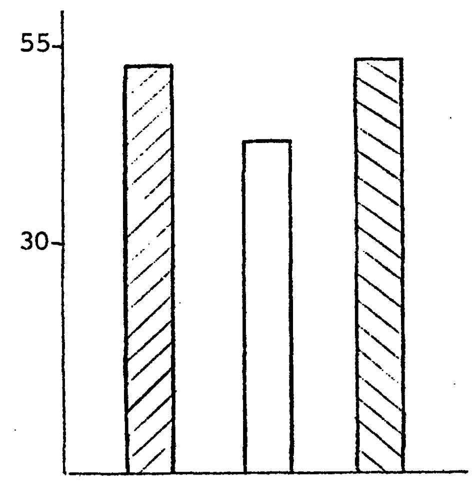


Figure 4.3b: Average age, in years.

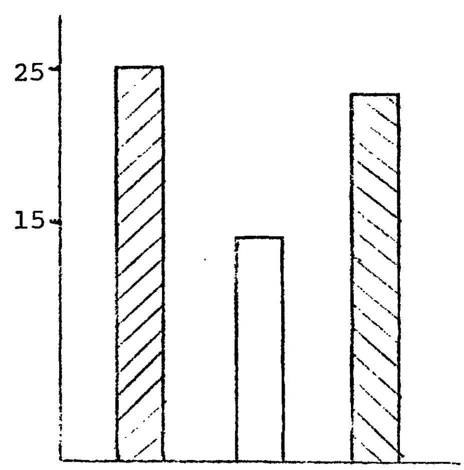


Figure 4.3c: Average residency, in years.

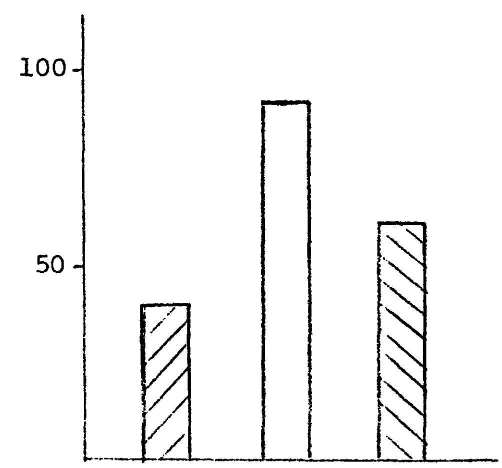


Figure 4.3d: Percentage who have served in a major town office.

sponsors guardians preservationists

Figure 4.3: Personal characteristics of participants in the simulation, by type. Characteristics examined include (a) average income, (b) average age, (c) average years of residency in Worcesterville or Essexton, (d) percent of participants who have served in a major town office (see Appendix C), and, on the next page, (e) degree of interest in the problems of hazardous waste, as expressed on the questionnaire.

I. The Perceptions of Sponsors

Meeting to interview a typical sponsor was an adventure in its own right. Harold (not his real name) was rather special. He owned and managed an industrial firm that produced hazardous waste. We talked astride large vats of process chemicals. The noise and activity of the main floor drifted in and out of his office, while through the office window I could watch two of his older children working alongside several other employees. He was proud of his work, did a first rate job. He was gruff and straight talking: "A community without waste is nothing, a dry shell."

Like most sponsors, he generally trusted industry and supported free enterprise but also believed in the need to protect the environment. He was ambivalent about citizen and local government involvement in the siting process, generally thought that experts should take

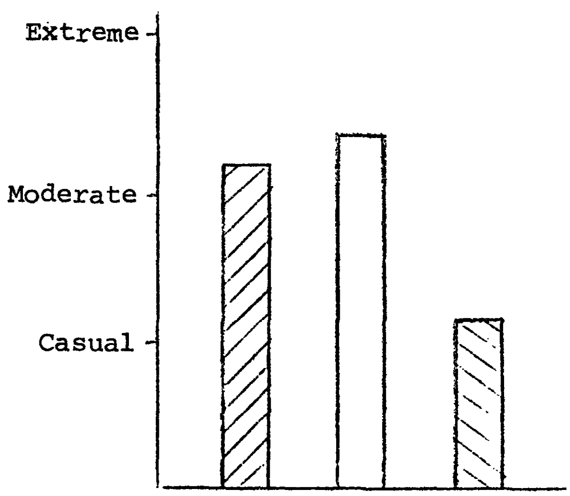


Figure 4.3e: Degree of interest in the problems of hazardous waste.

care of the problem. But he was also wary about who would make sure things were done right.* Unlike most sponsors, Harold is reasonably familiar with the problems of hazardous waste. Another engineer and a fireman also have professional experience with hazardous waste, but most sponsors were only vaguely aware of the issues before the start of the simulation. They work as realtors, builders, fire chiefs, or are retired from business. They are entreprenurial and many are self-employed.**

Perceptions of Risk

Not everyone believes hazardous waste treatment facilities are inherently dangerous. While sponsors certainly are concerned with the safety of treatment facilities, as a group they feel that perceptions of risk are largely overblown. To some, the risks were simply inconsequential.

> I think hazardous waste is less safe than nuclear power, but the risk percentages on either are so low, I don't particularly pay attention to them. (17) Once they get that stuff inside the plant, it would affect little else. No one will even know it's there. The company won't want anyone interfering with their business, so they're bound to use good neighborly practices. Keeps people happy. (26) It's so overblown anyway. I lived within two miles of the Woburn site (a contaminated hazardous waste disposal site), drank the water that was

---

* As described above, these attitudes were determined from a questionnaire given to participants before start of the simulation.

** To preserve the anonymity of the participants, sources of the quotes used in this text are referenced by number only. A general description of the occupation and major offices held by each of these individuals is provided in Appendix C.

> supposedly carcenogenic. Our family was tested and we had no problems. The papers just blow everything out of proportion. People read about a problem and start making a fuss over something only vaguely related. I didn't stop eating swordfish during the mercury scare or lobsters because of PCBs. We want everything to be so sterile -- we could eat ten times the allowable levels of most pollutants and there'd be no problem. (5)

Most sponsors take a more comparative view of the risks. Relative to other risks they face, those of a hazardous waste treatment facility are seen as managable. Under these circumstances, sponsors are generally willing to accept these perceived risks, albeit cautiously.

> I don't care where they locate the plant, because it's already everywhere. Why are people afraid of a plant? It's on every road. What they really should be worried about is the railroad cars and trucks that go through here every day loaded with the skull and crossbones. Nobody wants it in their back yard, and yet they've got it at their front door, without regulations and safety precautions! I see chemical trucks on Main Street: little Main Street that is so congested that you can hardly get across. My God, if a car ever pulled out, gonzo! The whole center of town would blow up. It's all around us. Nobody in town lives more than a quarter of a mile from either a railroad or a highway. Someday there's going to be an accident, but a plant like this certainly won't be the cause of it. (19)

> The words "hazardous waste" scares so many people because of a few past incidents. There needs to be more public awareness. Those who voice concerns are worried about their health, but they can't relate it to other things that can be equally risky. Twenty-two cars of vinyl chloride are shipped through here on train cars every day. A nearby town has the second largest LNG storage facility in the country: 3 million cubic feet of LNG. People don't even know this. If one of these tankers were to go, it would take half of Worcesterville with it. Yet the plant has never had any problems. They are really safety conscious. They trained the town fire department, bought them special equipment, built extra safety dikes. If you explain these safety features to intelligent people and let them see that it can work, it might change their minds. But people let emotions and peer pressure affect their decisions, and nothing gets done. (14)

> Its not that I don't think hazardous waste is dangerous. The only thing I consider as dangerous is genetic engineering, and I'm really scared of that. I don't think we know enough about the long range effects of hazardous waste -- cancer, groundwater contamination, environmental pollution -- to really know how to manage it. With this level of uncertainty, we need to be very cautious. But I feel that a cautiously run treatment facility would be a safe option. I wouldn't have a problem living near such a treatment facility because it's likely to have properly trained personnel and to be effectively regulated. (14)

Preserving the Character of the Town

Sponsors give little attention to issues of town preservation. When talking about the effects of a hazardous waste treatment facility, over half of the sponsors were silent about both the character of the town and the aesthetics of the plant. To these people, the only issue of great importance was the potential hazardousness of the facility, and this hazardousness they thought largely managable. Those that did mention a concern about the town character rated development quite positively.

> Nobody wants anything to come into Worcesterville. Nothing! They don't want any development. They want to lock the gates. You can't afford to live in a town if there's not some development, some growth. (19) The way I look at it, people make a big thing about the way a plant like this looks. You know, once it was up and running smoothly, nobody'd know it was there. An operator of a plant like this isn't dumb. They know enough to keep a low profile. (26) As for me, I don't get emotional about how these things look. The way I see it, a community without waste is nothing, a dry shell. (17)

Technical Expertise

More than any other group, sponsors accept the general notion that risks are managable through technology. The reasons for this acceptance, however, varies considerably. To some, the risk is not part of their consciousness. The risks are insignificant, requiring only standard management procedures. Technology is not so much trusted as a solution to a problem as the reason the problem does not exist. To these individuals, the issue of hazardous waste management is less one of optimizing a control strategy than one of thinking the problems have been blown out of proportion. Even among those sponsors who believe hazardous waste treatment facilities pose important risks, technology is viewed as well-tested and trustworthy. Problems will not develop if the technology is properly designed.

> As an engineer, I would have no qualms about a hazardous waste plant. If I lived in a community that had the right conditions to make it safe, I'd be a big proponent. Given the scrubbers, monitoring and process systems that IT is proposing for Warren (the Massachusetts town where IT Corporation has proposed siting a hazardous waste treatment facility), I would not be concerned if I live there. Unfortunately, someone hasn't educated the residents of Warren. If the people of Warren had taken the time to visit plants and become educated, they wouldn't have as many doubts. They would realize that there is a solution to all of these problems. (5) In fact, I'd rather put money into technology than improved management. People who manage these plants are human. They'll look out for their own personal point of view. I'd trust technology because you can't bribe it. If you put it in right from the beginning, it'll go on protecting you through the years. (7)

> Our town had a problem with odors from our sewage treatment plant. The engineering firm who designed it botched the job and the feds and the state didn't check the plan for engineering defects. How were we to know? We were led astray because we didn't have enough expertise to know better. Now we know that iron clad guarantees are only as good as the technical knowledge on which it is based. If we had more expertise ourselves, we wouldn't have the problem. (17)

Monitoring

Given the basic trust that sponsors have in technology, it is not surprising that as a group they put little emphasis on the need for local monitoring. Rather, they see the problem of regulating the plant as rightfully a state and federal responsibility. Through strict enforcement of standards, these higher levels of government can ensure safety. Without such enforcement, there is little the local community can do.

> The most important risk factor is the lack of enforcement. There's no one to enforce any of the regulations. The federal agencies have neither the manpower nor the time. We regulate driving and use police to enforce the laws. NRC regulates the nuclear industry. Without effective regulations, the risks are likely to be significantly higher. (14, 26, 17) What good are laws if you can't enforce them. Don't write them. It's false security. This is a very serious thing, more important than finding kids with marijuana. We don't enforce the hazardous waste laws. We need a real good enforcement team to do nothing else. The state Department of Environmental Management has two people. Two people in the whole state to enforce these regulations, the manifest system, everything. (19)
>
> Massachusetts had a manifest system, a hazardous waste facility siting process, and an inspection system even before RCRA. The only problem was that only four people had to do all the work on hazardous waste, industrial waste and oil pollution. It was impossible. But resources weren't the only problem. The state Department of Environmental Quality tried to close Silresim (a hazardous waste treatment facility located in Lowell, Massachusetts) for four years before they succeeded. If the state tries to close down a functioning company, the courts will give them every chance to correct the situation. By the time the state succeeds, the problem has become enormous. (5)

Risk Management

To sponsors, the management of risk is not an issue of much concern. Management is largely irrelevant to their considerations about safety. Moreover, sponsors believe that the town's role in decision making for and management of the plant should be strictly circumscribed. To sponsors, towns do not have the ability to effectively participate. The problems of management are best left to experts. At most, the town's role should be one of information sharing and goal setting.

> I would want a company that would be willing to work with the community and allow some community input. But sometimes too many cooks spoil the broth. Many people let their emotions rule their mouth. They don't stop and think and they don't have the expertise to make decisions. Worcesterville should hire an independent engineer to keep tabs on the plant, and leave it at that. There has to be an assumption of "good faith" between the operators and the town. Until the company screws up, we need to assume that they will do what they agree to do. (14)

> Essexton would be ill fit to negotiate with such a large company. The operating budget for this facility would be is $30 million; the town's budget is only $6 million. We wouldn't know how to manage such a large enterprise, we'd be lost. (26) Besides hazardous waste is a national problem. EPA and the state should provide the watchdogs. They should have the lion share of responsibility for regulating this plant. The town should not be burdened with a protection role. We don't have the necessary skills. (17)

II. The Perceptions of Guardians

Diverse in background, guardians are strikingly similar in attitudes and concerns. Two stand out in my mind, for at first glance Tessa and Paul (not their real names) seem quite different. Tessa is director of Essexton's art association and works in a wonderfully sunlit office. She is optimistic, buoyant and at times exuberant. Tessa has lived in Essexton most of her life. She works hard to promote its civic life: she has been a selectman for nine years, served on the recycling and solid waste committees for fifteen years, and on the conservation commission for one year. She belongs to the League of Women Voters, the Sierra Club, the Appalachian Mountain Club, and the Conservation Law Foundation.

Paul, by contrast, is chief of police in Worcesterville. His office is lit with the glow of florescent light. The outside world is completely cut off except for the squak of CB radios and telephones. Paul arrived in Worceterville only a few short years ago. He belongs to no political organizations, but when he talks politics he talks straight and with considerable insight. As police chief, he has seen the worst of small town life, yet he remains cool headed, even optimistic.

Despite these differences in occupation and background, Tessa, Paul, and other guardians share a very similar vision. Guardians perceive the risks of hazardous waste treatment facilities to be significant but potentially controllable. As a consequence, the problem of hazardous waste attracts their attention more readily than it does the attention of sponsors or preservationists. While sponsors have little fear of hazardous waste and preservationists little hope of designing acceptable solutions, guardians have both the fear and the hope. They value orderly growth that protects and promotes the public interest and are strongly aware of the need to site treatment facilities. They therefore confront the problems of facility siting in great detail, examining pros and cons to look for preferred solutions.

More so than sponsors or preservationists, guardians share a common set of attitudes, beliefs and values. As expressed in the questionnaires answered before the start of the simulation, guardians are the strongest supporters of environmental protection, local government management of development, and community control over facility siting. They most stongly believe in the need for siting hazardous waste treatment facilities. At the same time, they are the most wary about the desirability of industrial development, the trustworthiness of hazardous waste facility owners, and the reliability of the state and federal governments.

Guardians are, on average, ten years younger than sponsors or preservationists, and more likely to be women. Almost all guardians had a general understanding of the problems and history of hazardous waste management before the start of the simulation. For the most part, this interest is not professional. Guardians are employed as business managers, editors, engineers, museum directors, planners, police, farmers, and assistants to selectmen. Rather, the interest comes from a general concern with promoting the quality of life in their community. Like the League of Women Voters to which several guardians belong, they believe in responsive government coupled to an informed and responsible citizenry.

Perceptions of Risk

When talking about the risks of hazardous waste, guardians do not need much prompting. They give expression to what they think and fear in great detail. To some, the reaction is visceral.

> I fear what we're doing to ourselves with these chemicals. I fear the chemicals themselves. I remember in particular a trip to New Jersey I took several years ago. I was on the New Jersey Turnpike around sunset. The sky was brilliantly colored with purples and oranges. Only a few cars were on the road; the place seemed so desolate. The air stank horribly and I began to have trouble breathing. I was afraid that I would pass out but felt I had to keep driving. On that day, my sense of chemicals changed dramatically. They became dangerous to me, personally. (23)

Central to their concern is the uncertainty of environmental risks. Facilities bring with them the possiblity of accidents that will greatly affect their security, as well as ongoing pollution that has unknown effects.

> My initial reaction was "Oh my God. I don't want it. It's too big and noisy. Property values would decrease." After thinking about it for a while, the potential environmental problems became more important. (12) I'm most concerned about making sure things don't get any worse. We've got ocean dumping 15 miles south of us and nuclear power 15 miles north. And now we're going to create a hazardous waste treatment plant at ground zero where we're living. It doesn't make sense unless we can do something better than is being done now. We've got to make sure we aren't creating a third potentially explosive situation. Protecting the environment, our water supplies, the ecology, these are essential. (18) I worry about the emissions. They're small, but that's when the plant is working properly. You're going to get these bursts, and the operators aren't going to tell anyone. Somebody will forget, or leave something open, or a tank will leak. They could easily contaminate the groundwater. You put a hazardous waste plant here, and it leaks, the chemicals are going to travel. Nothing can stop it. I'm scared. It's not knowing. A hazardous waste plant might not be any more dangerous than many seemingly benign activities, but then again you never know. You'd find out five years later, and then it would be too late. (23)
>
> Statistically, a modern hazardous waste facility might be safer than driving or working out in a thunder-storm. The difference is that you never know when the effects are going to show up. Twenty-five years down the line everyone might get cancer. All these things we used to think were safe are no longer considered safe.

> Tomatoes aren't safe! (laughs) There's hardly anything that doen't have a risk. (22) A little here and a little there. It all adds up. You just don't know what will make a difference. (30)

The sense of losing of control is a recurrent theme. Guardians believe that inasmuch as possible, people ought not impose risks on others. Risks that spill over onto non-participants, that reduce an individual's autonomy to protect his or her health, are to be avoided.

> I take all kinds of risks. I smoke, drive without a seatbelt. I think these things are worse than living near a hazardous waste plant. But they're also personal choices that I make and they don't affect anyone else. (29) It's my choice, my responsibility and I face the consequences. I die or I don't die from cancer. But the operator of a plant can live elsewhere and divorce himself from the effects. (32, 18) Moreover, when I drive, I know what the risks are. I know if I'm driving safely or not. With this you aren't given the information, or you can't interpret what information you're given, or you can't trust the people who've given you the information to begin with. (16, 22) We already have so little control over our bodies. Everything we eat has additives which could lead to cancer. So if I can stop an additional hazard, I'll exercise it. (13)
>
> You can't make guarantees about the future that all people will believe. Things happen to change guarantees. People would rather control the present as much as they can, not take any chances, than to gamble on losing control. This is true even if the gamble has lots of advantages. (2)

But the concern with uncertainty and loss of control does not lead to blanket rejection of hazardous waste management facilities. Guardians believe that unless handled cautiously, problems will develop in hazardous waste plants. But they also believe that safe managment is possible.

> Hazardous waste has had a bad history and now people have a lot of information as to what might go wrong. Certainly hazardous waste plants are objectionable, but they needn't be dangerous. (12) Safe plants can

> certainly be built, but it depends on how its approached. The company needs to go out of its way to insure that the community and the environment are protected. (18) If a plant were handled to my satisfaction, I would expect the risk to be reasonable, no greater or less than driving on the Mass Pike every day. Not to treat the wastes is certainly a greater risk, (22) because it leads to illegal dumping which jeopordizes lives. But when a facility is proposed, everyone opposes it. People don't believe that they already are potential victims of improper disposal. (2) So we don't really have the choice of being risk free. We just get to choose your risks. Like this old Vermont farmer a friend of mine visited. My friend took one sip of his well water and nearly gagged. Told the farmer to get it tested. The State Board of Health came out to the farm as soon as they looked at the water: the stuff was just awful. The inspector found that the farmer had located his well below his septic system and suggested he relocate one or the other. He moved the septic system, and his well ran dry. (29)

Because of this recognition that improper disposal of hazardous waste is a problem of significant proportions, guardians believe that treatment plants need to be sited. They see haphazard management as irresponsible.

> There has to be some treatment plants. Landfills aren't working. Like the state-of-the-art landfill out west. It leaked within a year, and that was with enormous dikes, double lining and monitoring. It's clear that we've got to treat these wastes because we have more and more contaminants turning up each year. (23)
>
> I know we have a problem with hazardous waste. Right now they're dumping much of it in the ocean. We have a dump 15 miles south of here. They've been dumping 55 gallon drums into the ocean for years. Just recently the papers had a story about PCBs in bluefish. We go out bluefishing. We had to give our fish away. Our business went right down the tubes. I think it was a bum steer on the bluefish. If the bluefish have this problem, so do the flounder, the pogies and the lobster. They're all taken from the same area. The pogies are taken to the dehydrating plant and then fed to chickens. If the PCBs are in the pogies, sure as heck they're going to be in the chickens, in their eggs, in cattle feed... So what are we doing with hazardous waste now? We're shipping it to Alabama and dumping it in the ocean. I think we're

> going to have to face the problems instead of sweeping them under the rug and I'm willing to do that. There's thousands of drums out there. You catch one in your nets and you just dump it back overboard. It's not a solution. (18)

Preserving the Character of the Town

Guardians think highly about their community. They wish to preserve its small town and rural character. While recognizing the potential problems of a hazardous waste treatment facility, guardians believe the problems are solvable. To most, the facility need not necessarily be detrimental to the character of the town, as long as the siting is handled with care. This concession marks an uneasy truce between the desire to keep the problems of hazardous waste at arms length and the desire to be socially responsible.

> Given our lack of industry, it's easy to say it belongs some place other than this little rural town. Most people would feel that they shouldn't get this kind of plant. It would be seen as ruining its rural character and its reputation. I have this too. I wouldn't want to live in a town with a hazardous waste plant. (22) If we had a plant, I think people's perception of Worcesterville would change. If I were looking for a new home and I had a choice, I'd stay away. (23) I wouldn't want people to drive into the town and see an ugly plant with a huge smokestack. Still, I do feel that we have a responsibility to the state as a whole. This might be part of that responsibility, but I'd want to know a lot more before I accepted it. (22)

Guardians do not talk extensively about preserving character for its own sake. They work hard to keep a perspective on what is most important. Protection of health and safety that is their dominant consideration.

> Sure, if it's an ugly eyesore, it would affect the reputation of Essexton. We're a clean, little New England town, and people know us for that. But if it couldn't be seen, it wouldn't be a major consideration. (13) So while the plant isn't beautiful, there are areas where no one could see it, (18) and under these circumstances, the biggest problem is one of perceptions, not reality. People are disgusted with the idea of hazardous waste, whether or not it actually affects their lives. Personally, I could live with it, if its safety were insured. (29) Placed alongside issues of safety, I think the aesthetics of the plant are inconsequential. The size, shape and color of the plant seems irrelevant. (32) These issues of aesthetics and the town's character are important to people because they lead such protected lives. People can get caught up in their own little dream world. They come home from work, have supper with their family, watch a little TV and go to bed. Next morning, they go into the town center to have a cup of coffee with all the local good guys and off they go to work again. It's a cycle that keeps them from having a realistic perception of what the world is really like. So any little disturbance becomes a major concern. They worry about roosters crowing and a few trucks on their streets. They have no idea about some of the problems other people have right here in their own town. I don't blame them. Maybe their better off. But for me, I count my blessings, fully aware of how fortunate I am. I don't spend too much time worrying about the small problems in my life or trying to control things that aren't part of my domain. Safety is part of my domain. What a plant looks like and whether other people will like it aren't. (2)

The tension between safety and town character shows itself clearly when guardians discuss ideal locations for a hazardous waste treatment facility.

> It should be located in a place like Acton, which already has a hazardous waste problem. The facility developers should promise to clean up the W.R. Grace problem. You wouldn't be starting with virgin land. You could increase their safety as compensation for this new hazard. (12)

> If I lived in western Massachusetts, I would want to locate the facility where the wastes are produced. Why truck it all over the state and expose everyone to the danger, especially since a truck accident is the most likely accident. (23)

> Massachusetts is a vast state. We have lots of open space, near major highways. It's land that isn't near anyone's home, land enough to act as a buffer for air pollution, explosions, spills and fires. If not in Massachusetts, then in New Hampshire. Certainly somewhere in New England. Its got to be better to put it in some wilderness somewhere. (30)

> What good is a buffer zone? If the plant works right, it shouldn't make a difference how far you live from it, except for the effluent from the stacks. Your offering a false security. A hundred yards of trees won't protect you from a mismanaged facility. Putting it in an industrial zoned area, even if it is located in an urbanized area, would be better because it wouldn't change the character of the area. The operators have already assured us the plant is safe. You can't say both that it's safe and that, just in case, we also want to put it in the boonies. (32)

Technical Expertise

Guardians do not equivocate about expertise. They rally around the belief that "technology is necessary but hardly sufficient."

> So while the nuclear industry has been the most tightly regulated industry we've ever had, it has still had many problems. The best available technology is necessary, but hardly sufficient without cooperation with the town. I've worked with solid waste for years. A regional facility was being developed in this area. The most advanced technologies were being employed to convert waste to energy. All the components had been employed elsewhere: the shredders, the grinders, all the equipment had been tested in other plants. In this plant, they were putting components together in a new way to achieve a new goal. They thought it would work, but it hasn't always. In Conneticut, a plant blew up. They used to spray their garbage with an embrittling agent and this seems to have caused the explosion. On paper, everything was the best available, and yes it should have worked, but it didn't. You need more than good technical equipment. (13)

> I was working for a nuclear engineering firm on the day of the Three Mile Island accident. They hadn't designed TMI, but they did similar work. They were absolutely crestfallen. They had done everything as perfectly as they could; they didn't know any better way

> to do it. They didn't want people to get hurt. They were human beings and felt badly. I feel like I could trust them as people, even if something went wrong. The problem was that nothing caught the problem earlier. You can't design a foolproof system. I really think you have to have faith in the people running the plant, or you're lost. Ways to improve credibility are essential, and must be designed into management. (22)

Technology is viewed as a tool which is malleable. Whether the tool works well or poorly depends most strongly on the management of design, construction, and operating procedures. It is these processes that determine the variability in physical systems. Guardians believe that by focusing exclusive attention on the physical component, risk managers miss opportunities for improving hazard control through better management.

> Reliance on technology alone has proven a failure. Three Mile Island showed that everyone tries to cover themselves until something gives. Then its too late. In Browns Ferry, a fire wiped out an entire control sector. In some plants, valves have been put in backwards. These failures are a real concern. Closed technocratic systems create problems for the community because they don't know the local community concerns and they aren't looking out for the community's interests. (29)
>
> Objectively, I think a plant could be designed and managed to run safely. The problem is simple enough. You need a container to burn things at a higher than usual temperature. However, in design, safety margins are cut for reasons of economy and management is compromised because of the need for a profit. The technology is not big deal, but (as in the nuclear industry) the steel is not choosen right, the welds aren't applied carefully, the plant is mismanaged. (32)

Through all this is a skepticism of expert opinion, a "show me" attitude. Guardians want to be able to make up their own minds, to retain their own ability to choose.

> The way I look at it, the developers would have to prove to us that the technology was capable of doing what they said. There's a fish dehydrating plant in a neighboring town that just smells awful. The town's been after the owners for 20 years. If you couldn't get better assurances that this plant wasn't going to be obnoxious, you'd get a lot of objections. We have one of these problems already. What do we want two for? The dehydrating plant problem would probably have to be solved first, to prove the technology is there. We certainly ought to be able to get rid of fish odors more easily than we can handle the problems of hazardous waste. Show us first. Get that problem squared away, and if you can do that to our satisfaction, come back and talk to us. (18)

Monitoring

To guardians, systems for monitoring the plant are essential. While they generally believe that a well designed plant need not have any problems, they are very concerned about fluctuations from the ideal. Guardians believe that the potential for hazards evolve with changes in the facility and its management. Risks cannot be adequately predicted because the conditions that facilitate hazards are in flux. Under these conditions, the information that is of greatest use is not predictive data, but detective data. By noting changes in the flux, guardians feel confident that hazardous conditions can be detected and ameliorated before mishaps occur.

> The best of today's technology can have problems. You need monitoring because if the technology you put in today is not as good as you think, you can find out. (12)

The technology of monitoring is of little concern to guardians. The value of monitoring comes not from the collection of data, but from its use. Monitoring that is done by the company is subject to the same vagaries as prevention set up by the company. Such monitoring does little to reduce the perceived risk because the monitoring is not an independent check. It is just as likely to go awry as the technology itself if the same management controls both. Independent monitoring, on the other hand, encourages management to operate the technology in such a way as to reduce hazardous conditions. What was once a standard operating system becomes a feedback loop, with opportunity for learning and change.

> Any activity that is opened to scrutiny is less likely to be managed irresponsibly. (32) If monitoring is effective, spills will be minor. You can stop problems before they go too far. But someone needs to be scrutinizing the results of this monitoring. We don't need joint management of the day to day operations. After all, the company knows how to manage these processes best. But a company owes it to the people who live in the area to level with them, to shoot straight with them. This doesn't seem to be the practice of many companies. If they can't correct a problem, they hide it. (18)
>
> I like the monitoring being done by Pollution Control. But that's great. The company collects reams of data and as far as we know they sit on it. Is anyone going to analyze this data and make changes? (23) And figures can be manipulated so easily. What one person holds to be safe, another person reinterprets as a hazard. I have a friend who is very high up in Grace Chemical. I'm sure if I lived in Acton, I would have been one of those citizens protesting against Grace's chemical storage policy. But I listen to him, and he doesn't think Grace has done anything wrong. He's very upset with the citizens of Acton. (30)
>
> The problem is that you never know what's going on. I used to live within a half mile of the Vermont Yankee nuclear power plant. The managers of the plant sent us all kinds of material, but I didn't know what it all meant. We were disappointed with a lot of things we found out through other avenues, though. They weren't doing a lot of studies they said they would. (16) A company like this can monitor everything, but if they sit on the results themselves and there is no link to the public, then that doesn't do us any good. When those pollution levels start rising, they'll still be sitting there monitoring away. Without citizen input, they may not set about to correct the situation. (22)

The problem, therefore, is to design a system to allow for scrutiny on an ongoing basis. Guardians consistently promote a program of independent monitoring to be done by a locally hired engineer and coupled with agreements on acceptable levels of emissions.

> The planning of this type of facility requires a high level of expertise. The town needs an advocate with an appropriate background. (32) He should provide outside monitoring, a voice who can say "close down" or "do this" without fear of losing his job. (23) We also need a locally based system for monitoring safety data, how the plant is operating, groundwater quality, and air quality. We'd need to set standards before the plant is even built. If they went over the limit, that would be that. (18)
>
> We can't rely on federal standards. The EPA comes out with standards, and then changes them. The Clean Air Act may not make it again. All of a sudden, the plant you thought was clean has more emissions. Standards have to be set beforehand so that there is no way emissions can increase, but rather can only decrease as technology gets better. This would be part of the negotiations. (23) And if the plant exceeds the standards to which it has agreed, it should be shut down to correct the problem. Every few years, a review process could examine what's going on and how the state of the art has changed. In this way, we ought to be able to anticipate almost all problem scenarios. (32)

Risk Management

To guardians, the essential problem of hazardous waste facilities is the trustworthiness of its operators. While physical systems of technology form the essential underpinnings of risk management, they are generally not the source of greatest variability. Differences between good management and bad management are seen as producing much more variability than differences between technologies. Two reasons exist for this emphasis. The current system for regulating technologies is seen as preventing truly bad technologies from being used, and good management is seen as the basis for selecting good technology. To guardians, trust of management is based at least as much on its perceived motivation and intentions as on its perceived expertise and ability.

> Why give advanced technology to an idiot or someone who would misuse it? It won't be used appropriately. I'd rather give average equipment to a good competent manager. You can't get away from the problem of human interests and human abilities. All technology must be managed by people who either act competently or not. (2)

> I really think that all you have to do is read the newspaper, and you know that you have to be skeptical. We just have to be if we're not totally naive. We've gotten to the point that no matter who tells us something is safe, we ask for proof. This is getting worse and worse. The League of Women Voters' studies show that it's become much more difficult to convince people. Why should we believe anyone? In the midwest, a new hazardous waste landfill, complete with double lining, leaked within years of start-up. I'm sure that it was presented as safe to the town in which it was built. I'm afraid that American business doesn't have that good a reputation. They're too concerned with stockholders' profits. If I really trusted that they would be forthright, then I would also feel that the plant would be run safely. (30)

> I've seen engineering consultants we've hired come to town meeting and just be run out of town. They're perfectly competent, but people just didn't trust them. They had no real connection to the town. (22) It's even worse when you talk about outside corporations. We're really skeptical of big companies coming in and saying this is the best thing. I'm a supervisor at an industrial plant that uses large quantities of sulfur, mercury, asbestos and similar substances. They don't always deal with a full deck. Big companies don't always tell you everything. I wouldn't trust a plan I didn't help create. (18) The credibility of the plant being built the way it should be without corners being cut is questionable. The company that builds this isn't in it for the crusade of safe waste management. They set it up as a way of applying their knowledge and capital to turn a profit. Their priorities will never be those of the community. (32) Because of this basic difference in what the company and the town each consider important, there

> would have to be a lot of trust established. The people running it would have to really sell themselves as competent and responsible. If that could happen, then the rest becomes possible. (22)

Guardians believe that a risk management policy that does not share decision making powers is not reliable. The sentiment is nearly universal in this group.

> People are afraid of hazardous waste because of past experience. Love Canal, Woburn, gasoline being dumped into deep wells. Unless you can develop reassurances that this can't happen, people won't accept the chance. And the only assurances people trust are the ones they help create. They need to be right in on the ground floor. A company can come in with a superb plan using the best technologies and the most advanced methods of disposal and everyone will walk away from it. The people who are going to be living with the thing from day to day haven't had an opportunity to give input. People are gun shy. If they don't help create the solution, they see it as someone else's problem. (18)
>
> These national companies and state government tend to be less personal. They look at us as numbers, towns, groups. We're not individuals. But here in our own town, we're concerned with our families and their lives. We're more diligent. And while we have a freer and hotter exchange over issues, our politics are less easily manipulated. That's why I'd rely on strong citizen involvement. We're not experts, but we care. If we tried to keep the plant safe, even if an accident did happen, I'd feel better. I wouldn't feel so much like I was being indiscriminantly dumped upon. (13)

Not only do guardians see incompetent and poorly motivated management as promoting the risk problem, but they also believe that with good management, risks can be greatly minimized. Guardians believe that it is possible to cope with the risks of hazardous waste treatment plants, and that the most effective avenue towards this end is through effective management.

> I prefer to rely on people who believe in cooperation with the community more than on technical systems if I must make a choice. (22) If management is open and above board, they can handle the problem. The technology is there. Even if you can't predict exactly what would happen, a good company can adapt technology when needed. But if they're going to hide their problems, if they aren't going to tell the truth, no way do I wan't to have anything to do with them. If you can't have confidence in a company, if you have to put a lot of constraints on them, it's not worth the risk. (18)
>
> The plant could be extremely risky if not properly managed. Even if carefully managed, I would expect some mishaps. I look at the East Bridgewater resource recovery plant, which was supposed to be very well engineered. That blew up. There are going to be accidents in a plant like this, not necessarily disasterous ones that will affect people outside the plant, but accidents nonetheless. I think there needs to be fairly heavy bonding or insurance that can be easily reached so that problems could be dealt with forthwith without years of litigation while the problems spread. A small hot area is much easier to clean up. With the right action, problems can be contained. The problem is to make sure that the "right actions" can be taken quickly. (29)

The problem is not so much "what should we control?" but rather "how can we design a sharing that accounts for our mutual strengths and weaknesses, and properly balances responsibilities?" Guardians are very aware of their limited abilities and powers.

> What really worries us is that we've all been on town boards and seen situations where we were powerless. When the Conservation Commission tried to impose stricter standards for development on soils that were inadequate for good septic system operation, the state reversed our decision. Within two years of occupancy on such a site, the septic systems of the homes were leaking. We find something that needs to be done, we work hard to do it right, and we're overruled. I would hesitate on taking on any responsibility for the plant unless we could both obtain the expert assistance necessary for intelligent decision making and we were assured of having a meaningful voice. It's scary to have responsibility without a real ability to effect safety. If you don't know what your doing, if you miss something important... (23) To site a hazardous waste plant, you need a lot of people who are unbiased and really concerned with humanity.

> That's hard to find. (30) But even with these difficulties, I would want to retain sufficient authority to protect the community. While it means also increasing our liability, it seems the only responsible path to follow. (2)
>
> For the company to really build up a relationship with the town, it would have to offer some real control over choices. That takes a lot of faith on the part of the company, a very positive attitude on their part. The usual game, where the company offers as little as possible and the town wants as much as possible, doesn't work. But the alternative will not be easy, for either the town or the company. (22)

The difficulties of effective power sharing, however, do not all lie in the availablility of expertise nor in the balancing of power between the company and the town. Deep concern exists over the capacity of the town to handle anything this complex. Both the structure of town governance, and to some extent the trustworthiness of elected officials, are questioned.

> Small insignificant nonsense consumes a community like this. People worry about crowing roosters and banning truck traffic. They and their government would have a great deal of trouble in handling anything this complex. It would be virtually impossible to do anything constructive in a town meeting on a topic as big and as controversial as this one is. I'm not prepared to suggest an alternative, but the problem is there. (2)
>
> Even our elected officials have little power to act independently. People suspect your intentions as soon as you get elected. We tried to sell the old fire station for years. Everyone was so afraid that if they gave the selectmen permission to sell it they'd do something horrendous. Unless you could find negotiators from the town that would be absolutely trusted, you could never manage anything this complex. (22)

To facilitate better management, guardians rely almost exclusively on systems of joint policy making and clear lines of responsibility in which the facility operator is given free reign within the general policies established jointly. The objective is to provide incentives to both the operator and the town to act responsibly, while recognizing the expertise and interests of both.

> We can do without them, but they can't do without us. And so we have the upper hand. Until there's some competition among towns wanting hazardous waste plants (laughs), I think we could take advantage of our position. The advantage I would want is to have authority, to have a say over things. My responsibility is to protect this town, and it is the plant operators duty to make the changes necessary for this to happen. (22) It is important for the town to retain this authority for controlling the safety of a plant, but the responsibility of running the plant should be left to the plant managers who do this for a business. A citizen safety committee should focus on safety policy, the company on fulfilling their responsibility in meeting these standards. (2)
>
> I don't like government involved in business any more than necessary. We needn't be involved in the day to day operations, but we do need to know what is going on at all times, have the capacity to respond rapidly in a crisis and have the power to close the plant if they don't follow the guidelines or meet the standards. (29)

Within these systems of management, guardians look for a way of holding the operator accountable. This concern for accountability leads them to couple detection systems with promises contingent on particular problems being detected. Given that not all problems can possibly be predicted before operations begin, guardians also look for ways of resolving future disputes between the town and the operator.

> The exact conditions under which the citizen board could close the plant down need to be spelled out before hand. If problems are thought out and response scenarios are written, then there should be few problems determining who is responsible for what in a crisis situation. (13) To hold them accountable, we would need to hire an engineer who would have full access to the plant and its operations. (16) If there's a problem that hadn't been foreseen and we disagreed with the facility manager, then we'd need to call in some experts and hanker this thing

> out. Periodic reviews could be used to figure out if problems are developing. (29) If something new comes up that has to be dealt with quickly, the plant manager should take care of it. But after that first time, a community group would need to meet with the managers to decide how to correct it in the future. If they disagree, a board of arbitration would have to be created to settle the problem. (13) It probably wouldn't be good for the town to have the final say in these situations of disagreement, since we may make decisions that are neither in our interest nor that of the company. The accountability needs to be balanced with the competence of trained personnel. (16) And one good way to promote caution on the part of the company is to require that all employees and managers of the plant to live within one mile downwind of the plant. It would then be in their best interest to keep the plant clean. They'd have families at home to worry about. (23)
>
> I would also like to see very stiff penalties for violating agreed upon guidelines. I'd like to give them leeway to run the plant, but if something goes wrong because of poor management, they'd have to pay out. If an accident occurs because of honest mistakes -- mistakes which they should not necessarily have known about ahead of time -- that's one thing. But if they take short cuts or bring in materials the plant is not equipped to handle, they should be heavily penalized. In the same light, the town should take responsibility for its own actions. If it does something that impinges on the plant, it should be equally liable. (29)

In general, guardians see monitoring of management and technology as needing to exist at the local level. The state is seen as an unreliable partner in the process of regulating hazardous waste treatment facilities. While holding power, the state is slow to act and frequently has its own agenda, an agenda that is not consistent with the interests of the town. Guardians see the present system as politically motivated. Only with political pressure can the state be forced to act responsibly.

> The state should have an agency to check the functioning of these plants, but I frankly haven't much faith in the state government. I've seen departments riddled with appointees that do not serve the towns. This

> bothers me very much. But if your local watchdog committee knows these regulations and is monitoring the plant, to me the state regulations could be made to work. With enough kicking and screaming and with citizen actions to bring these things to light, problems are usually solvable. It's always a hassle. But if we stand up and take responsibility for our own lives and do not accept something which we feel is irresponsible and dangerous, the state eventually backs down. (13)
>
> The state isn't always reliable. Sometimes they're in cahoots with the developer and sometimes they just don't care. But if the community was monitoring and could show that the facility was spewing pollution outside the tolerances set up, the state would have to respond. (18) If you make enough noise, and ring the bell loud enough, I think the state would act. (22)

III. The Perceptions of Preservationists

By valuing stability, a traditional life style, and control over their own environment, preservationists make conditions that almost no hazardous waste treatment facility could fulfill. It is not so much the absolute level of risk that concerns them, but the uncertainty of effect and loss of control. They perceive the risks of hazardous waste treatment facilities to be unpredictable and focus on the potential for disaster.

Jeffery expresses this idea quite clearly. As an architect, he works in downtown Boston. Daily he fights traffic along overly crowded highways in his long commute. From his twentieth floor office, he overlooks all of central Boston. At night, he returns home to clean air and open space. He loves the nearby ocean and the small town amenities. He has lived in Essexton for 20 years, and expects to die there. When we talked, he was clear and direct:

> There's no real benefit from this; it's just a question of degree of nuisance. But we don't really know very much except what we read in the paper. It's like the atomic bomb in Japan: we know its horrible and a potentially disastrous thing for a community, but we haven't been directly confronted with it. We haven't had to raise our children with this thing festering in our community. Unless I was absolutely convinced that nothing could go wrong, I wouldn't even consider it. (21)

In their attitudes, preservationists almost invariably stand between the extremes of guardians and sponsors. This middle ground is achieved not so much by agreement among preservationists but rather by averaging a wide range of opinions. There is little that binds preservationists together except their strong sense that a hazardous waste plant would not be worth the risks. Some would not accept a facility because the risks are so significant. Others are more concerned with preserving the rural and pastoral qualities of their communities.

There is, however, one set of attitudes which set preservationists apart. All sponsors and guardians believe that if detected quickly, hazardous waste mishaps could be contained and health and safety protected. In stark contrast, no preservationist trusts these detection and mitigation systems to be effective. (see Figure 4.1) This general pessimism over being able to control future problems pervades much of preservationist thinking.

Perceptions of Risk

To preservationists, small town life is a healthy life. It is life without the risks of larger technological centers, life that is safe and comfortable. To some preservationists, the risks of hazardous waste treatment are enormous. They speak of holding back the chemical world which threatens to pour out into their community.

> We're not so dumb as to allow hazardous and deleterious chemicals to enter our community. We are on the edge of ruining our towns with wastes that we've largely ignored in the past. We're about to lose our environment. If a company can't get rid of its wastes at the source, we shouln't allow them to just pass the problem on to others. It's not fair. We should design technologies that won't make other people take care of industry's problems. We are in danger and it's very serious (31, 28)

Most preservationists do not have this zeal. To them, the risks of hazardous waste treatment are uncertain and unwanted. These risks disturb the security of the home, threaten what is perceived to be a safe haven. In the absence of any critical reason to take these risks, preservationists react by holding to their ideal of a rural, healthy community.

> People who live here are concerned with health and safety. The air is good, clean. (4) The risks we have now, they're like day compared to the night of hazardous waste risks. Our way of life is slower, more relaxed. Our risks are relatively low level and minor, this treatment facility could be catastrophic. (1)
>
> Like 95% of Worcesterville, I say "Who needs it?" It's not critical to my life style. It's not critical to the economy of the town. Why take the risk? I think of myself as intelligent. I do my risk taking when I have to. I must drive to be gainfully employed. But I don't have to live near a hazardous waste plant. (6, 20)

<u>Preserving the Character of the Town</u>

When confronted with the possiblity of a hazardous waste treatment facility locating in their town, preservationists react emotionally. The question "what would a plant like this do to the character of our town?" raises as much concern in some individuals as do questions about potential health hazards. Concern over the character of the town is paramount to preservationists. Hazardous waste raises concerns about loss of control over local and personal decision making. The outside impinges in on a familiar and well loved home. To preservationists, a hazardous waste plant would be a great loss, one to be grieved.

> Our community would never tolerate a plant like this. (28, 24) The most important consideration is the sheer size of the facility. Essexton has almost no industry; this facility would change the community completely by converting a large area into industrial use. (1) If I lived in an area that produced hazardous waste, I'd feel different. I'd have the benefit of the producing industry and of proper disposal. I don't think any rural area that doesn't have these industries would want the disposal plant. It wouldn't fit in. It's a four story structure with an even higher smokestack. This is much larger than what now exists in Essexton. (4) Once this facility was built, you'd never get rid of it. If one incinerator goes down, they'd build another one on top of it, perpetually. We can't accept such changes. (31) And we've resisted them before. There's been a lot of proposals for the undeveloped area of Essexton -- bomber bases and missile silos. Nobody can leave a great wilderness tract alone. The idea of hazardous waste going there would be absolutely heart-breaking and fought tooth and nail. It's an asset that is irreplaceable. (21, 1)
>
> It would detract from the beauty of this town, which is why people live here. I'd gladly pay whatever it costs to keep what I enjoy. By myself, I can't buy all that I enjoy from what Worcesterville collectively offers, and I find the suggestion of such a plant to be absolutely distasteful. My neighborhood would be trashed. (20) You know what would happen if you sited this here. People would leave. Worcesterville would become an extension of its more industrial neighbors. You'd have a community that would want to cater to this facility. You'd lose Worcesterville as it is now. (24)

Technical Expertise

Preservationists are of two minds: those who think the risks of hazardous waste are just so unpredictable as to be unacceptably risky, and those who wish to preserve the town from hazardous waste for reasons other than health risks. This latter group has some of the same ambivalent acceptance of technological solutions as do sponsors:

> I would have confidence in the engineers and consultants to decide when the plant is safe enough. (4) I'd want them to use the very best equipment; human beings would have less opportunity to mess it up. How could Mario Andretti win races without the very best car? (20) But after you have the best equipment, you don't just start it up and ignore it. The piece will eventually fail, it has to fail. So you need monitoring to tell you when the piece will fail. (6)

> I believe a strong body of scientists, engineers and experts should develop and promote a solution. The state should then just go in and build it. No questions asked. This is one of those times when an authority figure stands up and says, "I know what's best for you." (6)

But most preservationists find the technical aspects of risk management to be frustrating, exactly the kind of problem they guard against having to confront in their town. The technical problems of hazardous waste treatment requires continual vigilance and poses potentially unresolvable questions. As such, they are to be avoided.

> Accidents aren't suppose to happen, but they do. We bought the recommendations of an engineering firm hired to design for us a sewage treatment plant. It doesn't work. This is the applied arts. They are not precise, and they don't always work. It's like a dog chasing its tail. It's an imponderable. We need the technology to do the job, but this won't happen until new systems are designed and tested, and regulations are in place. Government relies on industry to figure out a solution. Industry waits until it has to act. Now it may be too late. Nothing's been solved, and you can't trust either government or industry anymore. I might have been a little more trustful if the EPA had been allowed to exist as a beneficial overseer of environmental quality. Everyone in Washington should be run out of town based on this issue alone. Nobody's looking out for us. We're being dumped on. (31)

> I think I could live with the threat of a hazardous waste plant, but I worry about my children. I don't think there is any substance in the world that can keep wastes from permeating into the ground. Water is a universal solvent. I'd like to think that technologists know what they're doing. Maybe they could contain it for 20 years, but eventually the stuff would leak out. Incinerators are worse than landfills. They're terrible. Air pollution is immediate. You breath it, and you just don't know what it's doing to you. (24)

Monitoring

Like guardians, about a third of preservationists value monitoring as a tool of risk managment. Under the circumstance that the company could not be prevented from building in their community, monitoring at least provides a means for knowing what the company is doing.

> Anything that humans handle has the possiblity of error. We have so many unknowns. So many things are not a science; they're an art. You're dealing with the judgements of humans. You need to protect yourself with safety factors, but you also need to monitor and watch what is happening even more. But constant monitoring locked in a back room is useless. You need exchange of information and input into what mitigation measures are being taken. (1) The town engineer ought to have the right to shut down the plant if very clear and precise guidelines, specified prior to the opening of the plant, are not being met. (24) By anticipating problems in this way and cutting them off through surveillance, we do a service to our community. (1)

> I was the only one in my group that wanted the high technology option. But it's more than just good equipment. I was looking for checks and balances. Everyone knows that companies can come in with sophisticated equipment, but they don't give a damn once its there and the thing falls to pieces and there is no way of knowing what they're doing and no way of controlling the consequences. Monitoring is fine, but if it's all in-house it won't do me any good. We would need access to it. I would look for the best equipment, some transfer of information to the town on an ongoing basis, and a way of controlling the plant if something goes wrong. If they exceed certain limits, the town should have the right to

> close it down. Also, some method of arbitration would be needed, since the town might have no way of knowing now what might be objectionable later. (21)

But most preservationists want as little to do with the facility as possible. Monitoring, they believe, is a sham. They perceive that the town is powerless to alter the actions of a developer in any meaningful way once he has siting approval. Monitoring is of little use under these circumstances.

> Promises are easily made. I spent eight years on the planning board watching developers come in and say whatever they thought would most aid their cause. The mechanisms to hold them accountable are just not very satisfactory. Eventually they all end up in court. It's such a long drawn out approach. So developers feel free to take short cuts, knowing that there is little we can do. (20)
>
> Small communities can't stand the pressure of a company if its in concert with state government. Once something like this was sited, what could we do? We'd withdraw and become distrustful. (1)

Moreover, even those preservationists who support the use of monitoring do not believe that it will provide effective control. While all sponsors and guardians have neutral to strongly positive attitudes about the effectiveness of monitoring, the attitudes of all preservationists are neutral to strongly negative.

Risk Management

Like guardians, preservationists are deeply concerned with the trustworthiness of management. But unlike them, there is widespread pessimism that any system would improve the situation. By emphasizing the virtue of preserving the existing quality of life, preservationists are naturally pitted against people who seek to alter that way of life. There is little common ground on which trust might be built.

> A developer is an outside guy who comes in to cheat you. We need a situation in which no one stands to gain by cutting corners, one in which the efficient manager types were in control. I don't see that this is possible if a private corporation is the owner. (28)
>
> I like the idea of private enterprise. It's the American way. It has its own checks and balances due to competition. But things like this, certain corporations will have monopolies. Big corporations will own little corporations so that everything will be run by really large corporations. That's not my idea of capitalism. If they're going to do that it may as well be publicly owned. But the government has a track record of notoriously screwing up, be it by excess paper work, lack of committment, mismangement or what have you. So its six of one, half a dozen of the other. (24)

Moreover, preservationists feel at a disadvantage relative to the perceived power of outsiders. They feel their town is small and inexperienced in the ways of large industry. They feel vulnerable.

> There is no way that Essexton could participate effectively in this process. Residents here can't sit down, discuss problems and come to agreemnt about things which are essential to the town. They're too fragmented to work together. This issue is peripheral to the town. You would have non-professionals dealing with professionals, and a community which wouldn't be able to agree. No middle road could develop. Part time government can't handle this because its too complex. County, state and to some extent the federal governments can't make it work because they're too political. I have no faith in them to do what is good for my community. (1)
>
> I don't know that there is anyone in this community with enough expertise. I don't trust anyone anyway, so... (24) The more I thought about it, the more I realized that what control Essexton would have over a facility like this would be relatively minor. Co-management is more of a smokescreen than real power. Local control is great, but if there is a problem that exists and we can't get the problem corrected, then the community is also at fault. If I had to take this plant, I would rather limit the community's liability. Give the experts in the field the responsibility. Let them run the plant, knowing that if they make a mistake, they would be liable. (4)

Preservationists have little basis for hoping that management could minimize change in the community or limit what appears to be an impossibly compex risk. For most preservationists, there is therefore little advantage in improving management. Instead, preservationists talk generally about the virtue of openness. They avoid connection and cooperation with the facility operators, feeling better about maintaining an arms distance from a company they recognize largely as an adversary.

> Credibility of management is a third of the problem. If they play games, they'll lose it. They need to play straight, tell us the facts, and let us work together. (1) The developer needs to present their case with its deficiencies, in a straightforward way. Seventy-five percent of a developer's problems come from their holding back on problems that other people later ask them about. People get to wondering what else they are holding back. (6)

> Trust isn't built by a company telling us not to worry. The company has to lay it all out on the table. They've got to recognize us as a community that likes what it's got and would like to keep it that way. (21)

> The industry needs an insurance system or a pooling of resources to make sure there is enough money to cover corrective action. It's not the responsibility of government to bail out industry if they have a problem. The industry should stand on its own two feet. If you make it expensive for them to make a mistake, they aren't as likely to make one. (4)

This attitude is not quite universal. A quarter of preservationists concede that if forced to accept a plant like this, they would want some control over the plant.

> Local participation seems important as a check against the excesses of the company, to make sure they're not cutting corners. At the level of policy, we can develop checks and balances. But we needn't get involved in the day to day affairs of the plant. Open covenants openly arrived at and enforced is what I'd look for. (28)

IV. The Variety of Experience

In Essexton and Worcesterville, we have uncovered three distinct patterns by which residents perceive risk and evaluate the acceptability of those risks. Sponsors perceive the risks of hazardous waste treatment facilities to be relatively minor, generally support economic development, and believe that expertise can effectively employ technical analysis and preventative technology to control what risks remain. Guardians perceive the risks to be significant but potentially controllable, wish to protect the quality of life in the community without foreclosing change, and believe that technical expertise is necessary but hardly sufficient for effectively controlling risks. They strongly promote systems for detecting and mitigating hazards coupled to systems for holding management accountable and responsive to community concerns. Preservationists believe the risks to be unpredictable, generally oppose any development that changes the character of the town, and are frustrated by the ambiguity inherent in the use of technical analysis and prevention technology. They are skeptical about the value of systems for monitoring or for holding management accountable. They feel powerless to control the future should they allow a treatment facility to be sited. In the face of this uncertainty, they prefer to exercise control over the present by denying permission to site the facility.

These three groups each included approximately a third of the participants in both Essexton and Worcesterville. While this rough equivalency cannot be said to exist throughtout the community, it does suggest that each of these groups will be a significant force in the local politics of facility siting. At this point, we can speculate that unless sponsors are motivated to actively promote the proposal, the concerns of guardians for risk and safety are ameliorated, and the opposition of preservationists is minimized, a proposed facility will face stiff opposition from local residents. In a strategy for siting a facility which seeks to engage each of these groups, the nuances in their perceived risk must be carefully considered. In the next chapter, the dynamics of their risk perceptions are explored, followed by a chapter on the design of risk management strategies that account for these dynamics.

Chapter 5

The Dynamics of Risk Perception

The hazardous waste management industry and public regulators have argued that much of the opposition directed against hazardous waste treatment facilities is a consequence of misperception. Evidence that individuals perceive risks differently from experts is seen as evidence that lay perceptions are inaccurate. By this logic, public risk management policy ought to be based on technical assessments and solutions, and lay perceptions should be heavily discounted when they diverge from expert perceptions.

Policies promoting technical solutions and attempts to alter lay perceptions through education have consistently failed to reduce local opposition. Each of the patterns of perceptions demonstrated by sponsors, guardians and preservationists differ from technical perceptions in significant ways. Moreover, while sponsors are willing to entrust decisionmaking to experts, most guardians and preservationsts are not. They acknowledge expert opinion, but consistently frame the problem of risk in social and political dimensions as well. They do not think probabilistically, but rely on broad classifications and generalizations.

This chapter examines the dynamics of these differences in risk perception. Two aspects of perception are given particular attention: (1) the intellectual and cultural frames used to define risk; and (2) the cognitive and social processes used to evaluate risk. This chapter argues that laypeople, particularly guardians and preservationists, evaluate risk using characteristics generally not included in the analysis of technical experts. Risk perceptions are very sensitive to the characteristics used by both lay and technical publics to frame which hazards are to be considered most significant. Moreover, the process for inferring the probability of future events is systematically simplified, most noticeably by laypeople but also by experts when they assess highly uncertain futures. Together, these differences in assumptions about what characterizes a significant risk and in processes for inferring the levels of those risks lead to differing perceptions of risk. This chapter compares these differences, and suggests that (1) attempts to use public education to alter lay perceptions typically ignore these fundamental differences and hence lead to stalemated policymaking, and (2) acknowledgements of lay perceptions as valid reflections of deeply held values provides a basis for dialogue that could lead to more effective risk management policy.

I. Frames for Defining Risk

Risk analysis, as currently practiced, is designed to evaluate the potential hazardousness of an object or technology. Technologies are emphasized because the predominant cause of hazards is believed to be physical processes that go awry. By predicting the probability of system failure, and engineering ways to reduce those probabilities in particularly vulnerable subsystems, the analyst uses specialized skills to manage risks. At the same time, the analyst has framed the problem of risk in the language and interests of his or her specialization.

Risks are widely presumed to be objectively determinable and causally related to physical systems. In Essexton and Worcesterville, many sponsors hold this view. A number of corollary conclusions are implicit in this framework for understanding risk. When perceptions held by the lay public are inconsistent with specialists, it follows that they must be less accurate. When laypeople make distinctions that cannot be sustained in analysis, it follows that their assessments must be biased.

An alternative view is possible. Guardians and preservationists are not simply lay statisticians using faulty analysis. Rather, they offer a coherent framework for understanding risk and its management, one that supplements the frame used by technical specialists. The frame is a useful supplement to the one used by risk analysts.

In light of the high degree of uncertainty that exists in our understanding of the potential consequences of hazardous waste (as discussed extensively in Chapter 2), the risk analyst's assessments are themselves at least somewhat subjective. More importantly, most analysts employ physical indicators of risk that define and limit what is considered important and worthy of attention. The definitions chosen are physical: the expected number of deaths or expected increases in the number of tumors, for example. These definitions of risk are not generally shared by laypeople. Laypeople place greater emphasis on extreme outcomes, potential catastrophes, and uncertainty, and less on actual numbers of people killed. They are concerned more with maintaining normality and control over their futures, of avoiding "unnecessary" death, than they are with avoiding what they consider to be natural processes of living and dying. They therefore attend to some dangers that technically trained specialists ignore, while hardly considering other hazards with high levels of technical risks. Similarly, they design risk management systems that control sources of variability which technical specialists fail to consider. In this section, we examine the ways that technical and lay publics frame their understanding of risk.

The Subjectivity of Risk Assessment

Predicting future events has never been a reliable profession. The unknown future is a central feature of most consequential decisions. But not all futures are equally unknown. The behavior of certain random variables and many causally determined variables are well understood. While the consequence of a particular event remains unknown, the distribution of possible consequences does not. The expected distribution of possible outcomes is generally shared by most observers and is predictable. People gamble, buy insurance, build bridges and drive automobiles with some assurance that the potential outcomes are predictable and part of the human experiential base of knowledge.

On the other hand, the probability distributions of many events are themselves unknown and subject to significant disagreement. Under such conditions of uncertainty, decision strategies which depend on discovery of a reliable probability distribution of events may prove futile. This distinction between levels of uncertainty is based on the types of information available about the potential consequences. Highly certain estimates are based on reliable probability distributions, while highly uncertain estimates exist in the absence of reliable distributions.

An original distinction between objective and measurable "risk" and subjective and non-measurable "uncertainty" pioneered by Knight in the early 1900s (Knight, 1921:233) has become less clear since the inception of Baysian probability. The two insecurity concepts are sometimes used interchangeably. Arrow (1974:3) defines risk as the subjective uncertainty of consequences, thereby removing all distinction. This definition presumes that all probabilities are subjective and that some knowledge is applicable in even the most "uncertain" situation. The boundary between subjective and objective uncertainty therefore cannot be strictly delineated.

Like many other phenomena, some consequences of hazardous waste treatment facilities are too unique to be estimated by observation. Risk analysts have consequently developed theories to structure and give form to their estimates of these rare events. The validity of these theories are largely untested. Under these conditions, new information is likely to have important implications for estimates of risk. Choices for political action must therefore be based not only on valuations of consequences but also on relative beliefs in the occurrence of different states of the world. We have what Rowe (1977a:17) calls descriptive and measurement uncertainty. New information could have a significant effect on the estimates of risk when these levels of uncertainty are high. These estimates are not objective descriptions of reality, but subjective interpretations of experience.

Annual Mortality as a Technical Measure of Perceived Risk

Consider a survey in which individuals are asked to judge the relative "riskiness" of activities (such as skiing or driving) and technologies (such as nuclear power plants and liquified natural gas facilities) without specifying any particular measure of risk. Technical experts almost invariably order risks by the best available estimates of annual fatalities. Based on the strength of this correlation, Slovic and colleagues (1982a) concluded that technical specialists viewed risk as synonymous with annual fatalities. This is in keeping with prescriptive models of engineering risk assessment. To analysts, risks ought to be a measure of an unwanted consequence (in this case: death) over a given period of time (annual frequency). Implicit in these measures of riskiness is the presumption that all risks are equivalent in as much as their expected outcome is the same and that risks can be ordered by these measures of expected outcome (Rowe, 1977a; Lowrence, 1976).

When laypeople are similarly asked to judge the "riskiness" of an activity, their orderings vary considerably from that of experts. This inconsistency is frequently seen as evidence that lay perceptions are inaccurate. If risks are viewed as a straightforward consequence of hazards inherent in physical systems, then the inability of the lay public to discern these risks stems from their lack of proper training or their unfamiliarity with the facts. Under this assumption, however, we would expect that the poor performance of laypeople at estimating risks is caused by their unfamiliarity with death statistics. This, however, does not appear to be the case. While laypeople typically overestimate the absolute frequency of rare causes of death such as botulism and underestimate common causes such as stroke (Lichtenstein et al., 1978), they correctly rank order these causes of mortality by frequency. In light of the respondents' unfamiliarity with death statistics, this itself suggests a general sensitivity to causes of death. Given that laypeople have the skills to estimate risk in the way of experts, why do their estimates differ so radically under some conditions?

Variability as a Measure of Risk Perceptions

Studies of business investments, gambling, and insurance suggests that laypeople make unique estimates of risk because they are as concerned with variability (what is the range of potential outcomes?) as with expected value (what is the most likely outcome?). A number of psychologists have developed models of risk that explicitly incorporate these concerns with variability. The "variance/expected value" theory of Pollatsek and Tversky (1970) and Coombs and Bowen (1971) incorporate measures of expected value and the variance in a model that accounts for the relative importance of these two factors to individuals. The "portfolio theory" of Coombs (1975) and associates (Coombs et al, 1960, 1970b, 1970c; Pruitt, 1962) postulates that individuals change their preferences for variability with different levels of expected value. Risk is subjectively estimated as a function of the range of outcomes, probability of extreme outcomes, variance, and expected value. Likewise, risk preferences are based on subjective valuations of these variables. According to this portfolio theory, for any given expected value, preferences for risk are single-peaked. As the risk of lotteries either increases or decreases, the individual likes them less. A little risk is preferred to a dull certainty or a frightening gamble.

These, and parallel theories developed by Huang and Krelle (see Schaefer, 1978), describes the behavior of individuals in betting games more closely than engineering analysis. People have been shown to exhibit preferences for certain probabilities (e.g., Edwards, 1953, 1954a, b, c), for certain levels of variance (e.g., Coombs and Pruitt, 1960; Lichtenstein, 1965; Slovic, et al, 1968b), and for certain degrees of skewness (e.g., Coombs and Pruitt, 1960; Lichtenstein, 1965). Variance preferences are particularly strong; individuals are willing to give up a considerable amount of expected value to achieve a preferred level of variance. Probability preferences may be equally important (Edwards, 1954c).

All these studies are based on betting games with monetary pay-offs. The models are based on single person games in which the risks are small. These characteristics, and the absence of empirical data to differentiate among the various theories (Schaefer, 1978:22-24), makes the generalization of quantitative results difficult. Qualitatively, however, perceived risk is systematically linked to dispersion of outcomes and variability, not just to measures of expected outcome.

Variability and Extreme Outcomes in Large-Scaled Risks

When risks are capable of affecting large-scale social networks, the importance of variability is accentuated. The sources of variability are many. We have what Vlek and Stallen (1980) call "ambiguity of seriousness" and "ambiguity of probability." Both the range of consequences and the predictability of their likelihood are highly variable.

The attempt to uncover the determinants of risk perceptions in real life situations was sparked by the work of Starr. Starr (1969) held that historical data on fatalities and benefits could be used to reveal existing social preferences for risks. By his analysis, the public is willing to accept voluntary risks roughly 1000 times greater than involuntary risks and that the acceptability of risk (as measured in fatalities per person hour of exposure) appears to be crudely proportional to benefits (as measured in dollars per person involved). Applying these figures to nuclear power, Starr calculated that the cost of repairing a damaged nuclear power plant is a more demanding safety constraint than that of social acceptability. By his estimate, economic considerations for protecting capital yielded a safety factor 40 times more stringent than those applied to coal burning electric generating plants, the risks of which society clearly accepted. What this said about public opposition to the risks of nuclear power is hard to fathom, but the technical community generally received the paper with interest. By reducing complex, esoteric phenomenon to a simple index of preference, Starr had opened the way to applying engineering analysis to national risk management decisions.

Starr's work had several difficulties. Risks that are "involuntary" tend also to be ones that could potentially produce catastrophic consequences, are inequitable, and have a number of other features which might affect both the structure of perception and the range of acceptance. Since Starr's model did so little to explain the opposition to nuclear power (except to show how irrational it was), other explanations were proposed by Rowe (1977a), Otway and Fishbein (1977), Fischhoff et al. (1978b), and Slovic et al. (1977). The apparent relationship between voluntariness of risk and its acceptability could also be accounted for by the immediacy, controllability, newness, and other features of risk. Moreover, Otway and Cohen's (1975a) attempts to replicate Starr's work indicated that the results were excessively sensitive to assumptions and manipulation of data. A simple explanation of risk acceptance did not exist.

From research, it is becoming increasingly apparent that differences between technical and lay perceptions are consistent and identifiable. In studies of individual perceptions of risk conducted by Fischhoff et al. (1978b) and Slovic et al. (1980) factor analysis was used to help understand lay perceptions of risk. Are risks which are perceived to be fatal different from risks perceived to be uncontrollable? In what way do either of these traits help frame what hazards are considered most risky? The Fischhoff study clustered nine of these risk characteristics into two underlying factors* (a technological risk factor and a severity factor), while the Slovic study clustered eighteen traits into three factors** (an uncertainty factor, a dread factor, and an exposure factor). The structure of these factors is somewhat sensitive to the characteristics included,*** but once characteristics are selected, the factors remained relatively stable across laypersons and experts judging large and diverse sets of hazards (Slovic et al., 1982b).

In what ways are these factors indicative of perceived risk? To answer this question, Slovic asked his subjects to characterize a large number of hazards as to their perception of each hazard's riskiness and the degree to which each of the eighteen traits applied. Slovic found that perceptions of risk correlate most strongly with what Slovic called the "dread" factor, moderately with "exposure," and not very well with "uncertainty." Knowledge, when abstracted from consequences, are not an important determinant of risk perceptions. People are not afraid of potential consequences simply because little is known about them. Rather, they are afraid of (i.e., they "dread")

---

* (from the previous page) Fischhoff identified a "technological risk" factor that included the degree to which the risk is involuntary, delayed, unknown to the exposed, unknown to science, uncontrollable, and new. He also identified a "severity" factor that included the degree to which the risk is certain to be fatal. Both included the degree to which the risk is dreadful and catastrophic.

** (from the previous page) Slovic identified a "degree to which a risk is understood" factor consisting of risks that can be characterized as being unobservable, unknown to the exposed, delayed in effect, new, and unknown to science; a "degree to which it evokes a feeling of dread" factor consisting of risks that are uncontrollable, dreadful, globally catastrophic, fatal, not equitable, locally catastrophic, intergenerational, not easily reduced, increasingly risky, involuntary and personally risky; and a third factor of number of people exposed and the degree of personal exposure.

*** (from the previous page) The structure of the factors in the Slovic study (which included several characteristics not used by Fischhoff) differed from the structure found in the Fischhoff study. Characteristics that were once grouped together were now grouped apart with characteristics from which they were once separated.

consequences about which enough is known to consider them hazardous, and which appear to be uncontrollable, potentially catastrophic, intergenerational, not easily reduced, and not equitable. In a related study, Slovic (1982b:87-88) concluded that neither the annual number of lives lost nor the total number of lives lost in one mishap were indicative of the seriousness of a risk. Rather

> Accidents serve as signals regarding the probability and magnitude of further mishaps. An accident that takes many lives may produce relatively little social disturbance if it occurs as part of a familiar and well-understood system (e.g., a train wreck). A small accident in an unfamiliar or poorly understood system may have immense consequences if it is perceived as a harbinger of further and possibly catastrophic mishaps.

It is this variability in consequences, the possiblity of extreme consequences, that most strongly augments the perceived riskiness of large-scale technological systems.

Technical and Lay Perceptions of Risk Compared

Based on these studies by Slovic, Fischoff, and others, Vlek and Stallen (1980) argue that differences in perceived risk are more a function of what is valued than of how data is analyzed. Distinctions between risk preference and risk evaluation become blurred when preference measures (such as preferences for voluntary exposures, controllable consequences, and time and spatial limits on consequences) dominates analytic measures (such as cause-effect relationships, systems for safety, and the historical accident frequency). Otway and Fishbein (1976b and 1977) have used an attitude scale to develop an even more finely grained analysis of the beliefs about and evaluations of the risks and benefits associated with nuclear power. In both studies, individuals are presumed to perceive risks through processes that are more personal and social than rational. Perception of risks are not seen as independent of the perceiver.

Hohenemser and colleagues (1983), on the other hand, have had initial successes in generating a rational, cause-effect model that incorporates many of these "dread" risk characteristics, explains lay risk perceptions, and yet is still quantifiable through scientific and engineering methods. Hohenemser developed a "hazardousness" scale based on causally explainable events which could be measured and predicted. By choosing events that threaten what people value, Hohenemser was able to define an engineering function of risk that closely approximated lay perceptions. Based on this scale, the scores made by experts using scientific and quantitative estimates closely correlated with the scores of laypeople using intuitive and qualitative estimates for 93 hazards. Interestingly, of the factors used, nine are measures of consequence variability and extreme effects, while only two are measures of expected outcome.* Measures of human mortality are insignificant explainers of perceived risk. Once again, the factor most frequently chosen by scientists to represent risk does not appear to be a strong factor in estimates made by laypeople. The three factors that correlated most strongly with perceived risk are each factors of extreme consequences and variability: maximum credible human mortality, maximum credible nonhuman mortality, and potential for widespread exposure.

---

* Variability of effect is associated with the factors of potential for widespread exposure, concentration of release, persistence of release, recurrence of release, population at risk, delay of effect, maximum credible deaths, potential for transgenerational effects and maximum credible nonhuman mortality. Expected outcome is associated with average annual deaths and nonhuman mortality.

The Hohenemser model defines hazardousness by describing a sequence of causally connected events. The events are selected based on a model that begins with human needs and wants, and proceeds to the selection of technology, release of potentially harmful energy or material, and eventually to the development of harmful consequences. The model tries to rationalize lay perceptions within an engineering frame of cause and effect, showing that perceptions of riskiness are a function of this "hazardousness" scale and not just a function of the annual rate of mortality. Thus, the authors suggest that laypeople frame the problem of risk within a causally coherent structure, different from the way engineers and scientists normally frame risk.

Whether the structure of lay perceptions can be structured on a rational cause-effect model or more loosely on a decision situational model, it seems clear that the structure is widely shared, fairly consistent, and substantially more complex than current engineering models of decision making. The application of different models clearly leads to different conclusions as to what is risky and what is not.

II. Processes for Evaluating Risk

Whatever dangers we conceive to be important, perceptions of risk must invoke some process of prediction. Risks are about events whose consequences have not yet been felt, about fears of future losses and hopes of future gains. If the inferences we make about the possibility of these events becomes systematically biased, we may well make decisions which we would otherwise not make.

Because of the importance of probabilistic reasoning to risk decision making, decision analysts have devoted considerable attention to these problems of inference. They have found that both laypeople and experts tend to apply simplifying assumptions to probabilistic reasoning. These assumptions ease the process of inference but sometimes introduce considerable bias to the decision making process. Experts have argued that "intuitive" processes of inference are considerably less reliable than disciplined processes, and that laypeople are more prone to these biases than are experts.

Boundedly Rational Decision Processes

That these biases exist has been extensively documented (see Kahneman et al., 1982c; Nisbett and Ross, 1980). Beginning with the work on bounded rationality, studies have shown that intendedly rational behavior is constrained by limitations on cognitive and perceptual capacity. Classical optimization, which searches for a full and consistent ordering of outcomes, requires information processing that is beyond human abilities. Instead, aspiration levels are used to determine a subset of acceptable solutions. The theories of Simon (1956), Cyert and March (1963), Lindblom (1964), and Etzioni (1967) depict decision makers as coping with complexity by managing problems as they become important, by partially ordering outcomes by how well they satisfy needs, and by simplifying procedures for generating solutions.

These mental shortcuts, called heuristics by Tversky and Kahneman (1974), are important features of risk perception. Subjective estimation of probabilities and consequences are constrained by these simplifying procedures. Three heuristics for assessing probabilities are particularly common. Representativeness (similarity to other objects or events along some dimension) is used to group an unfamiliar object into existing subjectively held classes of familiar objects. Availability (ease with which instances of an event can be brought to mind) is used to assess the frequency or plausibility of a particular event occuring. Adjustments to an anchor (re-evaluation of an initial estimate) is used to make predictions when a prior opinion is already held (Tversky and Kahneman, 1974).

The hazardous waste debate provides ample opportunity for systematic bias to enter through each of these heuristics. By way of illustration, an individual's estimate of the likelihood of a hazardous waste catastrophe is likely to depend on whether hazardous waste is perceived to be more similar to nuclear waste, to recycling, or to city dumps (representativeness), on whether the individual can easily visualize the potential effects or can recall other instances of catastrophe because of news coverage (availability), or on whether the individual's initial estimate is colored by the estimates of proponents or opponents to the project (anchoring).

The theories of bounded rationality also suggest that information is processed sequentially. Options are eliminated by tightening criteria around an acceptance set until only a few alternatives remain. In a similar vein, events may be deemed risky (unacceptable) by comparisons against a critical value standard or by comparisons across or within attributes (Shoemaker, 1980).

Comparisons against a standard is a common form of searching behavior. Coombs (1964) initially described the use of satisficing criteria to simplify cognitive and decision making work. Criteria used to evaluate alternatives are tightened until one "optimal" option remains or until the subset of acceptable alternatives is managable. The rejection rule is usually disjunctive (i.e., divides alternatives into mutually exclusive sets). Criteria are used to eliminate options below thresholds of acceptability. Thresholds can be established for probabilities (e.g., the chance of failure exceeds a critical value) or consequences (e.g., an option has the possibility of exceeding a specified maximum cost).

Rejection rules are more frequently based on the probability and amount of losses than of gains because losses more strongly alter minimum aspiration levels than do gains (Slovic, 1967; Slovic and Lichtenstein, 1968; Andreissen, 1971). Kahneman and Tversky (1979) suggest that losses become increasingly important while gains become decreasingly important the further removed they are from an individual's point of psychological neutrality.

The Cultural Basis of Risk Evaluation

In the risk assessment literature, much has been made of these heuristics and biases in information processing. As Slovic and associates note in their analysis of the structures of perceptions: "People respond to the hazards they perceive. If their perceptions are faulty, efforts at public and environmental protection efforts are likely to be misdirected" (Slovic et al., 1982a:141). Thus, when the lay public opposes the siting of hazardous waste facilities against the advice of experts because of news accounts about disasters, their opposition to facilities is seen as misdirected.

Strategies to alter the way laypeople process information appears to offer little promise for improving the siting of potentially hazardous facilities, however. While the lay public clearly has problems in their role as "lay statisticians," the role itself has been created by expert statisticians. In interviews, local policymakers rarely conceive of risk as probabilistic consequences. Events are risky when they promote the potential for an unwanted consequence which the policymaker has subjectively defined as important. Probability is not explicitly considered both because laypeople recognize their unfamiliarity with statistical reasoning and because characteristics of the potential outcomes are more important.

These basic differences between how experts and laypeople evaluate what is significant and what is not make transference of knowledge between the two groups difficult. Frequently, these differences pose few problems. When experts are trusted and a dominant theory exists for explaining phenomena, controversy is muted. Until dams started to fail, for example, the lay public largely entrusted dam building to engineers. On issues of hazardous waste treatment facilities, sponsors have retained this basic trust of experts. Sponsors do not think more analytically than do guardians or preservationists, but they are more accepting of the apparent insignificance of risks that experts estimate to be comparatively insignificant.

When controversy becomes widespread and competing theories can be used to support partisan positions, guardians and preservationists challenge the adequacy of expert opinion. Guardians and preservationists will not simply define a problem as "technical" and assign it to experts to await solutions. They insist that these problems be negotiated amongst a larger pool of interested parties.

In the hazardous waste facility siting debate, technical experts have responded to lay resistance with education and public relation programs. The lay public is to be taught to rethink their perceptions based on decisionmaking techniques and the facts (as developed by experts). However, little evidence exists in the literature on attitude change or the history of public information campaigns to suggest that the education of one group (of laypeople) by another (of experts) works in any way except slowly and unpredictably when the basis for understanding reality differs substantially (see Nowotny, 1980, and Nelkin et al., 1977, for examples associated with the risks of nuclear power). Estimates which require some subjective judgement are difficult to change because they are based on inherently subjective processes of classifying objects, correlating events, and imagining consequences. No simple procedure exists for assessing the compatibility of subjective probability judgements with a total system of beliefs, and no compelling argument for changing a subjective estimate can be made unless some incompatibility can be shown.

As a consequence of this information processing pattern, people tend to persevere in their beliefs despite contradictory evidence. Nisbett and Ross (1982:192) note that people tend to seek out and interpret evidence in a way that sustains beliefs and to place too much confidence in evidence on which they first build their theories of causality. Evidence that gives support to each of two opposing views does not reduce confidence and moderate opinions, but rather reinforces confidence for holders of both views.

As demonstrated in a number of studies, experts are also prone to these biases. When forced to go beyond well understood phenomena or to convert incomplete knowledge into judgements for use in public policy, experts frequently rely on the same intuitive process as do laypeople (Fischhoff et al., 1982:252). Moreover, experts are typically over-confident about the accuracy of their judgements (Slovic et al., 1980). Engineering judgements are built upon experience and familiarity with risks. Just as the poor driver can feel safe because he has had extensive experience of driving badly with no mishaps, so too can the personal experience of an expert create unwarranted confidence.

A few conclusions are possible. Experts clearly know more than others about their specialized domain. However, the domain is built on models, a language of probabilistic events and judgements that confirm a particular view of reality. That view extends beyond what can be measured into areas of considerable uncertainty. This conjecture is not open to reliable testing and is limited by the bounds of the expert's knowledge and concepts. Truly interdisciplinarly problems of risk management may not give way neatly to any particular expert opinion.

In what sense can experts "educate" laypeople? As Otway and Thomas (1982:75) note, we have two sets of people who by different processes have each constructed a distinct view of reality. For each, meaning and beliefs are intimately linked to culture. Each group has learned to function more or less successfully, testing and correcting for error within their specified domain.

As Douglas and Wildavsky (2982:50-51) have emphasized,

> The choice of risks to worry about depends on the social forms selected. The choice of risks and the choice of how we live are taken together. Each form of social life has its own typical risk portfolio. Common values lead to common fears (and, by implication, to a common agreement not to fear other things). There is no gap between perception and reality and no correct description of the right behavior, at least not in advance. The real dangers are not known until afterward (there always being alternative hypotheses). In the meantime, acting in the present to ward off future dangers, each social arrangement elevates some risks to a high peak and depresses others below sight. This cultural bias is integral to social organization. Risk-taking and risk-aversion, shared confidence and shared fears, are part of the dialogue on how best to organize social relations.
>
> Questions about acceptable levels of risk can never be answered just by explaining how nature and technology interact. What needs to be explained is how people agree to ignore most of the potential dangers that surround them and interact so as to concentrate only on selected aspects... Once the idea that people select their awareness of certain dangers to conform with a specific way of life is accepted, it follows that people who adhere to different forms of social organization are disposed to take (and avoid) different kinds of risk. To alter risk selection and risk perception, then, would depend on changing the social organization... In addressing questions of acceptable risk without considering their social aspects, we are speaking to the wrong problems.

Education, then, may well be limited to cultural exchange, in which each learns from the other and neither view is deemed correct and hence superior to the other.

This is not meant to suggest that all perceptions are equally valid. Perceptions can be powerful even if completely devoid of reality. In the Frayser neighborhood of Memphis, Tennessee, a resident named Evonda Pounds was convinced that her rashes and other minor illnesses were caused by poisoning through toxic chemicals. An investigation in 1976 of her home found only trace concentrations of pesticides commonly used throughout Memphis to control termites and mosquitoes. She was not convinced and continued with her complaints. Over the next three years, other residents started reporting an increased incidence of rashes, headaches, urinary problems, heart disease and cancer. By 1979, the neighborhood was in an uproar "virtually identical to that of Love Canal" (Maugh, 1982b:645). EPA's analysis of air, water and soil samples revealed only background levels of pesticides. Historic records and old aerial photographs showed no evidence of chemical dumping. The Center for Disease Control conducted an epidemiological study of 300 families and found no evidence of toxic illness or severe health effects. After a year of emotional confrontation, the uproar slowly subsided (Maugh, 1982b).

Within Frayser, we should note, the change of perceptions was brought on by a process of interaction between the scientific and community cultures. While communities can and do panic because of misperceived realities, the solution is less one of education than one of engagement. In the siting of hazardous waste facilities, such engagement may well require opening risk management policy to new processes of give and take suggested by guardians and preservationists. Only when the perceptions of the various lay and expert publics are each given credance is the process of interaction likely to lead to new, potentially useful solutions. The next chapter examines what these solutions might entail.

Chapter 6

The Mitigation and Management of Risk

Risk perceptions are central to the process of siting a hazardous waste facility. Substantial disagreement exists over the significance of risks and the appropriateness of control strategies. Unlike many risk management issues, however, agreement does exist on the most fundamental question. In the abstract, lay people as well as experts believe that treatment facilities are a necessary element of any hazardous waste risk management strategy. Local residents, however, perceive that a regionally safer environment is achieved at the price of a more dangerous local environment. Abstract support does not therefore generate local consent.

To many professional risk managers, lay fears are becoming increasingly irrational as the public responds to problems of older, less effective facilities. Risk managers believe the risks of hazardous waste treatment facilities to be measurable, predictable, and comparable to other risks. Their careful analysis demonstrates that the siting of treatment facilities is the most efficient path to regional safe waste management. Moreover, local risks are also estimated to be within levels already accepted for other risks. State of the art treatment facilities, according to these analysts, makes everyone's environment safer. The analysis, however, is not compelling to those who hold a different view.

The resulting uncertainty frequently cripples public decision making. These uncertain risks lead to predictable behaviors. As discussed in Chapter 2, the uncertainty is systematically excluded or treated as a predictable effect, an inadequate theory is claimed as most appropriate in light of no clearly adequate alternative, and action becomes impossible in the absence of greater certainty. As was seen in the Love Canal example, hazardous waste management debates have all these characteristics.

Improved risk management, therefore, depends on improved treatment of risk perceptions. Public systems function to provide services, and perceptions influence the demand for, opposition to, and satisfaction with those services. As a basis for knowledge, perceptions are most important when public policy has no firm factual foundation upon which to rest. Perceptions of risk can overpower any analysis that is attempted if the analysis and its supporting theory are subject to dispute. As a basis for behavior, perceptions constrain the range of feasible risk management strategies. Perceptions can generate substantial opposition to proposed facilities. As a basis for experience, the fears generated have demonstrable psychological and social costs. (Kasper, 1980; Weinstein and Quinn, 1983). Perceived risks, even when not substantiated by analytic estimates, can cause considerable distress. If we are to break out of the cycle of denial, claiming, and inaction associated with uncertain and risky public policies, we must learn to cope with risk perceptions in the face of uncertainty.

Because of the seeming intractability of perceptions held by both the lay public and technical experts, the dynamics of risk perception have attracted considerable research interest. Most of this literature focuses on issues of perceived predictability within a general model of technically preventable risks. Control strategies based on this model focus on two aspects of risk management:

- **Prediction:** Do we know enough to forecast the likely effects of a hazardous waste treatment facility? Is this knowledge being impartially examined and presented?

- **Prevention:** Can we design systems for effectively reducing the potential risk? Will these systems be reliably managed?

As revealed by the simulations and interviews employed in this research, however, many individuals who are concerned about the siting of hazardous treatment facilities are concerned with two additional aspects of risk:

- **Detection:** If hazardous conditions develop, do we have the means to detect these changes? If so, will that data be collected and scrutinized so as to detect changes quickly?

- **Mitigation:** If serious hazards are detected, do we know how to reverse the dangers and the negative impacts? will these mitigation measures be applied with sufficient speed and skill to be effective?

When hazards are rare but potentially catastrophic, almost all laypeople prefer strategies of risk detection and mitigation to strategies of risk prediction and prevention. Likewise, guardians in particular prefer strategies that strengthen social control mechanisms to those that strengthen technological control mechanisms. In this chapter, we explore the rationale for these preferences, and examine the strengths and weaknesses of each as a basis for managing risks.

I. Predicting and Preventing Risks

The process of siting hazardous waste treatment facilities has ceased to function. According to several studies conducted for EPA (BNA, 1981:872; US EPA 1979c:12-13), opposition is motivated by several factors: fear of facility accidents and chemical exposure (with the conviction that a different facility located on a site "somewhere else" is better); distrust of industry and government (with fears of losing control over the community's future); and adverse beliefs about impacts on property values, the quality of life, and the aesthetics of the community (with concerns about equity and "being the dumping ground for other people's waste"). This fear and mistrust is based on experience. Though the safety of new facilities may be considerably improved, serious risks are clearly associated with many existing facilities. Analysis of problems does not provide a clear, unambiguous estimate of these risks.

In some cases, even modern secure facilities have failed. In 1977, studies by both the US EPA and the Illinois State Geological Survey found an SCA-run disposal site to be "a well designed, secure landfill which provides disposal by environmentally acceptable methods" (US EPA, 1979c:309). Public opposition from the township of Wilsonville continued despite these determinations, and the State Supreme Court eventually ordered the site closed and all material exhumed. Although the site had accepted wastes for only eighteen months, toxic organic solvents had already leaked from the disposal site (US OTA, 1983:255). In Sheffield, also located in Illinois, a barrier wall that state regulators claimed would prevent migration for 500 years was breached by organic solvents in just a few years (US OTA, 1983:255). A study of four secure landfills in New Jersey uncovered similar problems (Morell, 1982:82).

Arguments by proponents of hazardous waste treatment facilities must be judged in light of this difficulty in predicting and preventing hazards at even modern sites. While treatment facilities have generally proven more environmentally benign than disposal sites, the claims by industry spokespersons that these facilities are "like any other industrial or manufacturing facility" and "yield no adverse environmental impact" (Morell, 1982:66) have yet to be proven in practice.

Prediction as a Basis for Decision Making

While analysts may agree that the fundamental uncertainties in our current knowledge and ambiguities in defining risk may make truly objective analysis impossible, they disagree considerably on the implications of this finding. To those who espouse a view that the world is explainable, predictable, and controllable, subjectivity is a transitory phenomenon that continually gives way to objectively advancing science. Subjective data approximates the truth that is being discovered by research. Systematic biases can be remedied, and remaining error can be treated as random. Statistical and experimental tools remain our most valid and reliable methods for understanding risk. Thus, while Rowe (1977a:38-41) points out that risk parameters can be subjective, he nonetheless describes risk as that condition in which possible unwanted consequences exist, the occurrence of which can be expressed in the form of a probability distribution (Rowe, 1977a: 24). To Rowe and other analysts, subjective data requires more careful attention, but the probability of their occurence can still be estimated and analytically compared (Starr, 1969; Lowrence, 1976; Rowe, 1977a; Rasmussen, 1975).

In its purest form, the subjectivists' position differs radically. To subjectivists, hierarchy of truth does not exist. Knowledge is modeled on experience and mediated among people with similar experience. Knowledge is socially constructed and not inherent in the structure of the natural world (see Kuhn, 1970; Lindblom et al., 1979; Feiveson et al., 1976). Useful knowledge is built on paradigms of the world that are powerful explainers and predictors of the natural and social world. The paradigm constrains the way people frame concepts, pose questions and set research goals. It thereby ensures continuity in inquiry. When no paradigm is dominant, people see the world differently and base their inquiry on their most salient experiences and needs.

This is not to say that subjectivists believe that all perceptions are therefore equally valid. While we cannot know objective truth, in conditions where uncertainty is greatest most subjectivists hold that some patterns of perceiving remain more reliable than others (i.e., the scientific method, statistical empiricism, Baysian analysis, or religious revelation, depending on who is claiming reliability). Unreliable or inconsistent patterns of observation and analysis lead to biased choices.

The Search for Precision: The Technological Imperative

As discussed in Chapter 5, cognitive psychologists and decision analysts have identified important differences between individuals who base their perceptions of risk on scientific reasoning and those who base it on impressionistic reasoning. To these analysts, risk is a probabilistic function of potential, unwanted effects. Their focus on probabilities and scientific reasoning has a number of implications. They have identified heuristics used to assess probabilities subjectively (i.e., representativeness, availability and adjustments to an anchor), have demonstrated a number of satisficing criteria used to simplify cognitive work, and have prescribed theories about how we ought to measure risk and make decisions when uncertainty exists. By prescribing theories that require quantitative analysis, however, these analysts tend to limit their attention to that which is measurable. Probability functions are not precise (and hence useful) unless factors of analysis are either measurable or estimatable. To achieve measurability, analysts tend to emphasize technical engineering solutions and prediction-prevention strategies for managing risks.

Technology is emphasized because the search for truth, as defined by decision analysts, is a search for solutions that can be accurately predicted and reliably implemented. In their model, estimates of risk (based on aggregate, generalizable data analysis) requires fixed, measurable, and predictable functions. The model systematically ignores the sources of greatest variability (namely operational procedures, individual behavior and managerial structures) because there are no reliable methods for systematically generating numerical estimates of their probable future behavior.

In the absence of scientific consensus, attempts by facility sponsors to alter risk perceptions of guardians and preservationists have proven futile. Advertisements, public education and persuasion seem to have little effect on the perceived riskiness of hazardous waste facilities. Moreover, when given the opportunity to design risk management systems that most effectively minimize perceived risk (from their perspective), neither guardians nor preservationists stress investments in technological safety devices. Even sponsors, who generally rely on the advice of technical experts, did little to promote the use of technical prevention systems.

A look at how participants in the simulations acted and made decisions is illuminating. In the Essexton and Worcesterville simulations, individual participants had an opportunity to select a company (based on its safety proposals) that best satisfied each participant. The choice was between Waste Technology Incorporated (which stressed improvements in technologies for preventing risks), Pollution Control Corporation (which stressed improvements in detection and mitigation of risk), and Environmental Management, Incorporated (which stressed improvements in management systems for controlling risks). In the individual selections, only 15 percent of participants most preferred the technological options offered by Waste Technology Incorporated, and 61 percent saw it as the least preferred option (see Figure 6.1). In addition, trade-offs among the proposals of these three companies were made within small groups of about six people each. On average, 17 percent of resources were used to upgrade technical hazard

	Waste Technology Inc.	Pollution Control Corp.	Environmental Management Inc.
sponsors	38%	24%	38%
guardians	0%	30%	70%
preservationists	11%	56%	33%
AVERAGE	15%	37%	48%

Figure 6.1a: Most Preferred Options

	Waste Technology Inc.	Pollution Control Corp.	Environmental Management Inc.
sponsors	30%	8%	62%
guardians	90%	0%	10%
preservationists	56%	11%	33%
AVERAGE	61%	7%	32%

Figure 6.1a: Least Preferred Options

Figure 6.1: Preferences for safety options proposed by three companies, by type of participant. During the simulation, participants ranked the proposals of the three companies by order of preference. Figure 6.1a shows the percent of participants who ranked a company as <u>most</u> preferred of the three. Figure 6.1b shows the percent of participants who ranked a company as <u>least</u> preferred of the three.

prevention systems. This is compared in Figure 6.2 to 25 percent used to upgrade managerial structures, 28 percent taken in various forms of compensation, and 30 percent used to upgrade detection and mitigation systems.

Perceptions about the inability of technology to solve safety problems persist not because local residents are anti-technology. Most are not. Rather, individuals frequently believe that experts ought to be in the best position to estimate risks, but they are dissatisfied when expert knowledge is ambiguous (aggregate data cannot

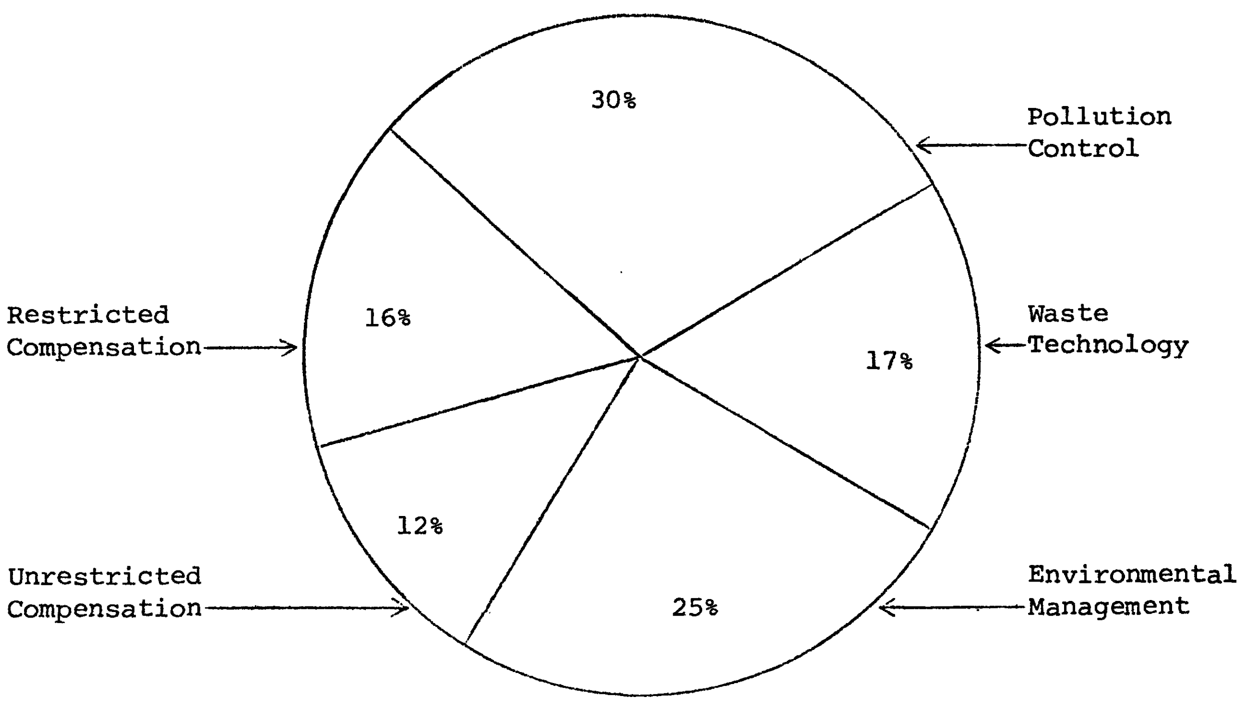


Figure 6.2: Average allocation of resources among five possible options, in percent of total budget. In the simulations, an annual budget of $3 million was given to each team. On average, the six teams allocated these resources as indicated in the figure.

be applied to any particular individual), contradictory (experts do not agree), and counter intuitive (expert opinion dictates against common sense). Experts frequently write off previous hazardous waste disasters as failures of incompetent management using inadequate technology. Individuals are left with a sense that the problem is larger than the expertise of those who claim to know.

Moreover, behind every probability estimate is an implicit model of causation. For the most part guardians and preservationists believe that good equipment backed by technical expertise is essential to the effective management of hazardous waste. Technology is the backbone of waste management for almost all participants in Essexton and Worcesterville. But for guardians and preservationists, the technology offered in the basic package (standard equipment and management good enough to meet state and federal standards) forms that backbone. Given additional resources, only a third of sponsors, a tenth of preservationists and no guardians choose primarily to strengthen this aspect of risk management. As shown in Figure 6.1, for 30 percent of sponsors, 90 percent of guardians, and 56 percent of preservationists, the proposals offered by Waste Technology are less desirable than those offered by either Pollution Control or Environmental Management.

Sources of Variability Beyond Prevention Technologies

By opting for detection, mitigation, and management systems over prediction and prevention measures, these residents are acknowledging the already superior development of technical systems for managing risks. Scientific study of risks associated with large scale facilities has focused primarily on these technological and engineering contributors to risk. The state of the art is already advanced. The risks associated with hazardrous waste treatment, however, cannot be managed simply through the application of better science and the construction of better facilities. Perfectly designed technologies are no insurance against inept use of those technologies. Only when technologies are integrated with systems for detecting and mitigating problems, and organizations to manage these systems, can prevention strategies work effectively. Thus, in the management of hazardous waste, release of chemicals can occur if the container or treatment systems malfunction (i.e., a holding tank leaks at an improperly set weld), if detection and maintenance procedures are inadequate (i.e., a holding tank leaks at a point of corrosion that was never detected), or if decisions are made erroneously or negligent (i.e., a holding tank leaks due to an explosion that occurs because two chemicals are improperly mixed). Only when the various parts of a risk control system are well integrated and functioning optimally can the facility operator most effectively manage risks. Thus, a well rounded management system is likely to yield a better record of safety than the disjointed use of more advanced techniques.

In practice, this integration is only weakly acknowledged. Specialists in the dominant field tend to assume a unique significance. In hazardous waste treatment facilities, the technological component dominates. Effective management is equated with containment or elimination: physical processes for treating the wastes. Alternatives consist of variations on the technological theme. Too little attention too late in the facility siting process is paid to the other aspects.

The Uses of Technologies for Prediction and Prevention

The use of methods for predicting and preventing risk is therefore two edged. While these technologies are perceived to provide the essential backbone on which a waste management system must be based, they are also seen as focusing the risk debate along too narrow a line.

Within a particular political risk management debate, the choice of an analytic method will powerfully influence the alternatives that can be considered and the analysis that is possible. Fischhoff and colleagues demonstrate this point in their comprehensive study of methods for estimating the acceptability of risks. As they point out, no approach is comprehensive or infallible, each gives special attention to some aspects of the problems while ignoring others, and hence "choosing an approach is a political act that carries a distinct message about who should rule and what should matter" (Fischhoff et al., 1981:xii). To those who stand to win or lose, tools for assessing intricate and politically explosive hazards are as controversial as the conclusions to which they lead.

The risks that the firm seeks to minimize, however, are not the same risks that a potential host community might want it to minimize. By restricting the debate to issues of technology, the firm can seek to isolate a whole range of risk related issues from public scrutiny. The incentives for the sponsoring firm to limit its own uncertainty help explain why discussion is restricted to technological alternatives. Compared to detection, mitigation, and managerial systems, preventive technologies are more precisely delineated and difficult to change once construction is complete. Future costs and organizational constraints are predicatible. The firm retains control over its future and precludes the town from shifting uncertainty back onto the firm. Moreover, the operating, financial, and managerial systems needed to construct these technologies can be easily integrated into the normal operations of the sponsoring corporation.

Changes in detection, mitigation and managerial systems are not so easily integrated into organizations. They require greater flexibility and openness to change in the environment. The firm can less perfectly measure and predict the effect of these more social forms of risk management. Finally, the firm's advantage in expertise is less consequential. Claims made by a facility developer about management and mitigation measures have less authority and are subject to greater challenge from citizen groups.

By preventing discussion of detection, mitigation and managerial alternatives, the firm can hope to limit its own uncertainity. However, this tendency for disputants to focus on facility construction and technologies rather than on the whole risk managment system can only aggravate disagreements based on divergent perceptions of risk. When the facility siting debate is couched analytically in the language of engineering probabilities, but concerns are more fundamentally about causes of risks and the equitable sharing of risks and benefits, then disputants talk about risk in ways which do not communicate real concerns.

When values are shared or power clearly delineated within an organization, these problems may have few consequences. Controversy is muted and decision making remains possible. In business organizations and other closed networks, decision rules and analytic conventions can be used to give form to uncertainty. In the political arena, the decision rules themselves are open to debate and charges of bias. Inquiry becomes a mixed blessing. As hazards are studied, new problems (with unknown solutions) are uncovered where before all seemed safe. While potential hazards are easily discovered, the safety of risk managment strategies are difficult to delineate. In the short run, assessments create a seemingly unsafe world, a world of wide ranging consequences, vague probabilities, and unanswered problems.

We become stuck in the assessment phase of public policy making. In the absence of a theory or process for reducing the newly discovered risk, each discovery increases the perception of risk while at the same time encouraging further investigations that discover yet more subtle risks. Our knowledge-seeking work engenders fear of the risk situation without a corresponding increase in our capacity to adapt and cope (Clark, 1980:11). Under such circumstances, the public system ceases to provide essential functions for people in the system (Schon, 1971).

II. Stabilizing Risks Through Detection and Mitigation

When knowledge is incomplete and the future uncertain, mistakes and surprises are inevitable. Effective policy must rely on a strategy of recognizing mistakes, learning from them, and modifying future actions accordingly (Clark, 1980). Our problem is not just of knowledge, but also of learning; not just of consequences, but also of coping. To effect changes in perception, efforts to manage risk must extend beyond a focus on prediction and prevention strategies. The design of detection and mitigation strategies to promote learning and adaptive control of hazards seems essential.

Detection and mitigation strategies are designed to be resilient. Problems are sought out and corrected as they are detected. These strategies have the potential for more effectively managing risks because consequences associated with hazardous waste facilities emerge for the most part gradually, not catastrophically. As consequences evolve, they become increasingly predictable. Detection and mitigation systems can reduce feelings of uncertainty by effecting control of hazards over time. If errors can be detected and corrected as they evolve, the possibility of error become less frightening. Repair and recovery are possible. By increasing the reliability and trustworthiness of these learning and control systems, the management of risk becomes more effective.

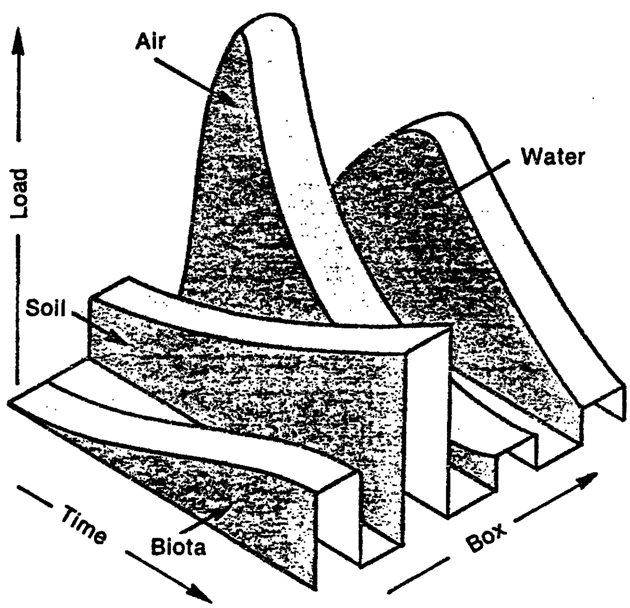
Detection Technology

Strategies for mitigating hazards while their potential consequences remain minor depend on effective compliance monitoring. For the residents of a community, the most significant hazards are likely to be caused by release of chemical waste from the facility. By comparing measurements of chemicals in the environment with measurements taken before the facility was constructed, the effectiveness of prevention strategies can be continually assessed. If effectively designed, detection can occur shortly after accidental spills or releases. In the absence of monitoring, the success of containment and treatment processes must remain a conjecture.

Wastes released from a hazardous waste treatment facility can be transported through several media in the environment. A rotary kiln incinerator (similar to the one proposed in the Essexton and Worcesterville simulations) is designed to burn solid and semi-solid organic wastes. Incompletely burned organic substances or vaporized non-organic waste constituents (i.e., sulfur, nitrogen, organic solvents, and metals) can be released via smoke emissions or through cracks in containment vessels. Organic compounds with sufficiently high vapor pressures can evaporate and escape from storage. Liquids can escape containment and leach into the soil and groundwater. All of these substances can, in turn, be taken up by plants and animals. As shown in Figure 6.3, the fate of chemical wastes accidentally released into the environment is likely to be distributed through all media to which it can bind.

Five types of monitoring can be applied to waste management practices (USOTA, 1983:246-247). Four of these (visual, process, emission and ambient monitoring) focus on identifying the occurrence and extent of wastes released into the environment. These data can be used as part of an information feedback system to improve facility operations. The fifth (monitoring of effects on biota resulting from exposure to wastes) is primarily useful in research settings.

Visual monitoring consists of routine inspections for container leaks, improper storage and handling practices, and equipment malfunction. Its primary purpose is to identify fugitive emissions, spills, and unsafe conditions. Process monitoring consists of checking for unexpected variations in process parameters (e.g., the temperature and flow rate in an incinerator). Because chemical, physical, and biological reactions can be controlled through careful management of material and energy flows, variations in these flows are indicative of potential probelms. Emission monitoring consists of examining conditions (e.g., pH, temperature, specific metals, and total organic content) to verify that the flow of material from the facility to the environment does not contain unexpected pollutants. If significant variations are measured, more comprehensive analytic tests can be conducted to further specify the problem. Finally, ambient monitoring consists of carefully controlled sampling and analysis of waste



SOURCE: Office of Technology Assessment.

Figure 6.3: Hypothetical environmental profile of a compound that binds strongly with organic material, showing transport and persistence in different environmental media. (Source: US Office of Technology Assessment, 1983: 245)

constituents in air, water, soil, plants and animals. If waste constituents are discovered, an attempt can be made to trace their source. Ambient monitoring can provide baseline data for comparison with changes in environmental conditions over time.

Conclusions that can be drawn from monitoring depend on a number of technical and institutional factors. As discussed in reference to the technical uncertainties surrounding Love Canal, monitoring is not an exact science. Particularly in attempting ambient monitoring, protocols for sampling and comparing data over time are not standardized, the environment itself is variable and can interact with waste constituents, and precise data can be collected only through complex and costly analytic techniques (USOTA, 1983:247-251). The consequences of imprecision and the conclusions drawn from such data are subject to the same differences in perceived risks as are predictive data.

Unlike predictive data, however, detective data is generated after the siting decision is made and the plant begins operation. The impacts of detective data on the facility are not known before the facility is sited. The facility operator and the community need not agree on the consequences of accidental releases of waste which cannot be measured and remain highly uncertain for years. Rather they can focus on standards of release (acceptable to the community and the operator) which can be measured, albeit with some uncertainty. Protocols for collecting, evaluating and sharing the data can be agreed upon beforehand. The facility operator, who has predicted low levels of release, need only believe his own analysis to feel secure. The community, which fears potentially greater releases, may be able to better trust the resilience of detection systems coupled to mitigation measures without believing in predictive analysis.

Integrating Detection and Mitigation with Management

Of the three companies simulated, Pollution Control Corporation stressed systems for detecting and mitigating hazards. Four systems of monitoring were offered: combustion monitoring (with automatic shutdown should air pollution standards be exceeded), ambient air monitoring to detect air pollution in the neighborhood, preconstruction monitoring and modeling of baseline environmental conditions, and groundwater monitoring. Systems for inspecting vehicles and to track wastes from the generating source to the treatment facility were developed. Spill containment measures were coupled to contingency and emergency response plans and a highly trained emergency response corps. Finally, the company offered to enter into negotiations with the community over additional mitigation promises.

If the participants of the simulation are any indication, systems for detecting and mitigating hazards have almost universal appeal. Out of 34 participants, only two preferred both the prediction and prevention strategies of Waste Technology and the management strategies of Environmental Management to the detection and mitigation strategies of Pollution Control. In Worcesterville, participants selected this company as the one they would most want to have managing a facility in their community. While allocating available funds among the three companies, each of the three teams in Worcesterville and one of the three teams in Essexton allocated more funds to the proposals of Pollution Control than to either of the other two firms. Figure

6.4 shows the average allocation of resources of these four teams.

Support for the proposal of Pollution Control Corporation, however, appears to interact with support for proposals of the other two companies, as part of a total package. As is shown in Figure 6.1, less than a third of participants chose Pollution Control as their first choice. For the two-thirds of the participants who selected either Waste Technology or Environmental Management, Pollution Control was the near universal second choice. Participants who preferred the prevention options of Waste Technology perceived monitoring to be an extension of the technological solution, while participants who preferred the management options of Environment Management perceived it to be an extension of management systems.

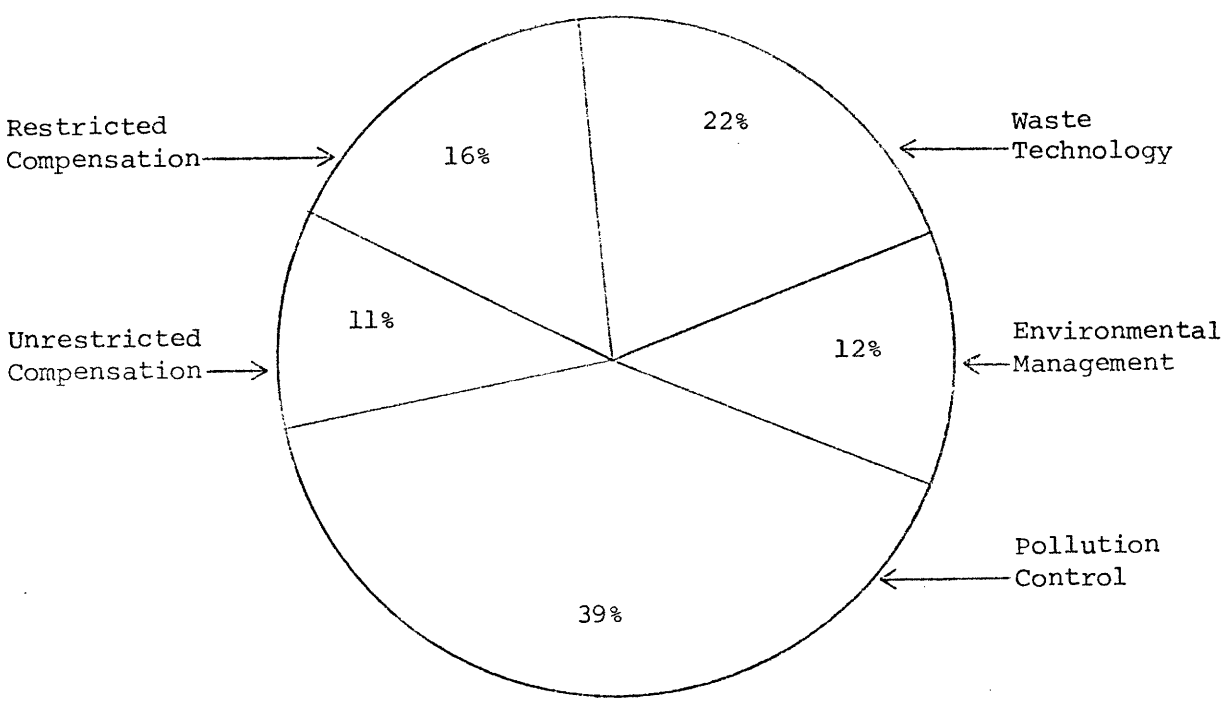


Figure 6.4: Average allocation of resources among possible options, in percent of total budget, for four teams that most preferred the risk management strategies of Pollution Control Corporation. In the simulations, an annual budget of $3 million was given to each of six teams.

In this light, monitoring (even with extensive mitigation promises) can only be a partial solution. It straddles the technological and the managerial emphases and is not sufficient unto itself. For those that trust technology, detection by itself is too little too late. For those that trust the control of management systems, monitoring without some form of power sharing is impotent in the face of conflicting interests.

This pattern of choosing detection and mitigation systems to support a more fundamental preference is particularly striking in guardians. Eighty percent of guardians selected the managerial strategies of Environmental Management for first consideration. All of these chose Pollution Control for second consideration. This overwhelming pattern of preference is indicative of a shared belief in the importance of social control over technological risks. In this context, detection and mitigation systems provide information for evaluating the effectiveness of social control and contingency promises for holding the facility operator accountable.

III. Management Side of Risk Management

To seventy percent of guardians (and a third of sponsors and preservationists), the most effective path to safe waste management is through improved management. Moreover, while four teams most preferred the detection-mitigation strategies of Pollution Control Corporation, the remaining two teams allocated over half of the $3 million budget to the risk management strategies emphasized by Environmental

Management Incorporated (see Figure 6.5). To these individuals, risks are socially constructed realities. Effective management of risk depends on social controls and incentives, as well as physical properties. *A priori* estimates of risk are fundamentally unstable because conditions that inhibit or promote risks are continually evolving. The purpose, reliability, and capability of this evolving management has major implications for the riskiness of hazardous waste treatment facilities. Management is a source of variability and uncertainty. Improper management can greatly increase the danger of a spill, slow leak, or other danger potentially associated with hazardous waste facilities.

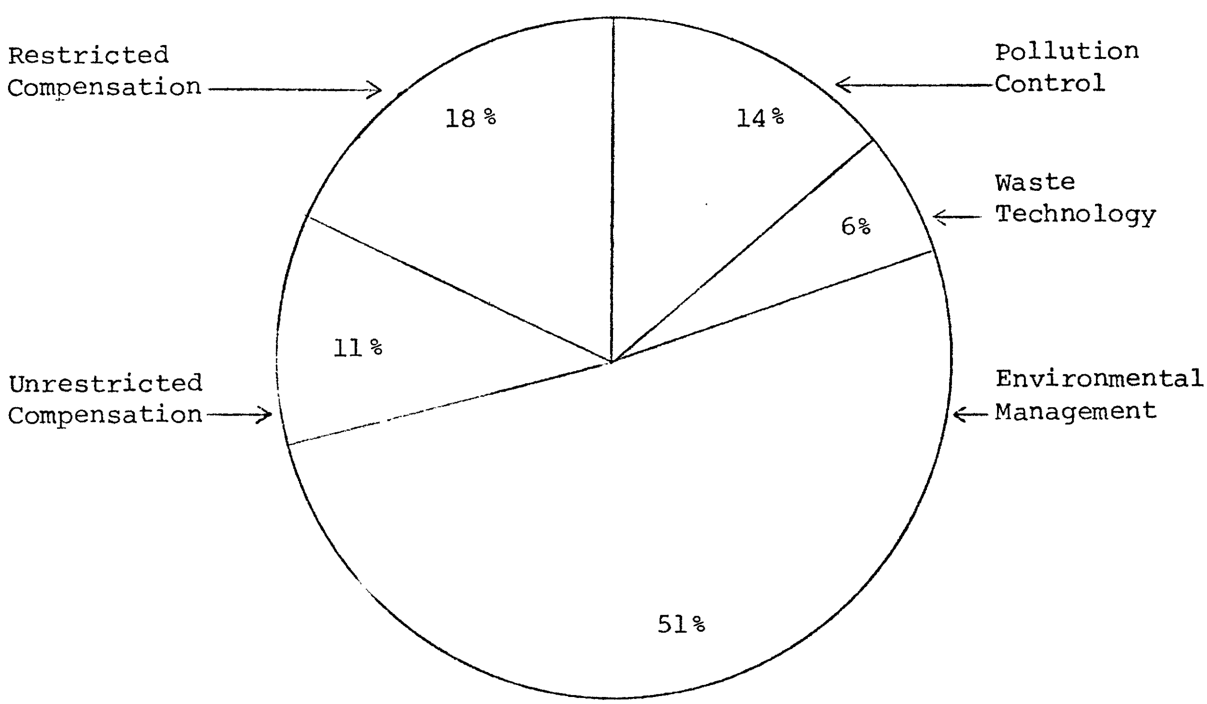


Figure 6.5: Average allocation of resources among five possible options, in percent of total budget. In the simulations, an annual budget of $3 million was given to each team. On average, the six teams allocated these resources as indicated in the figure.

Moreover, perceptions of risk depend not only on the strategy choosen to manage risk, but also on the reliability of its implementation. Excellently planned but poorly implemented strategies can generate great risks because they provide false security. Trust in the motivation, intentions, and power of risk managers is an essential aspect of reliability. In the absence of trustworthy systems of management, worst case scenarios can and will be conjured up by those who fear the worst (and stand to lose the most).

The Example of Three Mile Island

These points are underscored by the Presidential Commission's Study of Three Mile Island (Kemeney, 1980). What started out to be an investigation of equipment problems steadily shifted to a study of people problems. The equipment was well built and the technical support staff competent, but the managers of nuclear power (both private and public) were overconfident. They fundamentally believed the equipment was foolproof. They consequently ignored clear signals of problems and failed to train operators to handle crisis situations. The Nuclear Regulatory Commission, while paying close attention to technical problems, overlooked problems in training, inspection and enforcement. Moreover, they had developed no systematic way of learning from experience. Both the operators of the nuclear power plant and the NRC were "convinced that the equipment was so foolproof that nothing bad could possibly happen; they therefore honestly believed that whatever they were doing was sufficient to assure nuclear safety" (Kemeney, 1980:69).

Problems of management go beyond experts who are overconfident of prevention technologies. We have seen that risk perceptions are strongly influenced by perspective and culture. Differences in perspective on risks are particularly striking between corporate executives and elected officials. Corporate executives believe that the most significant risks the United States currently faces include the energy crisis, economic troubles, refusal by society to accept risks associated with technology, and overregulation by "big" government. Executives believe that society would be better off if the public allowed more leeway for corporate risk taking. In stark contrast, members of Congress (the group surveyed that is most like our local decisionmakers) are most concerned with the threat of nuclear war, economic troubles, and proliferation of chemicals. Out of a list of 20 possible risks, the only one that no executive considered particularly important was the profileration of chemicals (Marsh and McLennon, 1980:8). When coupled to the obvious differences between the interest of the firm and those of the residents, it is not surprising that half of the participants in the simulation preferred the power sharing and management systems of Environmental Management to more technological systems.

The Boundary Between the Firm and the Community

Community residents who support power sharing do not generally wish to participate in the day to day operations of a facility. Rather, they envision a system with boundaries that are clear but permeable to influence and control by the community. This task is difficult because as Katz and Kahn note (1966:91-93):

> The dominant tendency in ... powerful organization(s) will be to seek control over the environment rather than to modify internal structures to accord with external changes. The organization thus will proceed on the principle that it is easier to make the world adjust than it is to adjust the organization, and the latter alternative will be adopted only if the first offers small hope of success.... A change of internal structure is a threat to the organization. To resolve an organizational problem by changing the environment constitutes no such threat. Indeed, if it can be brought off successfully, it affirms the power and rightness of existing organizational structure. The limiting variable is the relative openness of the system to external influence.

Given these tendencies, Essexton and Worcesterville residents see three conditions as essential to effect sufficient community control over management. First, clearly defined responsibilities and obligations must be made contingent on hazards developing (control and constraint function). While management systems need to be adaptive and flexible, this flexibility must be constrained as to the limits of acceptable outcomes. Contingency planning allows for a clearer definition of expected behavior under various conditions. Ownership of waste delivery vehicles by the facility operator assigns clear lines of liability should an accident occur. The consequences of exceeding standards (e.g., shutdown of facility operations or payments of fines) would be established before the facility was sited to provide incentives to plant operators to manage the hazards cautiously.

Second, a system is needed to facilitate transference and analysis of information about facility operations (surveillance and feedback function). If the managers are to be held accountable, reliable information must be available against which their performance can be judged. Monitoring systems, and a shared understanding of what constitutes good monitoring and analysis, are clearly essential.

Transference of information in a form useful to the community is equally important. Moreover, surveillance should include visual examination as well as analytic measurements. The town is usually thought to need expert assistance to conduct inspections and properly analyze the resulting data. In the simulations, all six teams set aside funds to hire such an expert.

Third, a structure must exist for jointly solving problems and resolving disputes as conditions and concerns evolve (interdependence and interaction function). In the simulations, every team but one allocated money to create a joint community/company safety board to help set risk management policy and to oversee general compliance with standards. A third of the teams also set aside a fifth of their annual budget (i.e., approximately $600,000 annually) to provide a budget to the safety board for making improvements in the plant safety and to establish an emergency action trust fund to cover costs of emergencies. Most, however, saw these functions as the clear responsibility of the firm, not the town. In general, the powers of the safety board would need to be clearly delineated.

These limits are partly a consequence of an awareness that firms have the right to control their internal workings as long as they do not affect the safety of the community. Equally important, however, community control implies at least some level of community responsibility, and many individuals are ambivalent about accepting such responsibility. Liability issues are important, but concerns for potential regret and blame are even more important. Individuals active in decision making are subject to potentially greater feelings of regret should something go wrong. Every decision that a community representative will make (which could potentially affect the health of his or her neighbors) will cause stress because it may eventually bring on blame as well. While individuals, especially guardians, feel obliged to take on this responsibility (because they perceive the plant as being safer as a consequence), they do so hesitantly.

This pattern of quasi-integrated risk management, in which both the facility operator and the town have clearly defined rights as well as powers and must work together to arrive at a mutual accomodation, is fraught with the difficulties of all attempts at coproduction (Susskind and Elliott, 1983). Residents will try to avoid potential cooptation and to remain vigilant without creating a situation in which they must be hypervigilant and anxious. Facility operators will try to balance their willingness to negotiate (in light of their inability to obtain a site by conventional means) against their need to retain internal control over their corporation and flexibility over goal setting. For this coproduction of safety to be effective, risk management functions must be clearly delineated from other functions of the firm, differences in perceptions about appropriate risk management policy must be resolved, and a basis for mutual trust must be established.

While most participants in Essexton and Worcesterville recognize the difficulties, they perceive it as the only viable path to ensuring effective risk management. Guardians in particular perceive community participation in the safety of the facility as part of their responsibility to protect the town. To give up this authority is to abdicate too much control over the town's future.

Chapter 7

Beyond Mitigation: Risk Perceptions in Processes of Preemption and Compensation

The preceding chapters have focused on risk management strategies and their impact on risk perceptions. The preeminent importance of perceptions in generating opposition has been stressed. Some individuals (particularly guardians) may well support proposals that incorporate effective risk management systems. Most would not. Neither the possibility of rare catastrophes nor the costs of common impacts can be completely eliminated. Hazardous waste treatment facilities remain a bad bargain.

Most residents who oppose the siting of hazardous waste treatment facilities almost assuredly have more to lose than to gain. Hazardous waste facilities are strongly redistributive. Benefits of a hazardous waste facility are spread widely across a region, but no single beneficiary feels especially well rewarded. At the same time, the risks and costs are concentrated in the host community. Diffuse support is countered by concentrated opposition.

In aggregate, local opposition to facilities leads to shortages in their availability. Opponents who help generate local failures generally do not support this cumulative result. In 1979, three Massachusetts communities successfully obtained state legislation barring construction of hazardous waste treatment facilities in their towns. Even in these communities, virtually every citizen surveyed by the State Executive Office of Environmental Affairs believed that "appropriate" hazardous waste treatment facilities should be used to process wastes (O'Hare et al., 1983:2).

The question of how to site locally noxious but regionally beneficial facilities is the topic of an emerging literature on facility siting (see, in particular, O'Hare et al., 1983; Susskind et al., 1984; Morrell and Magorian, 1982; and O'Hare, 1977). This literature has generated two findings of interest to this discussion: (1) the conflict of interests between diffuse regional support and concentrated local opposition is aggravated by traditional regulatory systems, especially when these systems are coupled to state preemption of local governing authority and (2) the conflict can be diffused by new siting processes involving face-to-face negotiations and compensations. In this way, those who benefit can, on a project by project basis, share the gains with those who stand to lose.

These two approaches to facility siting are based on fundamentally different theories about political legitimacy and fairness. State preemption is coercive. Facility siting is generally thought to be a valid exercise of state police powers. For the persons whose property is taken, compensation is constitutionally mandated. For abutting neighbors and the community, no such compensation is required. Rather, individuals must accept personal loss for the greater social good. The state, in turn, has an obligation to ensure that facility siting is a technically competent and politically fair process. The state is obligated to protect the common good and to proceed impartially. In a democracy, the role of stewardship and protection are the basis on which political legitimacy is assured. While individuals or local communities may not like the outcome of a particular decision, they give implicit consent to the decision making process because overall it leads to good outcomes.

Negotiation and compensation processes of facility siting are built on different assumptions. Large-scale facilities, especially facilities with impacts as important as those of hazardous waste treatment facilities, cause unique nuisances. They impose local costs that are sufficiently imbalanced with benefits as to generate widespread local opposition and undermine the legitimacy of state preemption. Consequently, no facilities can be sited. To regenerate the siting process requires a new process for generating local consent. Consent cannot be achieved by simply mitigating risks and impacts. Even with the best means of mitigation, some impacts will remain. To leave the affected community at least as well-off after siting as before, compensation and rewards are needed. By altering incentives, compensation and rewards can lead to local consent and hence to a legitimate and fair siting process.

The debate between proponents of preemption (with its variants of centralized decision making) and negotiation (with its variants of local autonomy) is largely argued in the language of economics and politics. It is a debate over "efficient resource allocations" in which "highly threatened groups have much more effective power in the decision-making process than their total risk warrants" (O'Hare, 1977:417). In this chapter, I wish to extend this debate into the arena of risk perceptions.

Considerable attention has been given to the difficulties of risk assessment in this thesis. I have argued that no matter how carefully applied, technical analysis cannot answer the concerns raised by local opponents because lay people structure their perceptions of risk along distinctly different dimensions than do technical experts. I have further argued that effective siting of hazardous waste treatment facilities depends on mechanisms for coping with risk and uncertainty. These coping mechanisms must acknowledge and build on the risk perceptions of both technical and lay publics. As a consequence, risk perceptions and uncertainties fundamentally alter how we think about effective risk mitigation.

In a similar way, I will argue in this chapter that risk perceptions powerfully influence how individuals conceive of a "legitimate and fair" siting process. Preemption does not work because centralized decision makers are unable adequately to fulfill their stewardship and protector roles when perceptions of risk diverge widely. The use of negotiation and compensation processes are also complicated by apparent tradeoffs between mitigation and compensation, for in expending resources to improve safety, fewer resources are available to compensate individuals for the remaining risk.

I. Perceptions and the Legitimacy of Preemption

As a strategy for siting hazardous waste facilities, preemption of local siting authority is strongly rooted in options for predicting and preventing risks. As discussed in the previous section, preemption strategies rely on centralized decision making. Invariably, legitimization for this centralization is based on the potential impartiality and technical competence of the siting board. Technical criteria are used to select sites on which potential hazards would have the least deleterious impacts. These technical criteria, however, are themselves open to the uncertainties discussed throughout this thesis.

Moreover, as a system for state government to coerce local government into accepting unwanted land uses, preemption runs counter to the traditions of home rule and local zoning laws. While the federal constititution vests control of non-federal land in the states, the states have delegated much authority to local communities (Healy and Rosenberg, 1979). For over a century, local zoning ordinances were virtually the sole means of land use control in the United States.

These values of home rule are particularly strong among preservationists. While preservationists are most concerned with protecting the quality of life and physical amenities of the community, they also seek to maintain a high degree of political autonomy for their town. Many preservationists sharply delineate the boundaries of their autonomy, claiming the right to control whatever is in those boundaries and acknowledging little control over whatever is outside those boundaries. Thus, when confronted with the fact that he lives adjacent to an industrial park in a neighboring town and quite far from the one in his own town, one preservationist claimed he would do nothing to stop a hazardous waste plant from going into the adjacent town and everything to stop one in his own.

> I believe in home rule and accept the right of other towns to make a different decision. Once I cross the town line, I lose a great dimension of control. Their desires are their own perogative. I had a farm family upbringing, one that emphasized quality of life, self-reliance, and acceptance of the limits of our control. I call my own shots in my own sphere of influence. The rest I leave alone. (20)

Spheres of influence are an important political concept which preservationists guard jealously. To guard these spheres against encroachment sometimes requires considerable subtlety, as when a preservationist prefers a less desirable facility which maintains the integrity of the home rule concept to a more desirable one that threatens the concept. To some preservationists, the political traditions of local autonomy are more important than the particular issue of facility siting.

> I don't think the state should ever tell a town what to do. If private industry couldn't site a facility on their own, then the state should site a public facility on state-owned land. It's a real problem. I'd prefer private enterprise to run a plant like this, but if push came to shove, I'd rather the state not try to override home rule by telling us that we have to let one private industry do what we forbid of other industries. If the state owned the property, they wouldn't be overriding town laws because town laws don't apply. (4)

The goal of many facility siting reforms is to bypass local control. State siting boards are established to overcome opposition by denying local governments their power to zone land or regulate hazardous waste facilities. Out of 28 states who have enacted hazardous waste facility siting legislation, 19 have some form of state preeemption to bypass local ordinances (Nat. Con. of State Leg., 1982:II-3). Each of these laws went into effect between 1978 and 1981. Consequently, evaluation of their impact is largely speculative. The use of preemptive power has to date failed to obtain a site, but no other process has been more successful.

Several problems, however, suggest that preemption policies may increase opposition in ways which decrease the likelihood of site selection. First, while state intervention into local zoning has increased dramatically over the last twenty years, most interventions have been designed to preserve resources, not promote facilities. Vermont's Environmental Control Act, California's Coastal Zone, Florida's Environmental Land and Water Management Act, and similar laws in Colorado, Maine, Oregon, Washington, and Hawaii (Healy, 1976; Mandelker, 1976; Andrews, 1979) are all aimed at managing areas of critical statewide concern to ensure their protection. As such, they act as a double veto to unwanted development, not as an override of local opposition.

In some cases, states have experimented with the override of local opposition. Most common has been anti-snob zoning laws designed to open communities to low and moderate income housing developments. These laws have met with limited success in Massachusetts and elsewhere, but the results have not been exceptionally encouraging. Perhaps even more importantly, the justification on which these laws are built cannot be applied to large scale facilities such as treatment facilities. Anti-snob zoning laws are anti-discriminatory, built on principles of constitutional rights and equality. Inasmuch as all communities are treated equally under the law, consent for the local override is justified by appeal to principles for which individuals in the town have at least implied some consent.

As such, they fit into the framework of almost all other state land use innovations. As Bosselman and Callies (1972:3.4) note, these innovations are not "the result of battles between local governments and states from which the states emerge victorious." Rather, they emerge from "an awareness on the part of both local and statewide interests" that some problems are best solved by the state. Moreover, "these innovations have never involved a total usurpation of local control, and have rarely constituted an attack on the integrity of the local zoning process."

The siting of hazardous waste facilities, on the other hand, is highly discriminatory and no process for selecting the site can be shown to be implicitly acceptable to the potential host community. The process is discriminatory because a particular community must be chosen while others are relieved of responsibility. At the same time, the high degree of uncertainty and differences of opinion over site selection criteria implies that no technical process of site selection will be acceptable to all communities. Chosen communities do not see the selection of their community as just, equitable, or efficient. While some criteria (such as avoidance of the particularly hazardous conditions of flood plains or wet lands) are clearly important, most criteria are controversial because they favor one community over another. Rural residents promote use of land use compatibility criteria that preserves the character of communities (and insures that hazardous waste remains in urban industrial areas). Urban residents promote safety criteria that locates hazardous waste treatment sites far from population centers (and right in the middle of rural communities). In Essexton and Worcesterville, which are low density but still urbanized communities, residents made arguments in both directions: facilities should be located either in a more urban or a more rural area, but definitely not in their town.

When states have tried to develop siting criteria, the process has quickly become politicized. In Massachusetts, for example, the nationally renowned consulting firm of Camp, Dresser & McKee conducted an analysis of potential hazardous waste facility sites for the Department of Environmental Quality Engineering. When the report became public and before further analysis could be conducted, state legislators from the selected communites secured enactment of bills specifically excluding their communities from further consideration. In the case of Minnesota, described in Chapter 3, a coercive siting process, based on technical analysis, was not considered legitimate by the majority of the potentially affected communities. The facilities proposed in each of these states were not built.

Not surprisingly, the residents of Essexton and Worcesterville who support consideration of state preemption are people comfortable with technical expertise. Seven of thirty-four participants promote consideration of a state or federal siting board. Of these, five are professional engineers or scientists. Strikingly, this group includes all but one of the participants who works in these professions. Equally strikingly, these technical experts support preemption whether they are sponsors, guardians or preservationists. Their support, however, has two distinct characters.

To the few sponsors and preservationists who advocate state override of local authority, the problem is simply one of applying technical expertise. By applying expert knowledge, the state would simply "take care of the problem."

> I believe a strong body of scientists, engineers and experts should develop and promote a solution. The state should then just go in and build it. No questions asked. This is one of those times when an authority figure stands up and says, "I know what's best for you." (6: a preservationist)

> We've got to face up to this problem. The state should take land by emminent domain and site the facility. No questions asked. Let's just move on with this. You do the best you can and if that's not enough, tough. What else can you do? (5: a sponsor)

Interestingly, the few sponsors and preservationists who do support state preemption invariably believe that the state would impose these facilities on some community other than their own. In particular, they believe that hazardous waste treatment facilities should be sited in an even more rural community than their own.

> When I drove through western Massachusetts, through all those small towns in which hardly anyone lives, I kept thinking, Jesus, there's no reason for us to have these problems. We could site a facility in any number of places. No one would even see it. So why do we have a problem? (5: a sponsor)

This preference for a more rural location is consistent with the ideology of sponsors (who want to site a facility and therefore might choose the path of least resistence). It is, however, highly inconsistent with the ideology of preservationists. To preserve their own environment (which they wish to remain unaltered) through the use of technical safety criteria (which insures that a more rural community would be changed even more) is a political act and is recognized as such.

Guardians remain centrally concerned with locating these facilities where risks are most controllable. While a quarter of guardians believe that siting criteria is necessary to accomplish this task, they recognize the inherently political problem of developing criteria. As the physician, industrial process engineer, and police chief who support the idea of using criteria each noted:

> Once you assume you need it, which indeed we do, the state should set up geologic, hydrologic and transportation siting criteria. Once they've found a good site, the state should muster all the resources at its disposal to make sure its safe. Unfortunately, the state has been unable to conduct truly objective analysis nor to take the heat needed to effect the best decision. Expediancy doesn't lead to objectivity in issues which are this visceral. (32, 2, 12)

Despite this conditional support by a few residents, the vast majority of sponsors, guardians and preservationists are adamant in their belief that the state could never be both impartial and fair, and that state preemption is doomed to fail. As two preservationists describe their concerns:

> I would never trust the state. I have a chronic and habitual distrust of people who plug into politics. Those who impose themselves on our lives through political office get quickly buried with their own concerns. Politicians can be bought, bribed, wooed. There's so much mediocrity: Vietnam, Abscam, Watergate. I would just as soon keep the public sector as far away from these problems as possible. (20)

> The problem with the Department of Environmental Quality is that it's a state agency. It means well, tries to be professional, but is underfunded and understaffed. They try their best, but they can't do the job without the state being committed. I have no reason to believe that if the state were to take over the problem of siting a hazardous waste facility and maintaining its quality, that they'd have any more commitment to this new problem than they have had to all the other important things they've ignored in the past. (26)

In a similar vein, three guardians note:

> The thought of having the state override local decisions, people would go crazy at the idea. If they don't trust their own selectmen, you can imagine what they think of these other characters they don't even know. (22) The decision would be so political. Nobody's going to come in and say we've found the perfect site, it's impervious to leakage, it's not near anyone. No, they'll put it on somebody's brother's farm because he wants to retire. Or they'll put it where the fewest people will object, even if the land has poor soil conditions. (23) If you try to force a solution like this on someone, no matter how good the idea, they'll resist it. Even if you're bigger, there's always a few tricks a community has up its sleeve. (18)

Despite continued opposition to the override of local zoning and preeemption of local decision making powers, 19 states have enacted these laws. Without the implicit consent of local communities to this process, however, such powers may prove ineffective at best, and counterproductive at worst. In the Wisonville, Illinois story discussed in chapter 3 (US EPA, 1979c:303-317), local officials wanted to close down a hazardous waste treatment facility that was initially suppported by both the state and the federal governments. They had no local permit to issue and virtually no direct control over the SCA/Earthline hazardous waste facility. By the creative use of the township's power to repair culverts, the city closed the facility's access road. Permanent closure was successfully achieved through legal proceedings. The town was able to use various environmental and regulatory requirements to bolster its claim that the site was environmentally unsuitable. In light of various legal, quasi-legal and extra-legal powers that remain available to opponents, states remain unable to guarantee unhindered access to sites. Vehement local opposition to major facilities provide a veto even in the absence of apparent legal control. When perceptions of risk differ in significant details, the development of acceptable siting criteria using technical criteria itself becomes politicized. By accentuating the adversarial character of siting disputes, preemption aggravates problems of mistrust and divergent perceptions of risk, and hence lead to greater opposition (Morell and Magorian, 1982; O'Hare, Bacow and Sanderson, 1983).

II. Perceptions and the Acceptability of Compensation

The impasse over siting hazardous waste treatment facilities has led to widespread interest in compensation mechanisms for reducing local opposition. By mitigating some of the local impacts of these facilities and offsetting others with compensation, facility proponents hope to restructure the interests of local opponents. While eight states have enacted compensation plans coupled to state preemption, four states (Colorado, Massachusetts, Rhode Island and Wisconsin) have coupled compensation to extensive local autonomy (Nat. Con. of State Leg., 1982: II-5). The Massachusetts Hazardous Waste Facility Siting Act, for example, vests primary authority for siting hazardous waste facilities with local communities and mandates a process of negotiation over mitigation and compensation involving the community, the developers and the state (Bacow, 1982). The law thereby explicitly acknowledges the primacy of local control over local land use, and the necessity of compensation to minimize impact. At the same time, the law specifically refrains local communities from denying applications on industrially zoned land if the facility meets all permits and licenses that were required before enaction of the siting law and it does not pose a significantly greater danger to public health and safety than do comparable enterprises. While these conditions might eventually be used to preempt local authority, the law is clearly designed to reach a negotiated settlement that precludes such a confrontation.

The possibility of preemption is, however, not lost on residents of potential host communities. In their ambivalence toward the state, residents are somewhat leary of state intentions in establishing a siting process that requires final arbitration over siting disputes.

> The Hazardous Waste Facility Siting Act created a bad process in that the community really doesn't have a say on whether the plant can be sited or not. We go through the niceties of negotiation, but in reality the state and the company are already assuming that the plant is technically safe since it will meet state standards. The community therefore has no valid reason to oppose it. If the town goes along with this game of negotiation, and does not get so emotional that they force the state and the developers to back down, then it won't be able to stop the plant. We have a say in the size, the shape, the landscaping, how much money we're going to get, other inconsequentials. But in the end, the choice is made in arbitration and will be based on technical arguments that may have little to do with our concerns, and the plant will go in. Under these circumstances, where is the basic for trusting the state? (32: a guardian)

The use of compensation in Massachusetts and other states is specifically intended to promote local support of hazardous waste treatment facilities by altering incentives. Compensation can take several forms: monetary payments to enhance town revenues; monetary payments to provide specified services; in-kind replacement of natural resources, physical amenities or services; and provision of contingency funds. Each of these forms of compensation will promote the interests of different constituencies. Hence, negotiation must include not only the total amount of compensation, but also its distribution within the town.

The most important tradeoff is not among types of compensation, but between compensation and mitigation measures. Research to date has largely ignored potential interactions between mitigation and compensation. Several are of particular importance:

-- divergent perceptions of risk can create significant differences in what is considered fair compensation;

-- increase in compensation will almost assuredly reduce resources available to mitigate risks;

-- compensation can divert attention away from adverse impacts by focusing it onto financial concerns; and

-- if perceived risks are above some threshold of acceptability, any discussion of compensation can be construed as an attempt at bribery to accept an "unsafe" facility and hence contrary to the public interest.

Sponsors focus on the first consideration of "fair" compensation, guardians on the middle two considerations of resource allocation, and preservationists on the last two considerations of "bribery." To each, compensation has both desirable and undesirable effects.

Sponsors

Most sponsors strongly approve of the use of compensation to promote the siting of hazardous waste treatment facilities. For the most part, however, compensation is not the reason they support the proposal. As discussed earlier, general acceptance comes more basically from a willingness to give industry a free hand or from a sense that hazardous waste plants are needed. Sponsors couple these attitudes to a belief that these facilities are relatively safe.

Compensation, while marginal to their implicit acceptance, remains an important consideration in their explicit support. Compensation increases the motivation of sponsors to promote the plant. It turns passive acceptance into active sponsorship. Without compensation, only those few individuals who really believe in the need for the facility have any incentive to voice their beliefs.

> Essexton isn't producing this waste. If we're going to do a service for the state, we ought to be able to receive economic advantages. With this compensation, I could accept a plant being built here. I see $$$ bills in my eyes. The best schools, the safest roads, the best of everything. (17) We could reduce our taxes to almost nothing. Plymouth has the lowest tax rate in Massachusetts because of the Pilgram nuclear power plant. Nuclear power certainly is more risky than hazardous waste. (5) It'd be great for the community. Getting the town to agree on what to do with the money would be the only real problem. Like pulling teeth. Each person has a different idea about what they'd want. (26)

While the majority of sponsors hold the above view, a fifth are more ambivalent about compensation. These individuals make a distinction between justifiable compensation and unjustifiable rewards. Inasmuch as the facility generates problems or costs for the town, it should compensate the town accordingly. Pure rewards, in which the town is compensated for more than its real costs, is considered suspect, however.

> I was perturbed at several individuals who wanted more compensation. I didn't want the tipping fee because the company will already be paying big bucks in taxes. I don't think extra compensation is necessary or relevent. If the town wants to build a swimming pool or increase its services, they should do it themselves. It's not the town's place to put these monetary restrictions on the

> company. The company ought to do what it is responsible for, and should not be required to do more. The biggest problem in making a decision lies in determining who is responsible. I feel that hazard mitigation is the responsiblity of the plant, and the plant operators need to take every necessary precaution in that direction. I also feel that road improvements, water supply guarantees, and co-generation are appropriate responsibilities for a hazardous waste company. Tipping fees are not. We shouldn't financially overburden a company with unnecessary restrictions. (14)

To avoid excessive local demands for compensation, sponsors feel the state should provide guarantees of safe operation to the town, and be willing to provide compensation directly to the town if damages should occur.

> The state should provide the support we need. They've got to provide relief and insurance immediately in case of an accident. They should act as an intermediary between the town and the courts in these cases. The state provides the relief and then goes after the company in court. (17)

Guardians

To guardians, compensation is clearly justified, though to some it is an irrelevent consideration. The distinction between compensation and rewards has little meaning. Since they believe the plant is undesirable, payments over-and-above the costs to the town are simply a means of compensating for the non-monetary costs of the plant.

> The operators of a hazardous waste treatment facility should perform some form of compensation. At the very least, they need to cover the real costs of the facility, the extra pressure it puts on the community. And over and above this, they need to compensate for the shear nastiness of it all. (13) Otherwise, why should a town take a $10 million hazardous waste plant when it can

> get a clean $10 million computer plant? Without a carrot in addition to taxes, it won't be palatable to the town. (30) After all, the plant would affect the desirability of the town, thereby reducing our ability to raise taxes in the future. (23)

Compensation, while justifiable, is not necessarily seen as beneficial. Guardians are most strongly attentive to the safety of the facility. In this light, guardians consistently raise the issue of whether increased compensation is offered at the expense of necessary mitigation measures. In making this comparison, guardians are directly confronted with the reasonableness of risk taking. Since additional safety can always be bought at a higher price, at what point can a line be drawn?

> I wouldn't want a plant with a lot of negatives attached to it. If you could take care of all the problems, then I'd feel great about compensation. But I wouldn't trade increased safety for compensation. If the town accepted a proposal in which a company offered compensation and fell short on extra safety features, it would be accepting a bribe. The company would be buying out of its responsibilities to be as safe as possible. But I think you can go to extremes in buying safety. I think at some point you don't gain much by these features. (12) If we started with a budget for mitigation and compensation, and there was money left over after meeting basic needs for safety, with margins for error, then there is no need to pile one safety system over another. You do what is reasonable, and then take whatever is left over as compensation. (18) At this point, I'd feel great about compensation. (12)
>
> So while compensation is less important than safety, it is still essential. I don't rightly know how you figure what level of compensation is fair or when safe is safe enough, but you've got to try. I think people who equate compensation with bribery are doing this to protect themselves from having to change their mind. The compensation may be just too good. People who lived in the town where Vermont Yankee was located didn't mind the plant. It paid almost all their property taxes. People outside the town were the ones who cared. (16, 2)

While a third of guardians have a generally optimistic sense about being able to balance mitigation with compensation, the remaining two-thirds finds this tradeoff considerably more problematic. To a few, the problem lies not so much in making tradeoffs, but rather a concern that the town would make the wrong tradeoffs or should not be demanding compensation at all.

> Some people in the town would want to put compensation directly into the town's general revenues. I disagree with this approach. These funds will get funneled off into particular projects, like building a new school or improving services. We've cut out services in half because of Proposition 2 1/2. In the rush to reinstate them, important things like better safety equipment for the fire department and buffer zones around the plant might get lost. These safety features need to be considered first. (29)
>
> There's a certain amount of risk we take every day in getting up, going to work, or playing at home. As long as it's reasonable, that's all you can be expected to do. You can't make your life risk free. If there wasn't very much left over for compensation, but I felt that the risks had been handled reasonable, I'd accept the plant. I wouldn't demand a lot of money. It borders on blackmail. If you hold up somebody just for the sake of some extra dollars, that's a bit unfair. If the plant could be run safely, that's all you can really expect. I'd be happy with a plant that met the basic needs of the town, even if there wasn't much left over for compensation. (18)

Others are ambivalent about the offer of compensation itself. To a fifth of guardians,

> The offer of compensation feels like a bribe. It doen't seem immoral or unethical, but it's being offered only because we have the upper hand. It's good business sense for the firm to offer the compensation, but for most of us the money is the least of it. That's partly because we don't want to feel like we're being paid off. (22)
>
> If the firm offers physical amenities like a swimming pool or a cultural center, it's even worse. That

> really feels like I'm being bought, that if they think of enough things to give me I will overcome any reservations. I really have a strong reaction against being offered unrelated things. We'd be a company town, they'd own the recreation center and we'd owe them something for its continued use. They'd have something to hang over us. Compensation that is related to what's going on seems more like a benefit of the project. Straight compensation in the form of tipping fees seems cleaner. If the tipping fees were large enough to make a difference in my finances, and all the safety features were already in place, I might accept the plant. (22)

But for half the guardians, the problem lies squarely in trying to make tradeoffs between mitigation and compensation. To these individuals, safety cannot be separated from compensation because there is simply insufficient funds available to both mitigate hazards and provide any meaninful compensation. In light of this economic reality, these guardians see no choice but to expend the available resources on safety.

> This tradeoff between compensation and additional safety features bothers me. Well, the company is not going to build a plant unless it is profitable and they can't make it profitable by offering the best safety features and adequate compenstion, but who's setting the profitability of these companies? The company shouldn't be allowed to put us at risk because it increases the company's profit. (30)
>
> In Worcesterville, not enough people are that close to the edge that we would worry about just how much the plant could offer us. The big push in compensation would be to plow it back into safety and protection for the environment. Monetary compensation is nice, but it has nothing to do with our concerns. There's got to be provisions to help if something goes wrong. Somebody's car, or home or family gets damaged, you've got to have a way to compensate them. (33) It is these issues of liability and safety that are important. They shouldn't be so uncertain. The money needs to be set aside in trust. (13)
>
> Compensation has a negative effect for me. I think a person will go along with a treatment facility because they perceive a need to straighten out the problems of

> hazardous waste now rather than have 55 gallon drums dumped all over the area. So while the facility would change our world, if designed and managed safely it might improve our overall environment. On the other hand, even if you give a million dollars to the community each year, that amounts to a couple of hundred dollars per person. That's a joke, an extra. The decision should be based on safety. What you do with the spare change seems totally unimportant. If the compensation distracts from this fundamental concern, it becomes a bribe. (32)

Preservationists

Preservationists rarely talk about the benefits of compensation. To them, there are few. The guardian's occasional and considered references to compensation as "bribery" become quite prevalent when talking to preservationists. Some individuals focus on the incompatability between a hazardous waste treatment facility and the character of the town. Others focus on the impossibility of making a hazardous waste plant safe. Having defined the issues so sharply, however, there is little room for compensation. The only acceptable solution is to ameliorate the perceived problem, but this is believed to be impossible.

> The developer is trying to ameliorate the opposition against a facility that shouldn't be there by diverting the issue from the real concerns of public health and safety. (31) He's using compensation as a form of bribery. That's what you do with a child. I don't like being treated like a child, being rewarded for acting like somebody else wants me to act. (6) Through compensation, the developer is trying to structure a christmas tree of goodies to spread before the town. The developer wants the town to gravitate toward a proposal which the town would not accept otherwise. For the town to do so is morally inconsistent. It's accepting bribery. If the plant has characteristics which the town doesn't like, the town should reject it whether it comes with a christmas tree or not. (20)
>
> The only reason you're offering compensation is because there's something wrong with the initial proposal. You're paying me to take a risk. There's just no

way you can make it worth my while to take that risk. (6) If somehow the state forced us to take the plant, and threw in some compensation, I would take all the money and make the plant safer. Extra sweetners don't mean much to me. (28) The plant should have every possible safeguard. Costs shouldn't be a consideration for something this dangerous. I would not tradeoff safety for compensation. What good will all this compensation be if something goes wrong? It won't cure things after an accident. (4)

They'd be playing games with us. A few individuals will cut a deal. The administrators of the town may see it as a great opportunity to set their own priorities. In the future, new deals will be cut. Anything that can be fixed can be unfixed. (7)

If the town were to decide to enrich itself with the amenities of the compensation package, it's their choice. But if it were located near me, I'd get up and move. (20)

Compensation is seen as having a potentially insidious effect on the host community. By expanding the resources available to the town, the compensation could undermine the independence and self-reliance of the town. To some preservationists, this change itself should be resisted.

Even if revenues from the plant equalled all our current tax revenues, we wouldn't want it. We're a well managed little town. Our taxes are moderate, we're frugal in our spending. No fat cats sit in our town hall. We have a lot of volunteer labor who work as a form of public service. Maybe a town that was financially strapped, because they've mismanaged their funds, would look to this as a way to bale out. But the funds would have less leverage in a town that is well managed, with a tax rate that's already acceptable to the residents. (4)

People find the status quo acceptable. It's a small town way of life. People volunteer here because it's the way we do things. We like the quality of our life. If you had all this money, I'm not sure it would be an improvement. The people who would want to live here, who would want to volunteer to work for the town... I'm just not sure. (4)

In a similar vein, the legitimacy of using compensation to ameliorate community opposition was also questioned. In particular, the issue of equity was raised by a fifth of the individuals.

> If the plant doesn't offer compensation, they just won't be located there. Good, bad, it's a moot point. They have to do it. It's bribery. Its not an illegal bribe because it's greasing the community's pockets and is above board. It's up to the community to decide if it'll accept the bribe. But I worry about a town being poor enough to say "we don't care about the risks, we need the money." Like New Bedford, which is highly populated. These people are being bought. They're weighing the risks against how poor they are. If communities accept these facilities based on compenstion, a town like Worcesterville would never take it. People here are not hungry enough. Unless people are jobless and hungry, they are not going to want that kind of a risk. We're not talking morality here, we're talking practicality. I think it stinks. It's just another way of descriminating against the poor. Even if you somehow got a treatment facility into Worcesterville, say by paying enough money to cover property values, people would sell off and move. People who were hungry enough to want that kind of revenue would move in. Worcesterville would die. (24)

And, turning the bribery argument on its head, a tenth of preservationists (like several of the sponsors) felt that compensation was an improper demand on the facility operator.

> I certainly wouldn't reject the compensation, but I wouldn't want to go after it. I feel like I'm blackmailing the company in exchange for my approval. It's a tax that is not equitable. It's selective. On the other hand, if all large industrial facilities are treated the same, I call it "bearing the cost." (1)

The reaction of preservationists against compensation is not based on an unwillingness to be compensated, but rather on an unwillingness to take compensation into consideration as part of the site decision making process. About one-third of preservationists consider compensation to be potentially desirable. Even these individuals, however, mistrust its use to help convince towns to accept a locally undesirable facility. While compensation may be desirable, a decision to accept a facility should not be based on this criteria.

> Everybody wants to reject these facilities because of the mistrust. We don't trust the state or the developer. The lack of benefits doesn't make a community close up; the lack of trust does. There's no question that we will be swayed by the dollar, but without trust there's nothing. In this light, I see compensation as potentially exercising improper leverage. Either you fit our guidelines or you don't, and either you will change the character of the community or you won't. Why should we trust anyone who wants to change us. The way I look at it, any town which seeks to attract industry should accept a treatment plant as a consequence of accepting waste generators. I lived six years in two industrial towns. They could use the compensation, and the treatment facility wouldn't change the character of the town. They already have industrial parks. That's where it should go. (1)

> We can all find good uses for compensation. After all the safety considerations were complete, compensation becomes an icing of sorts. But I don't think a proposal would ever get far enough along to consider compensation. There are too many questions about the hazards, not enough trust in either the company or the state. (21)

Preservationists also generally support the desirability of compensatory trust funds to protect the community against damage, should the plant be located in their community.

> We're all gun shy of the court solution. The court system is near a breaking point. It can be manipulated and takes decades to make a decision. Meanwhile there are real health costs as the conditions continue. We need a more direct way of insuring that the facility is well handled. If we have a problem, we don't want to trust our future with the courts. We need something closer to home. That's why trust funds and insurance schemes are necessary. Money would become available when needed. (28, 1)

The Use of Compensation and Incentives

The risk perceptions of sponsors, guardians and preservationists generally correspond to their perceptions of benefits. Sponsors perceive the least risk and the greatest benefit, and preservationists are at the opposite extreme. A close look at the individuals in these groups, however, suggests that actual benefits (as measured in economic worth or increased service provisions) do not vary much between these groups of individuals. Neither does utility for benefits appear to differ significantly. What stands out more sharply are differences in perceived risks and ideological beliefs. Sponsors support business and free enterprise, and generally view risks as managable by those institutions. Guardians support governmental and social responsibility, and are generally cautiously optimistic about the potential for safe waste management. Preservationists support home rule and self-determination, and are generally pessimistic about the ability of industry and government to mitigate aesthetic, environmental, and health impacts. Perceptions of benefits, while consistent with this pattern, appear to be a secondary consideration.

The gaming simulation allowed the residents of Essexton and Worcesterville to allocate up to $3 million annually to mitigation and compensation. Thus, each commmunity could choose any amount of compensation up to that approaching the limit a private firm (operating a rotary kiln incinerator with annual gross revenues of $30 million) could pay while remaining competitive. Given the choice as to how to allocate these funds, participants almost invariably opted to purchase greater safety (and hence receive lower compensation). On average, of the $1.1 million in compensation (that was initially designated as fees to be paid to the town's general revenues), 30 percent was reallocated to safety features. In the simulation, no individuals switched from opposing to supporting the proposed facility based on this amount of compensation. Even when compensation was increased considerably (to the equivalent of the town's entire tax burden through state subsidies), only one in ten people changed their preference to accept a previously rejected facility.

Equally striking, participants in the simulations redistributed funds away from direct monetary payments to enhance town revenues towards payments to establish contingency funds for guaranteeing compensation for injuries, decreases in land values, and problems with water supply. In Worcesterville, these shifts were particularly striking. Averaging the three team results, the $1.1 million in annual community revenues was reduced to about $100,000. In its place, over $400,000 annually was allocated to contingency funds, $200,000 annually to improvements in community services that would be used by the facility (i.e., roads and technical help for the town), and $600,000 annually to the purchase of safety features. In Essex-ton, annual revenues of $500,000 were left in the community treasury, with $300,000 shifted to contingency funds and $500,000 shifted to safety features.

Why does this emphasis on safety exist? Clearly, perceptions of both compensation and risk are heavily influenced by perceptions of the status quo. People do not balance risks and benefits using a baseline of zero, accepting risks if the net benefits are positive. For the comfortable, potential benefits are greatly outweighed by potential challanges to comfort. Uncertainty is a strong challange to comfort. Compensation is heavily discounted relative to stability of safety. Those who perceive the risks of a hazardous waste treatment facility as being relatively controllable (i.e., sponsors) are freer to consider benefits than those who do not (i.e., guardians and preservationists).

In addition, emphasis on compensation introduces new tensions into the siting dispute. Ideologically, tension exists between individuals who believe that industry should be left to manage their own resources, should not be taxed, and has certain rights, and individuals who believe the opposite. Practically, people have enormous difficulty making tradeoffs between increased compensation and increased safety. Individuals and communities will expend almost all available resources on safety, leaving little for compensation, but will also reject the plant if it offers few benefits to their community. Given the choice, they prefer arrangements that mitigate risks, retain community control, cover the cost of impacts that are measurable, and compensate for damages that actually occur rather than arrangements that compensate for intangible impacts of the plant. Most are uncomfortable with offers of incentives for taking risks when the offer appears designed to alter their choice to accept a facility or to reject it.

Nonetheless, the generally positive attitude of sponsors toward compensation and the sense among most guardians and preservationists that a facility with compensation is better than a facility without compensation (as long as compensation is not used to influence the choice of site or the levels of safety) suggests that compensation does have an important role in increasing support for facilities.

This conclusion is consistent with a survey of Wisconsin residents conducted in 1980 (Carnes et al., 1982). Substantial payments to the community had little affect on the willingness of the individuals surveyed to accept a nuclear waste repository (acceptance increased from 22 percent to 26 percent). When these payments were coupled to various forms of community control over the facility (i.e., access to information, independent monitoring, representation on a governing board of the facility, and the power to shut the facility down), support increased to 42 percent.* No one incentive led people to change their minds; rather it is the total package that seems to make the difference. Compensation induces sponsors to actively promote facilities, while decreasing opposition among some guardians and preservationists. However, great care must be taken to separate considerations of safety from those of compensation and to recognize possible interactions between the two.

* We should note that men were significantly more likely than women to become more favorable to siting a waste facility in their community when offered incentives, and that although not statistically significant, higher income families also responded more favorably than lower income families (Carnes et al., 1982:71). Since the participants in the simulations were predominantly male with above average incomes, we might expect these individuals to respond most positively to incentives.

Chapter 8

Coping with Perceptions in the Management of Risks

Perceptions of risk are rooted in the selection, from a wide range of uncertain possible futures, of alternatives that might be most devastating. Risk perceptions are inevitably tied to definitions of significance, for it is in such definitions that individuals chose some possiblities for special review, treat others in standard ways, and ignore most as inconsequential. I have argued that differences between technical and lay perceptions of risk emerge as much because of differences in their models of significance as because of differences in their information processing capabilities. What is believed to be a risk is derived from cultural values, not simply from physical properties measurable through technical analysis. As such, risk perceptions are subject to the vagaries of social judgements.

For problems that are amenable to scientific or engineering analysis, technical perceptions have historically been given greatest credence. Broadly speaking, risk management strategies traditionally preferred by technical experts focus on risks deemed most significant by those experts. The bitter debates that engulf risk management disputes, such as those associated with the siting of hazardous waste treatment facilities, reveal widespread political rejection of this technically dominated model of decision making. If we are to develop effective policies for coping with risk, policies that can be enacted and implemented, a new direction is needed.

This dissertation suggests an alternative approach. Technical perceptions need not necessarily compete with perceptions held by laypeople. Risk management policies, currently held hostage to the difficulties of reeducating the lay public or overpowering their political voice, can be redirected. Since lay and technical perceptions are based on different conceptions of what constitutes a significant risk, management strategies based on one set of perceptions can be imbedded into strategies based on the other. The resulting approach is one in which professionals do not alone make the critical judgements about what is significant and how risks should be managed. The approach focuses analysis and discussion on a wider range of concerns than those traditionally envisioned by technical experts.

Three questions immediately arise: What are the essential characteristics of an approach to risk management which accepts as legitimate the perceptions of both lay and technical publics? Would the resulting strategies actually mitigate the hazards that both lay and expert publics seek to manage? And would such an approach promote acceptance of currently stalemated risk management strategies?

I. Technical and Lay Perceptions in Risk Management

Differences in perceptions aggravate disputes over risk management proposals. These differences are not ephemeral. The disputes they generate are unlikely to be resolved in the absence of a better system for coping with perceived risks. In the siting of hazardous waste treatment facilities, in the setting of standards for chemical substances, and in a host of other facility siting and regulatory settings, these disputes have rendered our decision making processes inoperative.

Risk management in the public sector is an inherently social act. As a society, we must render our risks manageable. Our perceptions of risks must be coupled to a willingness to act, to make decisive choices. Within these context, it is strikingly clear that risk management is more than risk analysis (whether purveyed by technical or lay publics). Perceptions of consequences, and the analysis on which they are based, mean little in the absence of an ability to effect change in those consequences.

The central paradox of contemporary American risk policy is that the more we learn about risk, the less confident we are of our risk management abilities. We are a society that is longer living and more prosperous, and apparently also more fearful for our health and welfare, than ever before. Risk analysts are prone to conclude that we have lost our grip on rationality, for we must surely know that we are better off. But this assessment of the problem cannot explain the central question of why, if we are better off, are we incapable of moving forward with continued vigor. What are the essential characteristics of our indecisiveness?

This thesis has argued that this indecisiveness, at least in the context of hazardous waste facility siting disputes, springs most fundamentally from differing conceptions about what consequences are significant (particularly in light of the growing concern with potentially catastrophic risks) and differing perspectives on the chains of events that are most likely to cause these consequences. Analytic techniques can be employed only after characteristics of significance are defined and models of cause and effect are delimited. The debate about rational analysis is therefore misplaced. It presumes agreement on two prior concerns, agreement which does not exist. The technical conception of risk suggests one form of coping, while the lay conception suggests different forms. These conceptions (and the perceptions they generate) are currently at odds, but can conceivably be joined together.

Measurement and analysis are the tools of engineers and scientists. Without them, knowledge about hazards cannot be given meaningful (and testable) structure. With them, hazards are potentially predictable and controllable. To be useful to technical experts, indicators of risk must be measurable and methods for handling uncertainty analytic. Engineering principles of analysis, from which much of risk analysis technique is derived, has consequently given shape to an understanding of risk in which measures of unwanted consequences such as death are estimated over a given period of time to yield expected frequency. Implicit in these measures of riskiness is the presumption that all risks are equivalent inasmuch as their expected outcome is the same and that risks can be ordered by these measures of expected outcome. With this definition of significant outcomes (i.e., expected deaths) and model of cause and effect (i.e., only physical properties are important causes of hazards, and these properties are measurable, predictable and controllable) comes a preferred method of coping. If risks are caused by predictable physical reactions, then they are best prevented with predictable physical systems. The coping mechanism is one of engineered controls, of estimating the requisite probabilities, and designing for appropriate safety.

Within this model of risk management, much room for disagreement exists. It is not just laypeople who perceive differently than experts, but experts who argue among themselves. This is not surprising: the scientific method is based on premises that theories are held tentatively, contingent on the development of contrary evidence and new interpretation. These debates are part of the evolution of science. In an attempt to weed out error and inappropriate behavior, the scientific community regulates which perceived facts and theories are to be considered legitimate and which are not. The quality of these debates are controlled by means of independent experiments and peer review. For many of society's most fearsome risks, however, agreed upon facts and criteria of competence are lacking. Quality control is therefore difficult to ensure because quality is at times impossible to define. As in the Love Canal debate, the result is polarization and suppression of tentative viewpoints, even within the scientific community.

This is not to say that rigorous analysis has no place in resolving ambiguities in risk problems. Rather, it suggests that technical analysis can make no claim to a precision it cannot offer, for a problem it can only partially define. The power of technical analysts to design risk management systems, and to convince a skeptical public of their reliability, is limited by their potential fallability. Moreover, the scientific process for resolving differences of opinion among scientists, which is difficult to apply even among those who espouse its value, cannot provide the sole support for a risk management system in which entirely different processes make claims to legitimacy.

Despite these limitations, technical experts can do much to inform the risk management debate. Their methods of analysis yield the most precise predictions of unwanted consequences and provide the overview needed to design systems for preventing hazards. These skills are essential to operators of facilities. In addition, residents of Worcesterville and Essexton do not claim that these skills are unnecessary, but rather that they are insufficient as currently conceived. To the guardians and preservationists of these communities, the risk management problem goes beyond the skills traditionally employed by technical experts.

Because lay conceptions of risk are not bound to risks that are measurable, they are neither as precise nor as restricted as those of engineers and scientists. Laypersons are concerned less with expected outcomes, which tend to average out rare events, than they are with variability, the possibility of extreme outcomes, and uncertainty. The characteristic that most powerfully separates the lay public into sponsors, guardians and preservationists is the extent to which an individual focuses on extreme outcomes rather than expected outcomes.

Sponsors focus most strongly on expected outcomes, preservationists most strongly on potentially catastrophic events, and guardians moderately on both. These differences come about not because sponsors are more rational than preservationists or even that they think more like scientists and engineers. Rather, they come about because sponsors trust the current systems for managing risks, and believe in their spokespersons. They accept the logic of experts because management of these risks is part of the standard operating procedure for which experts are trained. The risks are simply not exceptional and hence do not require special attention. As sponsors put it, "Hazardous waste is less safe than nuclear power, but the risk percentages on either are so low, I don't particularly pay attention to them."

To guardians and preservationists, on the other hand, the risks associated with hazardous waste treatment facilities are exceptional and do require special attention. These hazards are viewed as more threatening than most. To introduce them into a community is to invite loss of control. Guardians focus on health and safety consequences. To place their town in jeopardy by accepting an unwarranted hazard, even one in which the probability is small, is to shirk responsibility to their community. "My responsibility is to protect this town, and it is the plant operator's duty to make the changes ncessary for this to happen," states the guardian. In addition to these health and safety concerns of guardians, preservationists also focus on aesthetic and cultural consequences. Much more pervasively, an uncertain future provokes anxiety in preservationists. "We really don't know much about the risks. It's like the atomic bomb: We know it's terrible and potentially disastrous, but we've never been directly confronted with it. We haven't had to raise our children with this thing festering in our community," is the view of preservationists. They are more prone to perceive hazards as uncontrollable and unpredictable.

Because of this basic concern for extreme outcomes and loss of control, guardians and preservationists do not find technical analysis very compelling. These analyses, generally based on the premise that expected outcome is the most appropriate indicator of risk and physical systems the most important causes of hazards, focus on neither the consequences nor the causes of greatest concern to guardians and preservationists. Rather, guardians and preservationists focus on systems for foreclosing worst case scenarios and for retaining community control over the processes that lead to these extreme outcomes. For the most part, they believe that in well designed treatment facilities, risks are most reliably controlled by means of systems for detecting and mitigating hazards, and for managing the treatment facility. These future-oriented, managerial based solutions form the basis for coping with rare but extreme outcomes as well as more common consequences.

In greater detail, seven principles for managing risk emerge from the simulation studies and interviews. These principles, as suggested most particularly by guardians but also by most preservationists and some sponsors, emphasize the outcomes and processes of risk management. They are not oriented towards altering perceptions or reeducating disputants (though learning is inevitably an element of any attempt to resolve disputes), but rather on managing risks as perceived by those disputants. Following a discussion of these principles, we shall examine their desirability.

II. Seven Principles for Managing Risk

This section presents and discusses seven principles for more effectively managing risks, as envisioned by community residents. The first three principles define the basic structure of the management system: how should risks be predicted, prevented, detected, and mitigated, and how much emphasis should be given each? The remaining four principles define the relationship between the community and the operator: how can openness and trust be ensured and what powers should exist to protect the community in case problems do develop? The prinicples are general; options can only be precisely defined within the context of a particular siting dispute.

Basic Structure: Prediction, Prevention, Detection and Mitigation

> 1. Community residents and facility operators need not agree on the precise likelihood of a risk. They must, however, reach agreement on the characteristics of risks to be managed and the standards of acceptable variation.

Perceptions of risk differ not simply because predictive analysis differs, but also because different characteristics of risk are of varying importance to different individuals. Facility operators and community residents need not agree on the precise likelihood of a particular risk to design effective prevention systems. At a minimum, however, they must agree on what consequences are acceptable and what consequences are not. In agreeing to standards of acceptability, operators can then rely on their own predictions to determine if the standards can be maintained and at what cost. They need not convince residents of the validity of these estimates as long as residents believe that the standards are physically possible to meet. The dispute is reduced from one centered around predictions of the future (in which the rightness or wrongness of views is only known in the future) to one centered around visions of desirable futures (which can be answered today). Prediction becomes more a tool of analysis that interest groups employ to answer their own questions and less a tool of persuasion that interest groups use to convince others.

State regulations that are perceived to be effective help legitimize the facility siting process and augment local confidence in the general safety of such facilities. State standards will serve as a benchmark against which local communities will undoubtedly demand more. Residents, however, are likely to make fewer demands when they perceive facility operators and state regulators to be competent and trustworthy.

While the problem of divergent perceptions of risk is simplified, it is not eliminated. The thorny question of cost-benefit tradeoffs between more or less safe alternatives remains. The effects of hazards, should they develop, are still uncertain. But by agreeing to local standards before siting, communities and facility operators can evaluate future performance based on mutually acceptable criteria. This evaluation is essential if communities are to replace their power to deny permission to site a facility with a more general power to prevent significant deterioration of the community's health and safety.

2. Emerging hazards and variations in operating conditions must be quickly and reliably detectable.

When knowledge is incomplete and predictions imprecise, then the means for recognizing problems early becomes necessary. As consequences evolve, they become increasingly predictable. If errors can be detected and corrected as they evolve, the possibility of error becomes less frightening. Repair and recovery are possible. By coming to agreement on how detection will be integrated into the ongoing operations of the facility, the standards established for safe waste management (as discussed in principle one) gain meaning. Protocols for collecting and evaluating data can be agreed upon beforehand.

3. Once detected, a hazard or unacceptable shift in operating conditions must be effectively mitigated.

Inasmuch as detective data indicates emerging hazards, mitigation becomes necessary. Mitigation is prevention adapted through time, adjusted to new conditions as they evolve. The management of risks are potentially more effective because the control systems are open to unexpected changes and to mistakes. At the same time, the reliability and trustworthiness of these systems are of paramount concern. Unlike prevention devices that are engineered into the facility, mitigation systems require conscious intervention and changes in standard operating procedures. Detection can provide information that is useful in aborting emerging hazards only if management adapts to the new requirements.

From the perspective of community residents, this flexibility is an essential component of effective risk management, but is also potentially unreliable if management fails to respond adequately. It offers more fine tuned control over hazards (hence potentially reducing risks) by increasingly relying on managerial skills and good intentions. This dichotomy is aggravated by community perceptions that poor management is the predominant cause of hazardous conditions. Only if competent and trustworthy management can be guaranteed will these systems of prevention, detection and mitigation provide an escape from the stalemate generated by differing perceptions of risk.

As a first step, then, expectations of how management will perform within this highly flexible system must be forthcoming. Local communities are not likely to give up control over the siting decision in exchange for a system in which facility operators gain total flexibility. This ambiguity creates precisely the "loss of control" that community residents seek to prevent. The ambiguity can, however, be greatly reduced through promises of specific actions contingent on the detection of emerging hazards. These promises give structure to an otherwise amorphous relationship between the community and the facility operator. Contingent promises can assign responsibility clearly, decrease the uncertainty over expected operator behavior in everyday and crisis situations, and create a basis for evaluating the operator's future performance.

On the other hand, promises do not in and of themselves guarantee performance, nor do they ensure results. Planning cannot cover all contingencies, nor can appropriate solutions be developed in the absence of experience. Effective mitigation systems must therefore be learning systems. Guardians and preservationists look beyond the substance of agreements to relationships between parties. The relationship must inspire trust and be open to learning as new information and concerns are raised. Only in this way can safety be secured. Guardians and preservationists, while acknowledging the difficulty of creating and maintaining a trustworthy and reliable relationship, believe that such a relationship must exist. Moreover, the relationship must be disciplined by an institutional framework which continually reinforces the sense of responsibility that facility operators feel toward the health and safety of the community. In the absence of these reinforcements, competing corporate goals can at any time weaken the resolve of facility operators to promote community well-being.

The Relationship Between the Community and the Plant Operator

> 4. The technologies and management of these prevention, detection and mitigation systems must be visible and comprehendable to at least some locally trusted community representatives and possibly to the community as a whole.

The ability to monitor the facility and its operations is essential if the community is to hold the facility operator accountable. Reliable information, independently confirmed, must be available against which the community can judge the performance of the facility operator. Community monitoring of emissions and ambiant conditions forms one tier of an information exchange system, analysis of these data a second tier, and onsite inspection of general conditions still a third. The town is usually thought to need expert assistance to examine and evaluate the ongoing conditions of the plant. State or operator inspections, in the absence of local quality control, will not suffice. The state is perceived as overburdened and hence unreliable. The facility operator has conflicting interests. But either the state or the operator may form the mainstay of a monitoring system as long as ready access to the facility and free flow of information is guaranteed, and the community can ensure the quality of the monitoring and analysis.

> 5. A structure must exist for jointly solving problems and resolving disputes as conditions and concerns evolve, and for altering prevention, detection and mitigation systems as knowledge improves.

All contingencies cannot be foretold before construction of a facility. Consequently, learning is integral to the process of risk management. Just as perceptions differ among various groups, so too will learning differ. Does a leak in one tank mean that all tanks must be relined? Of what use is a newly invented pollution control device?

To ensure that these questions are answered with the community's safety in mind, guardians and preservationists desire a voice in decision making about safety. A joint safety board, with some process for resolving irreconcilable differences, is seen as essential. At the very least, such a board would keep issues of health and safety at the forefront of corporate concerns and would provide some measure of integration between community and corporate decision making.

Creation of a safety board is an acknowledgement of the deep interdependencies between the community and the facility operator in the management of uncertainty and risk. By committing future control over resources and decisions to the board in exchange for resolving current disputes, each creates limitations on its future flexibility:

the community by acknowledging the legitimacy of the corporation to locate a facility in the town, the corporate operators by acknowledging the legitimacy of a continuing community presence in discretionary decision making and by providing resources to a safety board on an ongoing basis. At the same time, the joint decision making process creates a highly flexible system in toto for managing the hazardous waste treatment process.

> 6. The community should be involved only in the overview of safety operations, not in the minutia of plant operations.

Because safety and health concerns are so integrated into the operations of a facility, the boundary between risk management and facility management is difficult to delineate. Despite this difficulty, delineation is considered to be essential by community residents. Ideologically, most residents believe that firms have the right to control their internal workings as long as they do not impose risks on the community. Practically, control implies responsibility for error and residents are ambivalent about accepting this responsibility. Rather, they look for clear demarcation of rights and responsibilities, accepting discretionary power only when necessary to achieve the primary objective of risk management.

To arrive at the most appropriate demarcation, however, will not be easy. Disagreement over what is most appropriate exists not only between the community and the facility operator, but also within the community itself. Guardians, who emphasize community safety, are the most willing to accept responsibility in order to retain control. Sponsors, who emphasize a free market, are least willing. Yet most guardians prefer to limit their involvement to policy setting for risk management, and few sponsors desire to give total discretion to the operator.

Residents, especially guardians, demand control because they perceive the plant as being safer with this control, but they do so only hesitantly. The exact form of this control must be determined between the community and the plant operator, on a case by case basis. It is not the level of control that is ultimately essential, but rather the level of trust.

> 7. The community must have the power to hold the operator accountable for hazards as specified in a safety agreement. The community must also have the power to move decisively against hazardous conditions should the operator fail to do so.

Cooperation, in and of itself, is inadequate for ensuring safety. Residents believe that the firm must not be in a position to profit from unsafe conditions. Residents envision a system of fines for hazardous conditions, strict application of liability, and trust funds set aside by the firm to cover the cost of these contingencies. Equally important, sanctions must have a high likelihood of being imposed. The criteria for imposition must be unambiguous: if such a condition exists, whatever the cause or the intended consequence, then a specified sanction can be invoked. By making the consequences of hazardous conditions costly, the community seeks to create additional incentives for the firm to improve risk management. If it is in the best interest of the facility operator to act safely, the likelihood of error decreases.

In the final analysis, however, the greatest risk to the community is a hazardous condition that is not corrected for want of decisive action. The power to override corporate decision making in a time of crisis is the most controversial of suggestions, and the most difficult to envision. The time consuming judicial process is considered totally unacceptable to both guardians and preservationists. An alternative is generally sought in arbitration. If the safety board, which represents both community and corporate interests, is deadlocked, the dispute is brought to an outside arbitrator. The arbitration system is established before the facility begins operations. The system is state run (backed by appropriate state laws), but the arbitrators are selected by all interested parties. A trust fund or appropriate insurance program is established to ensure the availability of funds to cover emergency actions.

Moreover, if impacts of hazards are to be limited to temporary and reversable effects, potentially expensive guarantees (e.g., of water supply, property values, and clean-up funds) must be made. The state will probably need to financially back these guarantees of safe plant operation. As an additional benefit, state guarantees also provide financial incentives to the state to ensure proper waste management.

In designing a risk management system, the tension between the community and the firm is ultimately over who will bear what responsibilities and risks under how much uncertainty. From the perspective of the firm, the ideal condition is one in which it retains sufficient control over its environment to ensure flexibility in goal setting. While the firm may choose to promote safety above a minimum standard, it is likely to also prefer to have the flexibility to reverse that decision or to shift emphasis from one form of risk management to another. Only if a firm is unable to site a facility conventionally is it likely to enter into relationships of joint policy setting.

At the same time, however, the community recognizes this flexibility in goal setting as one in which safety goals can be compromised. In the absence of a basic trust in the intentions and capability of the firm, residents cannot be faulted for expecting the worst. Alternative risk management systems, in which facility operators are allowed maximum flexibility within a clearly delineated decision making process, are fraught with difficulties, but they offer the potential for increasing our capacity to cope with risks. If these systems increase the willingness of local communities to accept potentially hazardous facilities while reducing the riskiness of hazardous waste treatment compared to traditional approaches, then they may prove viable. The next section explores these questions of acceptability and risk mitigation.

III. Mitigating Risks, Promoting Acceptance

The seven principles for managing risks grow out of perceptions of risk held by local residents. They are based on self-reflections and opinions about what makes for a safer world. While this dissertation has focused on perceptions, ultimately issues of actual consequences must be addressed. Do intuitively plausible risk management measures proposed by the lay public actually decrease total risk, or do they lead to overly cautious and erratic behavior in ways that increase risk over time?

<u>Reasonableness of the Seven Risk Management Principles</u>

In a dissertation devoted to the uncertain nature and varying significance of risks, I will not be so bold as to claim a definitive answer to questions of reasonableness. In part, answers can only be obtained after siting facilties that incorporate these principles, and evaluating the experience. Until then, we can only speculate on what the nature of such risk management systems will be. In judging their reasonableness, however, two aspects of this new direction stand out for consideration.

First, risk management as envisioned by community residents emphasizes the organizational and managerial sources of risk. These risk management systems are potentially costly. Resources must be reallocated; other corporate goals may suffer. If the risk definition is essentially faulty, or if new risks (such as an increase in bankruptcy due to increased costs) emerge, then the new situation may prove less desirable than the old.

The experience at Love Canal, numerous other hazardous waste problem centers, and Three Mile Island, however, suggests than an increased emphasis on management is essential. Few analysts contest that better systems of managment are needed. Even federal regulations of hazardous waste strongly emphasize managerial and organizational considerations. Establishment of a system to track wastes from production to eventual treatment or disposal, changes in concepts of liability associated with clean-up of hazardous waste disposal sites, and requirements for creating financial arrangements to cover contingencies and post-closure upkeep were among the earliest federal regulatory changes proposed in the late 1970s. Historically, improper management has clearly contributed to improper disposal; hence increased emphasis on management is likely to create considerable improvement.

Where the resources will come from to improve management remains unclear. The impact of costs for an improved risk management system are heavily dependent on regulatory environment. Strong regulations will strengthen the financial position of firms promoting increased safety; weak regulations will make such firms uncompetititve. Moreover, a facility with few operational problems will incur fewer mitigation costs. Inevitably, the firm cannot survive if it incurs excessive costs. From the perspective of many community residents, however, if private enterprise cannot function under strict safety requirements, then an alternative such as a public utility or state financing is needed.

Second, the risk management system envisioned by community residents is one in which power is shared. If the community proves to be less responsible or competent than would the facility operator acting in isolation of community representation, then risks may actually increase. Will residents be reasonable in times of both standard operation and crisis? Technical experts, who believe that lay perceptions are inaccurate and laypeople too fearful, will also doubt that residents will be reasonable. In this dissertation, I have argued that laypeople act rationally to promote their best interests, that they are consistent in their use of power to protect what they value. This consistency and clear sightedness is easily maintained in adversarial relationships when the goal is to stop a proposed facility. It will be more difficult to maintain in cooperative relationships, when differing goals must constantly be maintained in balance.

But relationships of this complexity have been created and sustained in the past. In several European countries, public decisions about local matters are sometimes made through face-to-face negotiations between public officials and residents. Under these conditions, residents have demonstrated the ability to sustain a responsible involvement. The key has been in legitimizing resident involvement and converting conflictual relationships into ones in which public officials and residents seek to co-produce mutually desirable outcomes (Susskind and Elliott, 1983). Under conditions where the ability to affect decisions decreases over time, resident groups must exercise points of leverage quickly and decisively. When residents share in the ongoing responsibility (and control) for producing and maintaining the mangement of safety, strategic action becomes less important. By delineating risk management functions from other functions of the firm and linking responsiblity to power, a basis for mutual trust is created.

Carefully organized relationships can work: between some parties, under some conditions. These relationships are shaped throughout the siting process as communities and corporations clash, negotiate, and achieve compromise. From initial encounters and throughout facility operations, these relationships require a sensitivity to and basic acceptance of the goals and perspectives of each interested party. Ultimately, not only must the firm accept community goals, but the community must accept corporate goals. How likely is this acceptance?

Acceptance of Risk Management

As this thesis has argued, the design of a risk management system which does not lead to deadlock is essential if we are to cope effectively with risks. Well designed systems that cannot be implemented are of little use. The thesis has also argued that perceptions of risk are a core determinant of acceptance: without a perceptably safe facility, opposition is inevitable.

The reverse hypothesis, however, cannot be demonstrated. While safe waste management is necessary for siting, it is unlikely to be sufficient. No facility can be made completely safe, and hence all facilities may well remain noxious and unwanted. In promoting the acceptance of these facilities, attention must be paid to differences among community residents and their varying responses to issues of political legitimacy and compensation.

In general, risks that have impacts that are temporary and reversible, or that are inconsequential and readily compensated, are most likely to be accepted by local communities. Sponsors have a low threshold of acceptance because they believe risks to be inconsequential. Compensation, when clearly tied to the operation of the facility, is more important to some sponsors than are changes in risk management. For these individuals, compensation strengthens their incentives to openly and actively lend support to the proposed facility.

Guardians have a higher threshold of acceptance, but the criterion for acceptance is relatively straightforward. For guardians, the only issue of major concern is safety. Guardians are generally very aware of the need for treatment facilities and are supportive of their construction in principle. If convinced that the proposed site was selected with due attention for health and safety and the siting process adequately incorporates their concerns, guardians are predisposed toward accepting the facility. The seven principles of risk management may therefore form sufficient basis for acceptance if the impacts of remaining risks can be shown to be reversible should they occur.

Preservationists have the highest threshold of acceptance. They care most about protecting a way of life, one in which hazardous waste treatment facilities have no part. Neither careful attention to risk management nor compensation are likely to induce them to support the siting of noxious facilities, but they can be effective in reducing overt opposition. The seven principles are responsive to preservationist concerns about risk, local autonomy, and uncertainty. By ameliorating these concerns, and promoting the support inherent in the positions of sponsors (through compensation) and guardians (through improved risk management), an effective coalition might be built.

The actual effectiveness of these principles cannot be known in the absence of an attempt to employ them. Innovative modifications to the systems for managing risks have not been an item of negotiation in past siting disputes. Based on the reflections of local residents, however, these principles cut to the very core of the current deadlock in public risk management by working with differences in perceptions, rather than assuming inevitable conflict between them. In so doing, the principles hold open the promise of more effective risk management by both altering the sources of risk and promoting the acceptance of treatment facilities.

Bibliography

Acherman, Bruce, Susan Rose Acherman, James Sawyer and Dale Henderson (1974). The Uncertain Search for Environmental Quality (New York: MacMillan).

Albert, Jeffrey (1977). "Some Epistemoligical Aspects of Cost-Benefit Analysis," George Washington Law Review, 45(5): 1025-1036.

Alker, Hayward (1979). "Logic, Dialectics, Politics: Some Recent Controversies," presented to the Moscow Congress of the International Political Science Association, August 17.

Allison, Graham T. (1971). Essence of Decision: Explaining the Cuban Missile Crisis, (Boston: Little, Brown & Co).

Anderson, Richard and Michael Greenberg (1982). "Hazardous Waste Facility Siting," Journal of the American Planning Association, 48: 204-218, spring.

Andrews, Richard, ed. (1979). Land in American: Commodity or Natural Resource? (Lexington, MA: Lexington Books).

Andriessen, J.H. (1971). "Comments on a New Risk Taking Model," Acta Psychologica, 35: 173-87.

Argyris, Chris (1973). "Some Limits of Rational Man Organizational Theory," Public Administration Review, 33(3): 253-267 (May/June).

_______ (1982). Reasoning, Learning and Action, (San Francisco: Jossey-Bass).

_______ and Don Schon (1978). Organization Learning: A Theory of Action Perspective, (Reading, MA: Addison-Wesley).

Arrow, Kenneth (1963). Social Choice and Individual Values, 2nd edition, (New York: John Wiley & Sons).

_______ (1974). Essays in the Theory of Risk-Bearing, (Amsterdam: North-Holland Publishing Co.)

Bacow, Lawrence (1980a). Bargaining for Job Safety and Health, (Cambridge, MA: MIT Press).

_______ (1980b). "The Technical and Judgmental Dimensions of Impact Assessment," Environmental Impact Assessment Review, 1(2): 109-124, June.

_______ (1982). "Exploring Environmental Impacts: Beyond Quantity to Quality," Technology Review, 85: 32-37, January.

_______ and James Milkey (1982). "Overcoming Local Opposition to Hazardous Waste Facilities: The Massachuseets Approach," The Harvard Environmental Law Review, 6(2): 265-305.

Badaracco, Joseph Jr. (1981). "A Study of Adversarial and Cooperative Relationships Between Business and Government in Four Countries," Report to the Office of Technology, Strategy and Evaluation of the U.S. Department of Commerce, February 3.

Baldwin, John (1969). "Influences Detrimental to Simulation Gaming," The American Behavioral Scientist, 11:14-21, July-August.

Baram, Michael S. (1980). "Cost-Benefit Analysis: An Inadequate Basis for Health, Safety, and Environmental Regulatory Decision Making," Ecology Law Quarterly, 8(3): 473-931.

Bar-Hillel, Maya (1980). "The Base Rate Fallacy in Probability Judgements," Acta Psychologica, 44: 211-233.

Baum, Andrew, Raymond Fleming and Laura Davidson (1983). "Natural Disaster and Technological Catastrophe," Environment and Behavior, 15(3): 333-354.

Bazelon, David (1979). "Risk and Responsibility," Science, 205: 277-280, July 20.

Bell, David (1975). "Simulation Games: Three Research Paradigms," Simulation and Games, 6(3): 271-287.

Ben, Daryl, Michael Wallach, and Nathan Kogan (1965). "Group Decision Making Under Risk of Adverse Consequences," Journal of Personality and Social Psychology, 1(5): 453-460.

Benson, Dennis, Colleen McMahon, and Rishcard Sinnreich (1972). "The Art of Scenario Design," Simulation and Games, December: 439-463.

Benveniste, Guy (1972). The Politics of Expertise, (San Francisco: Boyd and Fraser).

_______ (1981). Regulation and Planning, (San Francisco: Boyd and Fraser).

Blake, Andrew (1982a). "Hazardous Wastes, Changing Rules," Boston Globe, March 20: 1 & 24.

_______ (1982b). "Warren and the Waste Site Fight," Boston Globe, August 1: 1 & 44; August 2: 1 & 20.

Booz-Allen and Hamilton, Inc. and Putnam, Hayes, and Bartlett, Inc. (1980). Hazardous Waste Generation and Commercial Hazardous Waste Management Capacity -- An Assessment, (SW-894, EPA Office of Water and Waste Management, December).

Bosselman, Fred and David Callies (1972). The Quiet Revolution in Land Use Controls, (Washington, D.C.: Report of the U.S. Council on Environmental Quality).

Bower, Joseph (1968). "Descriptive Decision Theory from the 'Administrative' Viewpoint," in Raymond Bauer, ed., The Study of Policy Formation: An Introduction, 103-148.

Boyer, Barry (1972). "Alternatives to Administrative Trial-Type Hearings for Resolving Complex Scientific, Economic, and social Issues," Michigan Law Review, 71: 111-170, November.

Brewer, Garry (1978). "Scientific Gaming: the Development and Use of Free-Form Scenarios," Simulation and Games, 9(3): 309-327, September.

Brown, Michael (1979). Laying Waste: The Poisoning of America by Toxic Substances, (New York: Pantheon Books).

Bryson, John, and Andre Delbecq (1979). "A Contingent Approach to Strategy and Tactics in Project Planning," American Planning Association Journal, 45(7): 167-179, April.

Bulanwski, Gerard, Greg Lazarus, Larry Morandi, and Jonathan Steeler (1981). A Survey and Analysis of State Policy Options to Encourage Alternatives to Land Disposal of Hazardous Waste, (Denver: National Conference of State Legislatures, July).

Bureau of National Affairs (1980). "EPA Hazardous Waste Siting Committee," Environmental Reporter, 11, June 20.

_______ (1981). "Siting of Hazardous Waste Management Facilites," Environmental Reporter, 12: 871-874, Nov. 13.

_______ (1982). "Hazardous Waste," Environmental Reporter, 13: 66, May 21.

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

_______, C.D. Fowle, and R.S. McCullough, eds. (1982). Living with Risk: Environmental Risk Management in Canada, (Toronto: Institute for Environmental Studies, University of Toronto).

Burgess, Guy (1980). "Risk Decision Assessment: Pathological Distortion Process," (Cambridge, MA: MIT Energy Lab Working Paper, June).

Byrd, Jack Jr. (1976). "A Conceptual Approach to the Use of Simulation Gaming in Technology Assessment," Simulations and Games, 7(2): 209-218, June.

Cairnes, John (1977). Cancer: Science and Society, (San Francisco: W.H. Freeman & Co).

Calabrese, Edward J. (1978). Methodological Approaches to Deriving Environmental and Occupational Health Standards, (New York: John Wiley & Sons).

Carnes, Samuel (1981). "Confronting Complexity and Uncertainty: Implementation of Hazardous Waste Management Policy," in Dean Mann, ed., Environmental Policy, (Lexington, MA: Lexington Books).

_______, et al (1982). "Incentives and Nuclear Waste Siting: Prospects and Constraints," (Oak Ridge National Laboratory, unpublished).

_______, et al (1982). "Incentives and the Siting of Radioactive Waste Facilities," (Oak Ridge National Laboratory, ORNL-5880 special, August).

Chamberlain, Neil (1982). Social Strategy and Corporate Structure, (New York: Macmillan).

Clark, William C. (1977). "Managing the Unknown," in Robert W. Kates (ed.), Managing Technological Hazard, (Colorado: Institue of Behavioral Sciences, 109-142).

_______ (1980). "Witches, Floods, and Wonder Drugs: Historical Perspectives on Risk Management," in Richard Schwing and Walter Andrew, Jr., eds. Societal Risk Assessment: How Safe is Safe Enough? (New York: Plenum Press).

Clark-McGlennon Associates (1983). "The BTN-Quandry Siting Simulation," (Boston: Prepared for Environmental Mediation International, April 15).

Cohen, Marsha (1977). "Same Data, Different Results -- A Study of the Use of Scientific Information in Legal Decision Making," in National Research Council, Decision Making in the Environmental Protection Agency: Selected Working Papers, Vol. IIb: 307-345.

Cole, Gerald and Stephen Withey (1981). "Perspectives on Risk Perceptions," Risk Analysis, 1(2): 143-163.

Conner, Desmond (1982). "Siting Hazardous Petro-Chemical Facilities: Real versus Perceived Risk," CCP, 10(3): 3-7.

Cooper, Richard (1978). "The Role of Regulatory Agencies in Risk-Benefit Decision Making," Food Drug and Cosmetic Law Journal, 33(12): 755-773.

Coombs, Clyde (1975). "Portfolio Theory and the Measurment of Risk," in Martin F. Kaplan and Steven Schwartz (eds.), Human Judgement of Decision Processes, (New York: Academic Press, pp 63-85).

_______ and Lily C. Huang (1970). "Tests of a Portfolio Theory of Risk Preference," Journal of Experimental Psychology, 85(1): 23-29.

_______ and James N. Bowen (1971). "A Test of VE-Theories of Risk and the Effect of the Central Limit Theorem," Acta Psychologica, 35: 15-28.

_______ and G. Avrunin (1977). "Single-Peaked Functions and the Theory of Preference," Psychological Review, 84: 216-230.

Coppock, Rob (1981). "Managing Technological Hazards," in Timothy O'Riordan and R. Kerry Turner, eds. Progress in Resource Management and Environmental Planning, Vol. 3, (New York: John Wiley & Sons).

Covello, Vincent, and Joshus Menkes (1980). "Issues in Risk Analysis," presented at the Annual Meeting of the American Association for the Advancement of Science, San Francisco, January 3-8.

_______, Joshus Menkes and Jiri Nehnevajsa (1982). "Risk Analysis, Philosophy, and the Social and Behavioral Sciences," Risk Analysis, 2(2): 53-58.

Coverdale, Ralph (1977). Risk Thinking, (England: The Coverdale Organisation Ltd).

Crandall, Robert and Lester Lave, eds. (1981). The Scientific Basis of Health and Safety Regulation, (Washington, D.C.: The Brookings Institution).

Crouch, Edmund and Richard Wilson (1980). "Estimates of Risk," Journal of Business Administration, 11: 299-317.

_______ and Richard Wilson (1981). "Regulation of Carcinogens," Risk Analysis, 1(1): 47-66.

_______ and Richard Wilson (1982). Risk/Benefit Analysis, (Cambridge, MA: Ballinger).

Cyert, Richard and James March (1963). A Behavioral Theory of the Firm, (Englewood Cliffs, NJ: Prentice-Hall).

Dawes, Robyn (1972). Fundamentals of Attitude Measurement, (New York: John Wiley & Sons).

Dierkes, Meinolf, Sam Edwards, and Rob Coppock, ed. (1980). Technological Risk: Its Perception and Handling in the European Community, (Cambridge, MA: Oelgeschlager, Gunn & Hain, Publishers).

Doniger, David, ed. (1978). "Hazardous Substances in the Environment: Law and Policy," Special Issue of Ecology Law Quarterly, 7(2): 207-677.

_______, Richard Liroff and Norman Dean (1978). "An Analysis of Past Federal Efforts to Control Toxic Susbstances," Report to CEQ by the Environmental Law Institues, July 20.

Dooley, James (1982). "Decision Making in Environmental Crisis Situations," in Howard Kunreuther and Erye Ley, eds., The Risk Analysis Controversy: An Institutional Perspective, (Berlin: Springer-Verlag, pp. 79-90).

Douglas, Mary and Aaron Wildavsky (1982a). Risk and Culture, (Berkeley: University of California Press).

_______ and Aaron Wildavsky (1982b). "How Can We Know the Risks We Face? Why Risk Selection is a Social Process," Risk Analysis, 2(2): 49-52.

Downs, Anthony (1966). Inside Bureaucracy, (Boston: Little, Brown).

_______ (1972). "Up and Sown with Ecology -- The 'Issue Attention Cycle'" Public Interest, 28: 38-50.

Druckman, Daniel, ed. (1977). Negotiation: Social-Psychological Perspectives, (Beverly Hills: Sage Publications).

Duberg, J., M. Frankel, and C. Niemczewski (1980). "Siting of Hazardous Waste Management Facilities and Public Opposition," Environmental Impact Assessment Review, 1(1).

Duke, Richard (1974). Gaming: The Future's Language, (New York: John Wiley & Sons).

_______ and Cathy Greenblat (1979). Game-Generating-Games, (Beverly Hills: Sage Publication).

Dubos, Rene (1965). Man Adapting, (New Haven: Yale University Press).

Dunn, Edgar Jr (1971). Economic and Social Development: A Process of Social Learning, (Baltimore: Resources for the Future).

Earle, Timothy C. and Michael Lindell (1982). Public Perceptions of Industrial Risks: A Free-Response Approach, (Seattle, WA: Battelle Human Affairs Research Center, June).

Ebbin, Steven and Raphael Kasper (1974). Citizen Groups and the Nuclear Power Controversy, (Cambridge, MA: MIT Press).

Edwards, Ward (1961). "Behavioral Decision Theory," Annual Review of Psychology, 12: 473-498.

Eisenbud, Merril (1978). Environment, Technology, and Health: Human Ecology in Historical Perspective, (New York: New York University Press).

Ember, Lois (1979). "Needed: Hazardous Disposal (But Not in My Backyard)," Environmental Science and Technology, 13: 913-915.

_______ (1982). "Love Canal: Uncertain Science, Politics and Law," in Christoph Hohenemser and Jeanne Kasperson, eds., Risk in the Technological Society, (Boulder, CO: Westview Press, pp 77-99).

Epstein, Samuel (1979). The Politics of Cancer, (Garden City, NY: Anchor Books).

_______ (1982). Hazardous Waste in America, (San Francisco: Sierra Press).

Etzioni, Amitai (1967). "Mixed Scanning: A 'Third' Approach to Decision Making," Public Administration Review, 27(5): 385-392.

Fairley, William (1982). "Market Risk Assessment of Catastrophic Risks," in Howard Kunreuther and Eryl Ley, eds., The Risk Analysis Controversy: An Institutional Perspective, Berlin: Springer-Verlag, pp 195-199).

Feiveson, Harold, Frank Sinden, and Robert Socolow (1976). Boundaries of Analysis: An Inquiry into the Tocks Island Dam Controversy, (Cambridge, MA: Ballinger Publishing Company).

Feldman, Martha S. and James G. March (1981). "Information in Organizations as Signal and Symbol," Administrative Science Quarterly, 26: 171-186.

Feldt, Allan (1972). "Developments in the Field of (Simulation and) Gaming in the United States," in H. A. Becker and H. M. Goudappel, eds., Developments in Simulation and Gaming, (Ultrecht, Netherlands: Boom Meppel).

Ferreira, Joseph Jr. and Louis Slesin (1976). "Observations on the Social Impact of Large Accidents," (Cambridge, MA: MIT Operations Research Center, Technical Report 122).

Fischhoff, Baruch (1975). "Hindsight ≠ Foresight: The Effect of Outcome Knowledge on Judgment under Uncertainty," Journal of Experimental Psychology: Human Perception and Performance, 1(3): 288-299.

_______ (1977). "Perceived Informativeness of Facts," Journal of Experimental Psychology: Human Perception and Performance, 3(2): 349-358.

_______ (1979). "Informed Consent in Societal Risk-Benefit Decisions," Technological Forecasting and Social Change, 13(4): 347-357.

_______ (1982). "Debiasing," in Danial Kahneman, Paul Slovic and Amos Tversky, eds., Judgment Under Uncertainty: Heuristics and Biases, (Cambridge: Cambridge University Press, pp 422-444).

_______ and Ruth Beyth (1975). "I Knew it would Happen: Remembered Probabilities of Once-Future Things," Organizational Behavior and Human Performance, 13: 1-16.

_______, Paul Slovic, and Sarah Lichtenstein (1977). "Knowing with Certainty: The Appropriateness of Extreme Confidence," Journal of Experimental Psychology: Human Perception and Performance, 3(4): 552-564.

_______, Paul Slovic, and Sarah Lichtenstein (1978a). "Fault Trees: Sensitivity of Estimated Failure Probabilities to Problem Representation," Journal of Experimental Psychology: Human Perception and Performance, 4(2): 330-344.

_______, Paul Slovic, Sarah Lichtenstein, Stephen Read, and Barbara Combs (1978b) "How Safe is Safe Enough? A Psychometric Study of Attitudes Towards Technological Risks and Benefits," Policy Sciences, 9: 127-152.

_______, Paul Slovic, and Sarah Lichtenstein (1979). "Weighting the Risks," Environment, 21(4): 17-20 & 32-38, May.

_______, Sarah Lichtenstein, Paul Slovic, Ralph Keeney, and Stephen Derby (1980). Approaches to Acceptable Risk: A Critical Guide, (Prepared for U.S. Nuclear Regulatory Commission under NRC Interagency Agreement 40-550-75, NUREG/CR-1614, ORNL/Sub-7656/1, December).

_______, Sarah Lichtenstein, Paul Slovic, Stephen Derby, and Ralph Keeney (1981). Acceptable Risk, (New York: Cambridge University Press).

_______, Paul Slovic and Sarah Lichtenstein (1982). "Lay Foibles and Expert Fables in Judgements about Risk," The American Statistician, 36(3.2): 240-255.

Fishbein, Martin, ed. (1967). Readings in Attitude Theory and Measurement, (New York: John Wiley and Sons).

_______ and Icek Ajzen (1975). Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research, (Addison-Wesley Publishing).

Fisher, Ann (1980). "The Toxic Waste Dump Problem and a Suggested Insurance Program," Boston College Environmental Affairs Law Review, 8(3): 421-461.

Florman, Samuel (1981). "Living with Technology: Trade-Offs in Paradise," Technology Review, August: 24-35).

Friedland, Steven (1981). "The New Hazardous Waste Management System," Harvard Environmental Law Review, 5(1): 89-129.

Friedman, Robert (1979). "Sensitive Populations and Environmental Standards," unpublished paper, (Washington, D.C.: The Conservation Foundation, October).

Friend, J.K. and W.N. Jessop (1977). Local Government and Strategic Choice, (Oxford: Pergamon Press, 2nd edition).

Fromm, Gary (1968). "Comment on T.C. Schelling's Paper 'The Life You Save May Be Your Own,'" in Problems in Public Expenditure, Samuel Chase, ed., (Washington, D.C.: Brookings Institution).

Gelpe, Marcie and A. Dan Tarlock (1974). "The Uses of Scientific Information in Environmental Decision Making," Southern California Law Review, 48(2): 371-427.

George, Alexander (1979). "Case Studies and Theory Development: The Method of Structured, Focused Comparison," in Paul Gordon, ed. Diplomacy: New Approaches in History, Theory, and Policy (New York: The Free Press).

Getz, Malcolm and Benjamin Walter (1980). "Environmental Policy and Competitive Structure: Implications of the Hazardous Waste Management Program," Policy Studies Journal, 9: 404-412, Winter.

Goldfarb, William (1979). "The Hazards of Our Hazardous Waste," Natural Resources Journal, 19: 249-260, April.

Gorden, Raymond (1969). Interviewing: Strategy, Techniques, and Tactics, (Homewood, IL: The Dorsey Press).

Green, Harold (1975). "The Risk-Benefit Calculus in Safety Determinations," George Washington Law Review, 43: 791-807.

_______ (1977). "Cost-Risk-Benefit Assessment and the Law: Introduction and Perspective," George Washington Law Review, 45(5): 901-910.

Greenberg, Michael and Richard Anderson (forthcoming, 1984). Hazardous Waste Siting, (Transaction Books, for the Center for Urban Policy Research).

Greenblat, Cathy and John Gagnon (1979). "Further Explorations of the Multiple Reality Game," Simulation and Games, 10(1): 41-59.

_______ and Richard Duke (1981). Principles and Practices of Gaming-Simulation, (Beverly Hills: Sage).

Hammond, J.D., ed. (1968). Essays in the Theory of Risk and Insurance, (Glenview, Ill: Scott, Foresman and Company).

_______ (1980). "Risk-Spreading Through Underwriting and the Insurance Institution," in Richard Schwing and Walter Albers, Jr., eds. Societal Risk Assessment, (New York: Plenum Press).

Hanraham, David (1979). "Hazardous Waste: Current Problems and Near-Term Solutions," Technology Review, Nov.: 20-31.

Harris, Louis (1980). "Toxic Chemical Dumps: Corrective Action Desired." Press release, July 7.

Harriss, Robert, Christoph Hohenemser and Robert Kates (1978). "Our Hazardous Environment," Environment, 20(7): 6-15, 38-41, Sept.

Hart, Fred C. and Associates (1978). "Task IV — Economic Analysis Draft," EPA Contract #68-014895, October 12.

Healy, Robert and John Rosenberg (1979). Land Use and the State, (Baltimore: Johns Hopkins University Press, second edition).

Hermann, Charles (1967). "Validation Problems in Games and Simulations," Behavioral Science, 12(3): 216-231.

Hershey, John C. and Paul J. Schoemaker (1980). "Risk Taking and Problem Context in the Domain of Losses: An Expected Utility Analysis," Journal of Risk and Insurance, 47(1): 111-132.

Hohenemser, Christoph, Roger Kasperson, and Robert Kates (1977). "The Distrust of Nuclear Power," Science, 196: 25-34.

_______, Roger Kasperson, and Robert Kates (1982a). "Causal Structure: A Framework for Policy Formation," in Christoph Hohenemser and Roger Kasperson, eds. (1981). Risk in the Technological Society, (Boulder, CO: Westview Press, pp 109-139).

_______ and Jeanne Kasperson (1982b). "Overview: Towards Determining Acceptable Risk," in Christoph Hohenemser and Roger Kasperson, eds. (1981). Risk in the Technological Society, (Boulder, CO: Westview Press, pp 191-201).

_______, Robert Kates and Paul Slovic (1983). "The Nature of Technological Hazard," Science, 220:378-384, Apr. 22.

Holden, Constance (1980). "Love Canal Under Stress: Psychological Effects May Be Greater Than Physical Harm," Science, 208: 1242-1244, June 13.

Holling, C.S., ed. (1978). Adaptive Environmental Assessment and Management, (New York: John Wiley and Sons).

Jaffe, Martin (1981). "Deadly Gardens, Deadly Fruits," Planning, 47: 16-18, April.

Janis, Irving L., and Leon Mann (1977). Decision Making: A Psychological Analysis of Conflict, Choice and Committment, (New York: Free Press).

Jones, Edward and Richard Nisbett (1972). "The Actor and the Observer: Divergent Perceptions of the Causes of Behavior," in Edward Jones et al, eds., Attribution: Perceiving the Causes of Behavior, (Morristown, NJ: General Learning Press, pp 79-94).

Kahneman, Daniel and Amos Tversky (1972). "Subjective Probability: A Judgment of Representativeness," Cognitive Psychology, 3: 430-454.

_______ and Amos Tversky (1973). "On the Psychology of Prediction," Psychological Review, 80: 237-251.

_______ and Amos Tversky (1979). "Prospect Theory: An Analysis of Decision Under Risk," Econometrica, 47(2): 263-292.

_______ and Amos Tversky (1982a). "The Simulation Heuristic," in Daniel Kahneman, Paul Slovic, and Amos Tversky, eds., Judgments Under Uncertainty: Heuristics and Biases, (New York: Cambridge University Press, pp. 201-208).

_______ and Amos Tversky (1982b). "Variants of Uncertainty," in Daniel Kahneman, Paul Slovic, and Amos Tversky, eds., Judgments Under Uncertainty: Heuristics and Biases, (New York: Cambridge University Press, pp 509-520).

_______, Paul Slovic, and Amos Tversky (1982c), Judgments Under Uncertainty: Heuristics and Biases, (New York: Cambridge University Press).

Kasper, Raphael (1980). "Perceptions of Risk and their Effects on Decision Making," In Richard Schwing and Walter Albers, Jr., eds., Societal Risk Assessment: How Safe is Safe Enough? (New York: Plenum Press, 71-84).

Kasperson, Roger and Arnold Gray (1982). "Societal Response to Three Mile Island and the Kemeny Commission Report," in Howard Kunreauther and Eryl Ley, eds., The Risk Analysis Controversy: An Institutional Perspective, (Berlin: Springer-Verlag, pp 61-77).

Kates, Robert (1978a). Risk Assessment of Environmental Hazard, (New York: John Wiley & Sons).

_______, ed. (1977). Managing Technological Hazard: Research Needs and Opportunities, (Boulder, CO: Institute of Behavior Sciences).

Katz, Daniel and Robert Kahn (1966). The Social Psychology of Organizations, (New York: John Wiley & Sons).

Keeney, Ralph L. (1980a). Siting Energy Facilites, (New York: Academic Press).

_______ (1980b). "Equity and Public Risk," Operations Research, 28: 527-534.

_______ and Howard Raiffa (1976). Decisions with Multiple Conflicting Objectives: Preference and Value Tradeoffs, (New York: Wiley).

_______, Ram Kulkarni, and Keshavan Nair (1979). "A Risk Analysis of an LNG Terminal," Omega: The International Journal of Manangement Science, 7(3): 191-205.

Kemeny, John (1980). "Saving American Democracy: The Lessons of Three Mile Island," Technology Review, June: 65-75.

Kerlinger, Fred (1964). Foundations of Behavioral Research, (New York: Holt, Rinehart and Winston).

Kiang, Yen-Hsiug and Amir Metry (1982). Hazardous Waste Processing Technology, (Ann Arbor, MI: Ann Arbor Science Publishers).

Kleindorter, Paul (1982). "Group Decision Making Methods for Evaluating Social and Technological Risks," in Howard Kunreauther and Earl Ley, eds., The Risk Analysis Controversy: An Institutional Perspective, (Berlin: Springer-Verlag, pp 181-193).

Knight, Frank H. (1921). Risk, Uncertainty and Profit, (Boston: Houghton Mifflin).

Kogan, Nathan and Michael Wallach (1964). Risk Taking: A Study in Cognition and Personality, (New York: Holt, Rinehart and Winston).

_______ and Michael Wallach (1967). "Risk Taking as a Function of the Situation, the Person and the Group," in George Mandler, et al, eds., New Directions in Psychology 3, (New York: Holt, Rinehart & Winston, pp 111-127).

Kolata, Gina Bari (1980). "Love Canal: False Alarm Caused by a Botched Study," Science, 208: 1239-1242, June 13.

Krag, Bruce (1982a). "Notes on the Hazardous Waste Management Industry," (Cambridge: Harvard Business School).

_______(1982b). "The Hazardous Waste Managment Industry," (Cambridge: Harvard Business School, mimeo draft, March 19).

Kraus, Richard (1976). "Environmental Carcinogenesis: Regulation on the Frontiers of Science," Environmental Law, 7: 83-135.

Krieger, Martin (1981). Advice and Planning, (Philadelphia: Temple University Press).

Krier, James and Edmund Ursin (1977). Pollution and Policy, (Berkeley: University of California Press).

Kuhn, Thomas (1970). The Structure of Scientific Revolutions, 2nd edition (Chicago: University of Chicago Press).

Kunreuther, Howard (1976). "Limited Knowledge and Insurance Protection," Public Policy, 24(2): 227-261.

_______ and Paul Slovic (1978b). "Economics, Psychology, and Protective Behavior," The American Economic Review, Papers and Proceedings, 68(2): 64-69.

_______ and John Lathrop (1981). "Siting Hazardous Facilities: Lessons of LNG," Risk Analysis, 1(4): 289-302, December.

_______ and Earl Ley, eds. (1982). The Risk Analysis Controversy: An Institutional Perspective, (Berlin: Springer-Verlag).

Langer, Ellen (1982). "The Illusion of Control," in Daniel Kahneman et al, eds., Judgment Under Uncertainty: Heuristics and Biases, (Cambridge: Cambridge University Press, pp 231-238).

LaPorte, Todd and Daniel Metlay (1975). "Technology Observed: Attitudes of a Wary Public," Science, 188: 121-127, April 11.

Lave, Lester (1972). "Risk, Safety and the Role of Government," in National Academy of Science, Perspectives on Benefit-Risk Decision Making, (Washington, D.C.: NAS).

Lawless, Edward (1977). Technology and Social Shock, (New Brunswick, NJ: Rutgers University Press).

Lawrence, Paul and Jay Lorsch (1967). Organizations and Environment, (Cambridge: Harvard University Press).

_______ (1969). Developing Organizations: Diagnosis and Action, (Reading, MA: Addison-Wesley).

Leape, James P. (1980). "Quantitative Risk Assessment in Regulation of Environmental Carcinogens," Harvard Environmental Law Review, 4: 86-116.

Lee, S.D. and J. Brian Mudd (1979). Assessing Toxic Effects of Environmental Pollutants, (Ann Arbor: Ann Arbor Science).

Lee, T.R. (1981). "The Public's Perception of Risk and the Question of Irrationality," Proceedings of the Royal Society of London, 376: 5-16.

Leonard, Herman and James Sebenius (1982). "Differences and Gains from Trade," (Harvard University Kennedy School of Government, mimeo, August).

Lennett, David (1980). "Handling Hazardous Waste," Environment, 22(8): 7-15, October.

Lerner, Allan W. (1976). "Experts, Politicians, and Decisionmaking in the Technological Society," (Morristown, NJ: General Learning Press, 1979).

Lester, James P. and Ann O'M. Bowman (1983). The Politics of Hazardous Waste Management, (Durham, N.C.: Duke University Press).

Levine, Adeline Gordon (1981). Love Canal: Science, Politics and People, (Lexington, MA: Lexington Books).

Levinger, George and David Schneider (1969). "Test of the 'Risk is a Value' Hypothesis," Journal of Personality and Social Psychology, 11(2): 165-169.

Lewis, Diane (1982). "Double Trouble for a Chemical Firm," Boston Globe, March 8: 17.

Libby, L.M. (1971). Technological Risk Versus Natural Catastrophe, (Santa Monica, CA: Rand Corporation, p. 4602, March).

Libby, Robert and Peter C. Fishburn (1977). "Behavioral Models of Risk Taking in Business Decisions: A Survey and Evaluation," Journal of Accounting Research, 15(2): 277-292.

Lichtenstein, Sarah and Baruch Fischoff (1977). "Do Those Who Know More Also Know More About How Much They Know: The Calibration of Probability Judgments," Organizational Behavior and Human Performance, 20: 159-183.

_______, Paul Slovic, Baruch Fischhoff, Mark Layman & Barbara Combs (1978). "Judged Frequency of Lethal Events," Journal of Experimental Psychology: Human Learning and Memory, 4(6): 551-578.

Lindblom, Charles (1959). "The Science of Muddling Through," Public Administration Review, 19: 79-88.

_______ (1977). Politics and Markets, (New York: Basic Books).

_______ and David Cohen (1979). Useable Knowledge: Social Science and Social Problem Solving, (New Haven, CN: Yale University Press).

Lindell, M.K., et al. (1978). Radioactive Wastes: Public Attitudes Toward Disposal Facilities, (Seattle: Battelle Human Affairs Research Center, B-HARC-411-004, October).

Lovins, Amory (1977). "Cost-Risk-Benefit Assessments in Energy Policy," George Washington Law Review, 45(5): 911-943.

Lowi, Theodore (1976). Poliscide, (New York: Macmillan Publishing).

Lowrance, William (1976). Of Acceptable Risk: Science and the Determination of Safety, (Los Altos, CA: William Kaufmann).

_______ (1980). "The Nature of Risk," in Richard Schwing and Walter Albers, Jr., eds., Societal Risk Assessment: How Safe is Safe Enough? (New York: Plenum).

Luce, R.D. and Howard Raiffa (1957). Games and Decisions, (New York: Wiley).

Lyon, Don and Paul Slovic (1976). "Dominance of Accuracy Information and Neglect of Base Rates in Probability Estimation," Acta Psychology, 40: 287-298.

MacLean, Douglas (1982). "Risk and Consent: Philosophical Issues for Centralized Decisions," Risk Analysis, 2(2): 59-68.

MacMahon, Brian (1981). "In Pursuit of the Public Health," Technology Review, 84(2): 50-65.

Maderthaner, R., et al. (1976). "Perception of Technological Risks: The Effect of Confrontation," (Laxenburg, Austria: RM-76-53, International Institute for Applied systems Analysis).

Mahoney, Robert and Daniel Druckman (1975). "Simulation, Experimentation, and Context: Dimensions of Design and Inference," Simulation and Games, 6(3): 235-270.

Mallow, Alex (1981). Hazardous Waste Regulations: An Interpretive Guide, (New York: van Nostrand, Reinhold).

Mandelker, Daniel (1976). Environmental and Land Controls Legislation, (New York: Bobbs-Merrill).

March, James (1978). "Bounded Rationality, Ambiguity, and the Engineering of Choice," Bell Journal of Economics, 9: 587-608.

_______ and H.A. Simon (1958). Organizations, (New York: Wiley).

Marris, Peter (1974). Loss and Change, (New York: Pantheon).

Marsh and McLennan (1980). Risk in a Complex Society, (Public Opinion Survey conducted by Louis Harris Associates, Inc.)

Massachusetts Department of Environmental Management (1981). Hazardous Waste Management in Massachusetts: Statewide Environmental Impact Report, (Boston: Commonwealth of Massachusetts, May).

_______ (1982). Kommunekemi: the Danish National Hazardous Waste Treatment System, (Boston: Commonwealth of Massachusetts, November).

_______ (1982). Analysis of Operation and Emissions from Typical Hazardous Waste Treatment Processes, (Boston: Commonwealth of Massachusetts, December).

Massachusetts Hazardous Waste Facility Site Safety Council (1982). "Hazardous Waste Facility Siting Act, and Regulations Implementing," (Boston: Commonwealth of Massachusetts).

Masten (1976). "Epistemic Ambiguity and the Calculus of Risk: Ethyl Corporation v. Environmental Protection Agency," South Dakota Law Review, 21(2): 425-451, Spring.

Maugh, Thomas (1979). "Toxic Waste Disposal an Growing Problem," Science, 204: 819-823, May 25.

_______ (1982a). "Just How Hazardous Are Dumps?," Science, 215: 490-493, January 29.

_______ (1982b). "Biological Markers for Chemical Exposure," Science, 215: 643-647, February 5.

Mazur, Allan (1973). "Disputes Between Experts," Minerva, 11: 243-262.

_______ (1981). The Dynamics of Technical Controversy, (Washington, D.C.: Communication Press).

McFarlane, Paul (1971). "Simulation Games as Social Psychological Research Sites: Methodological Advantages," Simulatin and Games, June: 149-161.

McGarity, Thomas (1979). "Substantive and Procedural Discretion in Administrative Resolution of Science Policy Questions: Regulating carcinogens in EPA and OSHA," Georgetown Law Review, 67(3): 729-810.

McMahon, Robert, Cindy Ernst, Ray Miyares, and Curtis Haymores (1981). Using Compensation and Incentives when Siting Hazardous Waste Management Facilities: A Handbook, (Washington, D.C.: U.S. Environmental Protection Agency, SW942).

Melber, Barbara, Stanley Nealey, Joy Hammsla and William Rankin (1977). Nuclear Power and the Public: Analysis of Collected Survey Research, (Seattle: Battelle Human Affairs Research Center, PNL-2430, November).

Merrill, Richard (1977). "Risk-Benefit Decision Making by the Food and Drug Administration," George Washington Law Review, 45(5): 994-1012.

Michael, Donald (1978). On Learning to Plan and Planning to Learn, (San Francisco: Jossey-Bass).

Mileti, Dennis (1980). "Human Adjustment to the Risk of Environmental Extremes," Sociology and Social Research, 64(3): 327-347, April.

Miller, Eric and A.K. Rice (1967). Systems of Organization, (London Tavistock).

Moldenhauer, David (1982). "A Case Study of Victim-Centered Political Action: Jackson Townships, New Jersey," in David Morell and Christopher Magorian. Siting Hazardous Waste Facilities, (Cambridge, MA: Ballinger Publishing).

Morell, David and Christopher Pollak (1982). Siting Hazardous Waste Facilities: Local Opposition and the Myth of Preemption, (Cambridge, MA: Ballinger Publishing).

Mosteller, Frederick. "Assessing Unknown Numbers: Order of Magnitude Estimation," in Statistical Methods for Policy Analysis.

Mumford, Lewis (1934). Technics and Civilization, (New York: Harcourt, Brace & Co).

Murray, James, Joseph Harrington, and Richard Wilson (1981). "Risks of Hazardous Chemical and Nuclear Waste: A Comparison," (Harvard School of Public Health, mimeo).

National Academy of Engineering, Committee on Public Engineering Policy (1972). Perspectives on Benefit-Risk Decision Making, (Washington, D.C.: NAS).

National Academy of Sciences (1975a). Decision Making for Regulating Chemicals in the Environment, (Washington, D.C.: NAS-NRC).

_______ (1975b). Principles for Evaluating Chemicals in the Environment, (Washington, D.C.: NAS).

_______, Committee on Environmental Decision Making (1977a). Decision Making in the EPA, (Washington, D.C.: NAS-NRC).

_______ (1977b). Perspectives on Technical Information for Environmental Protection, (Washington, D.C.: NAS-NRC).

_______, Committee on Risk and Decision Making (in preparation). Risk and Decision Making: Perspectives and Research, (Washington, D.C.: NAS).

National Conference of State Legislatures (1982). Hazardous Waste Management: A Survey of State Legislation, 1982, (Denver).

National Governors' Association (1981). Siting Hazardous Waste Facilities, (Washington, D.C.: Final Report, March).

Nealey, Stanley and John Hebert (1983). "Public Attitudes Toward Radioactive Wastes," in Charles Walker, Leroy Gould and Edward Woodhouse, eds., Too Hot to Handle? Social and Policy Issues in the Management of Radioactive Wastes, (New Haven: Yale University Press, pp 94-111).

Nelkin, Dorothy (1974). "The Role of Experts in a Nuclear Siting Controversy," Bulletin of the Atomic Scientists, 30(9): 29-36.

_______ (1977). "The Political Impact of Technical Expertise," in Geoffrey Boyle, David Elliott and Robin Roy, eds., The Politics of Technology, (New York: Longman, Inc).

_______ (1979). "Public Participation in Technological Decisions: Reality or Grand Illusion?" Technology Review, August: 55-64.

_______ and Michael Pollack (1977). "The Politics of Participation and the Nuclear Debate in Sweden, the Netherlands, and Austria," Public Policy, 25: 333-357, summer.

_______ and Michael Pollack (1980). "Problems and Procedures in the Regulation of Technological Risk," in Richard Schwing and Walter Albers, Jr., eds. Societal Risk Assessment: How Safe is Safe Enough? (New York: Plenum Press).

Nisbett, Richard and Lee Ross (1980). Human Inference: Strategies and Shortcomings of Social Judgement, (Englewood Cliffs: Prentice-Hall).

Noble, David (1979). "The Chemistry of Risk," Seven Days, June 5: 23-34.

Nowotny, Helga (1976). Social Aspects of the Nuclear Power Controversy, Research Memorandum 76-33, (Laxenburg, Austria: International Institute for Applied Systems Analysis).

_______ (1980). "The Role of Experts in Developing Public Policy: The Austrian Debate on Nuclear Power," Science, Technology and Human Values, 5(32):10-17.

O'Hare, Mike (1977). "Not on My Block, You Don't," Public Policy, 25(4): 407-458.

_______ (1980). "Information Management and Public Choice," Research in Public Policy Analysis and Management, 1: 223-256.

_______, Lawrence Bacow, and Debra Sanderson (1983). Facility Siting, (New York: Van Nostrand).

Okrent, David, (1980). "Comments on Societal Risk," Science, 208: 372-375, April 25.

_______ and Chris Whipple (1977). An Approach to Societal Risk Acceptance Criteria and Risk Management, Report to the National Science Foundation, Grant OEP 75-20318, UCLA-ENG-7746, (Los Angeles: UCLA School of Engineering and Applied Science, June).

Olson, Marcus (1971). The Logic of Collective Action, (Cambridge: Harvard University Press).

O'Riordan, Timothy (1982). "Risk-Perception Studies and Policy Priorities," Risk Analysis, 2(2): 95-100.

Osgood, Charles, George Suci, and Percy Tannenbaum (1957). The Measurement of Meaning, (Urbana: University of Illinois Press).

Otway, Harry (1975). "Risk Assessment and Societal Choices," Research Memorandum 75-2, (Laxenburg, Austria: International Institute for Applied Systems Analysis).

_______ and J.J. Cohen (1975a). "Revealed Preferences: Comments on the Starr Benefit-Risk Relationships," Research Memorandum 75-5, (Laxenburg, Austria: International Institute for Applied Systems Analysis, March).

_______, Philip D. Pahner and Joanne Linnerooth (1975b). "Social Values in Risk Acceptance," RM-75-54, (Laxenburg, Austria: International Institute for Applied Systems Analysis).

_______, R. Maderthaner, and G. Guttmann (1975b). "Avoidance Response to the Risk Environment: A Cross-Cultural Comparison," Research Report 75-14, (Laxenburg, Austria: International Institute for Applied Systems Analysis).

_______ and Philip D. Pahner (1976a). "Risk Assessment," Futures, 8(2): 122-134.

_______ and Martin Fishbein (1976b). "The Determinants of Attitude Formation: An Application to Nuclear Power," RM-76-80, (Laxenburg, Austria: International Institute for Applied Systems Analysis, IIASA, December).

_______ and Martin Fishbein (1977). "Public Attitudes and Decision Making," RM-77-54, (Laxenburg, Austria: International Institute for Applied Systems Analysis, November).

_______ and Kerry Thomas (1982). "Reflections on Risk Perception and Policy," Risk Analysis, 2(2): 69-82.

Page, Talbot (1978). "A Generic View of Toxic Chemicals and Similar Risks," Ecology Law Quarterly, 7(2): 207-244.

Pahner, Philip D. (1976). "A Psychological Perspective of the Nuclear Energy Controversy," RM-76-67, (Laxenburg, Austria: International Institute for Applied Systems Analysis).

Paigen, Beverly (1981). "The Love Canal Controversy: Constraints to Closure," (Hastings-on-Hudson, N.Y.: presented to the Institute of Society, Ethics and the Life Sciences, The Hastings Center, May 1).

Pate, Marie-Elisabeth (1981). "Acceptable Decision Processes and Acceptable Risk in Public Sector Regulations," (Cambridge: MIT Energy Lab EL 81-032WP, May).

Payne, John W. (1973). "Alternative Approaches to Decision Making Under Risk: Moments Versus Risk Dimensions," Psychological Bulletin 80(6): 35-44.

Peterson, Russell (1982). "Three Mile Island: Lessons for America," in Christoph Hohenemser and Jeanne Kasperson, eds., Risk in the Technological Society, (Boulder, CO: Westview, pp 35-45).

Pfeffer, Jeffrey and Gerald Slancik (1978). The External control of Organizations, (New York: Harper & Row).

Picciano, Dante (1980a). "Pilot Cytogenic Study of Love Canal, New York," prepared by the Biogenics Corporation for the EPA, May 14.

_______ (1980b). "Response to Love Canal: False Alarm," Science, 209: 754-756, August 15.

Plotkin, Steven (1983). "Incorporating the Risk of Control Failure into Environmental Assessments," (unpublished).

Pollatsek, A. and Amos Tversky (1970). "A Theory of Risk," Journal of Mathematical Psychology, 7: 572-596.

Porter, Richard (1982). "Environmental Negotiation: Its Potential and Its Economic Efficiency," (Institute of Public Policy Studies: Discussion Paper # 177).

Popper, Frank (1983). "LULUs," Resources, (Washington, D.C.: Resources for the Future, June, pp. 2-4).

Post, James E. (1978). Corporate Behavior and Social Change, (Reston, VA: Reston Publishing).

President's Science Advisory Committee, Panel on Chemicals and Health (1973). Chemicals and Health, (Washington, D.C.: U.S. Government Printing Office).

Preston, Valerie, S. Martin Taylor and David Hodge (1983). "Adjustment to Natural and Technological Hazards: A Study of an Urban Residential Community," Environment and Behavior, 15: 143-164.

Pruitt, Dean C. (1971). "Choice Shifts in Group Discussion: An Introductory Review," Journal of Personality and Social Psychology, 20: 339-360.

Raiffa, Howard (1968). Decision Analysis, (Reading, MA: Addison-Wesley).

_______ (1981). "Risk and Decision Making," unpublished draft.

_______ (1982). "Science and Policy: Their Separation and Integration in Risk Analysis," The American Statistician, 36(3.2): 225-231.

_______ (1983). Art and Science of Negotiations, (Cambridge: Harvard University Press).

_______, William Schwartz, and Milton Weinstein (1977). "Evaluating Health Effects of Societal Decisions and Programs," in The National Research Council, Decision Making in the Environmental Protection Agency, (Washington, D.C.: National Academy of Sciences, Vol IIb).

Ranyard, R.H. (1976). "Elimination by Aspects as a Decision Rule for Risky Choice," Acta Psychologica, 40: 299-310.

Ray, Paul and Richard Duke (1968). "The Environment of Decision-Makers in Urban Gaming Simulations," in William Coplin, ed., Simulation in the Study of Politics, (Chicago: Markham).

Rein, Martin (1976). Social Science and Public Policy, (New York: Penguin Books).

Rose, David (1981). "Continuity and change: Thinking in New Ways about Large and Persistent Problems," Technology Review, Feb.: 53-67.

Ross, Lee and Craig Anderson (1982). "Shortcomings in the Attribution Process: On the Origins and Maintenance of Erroneous Social Assessments," in Daniel Kahneman et al, eds., Judgment Under Uncertainty: Heuristics and Biases, (Cambridge: Cambridge University Press, pp 129-152).

Rossi, Peter, James Wright and Eleanor Weber-Burdin (1982). Natural Hazards and Public Choice: The State and Local Politics of Hazard Mitigation, (New York: Academic Press).

Rowe, William D. (1977a). An Anatomy of Risk, (New York: John Wiley & Sons).

_______ (1977b). "Governmental Regulation of Societal Risks," George Washington Law Review, 45(5): 944-968.

_______ (1980). "Risk Assessment Approaches and Methods," in Conrad, Jobst, ed., Society, Technology and Risk Assessment, (New York: Academic Press).

_______ (1981). "Risk Assessment and Policy Considerations," (Washington, D.C.: The American University, Institute for Risk Analysis).

Rubin, Brent and Linda Costigan Lederman (1982). "Instructional Simulation Gaming: Validity, Reliability, and Utility," Simulation and Games, 13(2): 233-244.

Sabatier, Paul (1978). "The Acquisition and Utilization of Technical Information by Administrative Agencies," Administrative Science Quarterly, 23: 396-417.

Salem, Steven, Kenneth Solomon, and Michael Yesley (1980). "Issues and Problems in Inferring a Level of Acceptable Risk," RAND Corp report prepared for DOE (R-2561-DOE), August.

Samuels, Sheldon W. (1979). "Role of Scientific Data in Health Decisions," Environmental Health Perspectives, 32: 301-307.

Sanderson, Debra (1979). "A Case Study of Four Negotiated Compensation Settlements," (Cambridge: MIT Lab for Architecture and Planning).

Schaefer, Ralf E. (1978). What Are We Talking about When We Talk about "Risk"? A Critical Survey of Risk and Risk Preference Theories, Research Memorandum 78-69, (Laxenburg, Austria: International Institute for Applied systems Analysis).

Schein, Edgar (1969). Process Consultation: Its role in Organization Development, (Reading, MA: Addison-Wesley).

Schelling, Thomas C. (1963). The Stategy of Conflict, (Cambridge, MA: Harvard University Press).

_______ (1966). "The Life You Save May Be Your Own," in Samuel Chase, ed., Problems in Public Expenditure Analysis, (Washington, D.C.: The Brookings Institute).

Schoemaker, Paul J. (1980). Experiments on Decisions Under Risks: The Expected Utility Hypothesis, (Boston: Martinus Nijhoff Publishing).

Schooler, Dean (1971). Science, Scientists and Public Policy, (New York: Free Press).

Schramm, Gunter, et al. (1979). The Value of Time in Environmental Decision Processes, Volume 1: Main Report, (Ann Arbor: University of Michigan, School of Natural Resources, November).

Schlove, Richard (1981). "Technological Politics as if Democracy Mattered," unpublished discussion paper, December 3.

Schon, Donald (1971). Beyond the Stable State, (New York: W.W. Norton).

Seidner, Constance and Richard Dukes (1976). "Simulation in Social-Psychological Research," Simulation and Games, 7(1): 3-20.

Seley, John E. (1983). The Politics of Public-Facility Planning, (Lexington, MA: Lexington Books).

Senkan, Selim M. and Nancy W. Stauffer (1981). "What to Do with Hazardous Waste," Technology Review, 84(2): 34-49.

Shaw, Marvin (1981). Group Dynamics: The Psychology of Small Group Behavior, (New York: McGraw-Hill).

Simon, Herbert A. (1955). "A Behavioral Model of Rational Choice," Quarterly Journal of Economics, 69: 99-118.

_______ (1959). "Theories in Decision Making in Economics and Behavioral Science," American Economic Review, 49: 253-283.

_______ (1982a). "From Substantive to Procedural Rationality," in Herbert Simon, ed., Models of Bounded Rationality, vol 2, (Cambridge: MIT Press)

_______ (1982b). "The Role of Expectation in an Adaptive or Behavioristic Model," in Herbert Simon, ed., Models of Bounded Rationality, vol 2, (Cambridge: MIT Press, pp 380-399).

Sims, John and Duane Baumann (1983). "Educational Programs and Human Response to Natural Hazards," Environment and Behavior, 15(2): 165-189.

Slesin, Louis E. (1978). "Potentially Catastrophic Policies," Unpublished doctoral dissertation, MIT Department of Urban Studies and Planning).

_______ and Joseph Ferreira (1976). "Social Value and Public Safety: Implied Preferences between Accedent Frequency and Safety," (Cambridge, MA: Report of the MIT Department of Urban Studies and Planning).

Slovic, Paul (1978). "Judgment, Choice and Societal Risk Taking," in K.R. Hammond, ed., Judgment and Choice in Public Policy Decisions, (Boulder, CO: Westview, pp 98-111).

_______ and Sarah Lichtenstein (1968a). "The Relative Importance of Probabilities and Payoffs in Risk-Taking," Journal of Experimental Psychology Monograph Supplement, 78: 3, part 2.

_______ and Sarah Lichtenstein (1968b). "Importance of Variance Preferences in Gambling Decisions," Journal of Experimental Psychology, 78(4): 646-54.

_______, Howard Kunreauther, and Gilber F. White (1974). "Decision Processes, Rationality, and Adjustment to Natural Hazards," in Gilber F. White, ed., Natural Hazards: Local, National and Global, (New York: Oxford University Press).

_______, Baruch Fischoff, and Sarah Lichtenstein (1976). "Cognitive Processes and Societal Risk Taking," in John Carroll and John Payne, eds., Cognition and Social Behavior, (Potomac, MD: Lawrence Erlbaum Associates, pp. 165-84).

_______, Baruch Fischoff, and Sarah Lichtenstein (1977). "Behavioral Decision Theory," Annual Review of Psychology, 28: 1-39.

_______, Baruch Fischhoff and Sarah Lichtenstein (1980). "Fears and Facts: Understanding Perceived Risk," in Richard Schwing and walter Albers, Jr., eds., Societal Risk Assessment: How Safe is Safe Enough?, (New York: Plenum Press).

_______, Sarah Lishtenstein and Baruch Fischhoff (1980b). "Images of Disaster: Perception and Acceptance of Risks from Nuclear Power," in G. Goodman, ed., Impacts and Risks of Energy Strategies: Their Analysis and Role in Management, (New York: Academic Press).

_______, Baruch Fischhoff and Sarah Lichtenstein (1982a). "Rating the Risks: The Structure of Expert and Lay Perceptions," in Christoph Hohenemser and Jeanne Kapserson, eds, Risk in the Technological Society, (Boulder, CO: Westview Press, pp 141-166).

_______, Baruch Fischhoff and Sarah Lichtenstein (1982b). "Why Study Risk Perception?" Risk Analysis 2(2): 83-94.

_______ and Baruch Fischhoff (1983). "How Safe is Safe Enough? Determinants of Perceived and Acceptable Risk," in Charles A. Walker, Leroy Gould, and Edward Woodhouse, eds., Too Hot to Handle? Social and Policy Issues in the Management of Radioactive Wastes, (New Haven: Yale University Press).

Smit, Peter (1982). "Proposed Planning Procedures: Gaming Simulation as a Method of Early Assessment," Simulation and Games, 13(3): 263-291.

Sontag, Susan (1977). Illness as Metaphor, (New York: Vintage Books).

Spangler, Miller (1982). "The Role of Interdisciplinary Analysis in Bridging the Gap Between the Technical and Human Sides of Risk Assessment," Risk Analysis, 2(2): 101-114.

Starr, Chauncey (1969). "Societal Benefit versus Technological Risk," Science, 165: 1232-1238.

_______, Richard Rudman, and Chris Whipple (1976). "Philosophical Basis for Risk Analysis," Annual Review of Energy, Volume 1, pp. 629-662.

_______ and Chris Whipple (1980). "Risks of Risk Decisions," Science, 208: 1114-19, June 6.

Stewart, Richard (1975). "The Reformation of American Administrative Law," Harvard Law Review, 88(8): 1669-83.

Stoner, James A. (1968). "Risky and Cautious Shifts in Group Decisions: The Influence of Widely Held Values," Journal of Experimental Social Psychology, 4: 442-459.

Straus, Donald B. (1979). "Managing Complexity: A New Look at Environmental Mediation," Environmental Science and Technology, 13: 661-65.

Summers, Gene, ed. (1970). Attitude Measurement. (Chicago: Rand McNally & Co).

Susskind, Lawrence (1982). "Incorporating Risk Assessment into Environmental Impact Assessment," prepared for Environmental Resources Ltd., January.

_______ and James Richardson, and Kate Hildebrand (1978a). "Resolving Environmental Disputes: Approaches to Intervention, Negotiation, and Conflict Resolution," (Cambridge, MA: MIT Lab for Architecture and Planning, Environmental Impact Assessment Project).

_______ and Michael O'Hare (1978b). "Managing the Social and Environmental Impacts of Energy Development," prepared for the National Governors Association, (Cambridge: MIT Laboratory of Architecture and Planning).

_______ and Alan Weinstein (1980). "Towards a Theory of Environmental Dispute Resolution," Boston College Environmental Affairs Law Review, 9(2): 311-357.

_______, Lawrence Bacow and Michael Wheeler (1984). Resolving Environmental Regulatory Disputes, (Cambridge, MA: Schenckman Publishers).

Swaton, E., et al. (1976). "The Determinants of Risk Perception: The Active-Passive Dimension," Research Memorandum 76-74, (Laxenburg, Austria: International Institute for Applied Systems Analysis).

Taviss, Irene (1972). "A Survey of Popular Attitudes Toward Technology," Technology and Culture, 13(4): 606-21.

Taylor, Graham (1981). Socioeconomic Analysis of Hazardous Waste Management Alternatives: Methodology and Demonstration, (Cincinnati, OH: U.S. Environmental Protection Agency, Municipal Environmental Research Laboratory, July).

Taylor, Shelley (1982). "The Availability Bias in Social Perception and Interaction," in Daniel Kahneman et al, eds., Judgment Under Uncertainty: Heuristics and Biases, (Cambridge: Cambridge University Press, pp 190-200).

Tchobanoglous, George, Hilary Theisen and Rolf Eliassen (1977). Solid Wastes: Engineering Principles and Management Issues, (New York: McGraw-Hill).

Thomas, Lewis et al. (1980). "Report of the Governor's Panel to Review Scientific Studies and the Development of Public Policy on Problems Resulting from Hazardous Wastes," (State of New York: Office of the Governor, October 8).

Thompson, James (1967). Organizations in Action, (New York: McGraw-Hill).

Thompson, Michael (1980). "Aesthetics of Risk: Culture or Context," in Richard Schwing and Walter Albers, Jr., eds., Societial Risk Assessment: How Safe is Safe Enough? (New York: Plenum Press).

_______ and Aaron Wildavsky (1982). "A Proposal to Create a Cultural Theory of Risk," in Howard Kunreauther and Eryl Ley, eds, The Risk analysis Controversy: An Institutional Perspective, (Berlin: Springer-Verlag, pp 145-161).

Toffler, Alvin (1974). Future Shock, (New York: Random House).

Tribe, Laurence H. (1973). "Technology Assessment and the Fourth Discontinuity: The Limits of Instrumental Rationality," Southern California Law Review, 46(2) 617-60.

_______, Corinne Schelling, and John Voss, eds. (1976). When Values Conflict: Essays on Environmental Analysis, Discourse, and Decision, (Cambridge, MA: Ballinger Publishing Company).

Trieff, Norman, ed. (1980). Environment and Health, (Ann Arbor: Ann Arbor Science).

Tversky, Amos (1972). "Elimination by Aspects: A Theory of Choice," Psychological Review, 79: 281-299.

_______ and Daniel Kahneman (1971). "The Belief in the 'Law of Small Numbers,' Psychological Bulletin, 76: 105-110.

_______ and Daniel Kahneman (1973). "Availability: A Heuristic for Judging Frequency and Probability," Cognitive Psychology, 5: 207-232.

_______ and Daniel Kahneman (1974). "Judgment Under Uncertainty: Heuristics and Biases," Science, 185: 1124-31, December 27.

_______ and Daniel Kahneman (1981). "The Framing of Decisions and the Psychology of Choice," Science, 211: 453-458.

_______ and Daniel Kahneman (1982). "Judgments Of and By Representativesness," in Daniel Kahneman et al, eds, Judgment Under Uncertainty: Heuristics and Biases, (Cambridge: Cambridge University Press, pp 84-98).

U.S. Congress (1982). Injuries and Damages from Hazardous Wastes -- Analysis and Improvement of Legal Remedies, Part 1 and 2, (Report by the Superfund Section 301e Study Group, Serial 97-12, September).

U.S. Congressional Research Service (1980). Six Case Studies of Compensation for Toxic Substances Pollution, (Report to the Senate Committee on Environment and Public Works, Serial 96-13, June).

U.S. Council on Environmental Quality (1979). Environmental Quality, Tenth Annual Report, (Washington, D.C.: Government Printing Office, December).

_______ (1980a). Environmental Quality, Eleventh Annual Report, (Washington, D.C.: Government Printing Office, December).

_______, et al. (1980b). Public Opinion on Environmental Issues, (Washington, D.C.: Government Printing Office).

U.S. Environmental Protection Agency (1974). Report to Congress: Disposal of Hazardous Waste, (Washington, D.C.: Government Printing Office, SW 115).

_______ (1975). Hazardous Waste Disposal Damage Reports, (Washington, D.C.: Government Printing Office, SW 151.2).

_______ (1977). State Decision-Makers Guide for Hazardous Waste Management, (Washington, D.C.: Government Printing Office, SW-612).

_______ (1978). Upgrading Hazardous Waste Disposal Sites: Remedial Approaches, (Washington, D.C.: Government Printing Office, SW-677).

_______ (1979a). Proposed Hazardous Waste Regulations, Volume 3, San Francisco Hearings, (Washington, D.C.: Government Printing Office, SW-52p, January).

_______ (1979b). Hazardous Waste Management Issues Pertinent to Section 3004 of the RCRA of 1976, (Washington, D.C.: Government Printing Office, SW-183C, November).

_______ (prepared by Centaur Associates, 1979c). Siting of Hazardous Waste Management Facilities and Public Opposition, (Washington, D.C.: Government Printing Office, SW-809).

_______ (1980a). Everybody's Problem: Hazardous Waste, (Washington, D.C.: Government Printing Office, SW-826).

_______ (1980b). Research Summary: Controlling Hazardous Waste, (Washington, D.C.: Government Printing Office, EPA-600/8-80-017).

_______ (1980c). "This Rat Died in a Cancer Lab to Save Lives," (Washington, D.C.: Office of Public Awareness 15/80, January).

_______ (1980d). "Taking the Hazard Out of Hazardous Waste," Environmental News: Region I, (Boston, MA: Office of Public Awareness).

_______ (prepared by Howard Bellman, Cynthia Sampson, and Gerald Cormick, 1982a). Using Mediation When Siting Hazardous Waste Management Facilities: A Handbook, (Washington, D.C.: Government Printing Office, July, SW-994).

_______ (1982b). "Assessment of Hazardous Waste Mismanagement Damage Case Histories," (prepared by Fred C. Hart Associates for the Office of Solid Waste, draft mimeo, December).

U.S. General Accounting Office (1979). "Hazardous Waste Management Programs Will Not be Effective," (Washington, D.C.: GAO, CED-79-14, January 23).

_______ (1980). "Hazardous Waste Disposal Methods: Major Problems With Their Use," (Washington, D.C.: GAO, CED-81-21, Nov. 19).

_______ (1981a). "Hazardous Waste Sites Pose Investigation, Evaluation, Scientific and Legal Problems," (Washington, D.C.: GAO, CED-81-57, April 24).

_______ (1981b). "Hazardous Waste Facilities with Interim Status May Be Endangering Public Health and the Environment," (Washington, D.C.: GAO).

_______ (1983). "Information on Disposal Practices of Generators of Small Quantities of Hazardous Waste," (Washington, D.C.: GAO, RCED-83-200, Sept 28).

_______ (1983). "Interim Report on Inspection, Enforcement and Permitting Activities at Hazardous Waste Facilities," (Report to the House Subcommittee on Commerce, Transportation and Tourism of the Committee on Energy and Commerce, Sept. 21).

U.S. House of Representatives (1979). Hazardous Waste Disposal, Parts 1 and 2, (U.S. House of Representatives: Subcommittee on Oversight and Investigations of the Committee on Interstate and Foreign Commerce, Serial # 96-48 and 49, March 21 - June 19).

_______ (1980a). Hazardous Waste Disposal: Our Number One Environmental Problem, (Subcommittee on Transportation and Commerce of the Committee on Interestate and Foreign Commerce, Serial 96-207, June 9).

_______ (1980b). Hazardous Waste Matters, (Subcommittee on Oversights and Investigations of the Committee on Interstate and Foreign commerce, Serial 96-200).

_______ (1980c). Long-Term Risks of Hazardous Waste Sites: Post Closure Liability, (Subcommittee on Transportation and Commerce of the Committee on Interstate and Foreign Commerce, July 25).

_______ (1981a). Hazardous Waste Matters: A Case Study of Landfill Sites, (Subcommittee on Oversight and Investigations of the Committee on Energy and Commerce, Serial 97-43, June 9).

_______ (1981b). Hazardous Waste, (Subcommittee on Natural Resources, Agricultural Research and Environment of the Committee on Science and Technology, # 150, Dec. 7).

_______ (1982). Hazardous Waste Facility Siting Problems: EPA Oversight, (Subcommittee of the Committee on Government Operations, April 23).

U.S. Office of Technology Assessment (1983). Technologies and Management Strategies for Hazardous Waste Control, (Washington, D.C.: Government Printing Office, March).

U.S. Senate (1979a). Hazardous and Toxic Waste Disposal, Parts 1 to 4, (U.S. Senate: Subcommittee on Environmental Pollution and Resource Protection of the Committee on Environmental Pollution and Resource Protection of the Committee on Environmental and Public Works, Serial # 96-H9, March).

_______ (1979b). Oversight of Hazardous Waste Management and the Resource Conservation and Recovery Act, (Subcommittee on Oversight of Government Management of the Committee on Governmental Affairs, July 19 - Aug. 1).

_______ (1980). Report on Hazardous Waste Management and the Implementation of the Resource Conservation and Recovery Act, (Prepared by the Subcommittee on Oversight of Government Management of the Committee on Governmental Affairs, March).

U.S. Surgeon General and the Congressional Research Service (1980). Health Effects of Toxic Pollution, (Report to the U.S. Senate Committee on Environmental and Public Works, Serial 96-15, August).

Van Horn, Andrew J. and Richard Wilson (1976). "The Status of Risk-Benefit Analysis," Discussion paper, Harvard Energy and Environmental Policy Center, December.

_______ and Richard Wilson (1977). "Factors Influencing the Public Perception of Risks to Health and Safety: A Brief Summary," Report to Brookhaven National Laboratory, BNL 24000, August.

Vlek, Charles, and Pieter-Jan Stallen (1980). "Rational and Personal Aspects of Risk," Acta Psychologica, 45: 273-300).

_______ and Pieter-Jan Stallen (1981). "Judging Risks and Benefits in the Small and in the Large," Organizational Behavior and Human Performance, 28: 235-271.

Waldbott, George (1973). Health Effects of Environmental Pollutants, (St. Louis: C.V. Mosby).

Wallach, Michael A. and Cliff W. Wing, Jr. (1968). "Is Risk a Value?" Journal of Personality and social Psychology, 9(1): 101-106.

Webster's New Collegiate Dictionary (1980). (Springfield, MA: Merriam & Co).

Weinburg, Alvin (1972a). "Science and Trans-Science," Minerva, 10: 209-222.

_______ (1972b). "Social Institutions and Nuclear Energy," Science, 177: 27-34, July 7.

_______ (1981). "Reflections on Risk Assessment," Risk Analysis, 1(1): 5-7.

Weinstein, Milton (1979). "Decision Making for Toxic Substances Control: Cost Effective Information Development for the Control of Environmental Carcinogens," Public Policy, 27(3): 333-383, summer.

_______ and Robert Quinn (1983). "Psychological Considerations in Valuing Health Risk Reductions," Natural Resources Journal, 23: 659-673, July.

Whyte, Anne V., and Ian Burton (1980). Environmental Risk Assessment, (New York: John Wiley & Sons).

Wildavsky, Aaron (1979). "No Risk is the Highest Risk of All," American Scientist, 67: 32-37.

_______ (1980). "Richer is Safer: Risk Assessment in the Large," Public Interest, 60:23-30.

Wilson, David Gordon (1977). "History of Solid-Waste Management," in David Wilson, ed., Handbook of Solid Waste Management, (New York: Van Nostrand, 1-9).

Wilson, James Q., ed. (1980). The Politics of Regulation, (New York: Basic Books).

Wilson, Richard (1978). "Risks caused by Low Levels of Pollution," The Yale Journal of Biology and Medicine, 51: 37-51.

_______ (1979a). "Risk Benefit Analysis for Toxic Chemicals," Presented to the 6th International Symposium on Chemical and Toxicological Aspects of Environmental Quality, Munich, Germany, September 17.

_______ (1979b). "Quantitative Estimates of Carcinogenic Risk," Discussion paper, Harvard Energy and Environmental Policy Center, October 18.

_______ (1979c). "Analyzing the Daily Risks of Life," Technology Review, February: 41-46.

Wolf, Sidney (1980). "Public Opposition to Hazardous Waste Sites: The Self Defeating Approach to National Hazardous Waste Control Under Subtitle C of the Resource Conservation and Recovery Act of 1976," Environmental Affairs, 8: 462:540.

Worobec, Mary (1980). "An Analysis of the Resource Conservation and Recovery Act," Environment Reporter, 11(17): 633-646; Aug. 22.

Worthley, John and Richard Torkelson (1981). "Managing the Toxic Waste Problem: Lessons from Love Canal," Administration and Society, 13(2): 145-160, August.

Wynne, Brian (1980). "Technology, Risk and Participation: On the Social Treatment of Uncertainty," in Jobst Conrad, ed, Society, Technology and Risk Assessment, (New York: Academic Press).

_______ (1982). "Institutional Methodologies and Dual Societies in the Management of Risk," in Howard Kunreuther and Eryl Ley, eds., The Risk Analysis Controversy: An Institutional Perspective, (Berlin: Springer-Verlag, pp 127-143).

Zeckhauser, Richard (1974). "Risk Spreading and Distribution," in Redistribution Through Public Choice, Harold M. Hockman and George E. Peterson, eds., (New York: Columbia University Press, pp 206-228).

Appendix A

Materials Used in the Presentation of the Gaming Simulation

Appendix A contains many of the materials used in the simulation. These materials include:

1. An outline of the presentation given by the research staff during the simulation. The outline was written to help participants who arrived late to quickly grasp the discussion. See pages 293 to 295.

2. Several small facsimiles of wall posters used in making the presentation and describing the process of treating hazardous waste. Included here is a simplified diagram of a rotary kiln incinerator, a photograph of such a facility, and a skematic diagram of the waste management process. See pages 296 to 298.

3. Miniature reproductions of the four quadrants of the game board. Each quadrant lists safety and compensation options and designates prices. In the gaming-simulation, budgets were established by use of pins given to each team. A single pin was equivalent to a $70,000 annual budget, and the cost of any given option was fixed by the number of dots adjacent to the description of the option. Participants were each given 42 pins, for a total budget of $3 million. Participants were free to move the pins into any position they liked. The startup position included an annual budget of $1.7 million in safety features proposed by the company they had selected as a negotiation partner, and $1.1 million in unrestricted compensation (in the form of tipping fees). See pages 299 to 302.

OUTLINE OF PRESENTATION

I. PURPOSE OF TONIGHT'S MEETING. Tonight's meeting is part of a project designed to improve the Massachusetts hazardous waste facility siting process. Several researchers from MIT and Harvard are trying to better understand how the concerns of local communities can be met while still siting facilities necessary for the safe management of hazardous waste. We have developed several general approaches to meeting the needs of local communities which will be presented tonight. We will be discussing these approaches, asking you to both think about them from the perspective of community residents and make choices as to which approaches you prefer.

To do this, we have imbedded the approaches in "hypothetical" proposals for siting a hazardous waste management facility. The facility we will be discussing is a rotary kiln incinerator. The facility is designed to burn hazardous wastes at very high temperatures. We have created several waste management companies, each with their own philosophy of managing wastes, to make proposals for siting this facility. In this way, we have tried to make the problems and opportunities of hazardous waste facility siting very clear, so that your reactions will be based on considerations that are as realistic as possible.

II. THE HAZARDOUS WASTE FACILITY SITING ACT. The facility siting law creates a framework for siting hazardous waste facilites through open negotiation among all interested parties. The law is based on the idea that only if the Commonwealth manages its waste disposal problems, the host and abutting communities negotiate a siting agreement that protects their interests and the developer builds an economically viable facility can a long-term solution to hazardous waste in the state be achieved. By requiring that developers and communities negotiate openly over any major proposal made in the state, and by acting as facilitator in this process, the Commonwealth hopes to achieve these objectives.

For our purposes tonight, five features of the law are most salient. First, once a developer's proposal has passed through an initial state review, the law requires the proposed host community to negotiate with the developer: the community cannot simply say "no" to the proposal. Second, the state will provide technical assistance and grants to the community to help it hire experts in technical, legal and financial matters. Third, the developer is required to prepare detailed reports describing the environmental and socio-economic impacts of the project. Fourth, any agreement that is reached between the community and the developer is legally binding. And fifth, if an impasse in the negotiations continues for more than two months after the state has accepted the impact reports, the Massachusetts Site Safety Council can arrange for arbitration to establish a binding siting agreement.

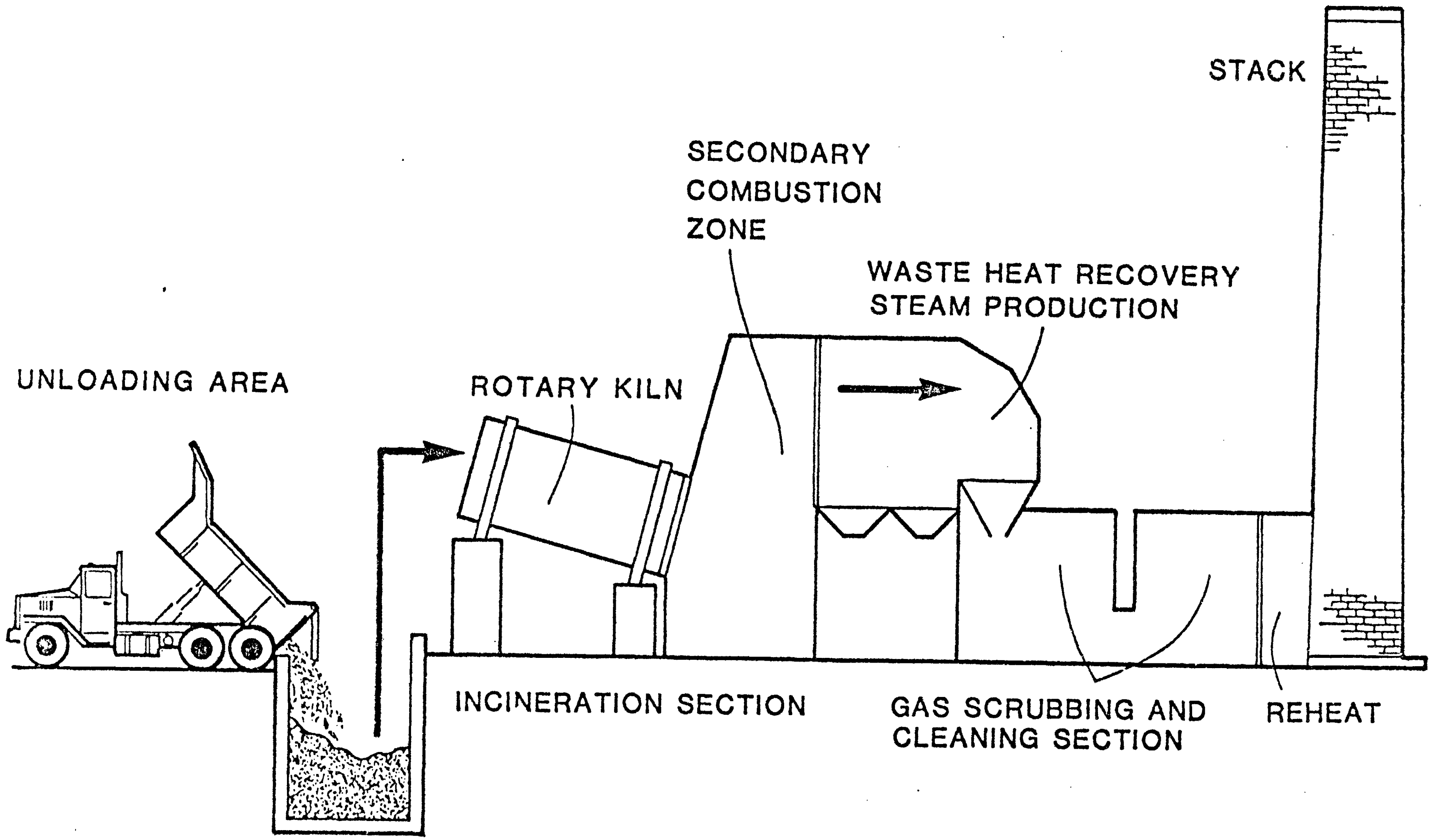
III. DESCRIPTION OF THE ROTARY KILN INCINERATOR. Tonight, we will be discussing a particular type of hazardous waste treatment: the rotary kiln incinerator. We have done this to make the issues of hazardous waste management more concrete than we could have done by talking about waste management in general.

Using today's technology, incineration can be the most effective way to dispose of hazardous organic waste. The incineration of hazardous waste involves controlled burning in a specially designed kiln and furnace. A rotary kiln is a slowly rotating cylindrical combustion chamber, slightly inclined to the horizontal. The rotation of the kiln during combustion continually mixes the solid and semi-solid waste material with air. This promotes uniform burning. The burn temperatures are extremely high (approximately 1,700 degrees F).

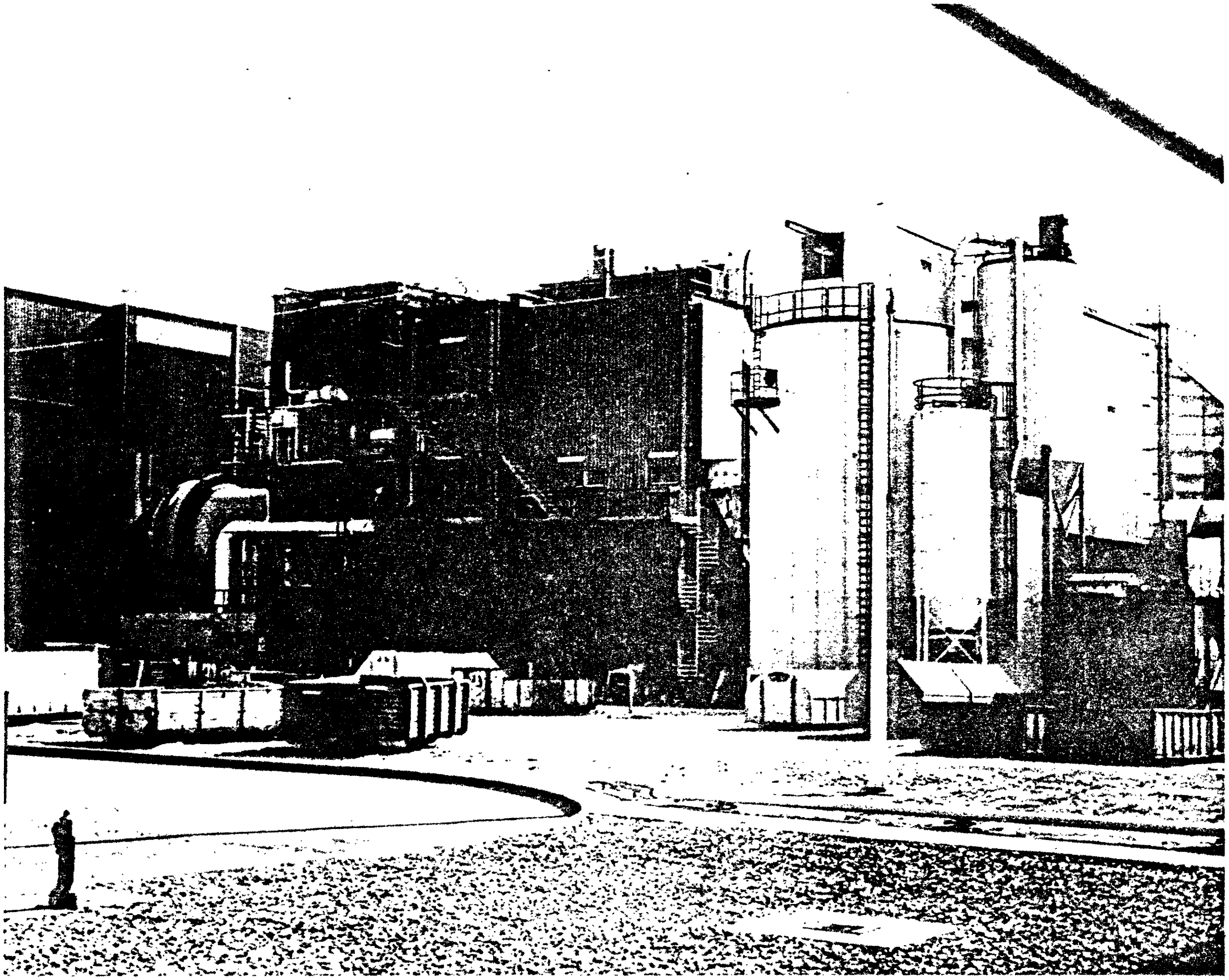
A picture of the facility can be seen in the posted photograph. The facility is large: approximately four stories in height and looks much like an oversized industrial boiler. Like an industrial boiler, it also has a tall stack.

The rotary kiln, together with a liquid injection unit for introducing liquids into the furnace, can incinerate distillation residues, oily wastes, chlorinated hydrocarbons, contaminated solvents, pesticides and a variety of other organic materials. For the most part, these materials are decomposed into carbon dioxide and water vapor. However, any incineration system will also have gaseous, liquid and solid emissions. In your packet you will find a diagram of these material flows. The proper use of control equipment can greatly reduce the risk of emissions, but even under the best of circumstances, small amounts of particulates and trace organics may be released to the environment.

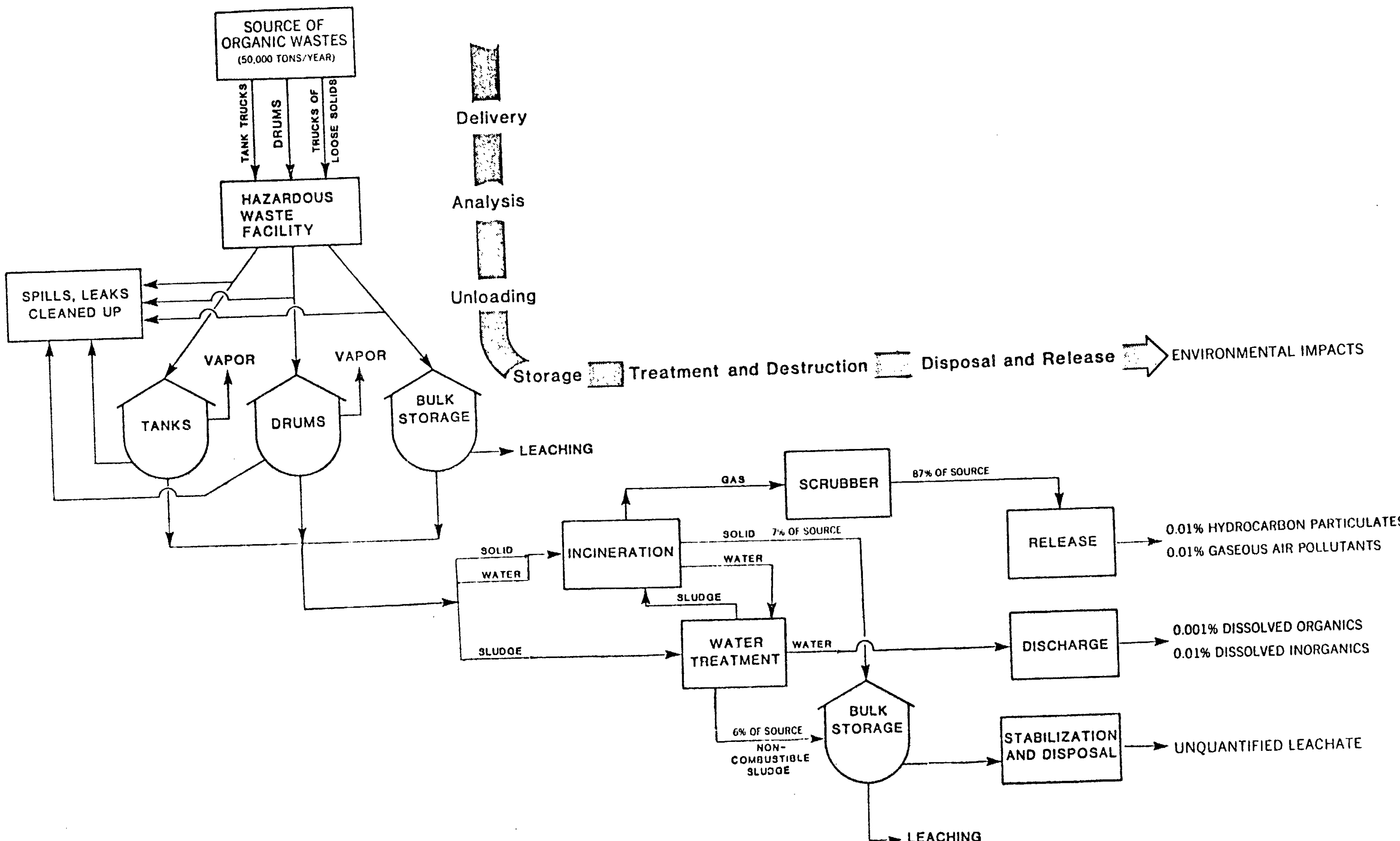
IV. THREE APPROACHES TO MANAGING HAZARDOUS WASTE. In order to facilitate discussion about what local communities would want from developers, we have created three companies with different approaches to managing the risks of hazardous waste treatment facilities. The first of these, Waste Technology, specializes in improved technologies. The second, Pollution Control, specializes in early detection and mitigation measures. And the third, Environmental Management, specializes in the ongoing management of the plant and increased cooperation with the host community. The proposals that each of these companies would make in a first round of negotiations are outlined in your packet (stapled behind the outline for the rotary kiln incinerator).



hazardous waste facility



ROTARY KILN INCINERATOR



hazardous waste disposal

WASTE TECHNOLOGY, INC.

- **vehicle safety standards** required of all waste delivery trucks	● ●
- **spill prevention and containment measures** including double lined storage tanks, dikes and ground material	● ● ● ●
- **oversized "packed" scrubber** to further reduce chloride and sulfur emissions	● ● ● ● ● ● ● ●
- **buffer zone** located around the treatment facility	● ● ● ● ●
- **best available technology** used for all health and safety equipment	● ● ● ● ●

POLLUTION CONTROL CORP.

- **emergency response corps** to train employees in accident containment	● ●
- **manifest system for tracking wastes** to track waste from the source to the treatment facility	● ●
- **vehicle inspection** to detect problems in waste delivery trucks	● ●
- **engineer for additional waste stream analysis** and more careful mixing for incineration	● ●
- **contingency and emergency response plan** for handling unusual events and training the emergency response corps	● ● ●
- **combustion monitoring and automatic shutdown** should air pollution standards be exceeded	● ● ●
- **air monitoring in neighborhood** to detect air pollution problems	● ●
- **preconstruction groundwater modeling** to help pinpoint future changes	●
- **groundwater monitoring** to detect pollution leaching from the site	● ●
- **spill containment measures** including dike, low permeable ground cover and pump system	● ● ●
- **mitigation promises** agreements to take corrective action should safety and health standards be exceeded	● ● ● ●

ENVIRONMENTAL MANAGEMENT

- **route restrictions** to specify delivery truck routes	●
- **vehicle ownership** facility operator to own and maintain all waste delivery trucks	● ●
- **delivery hour limits** to restrict deliveries to daytime hours	● ●
- **payment to town fire department** to purchase emergency equipment and train personnel in their use	● ●
- **Safety Board with emergency powers** creation of joint community/company board to oversee the plant's safe operation	● ● ●
- **budget for Safety Board** for making improvements in plant safety	● ● ● ●
- **engineer for additional waste stream analysis** and more careful mixing for incineration	● ●
- **payment to town for safety engineer with inspection rights** to be a watchdog for the town	● ●
- **dispute resolution agreements** to specify procedures for quickly resolving disputes, emergency powers of Safety Board and actions to be taken if unsafe conditions develop	● ● ● ● ●
- **emergency action trust fund** to cover cost of emergencies	● ● ●

COMPENSATION MEASURES

- **community service improvements** to improve roads and other services used by the facility	● ● ● ●
- **injury trust fund** to cover damage due to an accident	● ● ●
- **technical assistance** to support impact and planning studies	●
- **land value trust fund** to guarantee land values of adjacent property	● ●
- **water supply guarantees** to provide alternative water should groundwater be contaminated	● ● ● ●
- **community tipping fees** to enhance community revenues	○○○○ ○○○○ ○○○○ ○○○○
- **free local hazardous waste disposal** for industry and residents	● ●
- **cogeneration energy** provided to adjacent industry "at cost"	● ●
- **hiring local employees**	●
- **facility landscaping** to improve the aesthetics of the plant	● ●

Appendix B

Questionnaires Used in the Study

This appendix contains the three questionnaires used during the gaming simulation. They include:

1. A survey of attitudes, administered before the simulation was begun. See pages 304 to 307.

2. A form used for rank ordering the proposals put forth by Waste Technology Inc., Pollution Control Corp., and Environmental Management Inc. See page 308.

3. A post-simulation review of the team proposal, administered after individuals had broken into teams of six individuals and reached agreement on a proposal. See pages 309 and 310.

Welcome. Tonight's meeting is part of a larger effort to rethink Massachusett's policy for siting hazardous waste treatment facilities. We feel that a "rethinking" that takes better account of the views of community residents is needed. We have organized this meeting to introduce you to the problems of hazardous waste facility siting and to give you a chance to make suggestions.

To help make our discussions more fruitful, we need some basic information. Please take the next few minutes to answer the following questions.

YOUR VIEWS ABOUT HAZARDOUS WASTE AND GOVERNMENT REGULATION

The following 25 statements describe hazardous waste treatment facilities and the government's role in managing industrial development. You will probably agree with some and disagree with others. Please circle the number that best indicates YOUR OWN OPINION about each statement.

	STRONGLY DISAGREE	SOMEWHAT DISAGREE	NO OPINION	SOMEWHAT AGREE	STRONGLY AGREE
a. Local government best serves the community when it limits its attention to "essential" services like schools, roads, and fire protection.	1	2	3	4	5
b. Design and managment of hazardous waste treatment facilities are best left in the hands of experts.	1	2	3	4	5
c. Hazardous waste treatment plants present a constant threat.	1	2	3	4	5
d. If improperly managed, even the best designed treatment plant can be quite dangerous.	1	2	3	4	5
e. Hazardous waste treatment plants provide benefits which are essential to society.	1	2	3	4	5
f. Only with more effective community control over how treatment plants are designed and managed can local residents be sure that these plant will be safe.	1	2	3	4	5
g. Major health and safety problems can be prevented from occuring in hazardous waste facilities if they are designed with modern technology and managed carefully.	1	2	3	4	5
h. Environmental quality should be protected even when such protection is expensive.	1	2	3	4	5

	STRONGLY DISAGREE	SOMEWHAT DISAGREE	NO OPINION	SOMEWHAT AGREE	STRONGLY AGREE
i. Putting more money into trustworthy and effective managment for a hazardous waste plant will reduce risks more rapidly than spending the same amount on additional safety devices.	1	2	3	4	5
j. If detected quickly, hazardous waste mishaps can be handled so that major health and safety problems do not develop.	1	2	3	4	5
k. Hazardous waste companies can be trusted to be diligent in their efforts to make treatment plants safe.	1	2	3	4	5
l. Businesses should be allowed to manage their own affairs with minimal government regulation.	1	2	3	4	5
m. The federal government can be relied on to protect the health of communities in which hazardous waste facilities are located.	1	2	3	4	5
n. Generally, development and growth is good for our community.	1	2	3	4	5
o. The natural environment is one of our community's most important assets.	1	2	3	4	5
p. Hazardous waste treatment plants enhance environmental quality and safety.	1	2	3	4	5
q. When environmental protection inhibits industrial development, the regulations are probably too stringent.	1	2	3	4	5
r. Localities ought to have more power to ensure the safety of hazardous waste treatment facilites located in their jurisdictions.	1	2	3	4	5
s. Hazardous waste plants cause more problems than they solve.	1	2	3	4	5
t. State government can be relied on to ensure that hazardous waste treatment plants are safe.	1	2	3	4	5
u. Scientists and engineers do not know enough to design truly safe treatment plants.	1	2	3	4	5
v. New hazardous waste treament facilities are needed in Massachusetts to solve the state's hazardous waste problem.	1	2	3	4	5
w. Local government should take an active role in promoting environmental quality.	1	2	3	4	5

	STRONGLY DISAGREE	SOMEWHAT DISAGREE	NO OPINION	SOMEWHAT AGREE	STRONGLY AGREE
x. Dollar for dollar, safety in the operation of hazardous waste plants is best secured by improving the design of facilities rather than through better management.	1	2	3	4	5
y. Industry cannot be trusted to provide impartial information about the risks of hazardous waste facilities.	1	2	3	4	5

What do you think are the major problems and benefits of hazardous waste treatment facilities? ______________________________

____

____

____

____

____

FAMILIARITY WITH HAZARDOUS WASTE

1. Below is a list of places and laws associated with hazardous waste. Please circle the number that best indicates how familiar you are with what that association is. Don't worry if you never heard of any of them: many people haven't and your participation in tonight's discussion will be just as valuable whatever your previous experience.

NEVER HEARD OF IT	HAVE A VAGUE IDEA	GENERALLY UNDERSTAND IT	UNDERSTAND IT IN DETAIL	
1	2	3	4	Love Canal, New York
1	2	3	4	Department of Environmental Management
1	2	3	4	Hazardous Waste Facility Siting Act
1	2	3	4	Times Beach, Missouri
1	2	3	4	IT Corporation
1	2	3	4	toxic wastes in Holbrook or Woburn
1	2	3	4	Superfund
1	2	3	4	dioxin and PCBs
1	2	3	4	Resource Conservation and Recovery Act
1	2	3	4	facility siting debate in Warren

2. How interested would you say you are in the problems of hazardous waste?
   a. not at all interested.
   b. casually interested.
   c. quite interested.
   d. extremely interested.

3. Where do you get information about hazardous waste (circle more than one answer if applicable)?
   a. nowhere
   b. newspapers
   c. TV or radio
   d. casual discussions
   e. books or journals
   f. public meetings
   g. public documents
   h. personal experience
   i. other: ______________________________
   ____

4. Have you ever had any personal or professional experience with hazardous waste or with the Massachusetts Hazardous Waste Facility Siting Act? If so, please describe brielfly: ______________________________
____
____
____

5. Do you know anything about the technical aspects of hazardous waste and its treatment?
   a. practically nothing
   b. a little
   c. a lot

INFORMATION ABOUT THE PERSON ANSWERING THESE QUESTIONS

1. Statement of Confidentiality: I understand that the name of the community and the participants will be kept confidential, and that no statements made tonight will be publicly attributed to any individual.

   Signed (and printed for legibility): ______________________________
2. your phone number (day): ____________ (night): ____________
3. your occupation:
4. the income of your family: ___ less than $15,000 ___ $15,000 to $24,999 ___ $25,000 to $49,999 ___ greater than $50,000
5. your age:
6. the ages of any children that live in Rockport:
7. length of residency in Rockport:
8. length of time that you expect to continue living in Rockport:
9. amount of land owned in Rockport:
10. Have you ever been active in town government (for example, by being an active participant in town meeting, by running for office, or by serving on a town committee)? If so please describe: ______________________________
____
____

11. Do you belong to any organizations that have an interest in hazardous waste (for example: League of Women Voters, Sierra Club or Chamber of Commerce)? If so, please note the organization and the level of your involvement: ______________________________
____
____

1. Name: ______________________________

2. At this time, we would like to get your reaction to each of the three proposals that have just been discussing. In your opinion, which proposal would be safest for the community? Why? ____________________
____
____
____
____
____
____

3. Which statement most accurately reflects your opinion about the safety of your first choice?

   a. The facility seems quite safe.
   b. I have some reservations about the facility's safety but feel these could be easily worked out.
   c. I have major reservations about the facility's safety and would like substantial changes in the proposal.
   d. I feel the facility is basically unsound and a totally different approach is needed.
   e. other: ____
   ____
   ____
   ____

4. In your opinion, which proposal would be your second choice and why?
____
____
____
____

5. How much of an improvement do you feel your most preferred choice is over your second choice?

   a. About the same
   b. somewhat better
   c. considerably better

6. How much of an improvement do you feel your second choice is over your least preferred choice?

   a. About the same
   b. somewhat better
   c. considerably better

1. Your name: ______________________________

2. Please indicate your sense of how acceptable the proposal you have just worked on is to you:

   a. strongly acceptable
   b. somewhat acceptable
   c. I could go either way
   d. somewhat unacceptable
   e. strongly unacceptable

3. What are its major strengths? ______________________________

   Its major deficiencies? ______________________________

4. Attached you will find a smaller version of the board with which you were just working. The list of proposals is the same. Please indicate the mitigation or compensation measure that is most important to you by marking "1" in the space adjacent to its description. Mark your second choice with a "2". Continue marking until the package is MINIMALLY ACCEPTABLE as a proposal to site a hazardous waste treatment facility. Use the "other" space to add measures not listed.

5. Do you have any comments you would like to add: ______________________________

WASTE TECHNOLOGY, INC.

___ **VEHICLE SAFETY STANDARDS** required of all waste delivery trucks

___ **SPILL PREVENTION AND CONTAINMENT MEASURES** including double lined storage tanks, dikes and ground material

___ **OVERSIZED "PACKED" SCRUBBER** to further reduce chloride and sulfur emissions

___ **BUFFER ZONE** located around the treatment facility

___ **BEST AVAILABLE TECHNOLOGY** used for all health and safety equipment

POLLUTION CONTROL CORP

___ **EMERGENCY RESPONSE CORPS** to train employees in accident containment

___ **MANIFEST SYSTEM FOR TRACKING WASTES** to track waste from the source to the facility

___ **VEHICLE INSPECTION** to detect problems in waste delivery trucks

___ **ENGINEER FOR ADDITIONAL WASTE STREAM ANALYSIS** and more careful mixing for incineration

___ **CONTINGENCY AND EMERGENCY RESPONSE PLANS** for handling unusual events and training the emergency response corps

___ **COMBUSTION MONITORING AND AUTOMATIC SHUTDOWN** should air pollution standards be exceeded

___ **AIR MONITORING IN NEIGHBORHOOD** to detect air pollution problems

___ **PRECONSTRUCTION GROUNDWATER MODELING** to help pinpoint future changes

___ **GROUNDWATER MONITORING** to detect pollution leaching from the site

___ **SPILL CONTAINMENT MEASURES** including dike, ground cover and pump system

___ **MITIGATION PROMISES** agreements to take corrective action should safety and health standards be exceeded

ENVIRONMENTAL MANAGEMENT

___ **ROUTE RESTRICTIONS** to specify delivery truck routes

___ **VEHICLE OWNERSHIP** facility operator to own and maintain all waste delivery trucks

___ **DELIVERY HOUR LIMITS** to restrict deliveries to daytime hours

___ **PAYMENT TO TOWN FIRE DEPARTMENT** to purchase equipment and train personnel

___ **SAFETY BOARD WITH EMERGENCY POWERS** creation of joint community/company board to oversee the plant's safe operation

___ **BUDGET FOR SAFETY BOARD** for making improvements in plant safety

___ **ENGINEER FOR ADDITIONAL WASTE STREAM ANALYSIS** and more careful mixing for incineration

___ **PAYMENT TO TOWN FOR SAFETY INSPECTION ENGINEER** to be a watchdog for the town

___ **DISPUTE RESOLUTION AGREEMENTS** to specify procedures for quickly resolving disputes, powers of Safety Board and actions to be taken if unsafe conditions develop

___ **EMERGENCY ACTION TRUST FUND** to cover cost of emergencies

COMPENSATION MEASURES

___ **COMMUNITY SERVICE IMPROVEMENTS** to improve roads and other services used by the facility

___ **INJURY TRUST FUND** to cover damage due to accident

___ **TECHNICAL ASSISTANCE** to support planning studies

___ **LAND VALUE TRUST FUND** to guarantee land values of adjacent property

___ **WATER SUPPLY GUARANTEES** to provide alternative water should groundwater be contaminated

___ **COMMUNITY TIPPING FEES** to enhance community revenues

___ **FREE LOCAL HAZARDOUS WASTE DISPOSAL** for industry and residents

___ **COGENERATION ENERGY** provided to adjacent industry "at cost"

___ **HIRING LOCAL EMPLOYEES**

___ **FACILITY LANDSCAPING** to improve the aesthetics of the plant

___ **OTHER** ______________________

Appendix C

List of Participants

	sex	designation and town	occupation	major town offices held
1.	M	preservationist, Essexton	director of public works	
2.	M	guardian, Worcesterville	chief of police	
3.	M	undesignated, Essexton	engineer	Board of Selectmen
4.	M	preservationist, Essexton	realtor	Board of Selectmen Finance Committee
5.	M	sponsor, Essexton	sanitary engineer with specialty in hazardous waste	
6.	M	preservationist, Worcesterville	architect	Planning Board
7.	M	sponsor, Worcesterville	fire chief	
8.	M	sponsor, Worcesterville	contractor	
9.	F	undesignated, Worcesterville	newspaper publisher	Planning Board
10.	M	undesignated, Worcesterville	teacher	
11.	F	preservationist, Worcesterville	assistant to Board of Assessors	
12.	M	guardian, Worcesterville	mechanic	Industrial Development Commission
13.	F	guardian, Essexton	museum director	Board of Selectmen Conservation Commission, Solid Waste and Recycling Committee

14.	M	sponsor, Worcesterville	fireman, specialist in hazardous waste	Planning Board
15.	M	sponsor, Essexton	retired	
16.	M	guardian, Worcesterville	assistant to select-men	
17.	M	sponsor, Essexton	industrial process engineer	Board of Selectmen Planning Board Finance Committee
18.	M	guardian, Essexton	industrial production supervisor	
19.	F	sponsor, Worcesterville	salesperson	Industrial Devel-opment Commission
20.	M	preservationist, Worcesterville	businessman	Planning Board Zoning Board of Appeals
21.	M	preservationist, Essexton	architect	Planning Board
22.	F	guardian, Worcesterville	editor	Board of Selectmen Zoning Board of Appeals, Recycling Committee
23.	F	guardian, Worcesterville	farmer	Conservation Com-mission
24.	F	preservationist, Worcesterville	administrative assistant	
25.	F	undesignated, Essexton	nurse	Planning Board
26.	M	sponsor, Essexton	retailer	
27.	F	undesignated, Essexton	retired	
28.	M	preservationist, Essexton	retired	
29.	M	guardian, Essexton	planner	Board of Selectmen Planning Board
30.	F	guardian, Worcesterville	business manager	Conversation Com-mission

31. M	preservationist, Essexton	process engineer	Conservation Commission, Economic Development Committee
32. M	guardian, Essexton	physician	Board of Health
33. M	undesignated, Essexton	teacher	
34. M	undesignated, Worcesterville	manager	